A comparative analysis of vaccine lists, prices, and candidates, and the national immunization program between China and the United States

In brief

Our findings show that China has a similar number of marketed vaccines and preventable diseases as the US. However, improvements are still needed in the expansion of NIP vaccines and the development of novel vaccines based on their epidemiology in China.

Highlights

- The price of National Immunization Program (NIP) vaccines in China was demonstrated to be significantly lower than those in the US, but there was no price advantage for non-NIP vaccines.
- The types of diseases preventable in marketed vaccines in China were similar to those in the US. However, China had fewer NIP vaccines than the US.
- The majority of vaccines under development in China were mostly licensed vaccines, and there was a lack of novel vaccines compared to the US.

Authors

Xingxian Luo, Jingwen Liu, Xin Du, Jingshu Yang, Xiaomeng Jiang, Zhuangqi Li, Yifan Wu and Yue Yang

Correspondence

yanghappy@mail.tsinghua.edu.cn
(Y. Yang)
A comparative analysis of vaccine lists, prices, and candidates, and the national immunization program between China and the United States

Xingxian Luo,a,b,c Xingwen Liu,a,b,c Xin Du,a,b,c Jingshu Yang,a,b,c Xiaomeng Jiang,a,b,c Zhuangqi Li,a,b,c Yifan Wu,a,b,c and Yue Yanga,b,c,*

aSchool of Pharmaceutical Sciences, Tsinghua University, Beijing, China
bInstitute of Pharmaceutical Regulatory Science, Tsinghua University, Beijing, China
cKey Laboratory of Innovative Drug Research and Evaluation, National Medical Products Administration, Beijing, China
dTsinghua-Peking Center for Life Sciences, Beijing 100084, China
*Correspondence: yanghappy@mail.tsinghua.edu.cn (Y. Yang)
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ABSTRACT

Vaccines have an essential role in preventing infectious diseases and reducing the burden of disease. The differences in vaccine lists and prices, and the National Immunization Program (NIP) and vaccine development between China and the United States (US) in conjunction with epidemiologic data on infectious diseases were systematically compared. The epidemiologic data of infectious diseases in 2019 were extracted from the China National Health Commission and the US Centers for Disease Control and Prevention (CDC). The vaccine list was identified from the China National Medical Products Administration and US Food and Drug Administration databases. Vaccine prices were obtained via the China government procurement platform and the US CDC. The NIP vaccines for China and the US were obtained from the China and US CDCs. Vaccine candidates investigated in 2015-2022 were identified from the China Clinical Trial Registry Platform and the US clinicaltrials.gov database. Differences in the incidence of infectious diseases between China and the US were detected with both countries facing a lack of available vaccines for prevention of many diseases. The number of listed vaccines and preventable diseases in China was 59 and 36, respectively, which was higher than the US (45 and 31, respectively). The median price of NIP vaccines in China was significantly lower than the price in the US (median: $3.8 vs. $20; \( P<0.001 \)); however, there was no significant difference in the price of non-NIP vaccines (median: $68 vs. $86; \( P=0.498 \)). Vaccines developed by local manufacturers were less expensive than imported products despite the absence of significant differences (median: $16 vs. $31; \( P=0.180 \)). The number and types of NIP vaccines used to prevent infectious diseases in China was lower than the US. The majority of vaccine candidates in China were not novel compared to the US. Vaccines marketed in China for infectious diseases were comparable to the US. Our findings suggest that China should further expand NIP vaccines and incentive research and development on novel vaccines to improve accessibility based on infectious disease epidemiology.

Keywords: Vaccine, Epidemiology, List, National Immunization Program, Price, China, United States

CONTRIBUTION TO THE FIELD

What are the new findings?
1. The price of National Immunization Program (NIP) vaccines in China was shown to be significantly lower than the price of NIP vaccines in the US, but there was no price advantage for non-NIP vaccines.
2. The types of diseases preventable in marketed vaccines in China were similar to the US; however, China had fewer NIP vaccines than the US.
3. The majority of vaccines under development in China were mostly licensed vaccines and there was a lack of novel vaccines compared to the US.
What do the new findings imply?
1. The NIP vaccines should be further expanded in China based on a cost-effective analysis.
2. Vaccines that are already available abroad and not listed in China, such as the meningococcal B group vaccines, should be considered for accelerated introduction in China.
3. Our results support the opinion that China should implement incentives, including preferential policies and increased government investment, to encourage the development of novel vaccines.

1. INTRODUCTION

Vaccines are one of the most significant developments in public health and have been shown to be extremely effective in the prevention, control, and eradication of infectious diseases [1-3]. Numerous infectious illnesses that were formerly responsible for the bulk of human deaths have been eliminated in nations with strong coverage of immunization programs [2, 4, 5]. The World Health Organization (WHO) developed the expanded program on immunization (EPI) in 1974, which facilitated the use of vaccines worldwide. According to a statistics report from the WHO, significant progress has been made in reducing worldwide child mortality since 1990, with the number of children dying decreasing from 12.6 million in 1990 to 5 million in 2020 [6]. Hopefully, vaccines have had a critical role against the COVID-19 outbreak [7, 8].

The US, a developed country and global leader in medicine, has achieved significant results in controlling infectious diseases, as evidenced by the global introduction of the first mRNA COVID-19 vaccine [9], human papillomavirus 9-valent (HPV-9) vaccine [10], Ebola vaccine [11], and polysaccharide conjugate vaccine [12]. The Vaccines for Children (VFC) program was established in 1994 in response to the re-emergence of measles as a major public health issue in the US, ensuring that uninsured children are vaccinated despite financial constraints. According to the morbidity and mortality weekly report from the US Centers for Disease Control and Prevention (US CDC), VFC was estimated to prevent 322 million illnesses, 21 million hospitalizations, and 732,000 deaths at a net savings of $295 billion between 1994 and 2013 [13]. Furthermore, vaccination saves an estimated $295 billion in direct expenses and $1.38 trillion in overall social costs by preventing hospitalizations and saving deaths, indicating the favorable cost-effectiveness of vaccines [1, 13].

Substantial progress has been made in the prevention and control of infectious diseases in China since the introduction of the National Immunization Program (NIP) in 1978. The NIP strategy in China has evolved over time, growing from an initial mandate of 4 vaccines against 6 diseases in 1978 to 13 vaccines against 15 diseases by 2008 [14]. China is among just a few countries that can independently manufacture all NIP vaccines [15]. Previous studies suggested that vaccination coverage of NIP vaccines reached 99%, resulting in a considerable reduction in morbidity and mortality from infectious diseases [16, 17]. Furthermore, the National Regulatory Authorization of China fulfilled the World Health Organization (WHO) examination in 2011, a critical milestone for Chinese vaccines to enter the global market that indicated China's vaccine regulation satisfies international standards [14]. In addition, China has achieved significant advances in novel vaccines, including EV71 [18], hepatitis E [19], Ebola virus [20], H1N1 [21], and COVID-19 vaccines [22], which have contributed significantly to the prevention and control of infectious diseases worldwide. However, China still lags behind developed countries in controlling infectious diseases, such as cervical cancer [23], serogroup B invasive meningococcal disease [24], and dengue fever [25].

It should be acknowledged that vaccine accessibility and affordability are much higher in developed than developing countries, raising serious cross-country vaccine equity challenges [26, 27]. As the largest developing (China) and developed (US) countries, the role of vaccines may vary due to disparities between the two countries. Yet, no studies have systematically compared the differences in characteristics and development of vaccines between China and the US. Therefore, the aim of this study was to compare the characteristics and development of vaccines between China and the US in relation to epidemiologic data, vaccine lists and prices, the NIP and vaccine development with a view to optimizing vaccine policies.

2. METHODS

2.1 Epidemiology of infectious diseases
To better understand the discrepancy in vaccines between China and the US, we first identified the epidemiology of notifiable diseases in these two countries. The latest annual reported cases of notifiable diseases were extracted from China's National Health Commission [28] and the US CDC [29]. Then, we analyzed the availability of preventable vaccines for the notifiable diseases.

2.2 Vaccine list and price, and immunization
As of 22 April 2022, the marketed vaccines in China and the US were extracted from the National Medical Products Administration (NMPA) [30] and the Food and Drug Administration (FDA) databases [31], respectively. We referred to a previous study by Zhang et al. [14], considering the lack of marketing information for some vaccines in China. Vaccines are classified as NIP and non-NIP vaccines in China. The NIP vaccines are provided at no cost by the government (e.g., hepatitis B vaccine), while non-NIP vaccines are purchased by the patient (e.g., HPV vaccine). The classification, approval date, and indication of the marketed vaccines were extracted.

The price of NIP vaccines was obtained from the Chinese Central Government Procurement office [32], while the non-NIP vaccines were based on the price published in the National Public Resource Trading...
notifiable diseases was viral hepatitis, followed by tuberculosis, and syphilis were among the top 20.

### 3.1 Epidemiology of infectious diseases
Twenty-eight infectious diseases with reported cases totaling 3,072,338 in 2019 were identified based on the latest annual reported cases of notifiable diseases in China. The disease with the highest incidence among the notifiable diseases was viral hepatitis, followed by tuberculosis, syphilis, and gonorrhea. In China, 43% (12/28) of notifiable diseases still lack vaccines available for prevention. In 2019, 66 notifiable diseases with 2,976,278 cases were reported in the US. The most common infectious disease in the US was Chlamydia trachomatis, followed by gonorrhea, syphilis, and campylobacteriosis. Vaccines are not available for 65% (43/66) of infectious diseases. The top 20 reported cases of notifiable diseases in China and the US are shown in Figure 1. Hepatitis, HIV, pertussis, tuberculosis, and syphilis were among the top 20 reported cases of notifiable diseases for both China and the US. The detailed data are shown in Supplementary Tables S1 and S2.

### 3.2 Vaccine list
As of 22 April 2022, there were 59 vaccines approved in China and available for 36 preventable diseases (Table S3). Forty-five vaccines have been approved in the US to prevent 31 diseases (Table S4). Differences in the diseases preventable by vaccines marketed in China and the US are shown in Table 1. Eight infectious diseases that can be prevented in China but not the US include hepatitis E, furunculosis, trachitis, dysentery, hemorrhagic fever with renal syndrome, paratyphoid, leptospirosis, and brucellosis. Conversely, three diseases, including meningococcal B group, dengue, and adenovirus, can be prevented in the US but not in China. Compared to the US, vaccines marketed in China lack multiple large combination vaccines, such as DTaP-HepB/IPV and DTaP-HepB/HPV.

### 3.3 NIP for childhood vaccines
The differences in the NIP for pediatrics between China and the US are shown in Table 2. In 2021 China updated the NIP with 13 vaccines recommended for children against 12 diseases. In addition, three other NIP vaccines, including hemorrhagic fever with renal syndrome, leptospirosis, and anthrax, are provided for at-risk groups. Compared to China, the US recommends a wider range of vaccines for children, including rotavirus, Hib, PCV13, InFeV-quad, varicella vaccine, and HPV-9, totaling 15 vaccines against 17 diseases.

### 3.4 Vaccine prices
The prices for 22 vaccines between 2021 and 2022 were retrieved from the China government procurement platform. Of these 22 vaccines, 13 were included in the NIP with prices ranging from 0.4–4.5 US dollars per dose. The price for 9 non-NIP vaccines was 19.7–245.8 US dollars per dose. To better compare vaccine prices in China and the US, we assessed the vaccine prices in China and available for 36 preventable diseases (median: $3.8 vs. $20, $P<0.001). However, the price of non-NIP vaccines in China was comparable to the US (median: $68 vs. $86, $P=0.498). The price of zoster and DTaP-IPV-Hib vaccines in China was even higher than the price in the US. Vaccines developed by local companies were less expensive than imported products, although not significantly different (median: $16 vs. $31, $P=0.180). The detailed vaccine prices in China and the US are listed in Table S5.
3.5 Development of vaccines in clinical trials

Between January 2015 and September 2022, we retrieved 209 and 220 clinical trials conducted in China and the US, respectively. There were 59 vaccines in clinical trials in China for the prevention of 36 diseases. The top 15 vaccine candidates in development are shown in Figure 3, indicating that the majority of vaccine candidates have already been licensed and in use in China. The most common vaccine in clinical trials was HPV-9, followed by PCV13 and InfV-quad. Sixty-three vaccines against 41 diseases are in clinical trials in the US. Of these 63 vaccines, InflV-4, respiratory syncytial viral (RSV), and chikungunya were most common. Greater than one-half of the top 15 vaccine candidates in clinical trials are novel vaccines in the US.

4. DISCUSSION

Vaccines, as the cornerstone of public health illness prevention, have a highly favorable long-term cost-effectiveness [37, 38]. The World Health Organization Immunization Agenda 2030 (WHO IA2030), the current global vision for vaccines and immunization, set out a prioritized strategic plan for vaccines and immunization for 2021-2030 to save > 50 million lives over the next decade [39]. However, it is well-established that developed countries can provide a substantially better level of immunization than middle- or low-income countries [40]. In the current study, we first compared the epidemiology of notifiable diseases in China and the US. Large discrepancies in the types of notifiable diseases and the number of reported cases were detected in 2019. Notably, China had a dramatically lower number of notifiable diseases than the US (28 vs. 66), possibly due to an underestimation of the incidence and mortality of infectious diseases. Hepatitis (including hepatitis A, B, C, D, E and other untyped hepatitis) and C. trachomatis were the most frequently reported infectious diseases in China and the US, respectively. Despite the significant progress that has been achieved in vaccine development, 43% (12/28) and 66% (43/66) of notifiable diseases do not have vaccines available in China and the US, respectively. This finding highlights the immense challenge that China and the US continue to confront in the fight against infectious diseases.

The list of vaccines used to prevent infectious diseases in China was similar to the US. Based on the epidemiologic data, we further estimated the marketed differential types of vaccines in China and the US. Eight vaccines were accessible in China but not in the US. Of these eight vaccines, hepatitis E has caused more widespread concern. Epidemiologic data demonstrated that hepatitis E is a prominent cause of acute hepatitis in both developing and developed countries, with 3.3 million symptomatic
cases and 44,000 deaths annually [41]. According to a 2019 report and estimates of notifiable infectious diseases, there were 28,155 and 4236 hepatitis E cases in China and the US, respectively. Currently, several hepatitis E vaccine (HepE) candidates are under development. As of 2012, Hecolin® has been the only vaccination approved in China for HepE control [41]. It has been shown that vaccination was > 99% effective against hepatitis E in people who were followed for 4.5 years [42]. Therefore, it is of great importance that the Hecolin® vaccine can be further validated globally to promote hepatitis E control.

Given the different vaccines available in China and the US, cooperation between the two countries is essential for infection prevention and control. Additionally, vaccines approved in the US but not listed in China included dengue, meningococcal group B, and adenovirus. In 2019, a total of 22,188 dengue fever cases occurred in China. Dengvaxia, a vaccine for dengue fever, was approved by the US FDA for use in children and adolescents 9-16 years of age who have been previously infected with dengue fever. Dengvaxia was also recommended by the US Advisory Committee on Immunization Practices (ACIP) in 2021 [43]. Furthermore, although the meningococcal A and AC groups were included in the NIP, no available vaccine for the meningococcal B group exists in China. Surveillance statistics indicated that the incidence of meningococcal A group had greatly decreased, whereas the rise in serogroup B has become critical for preventing meningococcal illness in China [44]. It has been reported that the meningococcal B group mortality group can be as high as 15% and long-term injury can occur in 20% of survivors [44, 45]. Therefore, the introduction of meningococcal B group and dengue vaccines to control these diseases should be considered in China.

China has made significant progress in the NIP, from 4 vaccines in 1978 to 13 vaccines currently. However, the number and types of vaccines available for NIP for children in China were significantly lower compared to the US, including a lack of PCV13, Hib, rotavirus, varicella, HPV, and influenza vaccines. Of these vaccines, PCV13, HPV, Hib, influenza, and rotavirus vaccines were recommended by the WHO for inclusion in the NIP [14]. These vaccines, if incorporated into the China NIP, would significantly reduce the incidence of infectious diseases and deaths. Specifically, it has been reported that China accounts for nearly one-third of the worldwide cervical cancer burden, with approximately 98,900 new cases of cervical cancer in 2015 [46]. The previous study suggested that bivalent or quadrivalent cervical cancer vaccines can prevent 66% of cervical cancers caused by HPV, and the newly launched nonavalent HPV vaccine

### Table 1 | Differences in diseases preventable by vaccines marketed in China and the US.

<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>The diseases were not prevented by the available vaccines in the US but in China.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hepatitis E</td>
<td>Hepatitis E virus</td>
<td>Hepatitis E vaccine</td>
<td>28155</td>
<td>4236</td>
<td></td>
</tr>
<tr>
<td>Furunculosis</td>
<td>Staphylococcus aureus and Staphylococcus epidermidis</td>
<td>Furunculosis vaccine</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Tracheitis</td>
<td>Alpha-hemolytic streptococcus, Staphylococcus albus, and Neisseria diplococcus</td>
<td>Tracheitis vaccine</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Dysentery</td>
<td>S. flexneri and S. sonnei</td>
<td>Dysentery Vaccine</td>
<td>81075</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Hemorrhagic fever with renal syndrome</td>
<td>Hantavirus</td>
<td>Hemorrhagic fever with renal syndrome vaccine, inactivated</td>
<td>9596</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Paratyphoid</td>
<td>Salmonella typhi, Salmonella paratyphoid A and Salmonella paratyphoid B</td>
<td>Typhoid and paratyphoid A combined vaccine</td>
<td>NA</td>
<td>155</td>
<td></td>
</tr>
<tr>
<td>Leptospirosis</td>
<td>Leptospira</td>
<td>Leptospirosis vaccine</td>
<td>214</td>
<td>94</td>
<td></td>
</tr>
<tr>
<td>Brucellosis</td>
<td>Brucellosis</td>
<td>Brucellosis vaccine</td>
<td>44036</td>
<td>165</td>
<td></td>
</tr>
<tr>
<td>The diseases were not prevented by the available vaccines in China but in the US.</td>
<td>Meningococcal serogroup B</td>
<td>Meningococcal group B vaccine</td>
<td>NA</td>
<td>371</td>
<td></td>
</tr>
<tr>
<td>Dengue</td>
<td>Dengue virus serotypes 1, 2, 3, and 4</td>
<td>Dengue tetravalent vaccine, live</td>
<td>22188</td>
<td>1489</td>
<td></td>
</tr>
<tr>
<td>Adenovirus</td>
<td>Adenovirus type 4 and 7</td>
<td>Adenovirus type 4 and 7 vaccine, live, oral</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
</tbody>
</table>

$^*$Refers to meningococcal caused by serogroup B. China has approved meningococcal group ACYW but not group B. NA: not available.
Table 2 | Comparison of the National Immunization Program for childhood vaccines in China and the US.

<table>
<thead>
<tr>
<th>Vaccine</th>
<th>Birth</th>
<th>Months</th>
<th>Years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1-2</td>
<td>3</td>
</tr>
<tr>
<td>HepB</td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>HPV</td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>DTaP*</td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>MMR</td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>HepA-1</td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>BCG</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>IPV</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>DT</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>JE-L</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>JE-I</td>
<td></td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>MPSV-A</td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>MPSV-AC</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>HepA-L</td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>RV*</td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Hib</td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>PCV13</td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>InflA</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>InflB</td>
<td></td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

The numbers in the grid represent the doses of vaccination. *indicates that the timing of vaccination may vary depending on the manufacturer; BC: background color.

Figure 2 | Comparison of the same types of vaccine prices between China and the US.
(a) Comparison of NIP vaccine prices between China and the US. (b) Comparison of non-NIP vaccine prices between China and the US.

P=0.001

P=0.498
can prevent an additional 15% of cases [47]. However, a recent study demonstrated that HPV vaccine coverage in China was only 3.1% in 2021 compared to 68.1% in the US [48, 49], implying that the HPV vaccine is still insufficient for cervical cancer prevention. This finding may be partly due to the reluctance of young people or adolescents in China to request the HPV vaccine due to out-of-pocket payments [14, 50]. Hopefully, some provinces are piloting the inclusion of the HPV vaccine at no cost to improve its affordability, which is essential to reduce the incidence of cervical cancer in China [51]. According to the WHO IA2030 priority strategy, countries should include all WHO-recommended vaccines in their national immunization schedules and administer them throughout the course of life [39]. Therefore, China should develop a prioritization strategy for the NIP, expanding its range and use throughout the life course.

Vaccine prices vary markedly between China and the US. Government-funded NIP vaccines ($0.4–4.5 per dose) in China were significantly less costly than non-NIP vaccines ($19.7–245.8 per dose) that need out-of-pocket payments. The higher cost of non-NIP vaccines may be attributable in part to a lack of public awareness of vaccine benefits, resulting in a low demand in China. In addition, some non-NIP vaccines, such as the HPV vaccine, lack sufficient competition, resulting in higher prices. To better compare the differences in vaccines price between China and the US, the vaccines listed in the US were also classified as NIP and non-NIP, as defined in China. Interestingly, our results suggested that the price of NIP vaccines in China (0.4–4.5 US dollars per dose) was much lower than the US ($13.6–87.3 dollars), which was consistent with a previous study [14]. However, the cost of non-NIP vaccines in China was comparable to the US, and some vaccines were even more costly than in the US. This finding may be explained by the fact that some non-NIP vaccines are branded products in China (no similar products) and lack of competition, resulting in higher prices than in the US. We further evaluated the price of the same vaccines between imported and domestic products, which indicated that the vaccines developed domestically were less expensive than imported vaccines, most likely due to the small sample size, but not statistically significant. The previous study also showed that developing countries had a highly significant advantage over developed countries with respect to the price of producing vaccines [52]. Therefore, it is strongly recommended that China encourage local companies to develop non-NIP vaccines and promote competition, which will hopefully further increase the affordability of vaccines.

The study also assessed the landscape of the vaccine candidates in the clinical trials between China and the US. Fifty-six vaccines in development were shown to protect against 36 diseases, which was less than the 95 vaccines against 58 diseases in the US. Only 13% of the top 15 vaccines in clinical trials in China were novel vaccines, which was less than the 53% in the US, suggesting a potential problem in novel vaccine development and overlap issues in China. This phenomenon was associated with a lack of regulation experience, key technology and financial issues for vaccines. For instance, the development of novel combination vaccines in China lagged behind the US. Our previous studies revealed that China had made substantial gains in both regulatory review and in stimulating innovation in the development of the COVID-19 vaccine. It is expected that these experiences...
can be extended to the development of other vaccines. The vaccine development, from discovery-to-approval, need to cost billions of dollars for > 10 years with a 6% average probability of success [47]. Vaccines for some rare diseases, such as Rift Valley fever, Ebola, and Marburg disease, which have no commercial value but can have major health consequences, have seen increased government funding in the US and European Union [4]. Furthermore, WHO IA2030 has prioritized the development of innovative vaccines research agenda for countries [39]. It is therefore recommended that China should take steps to expand government investment in prioritizing vaccine development strategies, encouraging the development of combination vaccines, new adjuvants, and licensing new vaccine technologies to meet unmet medical needs.

5. LIMITATION

There were some limitations in this study. First, the vaccine candidates in the clinical trial were retrieved from January 2015–September 2022 since China initiated the implementation of the drug regulatory reform in 2015. Therefore, the results of clinical trials of vaccine candidates may change if the timing of the search is adjusted. Second, we obtained NIP vaccine prices of China via the central procurement network. However, we obtained non-NIP vaccine prices only from Beijing, which may have slight discrepancies from prices in other cities. Third, the COVID-19 vaccine was not included in the analysis of this study because the majority of these vaccines were approved under emergency authorizations or conditional approvals, and their product launches and development were changing rapidly. Therefore, the differences in the characterization and development of the COVID-19 vaccine in China and the US need to be further explored. Fourth, the technical aspects of the vaccines (e.g., recombinant or inactivated vaccines) were not identified between China and the US in this study. Additionally, the comparison between the NIP in China and the US was limited to childhood vaccines only, considering that China did not have a NIP for adults.

6. CONCLUSION

Large differences in the epidemiology of infectious diseases were observed between China and the US. Both countries are still facing the challenge of having no vaccines for numerous diseases. The price of NIP vaccines in China was much lower than the US, but there was no considerable price advantage for non-NIP vaccines. Though the vaccines listed on the market in China were similar to the US, the number and types of NIP were lower than that of the US. Furthermore, China still lagged far behind the US in novel vaccine development. It is recommended that China should take preferential measures to expand the number of NIP vaccines and motivate the development of novel vaccines based on infectious disease epidemiology.

ABBREVIATIONS

EPI, Expanded program on immunization; NIP, National Immunization Program; HepB, Hepatitis B vaccine; HepA-I, Hepatitis A, inactivated vaccine; HepA-L, Hepatitis A, live attenuated vaccine; HepE, Hepatitis E vaccine; DTaP, Diphtheria-tetanus-pertussis acellular vaccine; Tdap, Diphtheria-tetanus-pertussis acellular vaccine, adult; DTaP-IPV-Hib, Diphtheria-tetanus-pertussis acellular vaccine, inactivated poliovirus vaccine and Haemophilus influenzae type b conjugate vaccine; MMR, Measles-mumps-rubella vaccine; BCG, Bacillus Calmette-Guerin vaccine; OPV, Oral poliovirus vaccine; IPV, Inactivated poliovirus vaccine; DT, Diphtheria and tetanus combined vaccine; JE-I, Japanese encephalitis vaccine, live attenuated; JE-I, Japanese encephalitis vaccine, inactivated; CMV, Cytomegalovirus vaccine; MPSV-A, Group A meningococcal polysaccharide vaccine; MPSV-AC, Group A,C meningococcal polysaccharide vaccine; MPSV-ACYW, Group ACYW135 meningococcal polysaccharide vaccine; MenACWY, Group ACYW135 meningococcal conjugate vaccine; MenAC-Hib, Group A,C meningococcal polysaccharide conjugant vaccine and Haemophilus influenzae type b conjugate vaccine; Hib, Haemophilus influenza type b conjugate vaccine; PCV13, Pneumococcal 13-valent conjugate vaccine; PPV23, Pneumococcal 23-valent polysaccharide vaccine; PCV15, Pneumococcal 15-valent conjugate Vaccine; PCV20, Pneumococcal 20-valent conjugate vaccine; InNV-quad, Influenza vaccine (quadrivalent); HPV-9, Human papillomavirus 9-valent vaccine; HPV-4, Human papillomavirus quadrivalent vaccine; HPV-2, Human papillomavirus bivalent vaccine; RV1, Rotavirus vaccine, live, oral vaccine; RV5, Rotavirus vaccine, live, oral, pentavalent vaccine.

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DATA AVAILABILITY STATEMENT

The authors will provide unreserved access to the raw data supporting the conclusions.

REFERENCES

Research Article


