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Economic evaluation of national immunization program vaccines in China: a systematic review

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Abstract

Objective This study aims to systematically review the published economic evaluations of vaccines included in China's National Immunization Program (NIP), synthesise the current evidence base, and assess their cost-effectiveness.

Methods A comprehensive search was conducted across PubMed, Web of Science, Embase, CNKI, CSTJ, and Wanfang Data for cost-benefit analyses (CBA), cost-effectiveness analyses (CEA), and cost-utility analyses (CUA) related to NIP vaccines in China, from database inception to 14 July 2025. Studies were screened following the PRISMA guidelines. The study's reporting quality was assessed using the CHEERS 2022 checklist, while methodological quality was evaluated using the QHES instrument.

Results A total of 41 studies were included and demonstrated an overall moderate methodological quality (mean CHEERS score: 66.42; mean QHES score: 70.63). The included studies covered a range of NIP-targeted vaccines, including hepatitis B, measles, tuberculosis, diphtheria-pertussis-tetanus, hepatitis A, and meningococcal vaccines, with hepatitis B receiving the greatest research focus (*n* = 32). Most evaluations were conducted from a societal or healthcare system perspective. The majority of studies reported benefit-cost ratios (BCR) greater than 1 or incremental cost-effectiveness ratios (ICER) below the per capita GDP threshold, indicating substantial economic value. Despite variations in model structures, baseline parameters, and assumptions, all studies consistently concluded that NIP vaccines are cost-effective compared with no vaccination. Hepatitis B vaccination, particularly when combined with maternal transmission prevention strategies, demonstrated exceptionally high net benefits at both national and subnational levels.

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Conclusion NIP vaccines in China offer substantial economic value; however, interpretation of the findings may be influenced by methodological heterogeneity and the use of GDP per capita-based cost-effectiveness thresholds, and the adoption of standardised evaluation methods is essential to support policy optimisation and sustainability.

Keywords National immunization program, Cost-Effectiveness, Vaccine, China

Introduction

Immunisation is one of the most effective strategies for disease prevention in global public health [1–3]. In 1974, the World Health Organization (WHO) launched the Expanded Programme on Immunisation (EPI) to provide guidance and support for improving vaccine delivery, supply, and administration worldwide [4]. Since then, global immunisation programmes have averted approximately 154 million deaths, the vast majority among children under five years of age, significantly improving child survival rates, particularly in low-resource settings [5]. China officially launched its National Immunization Program (NIP) in 1978, initially covering four routine vaccines, including Bacillus Calmette-Guérin (BCG), oral polio vaccine (OPV), diphtheria-pertussis-tetanus (DPT) vaccine, and measles vaccine, to prevent six targeted infectious diseases. Over the following decades, China gradually expanded the programme to include additional vaccines, such as hepatitis B, hepatitis A, Japanese encephalitis (JE), meningococcal vaccines targeting Neisseria meningitidis serogroups A and C, among others [6–9].

Since 1978, China's NIP has markedly reduced the incidence of targeted vaccine-preventable diseases. For example, the incidence of pertussis declined from 126.35 to 1.58 per million, representing a 98% reduction, while the incidence of measles, meningitis, and Japanese encephalitis decreased by 99%, 99%, and 98%, respectively [10]. It is estimated that from 1974 to 2024, immunisation efforts in China have prevented approximately 703.02 million cases, 2.48 million deaths, and 160.22 million disability-adjusted life years (DALYs) [11]. China has made substantial progress in controlling and eliminating multiple vaccine-preventable diseases [12–14], and maintaining high vaccination coverage remains crucial for sustaining disease control.

However, expanding the NIP to include both new vaccines, such as pneumococcal conjugate vaccine (PCV), rotavirus vaccine, and human papillomavirus (HPV) vaccine, and improved formulations of existing ones poses significant financial and institutional challenges [15–17]. Given China's large population and uneven distribution of economic development and health care resources, a central challenge for public health policy is how to expand the NIP in a fiscally sustainable manner while ensuring equitable and continuous access to vaccination services [18]. Although the long-term health and societal benefits of immunisation are well recognised, the substantial upfront financial investment required for vaccine introduction continues to hinder policy progress [19].

Against this backdrop, high-quality economic evaluations are essential to inform evidence-based immunisation policymaking [20]. In recent years, a growing number of domestic studies have assessed existing and candidate NIP vaccines using cost-benefit analysis (CBA), cost-effectiveness analysis (CEA), and cost-utility analysis (CUA), providing valuable insights for decision-making [11, 21]. However, these studies vary considerably in methodological rigor, including differences in cost components, effectiveness parameters, discount rates, modelling structures, analytical perspectives, comparators, and time horizons. Such heterogeneity limits comparability and synthesis of results, thereby reducing the utility of these findings for policy formulation. This study systematically reviews published economic evaluations of NIP vaccines in China, analysing research characteristics, methodological quality, and key outcomes to summarise the economic value of immunisation and support the optimisation and sustainability of NIP policies.

Methods

Search strategy and study selection

We conducted a comprehensive literature search across three international databases (PubMed, Web of Science, and Embase) and three major Chinese databases: China National Knowledge Infrastructure (CNKI), China Science and Technology Journal Database (CSTJ), and Wanfang Data, from database inception to 14 July 2025. The search strategy incorporated both free-text terms and Medical Subject Headings (MeSH) related to the economic evaluation of vaccines included in China's NIP. The detailed search strategy is provided in Supplementary File S1.

The reporting of this review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [22]. A four-stage selection process was used, with each stage independently conducted by two researchers to ensure transparency and reproducibility. During the initial screening, reviewers independently assessed titles and abstracts to exclude studies that clearly did not meet the inclusion criteria. When abstract information was insufficient to determine eligibility, full texts were retrieved and assessed. Disagreements between reviewers were resolved through discussion or consultation with a third researcher. The inclusion and exclusion criteria are summarised in Table 1.

Data extraction

This study employed a self-designed, standardised data extraction form to collect information from the included studies. The form comprised three main sections: (1) basic information, including author, year of publication, title, and study region; (2) study design characteristics, such as type of economic evaluation, type of model used, intervention and comparator, study population, analytical perspective, time horizon, discount rate, and cost-effectiveness threshold; and (3) key outcome indicators, including the incremental cost-effectiveness ratio (ICER), incremental cost-utility ratio (ICUR), and benefit-cost ratio (BCR). To ensure objectivity and accuracy, data extraction was conducted independently by two researchers.

Quality appraisal of economic evaluations

This study conducted a dual quality assessment of the included studies using the Consolidated Health Economic Evaluation Reporting Standards (CHEERS 2022) and the Quality of Health Economic Studies (QHES) scale [23, 24]. The CHEERS 2022 checklist (28 items) was used to evaluate reporting completeness, with each item scored as fully reported (1 point), partially reported (0.5 points), or not reported (0 points), and the scores converted to percentage-based grades (poor: <50%; moderate: 50–75%; good: 76 – 5%; excellent: >95%). The QHES instrument (16 items, total score of 100) was applied to assess methodological rigor, using its original grading criteria (poor, moderate, or good). To examine the relationship between the results obtained from the two tools, we performed both Pearson and Spearman correlation analyses to assess score consistency.

Table 1 Inclusion and exclusion criteria of literature

Criteria	Inclusion	Exclusion
Population	NIP target populations	Animal studies
Intervention	NIP vaccines	Other interventions, Combined intervention
Comparator	non-NIP vaccines	NA
Outcome	ICUR, ICER, BCR	Costs/outcomes only
Study design	CUA, CEA, CBA, CMA	Abstract, review, comment, peer-reviewed articles, grey literature, no full text
Language	Chinese and English	NA

NIP National Immunisation Program, *BCR* Benefit-cost ratio, *CBA* Cost-benefit analysis, *CEA* Cost-effectiveness analysis, *CMA* Cost-minimization analysis, *CUA* Cost-utility analysis, *ICER* Incremental cost-effectiveness ratio, *ICUR* Incremental cost-utility ratio, *NA* Not applicable

Synthesis of results

Following established guidelines, we conducted a narrative synthesis using structured tables and descriptive analysis to summarise and compare the findings.

The protocol for this systematic review was registered on PROSPERO (Registration Number: CRD420251119790).

Results

Study selection

A total of 2,335 records were identified through electronic database searches. After removing 565 duplicates, 1,770 records underwent screening based on titles and abstracts. Following this initial screening, 1,668 records were excluded, leaving 102 for full-text review. Ultimately, 41 studies met the eligibility criteria and were included in the systematic review. The study selection process is detailed in the PRISMA flow diagram (Fig. 1).

Quality of included studies

Across the 41 studies, the mean CHEERS score was 66.42 (SD = 12.77; range, 39.29–89.29), and the mean QHES score was 70.63 (SD = 12.68; range, 44–99), indicating moderate reporting quality (Fig. 2). Shapiro-Wilk tests for normality showed that both scores followed a normal distribution ($p > 0.05$); therefore, Pearson correlation analysis was used to examine their linear relationship. A significant positive correlation was observed between the two scores (Pearson $r = 0.80$, $p < 0.001$). Additionally, Spearman rank correlation analysis, used to assess ranking consistency, also demonstrated a significant positive correlation (Spearman $\rho = 0.76$, $p < 0.001$). These findings indicate that the two evaluation tools show good correlation and consistency in assessing the quality of the included studies. Detailed quality assessment results for all 41 studies are provided in Supplementary File S2.

Study characteristics

Study settings

The final 41 papers included in this review comprised one published in 1995, nine between 2000 and 2010, 26 between 2011 and 2020, and five between 2021 and 2025. Regarding study settings, 12 studies (29.3%) were conducted at the national level, whereas the remaining studies focused on the subnational settings. Of these, 22 studies were concentrated in eastern provinces, four in western provinces, two in central regions, and one in the northeast. In terms of vaccine types, studies related to the hepatitis B vaccine accounted for the largest proportion (n = 32). In addition, two studies evaluated meningococcal vaccines [25, 26], while one study each assessed on epidemic haemorrhagic fever [27], hepatitis A [28], BCG [29], measles [30], JE [31], and DTP [32]. Another study evaluated immunisation programme vaccines targeting

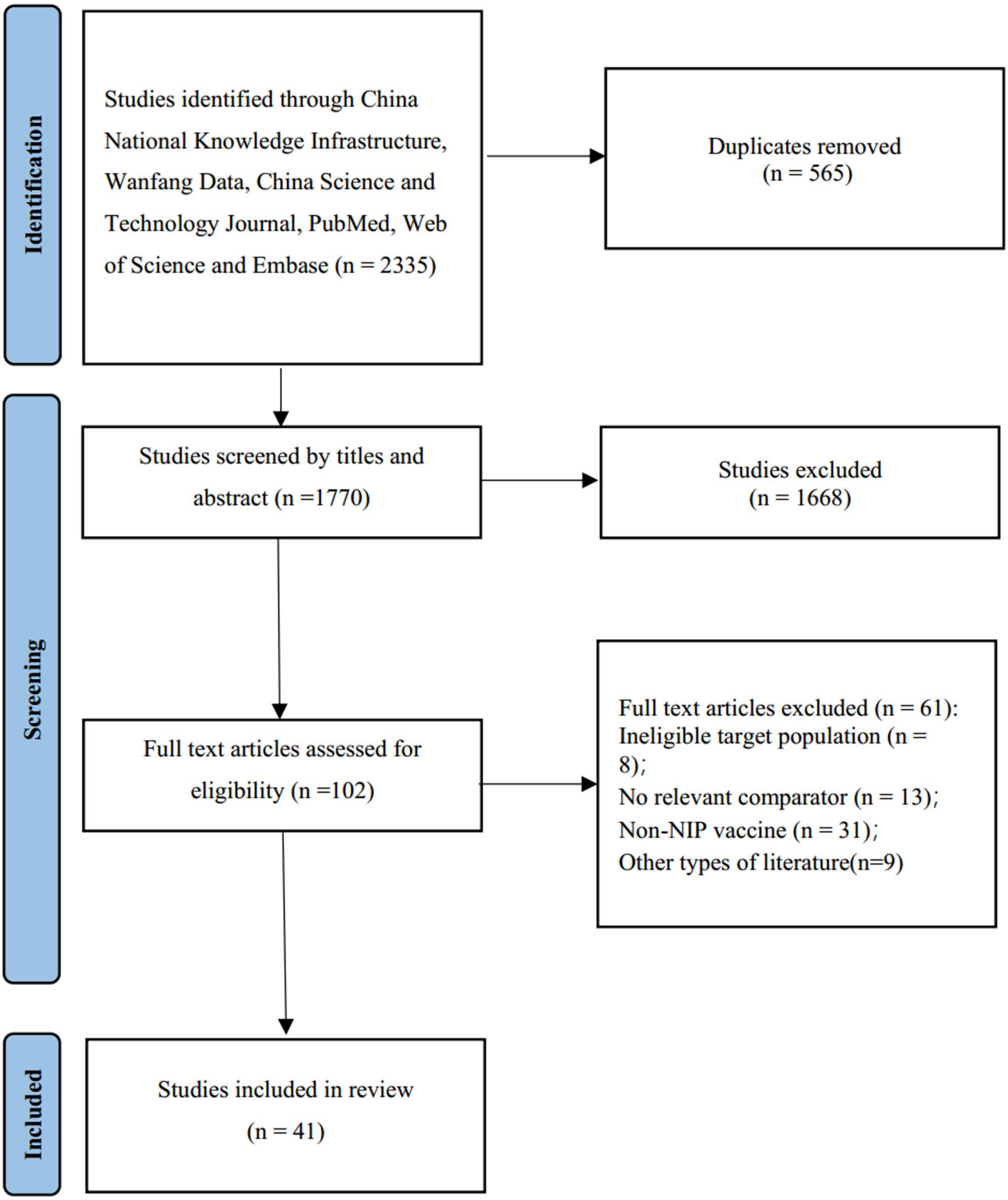

Fig. 1 PRISMA flow diagram of the study selection process

eight pathogens simultaneously, including measles, pertussis, hepatitis B, tuberculosis, hepatitis A, Japanese encephalitis, meningitis A, and poliomyelitis [11]. (Table 2)

Study design of economic evaluations

A total of 19 studies applied CBA, using the economic burden of disease averted by vaccination as the primary evaluation metric [25, 27, 28, 32–47]. Four studies

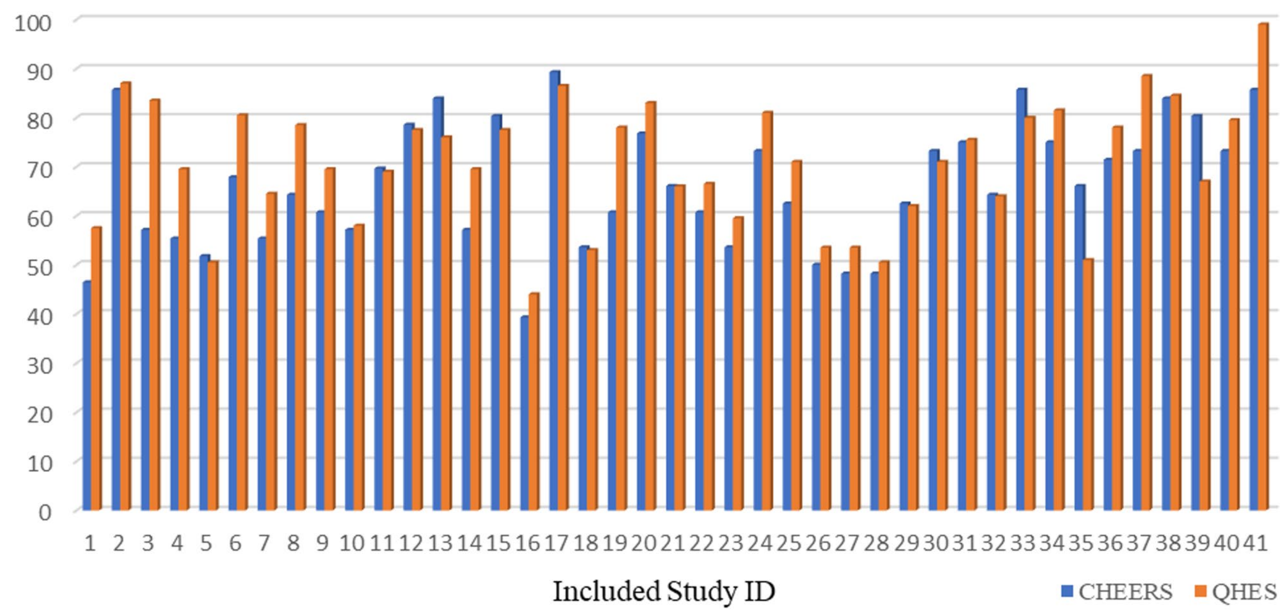

Fig. 2 Reporting quality of included economic evaluation studies

adopted CUA, measuring outcomes in quality-adjusted life years (QALYs) or DALYs [26, 48–50]. One study used CEA, using the number of cases averted as the outcome measure [51]. In addition, 17 studies employed combined analytical approaches, including eight that applied both CBA and CEA [30, 52–58], five that combined CUA and CBA [11, 31, 59–61], two that used both CEA and CUA [29, 62], and two that simultaneously performed CBA, CEA, and CUA, simultaneously [63, 64].

Regarding study perspectives, seven studies adopted a single analytical perspective, including six that used a societal perspective [26, 29, 33, 45, 46, 60], one that used a healthcare system perspective [48], and one that used a payer perspective [30]. Ten studies adopted multiple perspectives, including four combined the healthcare system and societal perspectives [11, 31, 32, 47], three combined the payer and societal perspectives [40, 50, 62], and three applied healthcare system, payer, and societal perspectives [41, 52, 54]. The remaining 23 studies did not report their analytical perspective.

A total of 21 studies explicitly reported the models used. The most common approach was a combination of decision tree and Markov models (n = 11), while fewer studies employed a decision tree model alone (n = 6) or a Markov model alone (n = 5). Regarding time horizons, most studies adopted a time horizon of more than 40 years (n = 17). Equal numbers of studies reported time horizons of 1–10 years and 11–30 years (n = 12 each). Among studies reporting discount rates (n = 27), 18 applied a 3% rate [26, 29–32, 38, 41, 42, 47, 48, 50, 52, 54, 61, 62, 64], six applied a 5% rate [25, 37, 40, 45, 51, 58], one study used both 3% and 5% in a sensitivity analysis [11], and one study applied a specific rate of 3.38% [28]. Notably, only one study reported using differential discounting (3% for costs and 1% for health outcomes) [49]. Fourteen studies did not report discounting information. In addition, most studies conducted sensitivity analyses (n = 25).

Regarding threshold settings for economic evaluation, all studies that reported ICER (n = 8) adopted the threshold recommended by the WHO, applying one to three times the gross domestic product (GDP) per capita as the cost-effectiveness benchmark. In CBA studies, most studies (n = 31) considered an intervention economically favourable if the BCR exceeded one (Table 2 and Supplementary File S2).

Economic evaluation results

Health economics evaluation of hepatitis B vaccine

Many studies have focused on the health economic evaluation of hepatitis B vaccination. A national-level study reported that between 1992 and 2005 [58], the total investment in neonatal hepatitis B vaccination in China was approximately 5.35 billion CNY, generating a comprehensive economic benefit of about 272.83 billion CNY. Another national study assessed a catch-up vaccination strategy targeting individuals under 15 years of age from 1990 to 2009, showing that the strategy reduced the economic burden by 1,222.77 billion CNY compared with no catch-up vaccination, at a cost of 10,260.7 CNY per QALY gained [49]. A further study simulated the short-term (2006–2015) and medium- to long-term (2016–2030) impacts of implementing the free hepatitis B vaccination policy [52]. The findings indicated that nationwide vaccination was expected to generate a cumulative total of 12.95 billion life years (LYs) and 10.61

Table 2 Study characteristics

Characteristic	Items	Number	Percent
Publication year	~ 2000	1	2.44%
	2001 ~ 2010	9	21.95%
	2011 ~ 2020	26	63.41%
	2021 ~ 2025	5	12.20%
Area	National Level	12	29.27%
	Guangdong Province	6	14.63%
	Shandong Province	4	9.76%
	Beijing Municipality	3	7.32%
	Guizhou Province	3	7.32%
	Zhejiang Province	3	7.32%
	Jiangsu Province	2	4.88%
	Anhui Province	1	2.44%
	Hainan Province	1	2.44%
	Hebei Province	1	2.44%
	Liaoning Province	1	2.44%
	Shanxi Province	1	2.44%
	Shanghai Municipality	1	2.44%
	Tianjin Municipality	1	2.44%
	Sichuan Province	1	2.44%
Type of Vaccine	Hepatitis B	32	78.05%
	Meningococcal disease	2	4.88%
	Haemorrhagic fever with renal syndrome	1	2.44%
	Hepatitis A	1	2.44%
	Tuberculosis	1	2.44%
	Measles	1	2.44%
	Japanese encephalitis	1	2.44%
	Diphtheria, Tetanus, and Pertussis	1	2.44%
	EPI against eight pathogens (measles, pertussis, hepatitis B, tuberculosis, hepatitis A, Japanese encephalitis, meningitis A, and poliomyelitis)	1	2.44%
Type of economic analysis	CBA	19	46.34%
	CUA	4	9.76%
	CEA	1	2.44%
	CBA, CEA	8	19.51%
	CBA, CUA	5	12.20%
	CEA, CUA	2	4.88%
	CBA, CEA, CUA	2	4.88%
Type of model	Decision tree -Markov	10	24.39%
	Decision tree	6	14.63%
	Markov	5	12.20%
	Not used	20	48.78%
Study perspective	Societal Perspective	6	14.63%
	Healthcare System Perspective	1	2.44%
	Payer Perspective	1	2.44%
	Healthcare System Perspective and Societal Perspective	4	9.76%
	Payer Perspective and Societal Perspective	3	7.32%
	Payer Perspective, Healthcare System Perspective, and Societal Perspective	3	7.32%
	Unreported	23	56.10%
Time horizon	1–10 years	12	29.27%
	11–30 years	12	29.27%
	≥ 40 years	17	41.46%

Table 2 (continued)

Characteristic	Items	Number	Percent
Discount rate	3%	18	43.90%
	5%	6	14.63%
	3% and 5%	1	2.44%
	Else	2	4.88%
	Unreported	14	34.15%
Threshold	BCR>1	31	75.61%
	Per capita GDP	8	19.51%
	NA	2	4.88%
Sensitivity analysis	Yes	25	60.98%
	No	16	39.02%

CBA Cost-benefit analysis, *CEA* Cost-effectiveness analysis, *CUA* Cost-utility analysis, *GDP* Gross Domestic Product, *BCR* Benefit-cost ratio, *NA* Not applicable

billion QALYs during 2006–2030, representing increases of 187 million LYs and 233 million QALYs compared with no vaccination. From healthcare system and societal perspectives, the cumulative BCR of the strategy over the period 2006–2015 was 7.96 and 7.61, respectively. These ratios increased to 10.7 and 9.73 for the subsequent period of 2016–2030.

Regional-level studies consistently confirmed the significant economic benefits of hepatitis B vaccination. A CUA conducted in Beijing from 1992 to 2013 showed that the ICUR was negative, indicating that the vaccination strategy not only generated more QALYs but also reduced costs [48]; during the same period, the BCR for preventing hepatitis B–related cirrhosis was 8.58 [33]. In Dalian City, Liaoning Province, data from 2001 showed that the annual population BCR of the hepatitis B immunisation strategy in four urban districts was 1.48 [35]. In Guangdong Province, following the inclusion of the hepatitis B vaccine in the immunisation programme from 2002 to 2006, the cumulative net benefit over four years was approximately 796 million CNY, with a BCR of 9.86 [36]. In Guizhou Province (1999–2016), the cost per case averted for hepatitis B surface antigen carriers, chronic hepatitis B, cirrhosis, and liver cancer was 579.79 CNY, 78.09 CNY, and 359.12 CNY, respectively [51]. In Hainan Province, from 2004 to 2009, the hepatitis B vaccination strategy reduced 127,945 DALYs, at a cost of 113.50 CNY per DALY averted, yielding a total benefit of 8.12 billion CNY and a BCR as high as 511:1 [59]. In Ningbo City (2002–2017), an investment of 53.81 million CNY reduced 12,480 hepatitis B cases and 232 deaths, resulting in a BCR of 20.29 [53]. In Rizhao City (1993–2009), the net benefit was 127 million CNY, with a BCR of 19.17 [39]. In Shanghai (1992–2001), the BCR was as high as 172:1 [63]. In Shijiazhuang City, the total BCR of the neonatal immunisation strategy was 32.52, with a net benefit of 170 million CNY [42]. In Sichuan Province, the BCR of hepatitis B vaccination was 3.85:1, with a net benefit of approximately 116 million CNY [55]. In Tianjin, the net benefit of hepatitis B vaccination reached 47.31 billion CNY, with a BCR as high as 1213:1 [56]. In Wuxi City (1994–2012), neonatal vaccination generated a cumulative benefit of 4.54 billion CNY, with a BCR of 216:1 [43]. In Bengbu City, disease-avoidance benefits were approximately 44,353 CNY, with a BCR of 3.94 [44]. In Yantai City, the BCR was 75.04:1, with a net benefit of 2.73 billion CNY and a cost of 846.72 CNY per DALY averted [64]. In Huizhou City, Guangdong Province, the BCR from 2002 to 2011 was 10.28, with a net benefit of 155 million CNY [57].

Several studies have evaluated the economic impact of hepatitis B vaccination strategies targeting the prevention of mother-to-child transmission (PMTCT). Compared with routine vaccination, PMTCT strategies demonstrated greater economic benefits. At the national level, implementing PMTCT compared with no vaccination saved an average of 37,829.7 CNY per person. Compared with universal neonatal vaccination, PMTCT saved 239.8 CNY per person [62]. Another study, using the expected life expectancy of the target population as the simulation horizon, reported a net benefit of 12,283.50 USD per person and a BCR of 12.66:1 for PMTCT, which was higher than that of universal vaccination (9.49:1) [61]. Local studies also supported these findings. For example, a study conducted in Shenzhen in 2013 showed that PMTCT yielded a net present value of 38,097.51 CNY per person with a BCR of 14.37:1, whereas universal neonatal vaccination resulted in a net present value of 37,083.03 CNY per person with a BCR of 12.07:1 [54].

Economic evaluation of other vaccines

Other NIP vaccination strategies have also demonstrated high economic value. One study evaluating vaccines against eight pathogens (measles, pertussis, hepatitis B, tuberculosis, hepatitis A, Japanese encephalitis, meningitis A, and poliomyelitis) found that over a 50-year period, implementing the immunisation program incurred a total cumulative cost of 124.06 billion USD from a societal perspective, whereas the total benefit reached 2,417.85 billion USD. Accordingly, the overall BCR of China's

Expanded Programme on Immunisation was 19.48; from the healthcare provider perspective, the ratio was also as high as 8.02 [11]. An evaluation of the economic impact of implementing a meningococcal polysaccharide vaccine strategy for the 2022 birth cohort indicated an ICUR of 5,640 CNY/QALY compared with no vaccination, suggesting that the strategy is cost-effective within acceptable thresholds [26]. Another study conducted in Guizhou Province from 1990 to 2015 showed that meningococcal polysaccharide vaccination among eligible children generated a net economic benefit of 10.29 billion CNY, with a BCR of 13.54:1 [25]. Research on vaccinating children under five years of age with DTP vaccine reported lifetime direct cost savings of 46.99 billion USD and total societal savings of 82.01 billion USD [32]. From 2006 to 2011, BCG vaccination prevented one case of tuberculous meningitis and one case of miliary tuberculosis at costs of 85,978 CNY and 197,959 CNY, respectively, indicating high cost-effectiveness [29]. In Guizhou Province, a study evaluating JE vaccination over 65 years in a population of 100,000 reported a cost of 95.5 USD per DALY averted, which was lower than China's per capita GDP in 2009 [31]. In Zhejiang Province, a 40-year long-term evaluation of measles vaccination showed a BCR of 6.06 and a net present value (NPV) of 73.38 million USD [30]. In Guangdong Province, following the inclusion of the live attenuated hepatitis A vaccine in the immunisation programme in 2010, the total investment cost was 41.56 million CNY, resulting in 72,417 fewer hepatitis A cases, equivalent to an investment of approximately 573.84 CNY per case averted. The cumulative net benefit was about 292 million CNY, with a BCR of 8.02:1 [28]. In Baoji City, implementation of the haemorrhagic fever with renal syndrome vaccination strategy from 2008 to 2018 resulted in a cumulative net benefit of 8.63 million CNY [27].

Discussion

This review systematically synthesised evidence on the health economic evaluations of various vaccination strategies within China's NIP. The findings consistently indicate that vaccines currently included in the NIP—particularly hepatitis B, measles, BCG, hepatitis A, and meningococcal vaccines—demonstrate substantial economic value at both national and regional levels. From both the healthcare system and societal perspectives, most studies reported favourable economic outcomes, highlighting the effectiveness of immunisation programmes in reducing disease burden and the efficiency of public financial investment.

Hepatitis B vaccination is the most intensively studied vaccine type within the NIP, with numerous studies spanning a wide timeframe (from the 1990s to the present) and extensive geographic coverage. Both national- and provincial-level analyses consistently demonstrated very high net benefits and BCRs, with some cities even exceeding 100:1. For example, Shanghai reported a BCR of 172:1 for 1992–2001 [63], Tianjin reported 1213:1 for 1992–2010 [56], and Wuxi achieved 216:1 over 19 years of implementation [43], reflecting the cumulative health gains and economic savings of long-term immunisation strategies. With the vaccine's strong effectiveness, robust local financial subsidies, and high coverage rates, vaccine investment yields substantial social returns. Notably, multiple studies have confirmed that the PMTCT for hepatitis B is more cost-effective than routine universal neonatal vaccination. Both Shenzhen and national modelling studies showed that this strategy not only reduces the incidence of chronic HBV infection but also outperforms universal vaccination in terms of per capita cost and BCR [54, 62]. In terms of vaccination strategies, integrated approaches such as "routine immunisation plus catch-up vaccination," "PMTCT plus universal vaccination," and "intensified immunisation plus routine vaccination" often outperform single strategies, particularly in high-prevalence areas or populations with low coverage [40, 49].

In contrast, fewer studies have evaluated the economic value of other NIP vaccines, yet they also demonstrated favourable returns. For example, the meningococcal vaccine had a BCR of 13.54:1 in Guizhou Province, and the simulated ICUR for the 2022 national birth cohort was 5,640 CNY/QALY, both within acceptable cost-effectiveness thresholds [25, 26]. The DTP vaccine, due to its broad target population and long history of administration, exhibited substantial lifetime cost-saving potential—approximately 47 billion USD in direct savings and 82 billion USD in societal savings [32]. Although BCG vaccination has limited impact in most populations, it showed significant benefits in preventing tuberculous meningitis and disseminated tuberculosis, with costs of less than 2,000 CNY per DALY averted, indicating good cost-effectiveness [29]. It is noteworthy that the disease burden and transmission mechanisms associated with each vaccine considerably influence economic outcomes. Vaccine type, target population, strategy combinations, local financial support mechanisms, and baseline vaccination coverage collectively determine the economic benefits of immunisation strategies. Strengthening coordination across regions in identifying target populations, optimising strategy design, and aligning financing mechanisms is expected to further enhance the equity and sustainability of the NIP nationwide. Moreover, when formulating national immunization strategies, both domestic and international experiences have shown that adopting systematic and innovative intervention models can effectively enhance the capacity and efficiency of public health services [65, 66].

Despite the overall consistency of findings, the included studies exhibited substantial methodological heterogeneity. Some studies adopted a single perspective, while others applied multiple combined perspectives. However, nearly half of the studies did not clearly report their analytical perspective, limiting transparency and comparability in interpreting cost components. Differences were also observed in discount rates, time horizons, and model choices. Although most studies applied a 3% discount rate, some used 5% or did not specify discounting, and the time horizons ranged from 1 year to 50 years. Results from long-term simulation studies were often highly sensitive to parameter assumptions. Moreover, only about half of the included studies applied explicit modelling approaches, primarily limited to decision trees or Markov models, while the remainder did not employ structured modelling frameworks. Vaccine interventions constitute a public health issue characterized by interdependencies, feedback loops, and nonlinear interactions among multiple factors. Thus, adopting complex systems modelling approaches—such as system dynamics, agent-based models, or discrete-event simulation—could more effectively simulate the actual impact pathways within such complex systems [67]. Most studies reporting a cost-effectiveness threshold adopted the WHO-recommended benchmark of one to three times GDP per capita. However, as a generic metric, it lacks specificity and does not reflect country-specific health opportunity costs—the health benefits forgone when resources are allocated elsewhere [68, 69]. Future evaluations should therefore incorporate local opportunity cost estimates to better inform resource allocation decisions for NIP vaccines.

With increasing pressure to introduce new vaccines (e.g., HPV, pneumococcal, and rotavirus vaccines), there is an urgent need for economic evaluations to support the inclusion of future vaccines into the NIP. Future studies should adopt more standardised methodological practices, such as explicitly reporting discount rates and thresholds, improving transparency in modelling approaches, and conducting uncertainty analyses to provide more robust evidence for policy decisions. In addition, future research should focus on: (1) conducting cross-regional comparisons to reveal cost differences and distribution of health benefits underlying regional inequalities; (2) incorporating real-world data for model parameter calibration to improve external validity; and (3) expanding economic evaluations to older adults and special populations, which remain underrepresented in current studies.

This study has several limitations. First, there was substantial methodological heterogeneity across the included studies, which poses challenges for direct comparisons of findings. Second, this review was restricted to literature published in Chinese and English. Despite a comprehensive search, some relevant information may have been missed, leading to potential omissions. Third, the selection of cost-effectiveness thresholds represents an additional limitation. Given substantial regional disparities in economic development across China, the application of GDP per capita–based thresholds may not adequately reflect differences in fiscal capacity, disease burden, and health system efficiency across regions, and may risk classifying interventions that displace higher-value health gains as cost-effective. Fourth, regarding quality appraisal, it is important to note that the CHEERS checklist assesses the quality of reporting, not of the study itself. Therefore, coupling it with the QHES instrument constitutes a robust strategy for a more comprehensive evaluation. Finally, given the heterogeneity in study designs, we conducted a narrative synthesis of the results rather than a quantitative meta-analysis.

Conclusion

The evidence consistently supports the cost-effectiveness of NIP vaccines. Specifically, hepatitis B vaccination demonstrates the most robust and extensive body of economic evidence, while other vaccines currently included in China's NIP, including measles, BCG, DTP, hepatitis A, meningococcal, and Japanese encephalitis vaccines, have also been consistently shown to be cost-effective across the reviewed studies. Vaccine type, target population, strategy combinations, local financial support mechanisms, and baseline vaccination coverage collectively determine the economic benefits of immunisation strategies. In the context of limited healthcare resources, promoting standardised and methodologically rigorous vaccine economic evaluations will facilitate more evidence-based optimisation of vaccine inclusion strategies, resource allocation, and policy formulation.

Abbreviations

WHO	World health organization
EPI	Expanded Program on Immunization
NIP	National Immunisation Program
BCG	Bacillus Calmette-Guérin
OPV	Oral polio vaccine
DPT	Diphtheria-pertussis-tetanus
JE	Japanese encephalitis
PCV	Pneumococcal conjugate vaccine
HPV	Human papillomavirus vaccine
CNKI	China National Knowledge Infrastructure
CSTJ	China Science and Technology Journal Database
MeSH	Medical Subject Headings
CHEERS	Consolidated Health Economic Evaluation Reporting Standards
QHES	Quality of Health Economic Studies
BCR	Benefit-cost ratio
CBA	Cost-benefit analysis
CEA	Cost-effectiveness analysis
CMA	Cost-minimization analysis
CUA	Cost-utility analysis
ICER	Incremental cost-effectiveness ratio
ICUR	Incremental cost-utility ratio
NA	Not applicables

GDP	Gross Domestic Product
QALYs	Quality-Adjusted Life Years
DALYs	Disability-Adjusted Life Years
LYs	Life years

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13561-026-00745-9.

Supplementary Material 1.

Supplementary Material 2.

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Authors' contributions
Conceptualization: JS, XJ, HL; Data curation: JS, XJ, HL, WH; Formal analysis: JS, XJ, LZ; Funding acquisition: WH, TZ; Methodology: JS, XJ, HL, RL; Project administration: WH, TZ; Supervision: WH, TZ, JL, XC; Validation: JS, XJ, JS, YC; Visualization: XJ, HL; Writing-original draft：HL; Writing-review and editing: HL, LJC, WH. All authors read and approved the final manuscript. Weidong Huang is the leading corresponding author.

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Data availability
The datasets analysed during the current study are available from the corresponding author on reasonable request.

Declaration

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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