

# Analysis of Vaccine Supply and Demand in National Immunization Program for Children and the need for Establishing Vaccine Stockpiles in China

**Miao Ning**

Chinese Center for Disease Control and Prevention

**Cui Jian**

Chinese Center for Disease Control and Prevention

**Liu Yi**

Chinese Center for Disease Control and Prevention

**Zhang Guomin** (✉ [zhanggm@chinacdc.cn](mailto:zhanggm@chinacdc.cn))

Chinese Center for Disease Control and Prevention

---

## Research Article

**Keywords:** National Immunization Program, Vaccine, Supply, Demand

**Posted Date:** April 29th, 2021

**DOI:** <https://doi.org/10.21203/rs.3.rs-460908/v1>

**License:**  This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

---

# Abstract

## Introduction

The number of vaccines used in China's childhood immunization program had continued to increase, from four in 1978 to ten in 2019. We described the supply and demand of vaccines, and compared the ratio of vaccine supply and demand of each vaccine to illustrate the shortage of vaccines and the need of vaccine stockpiles in China.

## Methods

We downloaded the manufacturers supplying vaccines and the vaccination requirements for the national immunization program for children from 2016 to 2019 in the National Immunization Program Information system, as well as the batch issue data of biological products from the official website of China Academy of Food and Drug Control (CFDA). Vaccine prices were obtained from Chinese Central Government Procurement (CCGP). The demand, supply, and the ratio of vaccine supply and demand of each vaccine were calculated respectively.

## Results

On average, five out of ten vaccines were supplied by three or more enterprises, three kinds of vaccines were supplied by two enterprises and two kinds of vaccines were supplied only by one enterprise between 2016 to 2019. The ratio of vaccine supply and demand of Diphtheria-tetanus and Group A meningitis polysaccharide were 79.52% and 67.99% respectively, with a potential shortage. There were three vaccines with a supply-demand ratio below 80% in 2016–2018, and five in 2019. The number of potential vaccine shortage was increasing. The average price of vaccines with potential shortage was \$ 0.28. The average price of other vaccines without shortage was \$ 1.8.

## Conclusions

Most vaccines used in the childhood immunization program are available to meet demand, but there are also some vaccines with the risk of shortage and the number of vaccines with the risk of shortage tends to increase. The next step is to develop a national stockpiling mechanism to avoid a shortage of vaccines.

## Background

Immunization is one of the most successful tools for the prevention of infectious diseases[1]. Globally, the 77 preventive vaccines have been approved for 41 diseases by 2018[2]. The 64 vaccines can be produced to prevent 35 diseases in China. There are two types of vaccines in China. One is the national

Immunization program (NIP) vaccine, which is free of charge. The other is a non-NIP vaccine, which is self-funded. The number of vaccines used in China's childhood immunization program had continued to increase, from four in 1978 to ten in 2019. A total of ten vaccines were introduced into NIP for children, including hepatitis B vaccine(HepB), Bacille Calmette Guerin(BCG) vaccine, polio vaccine, diphtheria and tetanus toxoids and acellular pertussis (DTaP) vaccine, diphtheria-tetanus vaccine(DT), hepatitis A vaccine(HepA), serogroup A meningococ-cal polysaccharide vaccine(MPSV-A), serogroup A and C meningococ-cal polysaccharide vaccine (MPSV-AC), Live Japanese encephalitis vaccine(JEV-L), and measles-mumps-rubella (MMR) vaccine.

The NIP children vaccine schedules had been constantly updated according to the characteristic of disease and the capacity of the vaccine production. In 2016, China recommended measles-mumps (MM) vaccine at the age of 8 months and MMR vaccine at the age of 18 months, and did not recommend monovalent measles vaccine. At the same year, China introduced IPV into immunization programs as the first doses for essential immunization, and China replaced the trivalent oral polio vaccine (TOPV) with the bivalent oral polio vaccine (BOPV) for use as the other three doses. In 2019, the immunization schedule for polio vaccine has been updated from 1-dose IPV + 3-dose bOPV to 2-dose IPV + 2-dose bOPV. In 2020, MM vaccine was replaced by MMR, and two doses were given at 8 and 18 months of age.

At present, four global vaccine stockpiles are maintained[3], mainly for emergency response situations. However, NIP vaccine stockpiles have not been established in China. In China, the supply of vaccines has also faced some challenges, such as companies leaving the vaccine market and manufacturing or production problems as a result of vaccine-related incidents in China, Stricter control of vaccine production as provided in the Vaccine Administration Law of the People's Republic of China and changes in immune procedures. With the increase of vaccine varieties included in immunization programmes and the change of immunization procedures, there were already vaccine shortages in some local areas[4].The main purpose of this study is to understand the supply and demand of vaccines for the national immunization program for children in China, and to provide the basis for establishing the vaccine supply guarantee mechanism.

## Methods

### Data Sources

We obtained data from National Immunization Information System(IIS) on number of children required for vaccination between 2016 to 2019, following the national immunization procedure. We obtained the brand of manufacturers supplying NIP vaccines and the vaccine prices from Chinese government bidding procurement website(<http://www.chinabidding.org.cn/>).We downloaded the batch issue data of vaccines from the official website of of Chinese Central Government Procurement (<http://www.ccgp.gov.cn/>).The number of vaccines supplied to the national immunization program were screened by type of vaccines and the manufactures supplying the NIP vaccines from all the batch issue data according to the brand of manufacturers.

## Types of vaccines used in NIP between 2016-2019

Hepatitis B vaccine: 10µg recombinant hepatitis B vaccine was used in NIP between 2016 to 2019, including yeast-produced vaccines and Chinese hamster ovary cell(CHO)vaccines. HepB was administered at 0,1, and 6 month for the newborns.

Polio vaccine: 1-dose IPV and 3-dose bOPV were introduced as the primary immunization between 2016 and 2018. 2-dose IPV and 2-dose bOPV were used in 2019.

Measles-containing Vaccine(MCV): 1-dose MM vaccine and 1-dose MMR vaccine were used in NIP.

Hepatitis A vaccine: live attenuated HepA (L-HepA) and inactivated HepA (I-HepA) were used in NIP. There were four provinces integrated I-HepA, including Beijing, Tianjin, Shanghai and Jiangsu while the other 27 provinces integrated L-HepA.

### Definition

1. The number of vaccine supplied for the immunization programme= The number of vaccine batches issued\* The number of children who can be vaccinated by a vial/ Vaccine waste factor.

The number of children who can be vaccinated by a vial referred to the vaccine instruction book: BCG(5 doses per vial), bOPV(10 doses per vial), DT (4 doses per vial), JEV-L(5 doses per vial), and other vaccines(1 dose per vial). Vaccine wastage factor referred to Guidelines for vaccination 2020 version and was 1.05,1.2,1.5,2.0 and 2.5 respectively for vaccine of 1 dose per vial, 2 dose per vial, 3 dose per vial, 4 dose per vial, 5 dose per vial.

2. The ratio of vaccine supply and demand =the number of vaccine supply/ the number of vaccine demand\*100%.

3. Potential shortage

Taking into account the current status of non-epi vaccine alternatives and the stock of vaccines in each region, if the ratio of vaccine supply and demand was less than 80%, we can define it as a potential shortage.

4. vaccine prices

China government had conducted the bidding and procurement of NIP vaccines for all the provinces since 2018 and each province tenders and purchases vaccines by themselves before 2018. We calculated the average prices of vaccines between 2018 to 2019. The exchange rate for US dollars vs Chinese Yuan was 6.5.

### Data analysis

The data of the supply and demand of vaccine were imported into SPSS (version 23, IBM, New York, USA) for analysis. We generated descriptive statistics on NIP vaccines by the number of manufacturers, the number of supply and demand and vaccine prices. We compared the supply and demand of different vaccines between 2016 to 2019 .We calculated the ratio of supply and demand for each vaccine and compared the ratio.

### Ethical review

The data in this study was mainly from the published websites and did not require additional Ethical Review Committee approval. Individuals were not identifiable in IIS data used in this study.

## Results

### The number of manufacturers supplying the NIP children vaccines, 2016–2019

On average, five kinds of vaccines supplied more than 3 manufacturers were used in NIP for children, respectively HepB, polio vaccine, DTP, measles-containing vaccine and HepA. Three kinds of vaccines were supplied by 2 manufacturers, respectively BCG, JEV-L and MPSV-AC. Two kinds of vaccines were supplied only by one manufacturer, respectively DT and MPSV-A(Table 1).

Table 1  
The number of manufacturers supplying the NIP children vaccines, 2016–2019

Name of the vaccine	2016	2017	2018	2019	Average(2016–2019)
HepB	5	4	4	3	4
BCG	2	2	2	2	2
Polio vaccine	3	4	4	5	4
DTP	2	3	2	3	3
DT	1	1	1	1	1
MCV	4	3	3	2	3
JEV-L	2	2	2	2	2
MPSV-A	1	1	1	1	1
MPSV-AC	3	2	2	2	2
HepA	4	4	3	3	4
*JEV-L was used immunization program vaccine in all provinces.					

## 2 The supply and demand of vaccines according to the national immunization schedule, 2016–2019

The supply of hepatitis B vaccine are almost the same as the demand from 2016 to 2019 and the supply of BCG was more than demand in 2017. The supply of polio vaccine was lower than the demand in 2016 and 2019. The supply of DTP was lower than the demand in 2017 and 2018. The supply of DT was lower than the demand in 2016, 2017 and 2019. The supply of measles-containing vaccine was lower than the demand in 2018. The supply of JEV-L and MPSV-A was lower than the demand from 2016 to 2019. The supply of MPSV-AC was lower than the demand in 2016 and 2017. The supply of HepA was lower than the demand in 2016 and 2018(Fig. 1).

## 3 The ratio of vaccine supply and demand for children in NIP, 2016–2019

The average ratio of supply and demand for the two vaccines was less than 80% between 2016 to 2019, respectively DT(79.52%) and MPSV-A(67.99%). The ratio of supply and demand for the three vaccines was less than 80% in 2016, respectively Polio vaccine(74.89%), JEV-L (79.62%) and MPSV-AC(53.80%). The ratio of supply and demand for the three vaccines was less than 80% in 2017, respectively DTP(69.66%), DT (79.91%) and MPSV-A(72.95%). The ratio of supply and demand for the three vaccines was less than 80% in 2018, respectively DTP(79.25%), MCV (63.81%) and HepA (65.63%). The ratio of supply and demand for the five vaccines was less than 80%, respectively BCG (79.05%) in 2019, Polio vaccine(64.32%),DT(59.57%), JEV-L (68.19%) and MPSV-A (26.72%)(Table 2).

Table 2  
The ratio of vaccine supply and demand in children in NIP, 2016–2019

Type of vaccines	2016(%)	2017(%)	2018(%)	2019(%)	Average(2016–2019) (%)
HepB	100.61	107.35	97.51	98.31	101.22
BCG	100.84	140.42	81.82	79.05	102.17
Polio vaccine	74.89	124.82	136.69	64.32	93.20
DTP	104.29	69.66	79.25	119.75	92.21
DT	80.68	79.91	97.30	59.57	79.52
MCV	169.31	119.44	63.81	110.61	115.43
JEV-L	79.62	90.34	99.30	68.19	84.76
MPSV-A	83.63	72.95	83.98	26.72	67.99
MPSV-AC	53.80	94.60	115.17	117.03	96.41
HepA	89.20	97.50	65.63	117.29	91.76

#### 4. The average contract price of vaccine used in NIP between 2018 to 2019

Figure 2 showed the average price of vaccines for immunization programmes purchased by the Chinese government through tender in 2018 and 2019. The contract price of vaccines ranged from \$0.05 to \$5.4 per dose, with an average price of \$1.6 per dose. DT and MPSV-A were in potential shortage in 2016–2019, and the price was \$ 0.05 and \$0.5 per dose respectively, and the average price was \$ 0.28. The average price of other vaccines without shortage was \$ 1.8. The average price with potential shortage was lower than without shortage.

## Discussion

Sustainable Development Goals proposed by WHO, which aimed to achieve universal health coverage, including access to safe, effective and quality essential vaccines for all[5]. The supply of vaccines was essential to achieving universal health coverage. WHO had paid more attention to vaccine shortage in the report of addressing global drug and vaccine shortages[6]. Technical definitions of vaccine shortages should be developed as needed and the analysis should be from the supply side and the demand side. This study also analyzed the supply and demand of vaccine for childhood immunization programs in China. The results showed that the supply and demand of vaccine for childhood immunization programs in China were roughly balanced as a whole from 2016 to 2019, but there was a potential shortage of some vaccines in each year, and the number of vaccine with potential shortages increased.

In recent years, vaccine-related events occurred frequently in China. In 2017 and 2018, the number of batches of DPT vaccine was reduced due to disqualification of DTP vaccine potency produced by Wuhan Institute of Biological Products Co., Ltd and "Changchun Changsheng" Vaccine event in 2018, and there is a risk of shortage of DPT vaccine in 2017 and 2018. In addition, due to the impact of the "Changchun Changsheng" vaccine event in 2018, all live L-HepA produced by Changchun Changsheng Enterprise were not allowed to use and the company had stopped production, and as a result of this, the supply and demand ratio of hepatitis A vaccines in 2018 was only 65.63%, and there is a risk of shortage. The shortage of vaccine is a worldwide problem[7–10], and both UK and the United States have faced shortages[11] [12–14].

After the Changchun Changsheng Vaccine Incident in 2018, China issued the vaccine management law of the People's Republic of China, which tightened the supervision of the entire vaccine chain and further reduced the number of vaccine batches issued in 2019. Five kinds of vaccines could be in short supply in 2019. During 2016 to 2019, both DT and MPSV-A vaccines are only produced by Wuhan Institute of Biological Products Co., Ltd and the price of these vaccines was lower than other vaccines without shortage. All of these factors contributed to the vaccine shortage. Temporary yellow fever vaccine shortages had occurred in the United States as a result of manufacturing problems, at that time only one yellow fever vaccine was licensed for use in the United States[15].

In 2016, China carried out the program conversion of polio vaccine, TOPV (sugar pill) was no longer used, and IPV and BOPV were used for vaccination. However, IPV is only produced by one manufacturer

(Institute of Medical Biology, Chinese Academy of Medical Sciences), with limited production capacity and only 3.45 billion batches issued. To further boost supply, the vaccines made Sanofi by were purchased to increase supply, but only 7.28 million batches were issued by Sanofi. The batch issued by the two companies still cannot meet the demand, and there may be a shortage of polio vaccine in 2016. Many countries will face shortages of the IPV vaccine and 28% of countries (35 of 125) still had not been able to introduce IPV because of supply constraints or experienced a stock-out of vaccine according to WHO [16].

Vaccine is a national strategic and public welfare product, and the availability of vaccine reflects the fairness of society. Maintaining a balance between supply and demand for vaccines is therefore critical to preventing unfair events and the risk of epidemics arising from vaccine shortages. However, the analysis of vaccine supply and demand is complicated and affected by many factors, and this study also has some limitations: this study only analyzes the relationship between supply and demand from the perspective of the whole country, and does not analyze the situation of each provinces. There may be local shortages and surpluses caused by the unbalanced distribution of vaccines in some regions[17]

In conclusion, the supply of vaccines in China's national immunization program can meet the

demand of vaccines, but some vaccines are at risk of shortage. Reasons for these possible shortages were multi-factorial and included companies leaving the vaccine market, manufacturing or production problems, and Changes in vaccine procedures for immunization programmes[18, 19]. In 2020, China had faced with the serious threat of novel coronavirus epidemic, and the production and distribution of vaccines will be affected by the shutdown. Therefore, it is necessary for the country to develop a vaccine reserve mechanism in the next step, so as to avoid the shortage of vaccine supply in the childhood immunization program and prevent the timely and effective supply of vaccine from the impact of major public health emergencies[20]. However, the decision to establish and maintain a vaccine stockpile is complex and must take the consideration of disease burden[21], stockpile sizes, funding, the number of manufacturers, unanticipated production problems, and the dynamic nature of the vaccine market.

## Declarations

## Acknowledgements

The study was funded by the Operation of public health emergency response mechanisms – immunization program. Grant ID:216305

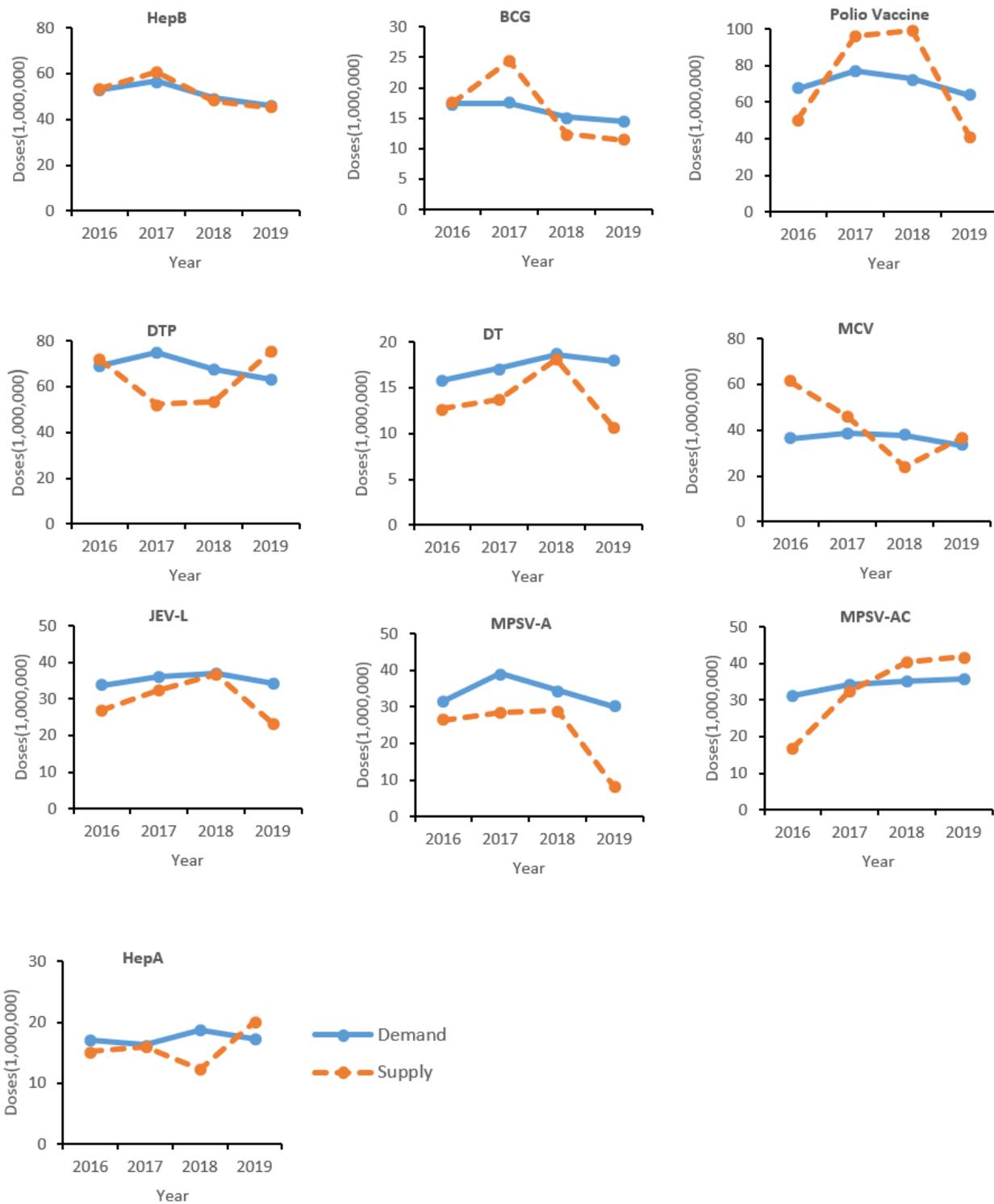
## References

1. Fan H, Yu Z, Su Y: **Survey and development tendency of vaccine market.** *China Medicine* 2019, **14**(6):940-944.

2. <https://www.evaluate.com/thought-leadership/pharma/evaluatepharma-world-preview-2018-outlook-2024#download>.
3. Yen C, Hyde TB, Costa AJ, Fernandez K, Tam JS, Hugonnet S, Huvos AM, Duclos P, Dietz VJ, Burkholder BT: **The development of global vaccine stockpiles.** *The Lancet Infectious diseases* 2015, **15**(3):340-347.
4. Li Z, Xu J, Xu J, Tan H, Zhang C: **Current situation, causes, and countermeasures to NIP vaccine shortages in Guangzhou, China.** *Human Vaccines & Immunotherapeutics* 2020, **16**(1):76-79.
5. <https://www.who.int/medicines/areas/policy/en/>.
6. <https://apps.who.int/iris/handle/10665/273236>.
7. Mandal S, Edelstein M, Ramsay M: **Public health leadership in the UK's response to hepatitis A and hepatitis B vaccine shortages.** *Vaccine* 2020.
8. Ebrahim SH, Assiri AM, Memish ZA: **Meningitis vaccine shortage and the 2019 Hajj mass gathering: market dynamics and epidemic control.** *Journal of travel medicine* 2019, **26**(5).
9. Kontturi A, Santiago B, Tebruegge M, von Both U, Salo E, Ritz N: **The impact of Bacille Calmette-Guerin shortage on immunisation practice and policies in Europe - A Paediatric Tuberculosis Network European Trials Group (ptbnet) survey.** *Tuberculosis (Edinburgh, Scotland)* 2016, **101**:125-129.
10. Jennings MC, Manchester C, Sauer M: **Navigating country decisions in response to a global rotavirus vaccine shortage.** *Vaccine* 2020, **38**(46):7201-7204.
11. Ziesenitz VC, Mazer-Amirshahi M, Zocchi MS, Fox ER, May LS: **U.S. vaccine and immune globulin product shortages, 2001-15.** *American journal of health-system pharmacy : AJHP : official journal of the American Society of Health-System Pharmacists* 2017, **74**(22):1879-1886.
12. <https://www.cdc.gov/vaccines/hcp/clinical-resources/shortages.html>.
13. Rodewald LE, Orenstein WA, Mason DD, Cochi SL: **Vaccine supply problems: a perspective of the Centers for Disease Control and Prevention.** *Clinical infectious diseases : an official publication of the Infectious Diseases Society of America* 2006, **42 Suppl 3**:S104-110.
14. Farfour E, Lesprit P, Chan Hew Wai A, Mazaux L, Fourn E, Majerholc C, Bonan B, Vasse M, Zucman D: **Acute hepatitis A breakthrough in MSM in Paris area: implementation of targeted hepatitis A virus vaccine in a context of vaccine shortage.** *AIDS (London, England)* 2018, **32**(4):531-532.
15. Gershman MD, Angelo KM, Ritchey J, Greenberg DP, Muhammad RD, Brunette G, Cetron MS, Sotir MJ: **Addressing a Yellow Fever Vaccine Shortage - United States, 2016-2017.** *MMWR Morbidity and mortality weekly report* 2017, **66**(17):457-459.
16. Sutter RW, Cochi SL: **Inactivated Poliovirus Vaccine Supply Shortage: Is There Light at the End of the Tunnel?** *The Journal of infectious diseases* 2019, **220**(10):1545-1546.
17. Huang Y, Lu CY, Li S, Gan M: **Distribution and management strategy of Guangxi immunisation planning vaccine in 2017.** *Prog in Microbiol Immunol* 2019, **47**(5):49-54.
18. Sutter RW, Zaffran M: **Addressing the inactivated poliovirus vaccine shortage.** *Lancet (London, England)* 2019, **393**(10191):2569-2571.

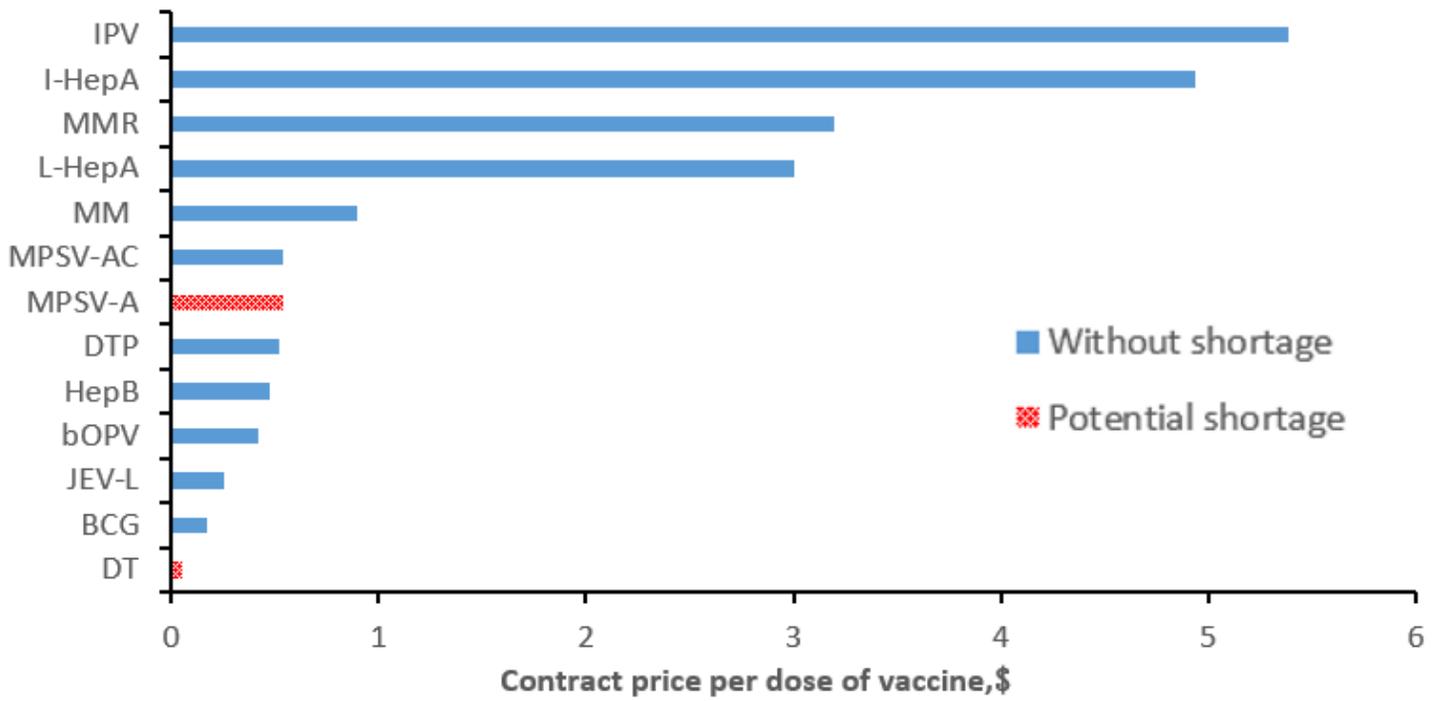
19. Li AJ, Kyesi F, Mwengee W, Mphuru A, Giattas MR, Shayo B, Nshunju R, Lyimo D, Loharikar A: **Impact of the human papillomavirus (HPV) vaccine supply shortage on Tanzania's national HPV vaccine introduction.** *Vaccine* 2021.
20. Shrestha SS, Wallace GS, Meltzer MI: **Modeling the national pediatric vaccine stockpile: supply shortages, health impacts and cost consequences.** *Vaccine* 2010, **28**(38):6318-6332.
21. Abela-Ridder B, Martin S, Gongal G, Engels D: **Rabies vaccine stockpile: fixing the supply chain.** *Bulletin of the World Health Organization* 2016, **94**(9):635-635a.

## Figures



**Figure 1**

The supply and demand of vaccine used in NIP between 2016 to 2019



**Figure 2**

The average contract price of vaccine used in NIP between 2018 to 2019