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A White Paper To Understand The Market Structure Of Pediatric Pertussis Hexavalent and Combination Vaccines



January 2024

Executive Summary

The objective of the present study is to understand utilization trends for acellular Pertussis (aP) based pediatric hexavalent and pentavalent combination vaccines and to identify the market structure (volumes administered by vaccine brand) among the pediatric pertussis combination vaccines.

The research methodology includes four steps

Step-I — Finding public and private markets for the target vaccine

Step-II — Market sizing calculation of vaccine volumes for all the available public and private markets

Step-III— Filtering the countries that constitute top 95% of the vaccine market

Step-IV — Analyzing brand shares for top vaccine markets (filtered in Step-III), to find the brand leader.

DTP Vaccine Market Split

As part of the study, we estimated the total market for the DTP vaccines to be around 441.7 Mn doses in 2022. The proportions of aP and wP combination vaccines for infant, and toddler is mentioned in the figure below (Figure 1). The wP vaccines volume includes vaccines in the National Immunization Schedule of 126 countries from the WHO. The aP vaccines are further classified into hexavalent, pentavalent, other aP combo vaccines and copurified vaccines. Other aP combo vaccines include trivalent and tetravalent primary and booster series vaccines. The other aP combo vaccines which include trivalent and tetravalent primary and booster series and the copurified vaccines (marketed exclusively in China and Japan) are excluded from this study.

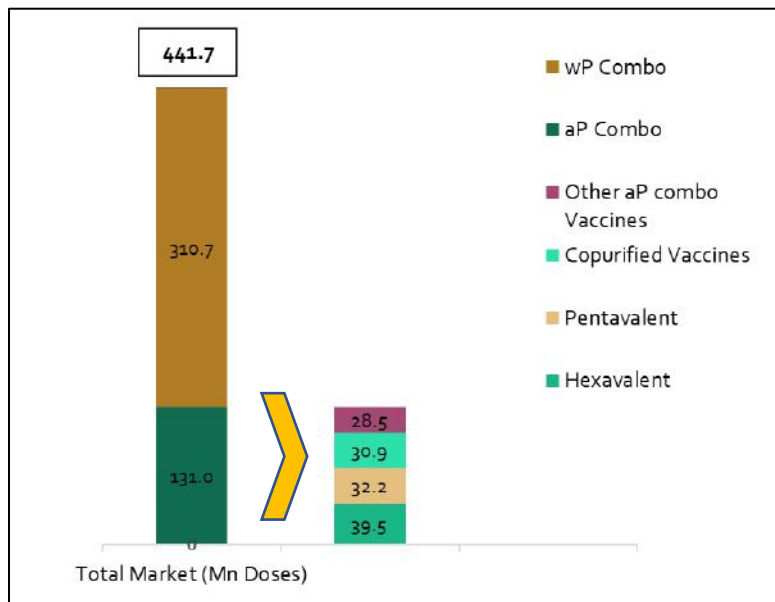


Fig 1: Global DTP vaccine market split, 2022

Outcomes Of the Study

This section provides the outcomes of the study for the top 95% of the DTaP hexavalent and pentavalent vaccines market.

The global aP-based pediatric hexavalent and pentavalent combination vaccine market has grown from 66.1 Mn doses in 2021 to 68 Mn doses in 2022. The hexavalent combination vaccine market has grown from 35.3 Mn doses in 2021 to 37.5 Mn doses in 2022. The pentavalent combination vaccine market has declined marginally from 30.8 Mn doses in 2021 to 30.5 Mn doses in 2022.

Sanofi retains its position as the global market leader among the aP-based pediatric hexavalent and pentavalent combination vaccines with 73% share in 2022 vs 75% in 2021. Sanofi vaccine brands hold the market leader position among hexavalent and pentavalent vaccines. GSK holds the second position with 19.3% share of the market in 2022.

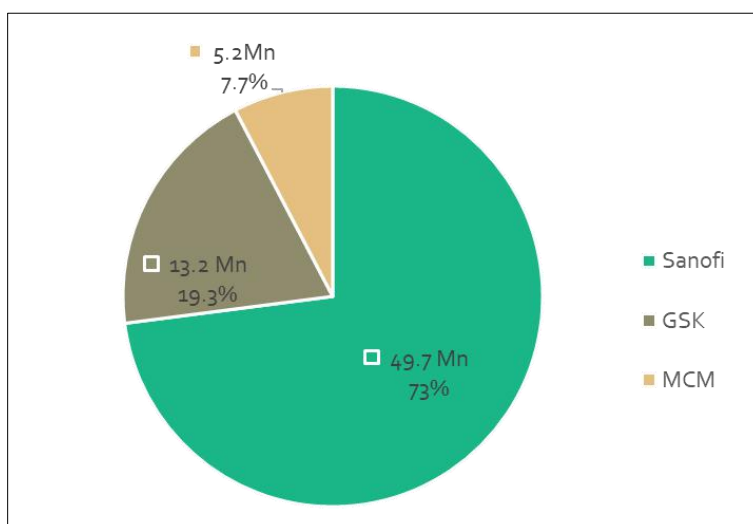


Fig 2: Global DTaP hexavalent and pentavalent vaccines market share by manufacturer, 2022

Company	Brand Names	Brand Volume (Mn Doses)
Sanofi	Hexaxim®, Pentaxim®, Pentacel®, Pediacel®	49.7
GSK	Infanrix Hexa®, Infanrix Penta®, Pediarix®	13.2
MCM	Vaxelis®	5.2

Table 1: Global DTaP vaccines brands, volumes, by manufacturer, 2022

According to our estimates of DTaP vaccine volumes for 2022, Hexaxim® (hexavalent vaccine), and Pentaxim® (pentavalent Vaccine) hold the leading position among the hexavalent vaccines and pentavalent vaccines across the globe, thus proving the dominance of Sanofi brands across aP based hexavalent and pentavalent vaccines.

Hexavalent Market Outcomes

In 2022, Hexaxim®, the hexavalent vaccine from Sanofi, holds the leading position in the top 95% hexavalent vaccines market with 62.8% of the volumes used across the globe.

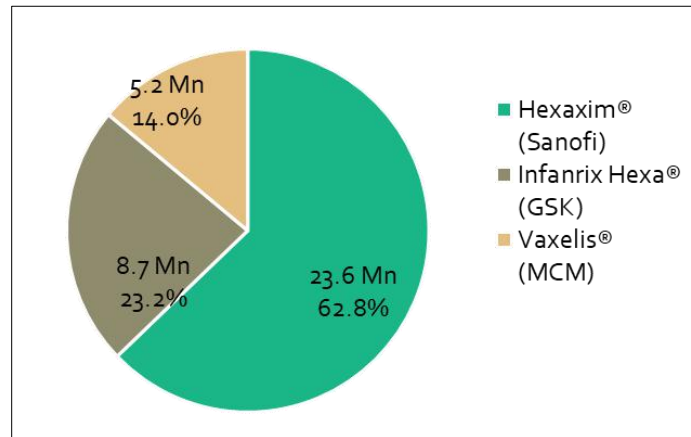


Fig 3: Global hexavalent vaccines volume, market share by manufacturer, 2022

In 2022, in the global hexavalent vaccine market, Sanofi's Hexaxim® brands contributed to a total volume of 23.6 Mn doses followed by GSK's Infanrix Hexa® brand to 8.7 Mn doses and MCM's Vaxelis® brand to 5.2 Mn doses.

A total number of 103 countries in the hexavalent vaccine market constitute a volume of 39.5 Mn. The top 95% (approximately) of the hexavalent vaccines constituting 40 countries have a total volume of 37.5 Mn.

The European Region (EUR) accounted for 33.6% share of the hexavalent market followed by the American Region (AMR) with a 31.8% share of the market. Among the top 40 countries, Mexico ranks number one in usage by volume in 2022 with 6.8 Mn doses followed by South Africa and United States of America with 3.9 and 3.2 Mn doses, respectively.

Among the top 40 countries, 12 countries namely Mexico, South Africa, Chile, Kazakhstan, Libya, Belgium, Jordan, Romania, Sweden, Panama, Austria, and Oman have an exclusive usage of only Hexaxim® in their market, and 11 more countries namely Germany, France, Malaysia, Saudi Arabia, Poland, Brazil, Czech Republic, Thailand, Slovakia, United Arab Emirates and Argentina use Hexaxim® as the major brand of hexavalent vaccine.

Pentavalent Market Outcomes

In the top 95% pentavalent vaccines market, Pentaxim® and Pentacel®, from Sanofi, hold the first and second positions with 66.5%, and 15.8% respectively of the pentavalent vaccine volumes used across the globe.

The manufacturer's share of the global pentavalent vaccine volumes for 2022 is represented below in figure 4.

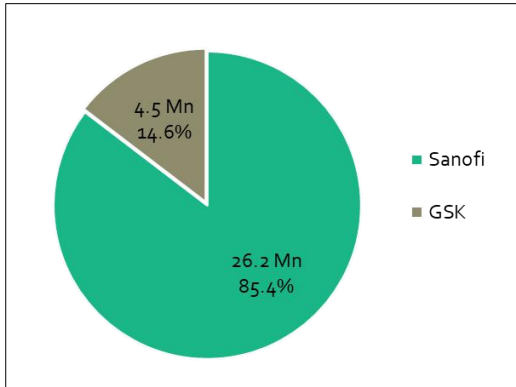


Fig 4: Global pentavalent vaccine volume, market share by manufacturer, 2022

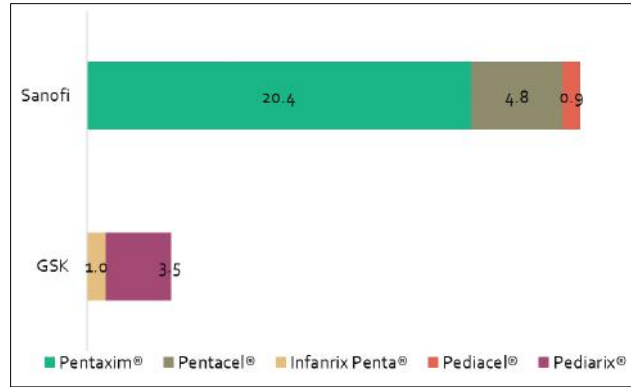


Fig 5: Global pentavalent vaccines brand volumes, by manufacturer, 2022

In 2022, in the global pentavalent vaccine market, Sanofi’s brands of vaccines namely Pentaxim®, Pentacel®, and Pediacel®, contributed to a total volume of 20.4 Mn, 4.8 Mn, and 0.9 Mn doses respectively, followed by GSK’s brands Pediarix® and Infanrix Penta®, contributed to 3.5 Mn and 1.0 Mn doses respectively.

In the pentavalent vaccine market, a total of 59 countries accounts for a volume of 32.2 Mn doses. The top 95% (approximately) of the pentavalent vaccines constituting 20 countries have a total volume of 30.6 Mn.

The EUR accounted for 39.1% of the pentavalent vaccine market followed by the AMR with a 31% share of the market. Among the top 20 countries, the USA ranks number one in usage by volume in 2022 with 8.4 Mn doses followed by China and Russian Federation with 6.3 and 5.2 Mn doses, respectively.

Among the top 20 countries, 11 countries namely China, Russian Federation, Turkey, Kazakhstan, Saudi Arabia, India, Hungary, Serbia, Costa Rica, Denmark, and United Arab Emirates have an exclusive usage of only Pentaxim® in their market, and seven more countries namely Republic of Korea, Israel, Taiwan, Poland, Thailand, Vietnam, and Portugal use Pentaxim® as the major brand of pentavalent vaccine.

Research Methodology

The study is based on the worldwide demand/usage estimates for aP based hexavalent and pentavalent combination vaccines. The other aP combo vaccines which include trivalent and tetravalent primary and booster series and copurified aP vaccines (marketed exclusively in China and Japan) are excluded from this study. Three factors determine the potential size of the worldwide acellular pertussis (aP) combination vaccine market — the surviving infant population, the immunization rate, and the number of doses of vaccine administered as per the recommended schedule.

The research methodology includes four steps as enumerated below

Step I — Finding public and private markets for the target vaccine

A total of 196 countries were selected (195 from WHO data + Taiwan), and public and private markets for vaccines were identified based on the inclusion of the aP-based hexavalent and pentavalent combination vaccine in the government supply and the national immunization schedule of the country. The countries

with an aP-based combination vaccine in their national immunization schedule were designated as public markets.

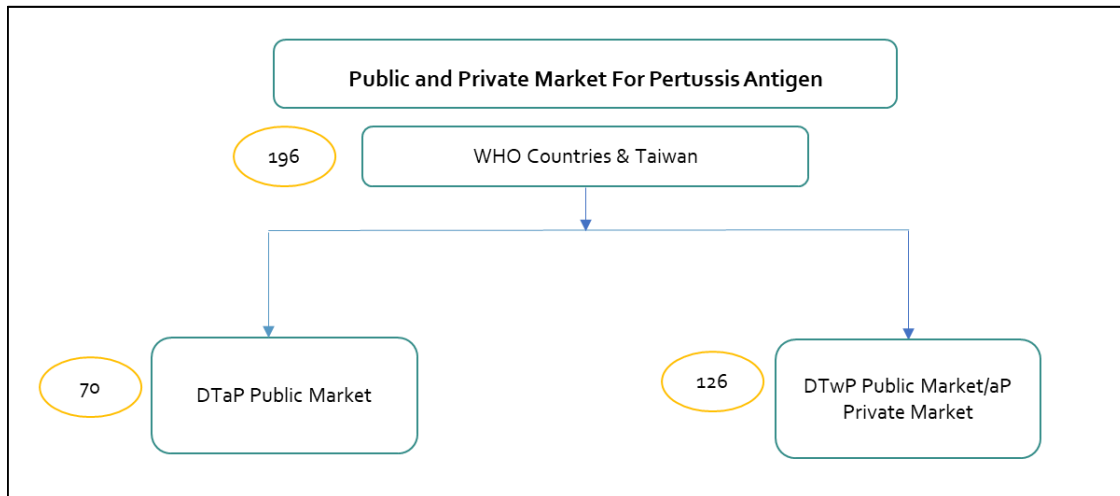


Fig 6: Public and Private markets for Pertussis antigen vaccines, 2022

Among these 196 countries, 70 countries having aP-based antigen were designated as public markets, and 126 countries using wP antigen were designated as aP private markets.

Public markets for hexavalent and pentavalent vaccines were identified from the 70 public markets using aP combination vaccines.

Private markets for all hexavalent and pentavalent combination vaccines were calculated from 196 WHO countries + Taiwan by eliminating countries based on their income category, region, and filtering criteria specific to the individual vaccine market.

Step II — Market sizing calculation of vaccine volumes for all the available public and private markets

The volumes of the acellular pertussis combination vaccines were calculated for each of the hexavalent and pentavalent markets by using three parameters — the surviving infant population, the immunization rate, and the number of doses of vaccine administered as per the recommended schedule.

Step III— Filtering the countries that constitute the top 95% (approximately) of the vaccine market

The countries that constitute 95% of the market for each hexavalent and pentavalent market were considered for further vaccine brand utilization analysis. As it is challenging to deduce the share of each brand of vaccine across all target countries (100%), we considered the statistically valid coverage of 95% of the market. Further, we assume that the brand that is dominant in 95% of the market will be a market leader.

The table below enumerates the total number of countries, their market size in million doses, and the number of countries constituting 95% of each market, for hexavalent and pentavalent markets.

Market	Total Countries	Total Volume (Mn)	Top 95% Market Countries	Top 95% Volume (Mn)
Hexavalent	103	39.5	40	37.5
Pentavalent	59	32.2	20	30.5

Table 2: Global hexavalent and pentavalent vaccine volume, 2022

Step IV — Analyzing brand shares for top vaccine markets (filtered in Step III), to find the dominant brand markets

Brand analysis was done for those countries that constitute the top 95% of the volumes for each market.

For the countries constituting the top 95% of each market brand analysis was done. The usage patterns for each brand of vaccines across the target countries are obtained through information gathered from various sources as below-

- National and Regional Tenders
- Ministry Of Health (MOH) and National Health Authorities
- Expert Interviews with key members of national immunization programs (NIP), medical advisors, university professors, UNICEF members, pediatricians, and immunization researchers.

We analyzed national tenders for available countries in each market (hexavalent and pentavalent). Tendering information such as the number of doses of vaccines or the brand of vaccine procured in 2022 is used for market estimations. We also reviewed the MOH and National health authority sources in each country to obtain information on specific brands of vaccines (among hexavalent and pentavalent) recommended in each country's national immunization schedules. Interviews are conducted with experts for the needed information for some countries with limited secondary information on vaccine procurement volumes and brand usage.

Global Trends in Pediatric DTP Vaccines

Some of the key trends in pediatric DTP vaccines for 2022 include

- In 2022, according to the estimates of the World Health Organization (WHO) and The United Nations International Children's Emergency Fund (UNICEF), the global immunization coverage of a third dose of a vaccine protecting against diphtheria, tetanus, and pertussis (DTP₃) reached 84% in 2022, from 81% in 2021.ⁱ Thus, DTP₃ immunization serves as the standard indicator for immunization coverage worldwide. Factors that contributed to the significant increase include recovery from COVID-19 pandemic, the introduction of pentavalent and hexavalent vaccines into the National Immunization Program (NIP) of some countries, the shift in income category from low-income to lower middle-income, inclusion into and exclusion of countries supported by Gavi, the vaccine alliance, and others. In 2022, among the 57 lower-income countries, 46% of the countries have coverage rate of DTP₃ at or above 2019 levels, with 54% yet to return to pre-pandemic coverage levels.
- Backslide from a pandemic, immunization rates improved significantly in countries like Mexico, Malaysia, Saudi Arabia, Chile, and Kazakhstan, contributing to the overall rise in vaccine

coverage in 2022. This rise in immunization rate helped in rise in vaccination coverage rate in 2022.

- The shift of the country's economies to a higher income group positively impacts immunization coverage in the respective country, with the increased affordability of vaccines. For instance, according to the data published by, the World Bank, countries such as Panama and Romania moved from the upper-middle-income category in 2021 to the high-income category in 2022 and Belize moved from the lower-middle income to the upper-middle income in 2022.ⁱⁱ The economic advancement of countries like Panama, Romania, and Belize to higher income groups has facilitated increased affordability, enabling expanded vaccine accessibility and contributing to a rise in vaccination coverage rates.
- In 2022, according to the data published by WHO and UNICEF, the South-East Asia Region DTP immunization coverage rate recovered to pre-pandemic 91%, a significant increase from 82% in 2021ⁱⁱⁱ.
- India and Indonesia are the countries that contributed the best immunization recoveries among all WHO Regions.^{iv} India recorded an all-time high of 93% DTP₃ coverage in 2022, a sharp rapid increase from 85% recorded in 2021, surpassing an all-time high of 91% of the pre-pandemic levels in 2019.
- Adapting to the trend of shift in the usage from wP to aP based vaccine owing to the safety profile of the aP vaccine, in 2022, according to the vaccine schedule published by WHO, Angola shifted to the aP pentavalent vaccine (DTaP-Hib-HepB) from wP pentavalent vaccine.^{vi}
- Continuing on improving the benefit of multivalent vaccines, HICs are completely shifting from pentavalent to hexavalent vaccines by removing pentavalent vaccines from their national immunization schedule. For instance, Monaco, Switzerland, Slovenia, Malaysia, and Malta have shifted completely to hexavalent vaccines. According to the immunization schedule published by WHO, the Monaco shifted from pentavalent to hexavalent vaccine in 2022^{vii}.
- Centers for Disease Control and Prevention (CDC) recommends diphtheria, tetanus, and whooping cough (pertussis) vaccination for everyone. In 2022, a summary of CDC recommendations includes giving infants and children 5 doses of DTaP, giving adolescents a single dose of Tdap, preferably at 11 to 12 years of age, giving women a single dose of Tdap during every pregnancy, preferably during the early part of gestational weeks 27 through 36.^{ix}
- Vaccine introductions have played an important role in increasing the 2022 vaccination coverage. The rate of vaccine introductions declined during a pandemic and improved with 47 introductions in 2022. 17 countries introduced a second dose of Inactivated Polio Vaccine, among several others. The introduction of vaccines into country programs, are largely attributable to gains in 2022 in comparison to 2019. This aided in rising the vaccination coverage rate in 2022.
- Following the launch and usage of Vaxelis® in the USA since 2021, the UK Health Security Agency (UKHSA) introduced and started supplying the vaccine, Vaxelis® in addition to Infanrix Hexa® for use in the primary immunization schedule in 2022.
- Immunization coverage is not improved in fragile states as they have characteristics that substantially impair their economic and social performance^x and in the countries affected by the Russia-Ukraine war, which disrupted global trade that was still recovering from the pandemic.
- In 2022, the number of countries with DTP₃ coverage of 50 percent or less increased to seven from five in 2019. Five of these seven countries are either fragile states or affected by conflict.^{xi}

- Economically improving countries are planning most possible changes which include a shift from pentavalent to hexavalent vaccine and a shift from wP vaccine to aP vaccine in the immunization schedule. Due to the safety profile of the aP vaccine, they can be offered to wider population groups.^{xii} In Barbados, aP hexavalent vaccine is currently given to children of HIV-positive mothers and is given to premature babies in Argentina. Argentina is considering to extend the aP hexavalent vaccine to its general population. Paraguay and El Salvador plan to introduce the aP hexavalent vaccine in the immunization schedule in 2023.^{xiii}

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Glossary

Antigen

Any foreign substance that produces an immune response in the body.^{xiv}

DTP Vaccine

A vaccine that produces immunity against three deadly diseases - namely diphtheria, tetanus, and pertussis (whooping cough) (DTP).^{xv}

DTP₃ Immunization Rate

The percentage of one-year-olds who have received three doses of the combined diphtheria, tetanus toxoid, and pertussis (DTP₃) vaccine in a given year.^{xvi}

DTaP Vaccine

DTaP is a combined vaccine against diphtheria (D), tetanus (T), and pertussis (P), in which the pertussis component is acellular containing purified components of *B. pertussis*.^{xvii} DTaP vaccine is approved to provide immunity from an early age (6 weeks).

DTwP Vaccine

DTwP is a combined vaccine against diphtheria (D), tetanus (T), and pertussis (P), in which the pertussis component is a whole-cell, which is an entire *B. pertussis* organism that has been inactivated.^{xviii}

GAVI

The Global Alliance for Vaccines and Immunizations (GAVI), is an international organization, that brings together public and private sectors with the shared goal of creating equal access to new and underused vaccines for children living in the world's poorest countries.^{xix}

Hexavalent Vaccine

A hexavalent vaccine (DTaP-IPV-HepB-Hib) is a six-in-one vaccine that protects babies against diphtheria (D), tetanus (T), pertussis (P), poliomyelitis (IPV), *Haemophilus influenzae type b* (Hib) and hepatitis B (Hep B). All hexavalent vaccines are intended for pediatric use.^{xx}

Pentavalent Vaccine

A pentavalent vaccine (DTaP-IPV-Hib) is recommended in three doses for infants and or as a fourth booster dose for a toddler to protect babies against diphtheria (D), tetanus (T), pertussis (P), poliomyelitis (IPV), and *Haemophilus influenzae type b* (Hib). All pentavalent vaccines are intended for pediatric use.^{xxi}

Pertussis vaccines (aP and wP)

Pertussis (P), also known as whooping cough, is a highly contagious respiratory disease caused by the bacterium *Bordetella pertussis*. Pertussis vaccines are available in two forms namely acellular pertussis (aP) or whole-cell pertussis (wP).^{xxii}

DTP Primary Series Vaccines

These vaccines are the initial doses of vaccines given to infants. DTP primary series vaccines are either 2 doses or 3 doses depending on individual countries' national immunization schedules.^{xxiii}

Public Markets (Pertussis Combination Vaccines)

Public markets include countries where pertussis combination vaccines are included under national immunization schedules and supplied to the entire nation by the government or governmental agencies. These vaccines are generally procured through tenders, and distributed to healthcare practitioners (HCPs).^{xxiv}

Private Markets (Pertussis Combination Vaccines)

Private markets include countries where pertussis combination vaccines are given by private practitioners and not included in the national immunization schedule or countries where pertussis combination vaccines are offered through private reimbursement. The price for this vaccine may be partially or completely reimbursed by insurance companies, or be borne through out-of-pocket expenditure.^{xxv}

Schedule

A vaccination schedule refers to the details of primary series vaccines as recommended by the national immunization program (NIP) in a country. Recommendations include the number of doses and the age at which a specific dose of vaccine is to be administered.^{xxvi}

Surviving Infants

Surviving infants are the number of children reaching their first birthday during a given year.^{xxvii, xxviii}

UNICEF

The United Nations International Children's Emergency Fund (UNICEF) works in 190 countries and territories to protect the rights of every child.^{xxix}

WHO

The World Health Organization (WHO) is a specialized agency of the United Nations (UN) working in 194 member countries. This organization deals with issues related to public health.^{xxx}

WHO Countries Income Status

WHO countries are classified based on income status into High-Income Countries (HIC), Upper Middle-Income Countries (UMIC), Lower Middle-Income Countries (LMIC), and Low-Income Countries (LIC).

WHO Regions

All regions mentioned in this report are according to the WHO countries' classification. For instance, countries under European Region (EUR) are the WHO classification of EUR, not limited to the countries which represent the European Union.

WHO Vaccine Prequalification (Prequalified vaccine)

The WHO prequalification ensures vaccines used in immunization programs are safe and effective. It provides the Member States and procurement agencies, such as GAVI and UNICEF, with the information required to purchase vaccines matching the specific needs of the program.^{xxx}

SAGE

SAGE is the leading advisory group to the WHO for vaccines and immunization. It guides WHO on global policies and strategies covering vaccine and technology, research and development, immunization delivery, and its connections to other health interventions.^{xxxii}

CDC

The Centers for Disease Control and Prevention (CDC) is the national public health agency of the United States of America. The Centers for Disease Control and Prevention promotes safe and healthy environments. It keeps track of health trends, looks for the cause of disease outbreaks and health problems, and responds to new public health threats.^{xxxiii}

PAHO

The Pan American Health Organization (PAHO) is the specialized international health agency for the Americas. It interacts with countries in the region to improve and safeguard public health. To tackle communicable and noncommunicable diseases and their causes, enhance health systems, and respond to emergencies and disasters, PAHO collaborates technically with its member countries.^{xxxiv}

VCR

The Vaccination Coverage Rate (VCR) is the percent of the target population that has received the last recommended dose for each vaccine recommended in the national immunization schedule.^{xxxv}

EPI

The Expanded Program on Immunization (EPI) was established in 1974 to ensure that infants/children and mothers have access to routinely recommended infant/childhood vaccines. The EPI initially included six vaccine-preventable illnesses: measles, diphtheria, tetanus, pertussis, poliomyelitis, and tuberculosis.^{xxxvi}

CIA Factbook

The Central Intelligence Agency (CIA) provides information on the history, people, government, economy, geography, and many more aspects which are known as CIA Factbook.^{xxxvii}

UN Population Data

The United Nations (UN) presents population estimates from 1950 to the present for 237 countries or areas, underpinned by analyses of historical demographic trends.^{xxxviii}

1. Research Objective

The primary goal of this white paper is to evaluate the market leader among pediatric aP-based hexavalent and pentavalent combination vaccines. The key objectives of this study include the analysis of

- Global volumes of aP and wP-based vaccines
- Utilization trends for aP combination vaccines including
 - hexavalent vaccines
 - pentavalent vaccines

Pediatric aP-based combination vaccines, described as the DTaP-based hexavalent, and pentavalent vaccines are considered for analysis. The outcomes of the study are presented for the DTaP-based hexavalent and pentavalent vaccines.

2. Introduction

This section provides an overview of the pertussis-based combination vaccines, the types of combination vaccines including tetravalent, pentavalent, and hexavalent vaccines in the market. Further information on the public and private markets for vaccines are detailed in this section.

Combination Vaccines- wP and aP, DTaP-based Vaccines

Pertussis combination vaccines can be either DTwP-based or DTaP based.

The combined diphtheria, tetanus, and pertussis (DTP) vaccine, which includes DTwP or DTaP, has already been incorporated into the national immunization schedules in most countries for pediatric vaccines.^{xxxixxl} These DTP-based vaccines are the backbone of several other combination vaccines such as tetravalent, pentavalent, and hexavalent.

For instance, DTaP-based tetravalent vaccines include DTaP-IPV.

Pentavalent vaccine combinations include DTaP-Hib-IPV, DTaP-HepB-IPV.

Hexavalent vaccine combinations include DTaP-Hib-HepB-IPV.

Combination Vaccines are used to overcome the problems associated with multiple administrations of monovalent vaccines. The use of combination vaccines, which include several antigens in a single administration, offers benefits such as reduced complications associated with numerous intramuscular injections, decreased costs of stocking, and a lower risk of delayed or missed vaccinations.^{xli}

Primary and Booster Vaccines

Pediatric vaccines can be defined as primary vaccines (series) or booster vaccines based on the age at which the vaccine is administered to the infant. Primary vaccination series include vaccination to infants and toddlers from birth to the age of three years. Booster doses are administered to infants who have completed a primary vaccination series. The booster vaccination schedule varies for each country and is administered after three years until the child is eligible to receive the adult vaccine. The objective of a booster dose is to restore vaccine effectiveness from that deemed no longer sufficient.

Inactivated polio vaccine (IPV) combinations are used for both primary and booster vaccinations. Owing to the high cost of these vaccines, they are used mainly by high-income and middle-income countries. All IPV vaccine combinations are aP-based vaccines.

The focus of this study is on DTaP-based combination hexavalent and pentavalent vaccines.

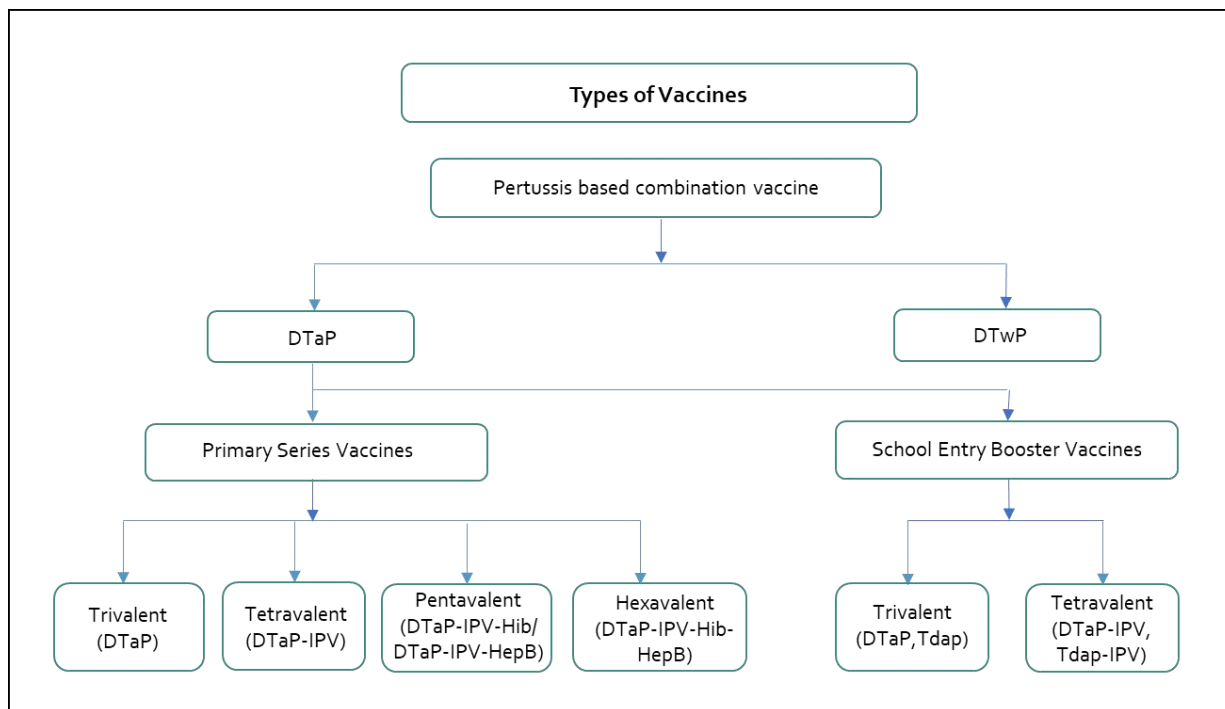


Fig 7: Types of vaccines

Countries are shifting from the DTP vaccine that includes a wP antigen (DTwP) to the DTP vaccine with aP component (DTaP) due to reduced adverse events after immunization. For instance, Angola in the year 2022 has shifted from wP-based pentavalent vaccine to an aP-based pentavalent vaccine.

Most countries using aP-based primary series vaccines use hexavalent or pentavalent vaccines. aP-based trivalent and tetravalent vaccines are less commonly used.

Types of Combination Vaccines and their Brands

- Hexavalent
- Pentavalent

Hexavalent Vaccines

Hexavalent vaccines are a way to increase compliance with the entire primary schedule and the immunization rate of the six antigens: diphtheria, tetanus, pertussis (DTP), hepatitis B (Hep B), inactivated poliovirus (IPV), and *Haemophilus influenzae type b* (Hib) infections, assuring simplification of administration and better control of vaccination program costs.^{xliixliiii}

Hexavalent vaccines are the preferred vaccines in the EUR and have replaced pentavalent vaccines as primary vaccines in most European countries. In 2022, among 196 countries, around 52 countries were using "DTaP-Hib-HepB-IPV" vaccines for routine immunization. In the EUR (according to the WHO definition), 31 of 53 countries were using hexavalent vaccines, whereas, in the AMR, only eight of 35 countries have included hexavalent vaccines in their immunization schedule.

The inclusion of hexavalent vaccines in the immunization schedule of a country is an approach to inactivated polio vaccine (IPV) access, which supports the commitment of the World Health Organization (WHO) to eradicate the poliovirus.^{xliv}

Types Of Hexavalent Vaccines

The acellular hexavalent vaccine (DTaP-HepB-Hib-IPV) is a six-in-one (all the antigens in the same container with no reconstitution) (or 5+1, the vaccine that needs reconstitution) vaccine recommended in three or four doses schedule to help protect babies against diphtheria, tetanus, pertussis, poliomyelitis, *Haemophilus influenzae type b* and hepatitis B.^{xlv}

Hexavalent Vaccine Brands

There are three aP hexavalent vaccine preparations commercially available for administration to children.

Sr. No.	Brand Name	Combination	Manufacturer
1	Hexaxim®/ Hexyon®/ Hexacima®	DTaP-HepB-Hib-IPV	Sanofi
2	Infanrix Hexa®		GSK
3	Vaxelis®		MCM

Table 3: Hexavalent vaccine brands, 2022

Hexaxim® and Vaxelis® are fully-liquid formulations available in ready-to-use syringes or vials, while the Hib component in Infanrix Hexa® is supplied as a lyophilized white powder that has to be reconstituted with the components present in the pre-filled glass syringe or vials.^{xlvi}

Infanrix Hexa® has three purified components of *Bordetella pertussis* namely Pertussis Toxoid (PT), filamentous haemagglutinin (FHA), and pertactin (PRN), whereas Hexaxim® includes two purified components (PT, FHA), and Vaxelis® includes five purified components (PT, FHA, PRN, FIM (*Fimbriae*) type 2, 3)^{xlvii} (Table 28). Though the number of pertussis antigens differs by the brand of hexavalent vaccine, the WHO position paper on pertussis states, “There is no sufficient evidence to establish any significant difference in vaccine effectiveness of aP vaccines with differing numbers of pertussis antigen components.”^{xlviii}

Hexaxim® is the only hexavalent vaccine with the WHO prequalification status and the only one available in both pre-filled syringes or mono-dose vial presentation.

Pentavalent Vaccines

The pentavalent vaccine is a combination vaccine that the WHO widely recommends as a substitute for prevailing vaccination practices for diphtheria, tetanus, pertussis (DTP), *Haemophilus influenzae type b* (Hib) or hepatitis B (Hep B), and poliomyelitis infections (IPV).^{xlix}

Most countries use pentavalent vaccines in their national immunization schedule. In 2022, among 196 countries, around 125 countries were using “DTwP-Hib-HepB” vaccines for routine immunization. During the same period, 31 countries were using the “DTaP-IPV-Hib” vaccine for routine immunization.

Types of Pentavalent Vaccines

Pentavalent vaccines combine five antigens in one formulation. It offers protection against diphtheria, tetanus, pertussis, hepatitis B or *Haemophilus Influenzae type b*, and poliomyelitis.^{li} These vaccines are of two types, either aP-based or wP-based.

aP-based pentavalent vaccines (DTaP-IPV-Hib) are mainly used by High Income Countries (HIC), Upper-Middle Income Countries (UMIC) and Middle-Income Countries (MIC).^{liii} In contrast, most wP-based vaccines (DTwP-HepB-Hib) are used by Low Income Countries (LIC) and Lower-Middle-Income Countries (LMIC).^{liiii}

wP-based pentavalent vaccines are procured by global organizations such as UNICEF and PAHO. UNICEF procures DTwP-HepB-Hib vaccines for the global alliance for vaccines and immunizations (GAVI) countries and several countries in support of expanded programs on immunization (EPI).^{liv}

Pentavalent Vaccine Brands

There are five aP-based pentavalent vaccine preparations commercially available for administration to children.

Sr. No.	Brand Name	Combination	Manufacturer
1	Pentaxim®	DTaP-IPV-Hib	Sanofi
2	Pentacel®		
3	Pediacel®		
4	Infanrix Penta®	DTaP-IPV-HepB	GSK
5	Pediarix®		

Table 4: Pentavalent vaccine brands, 2022

Public and Private Markets

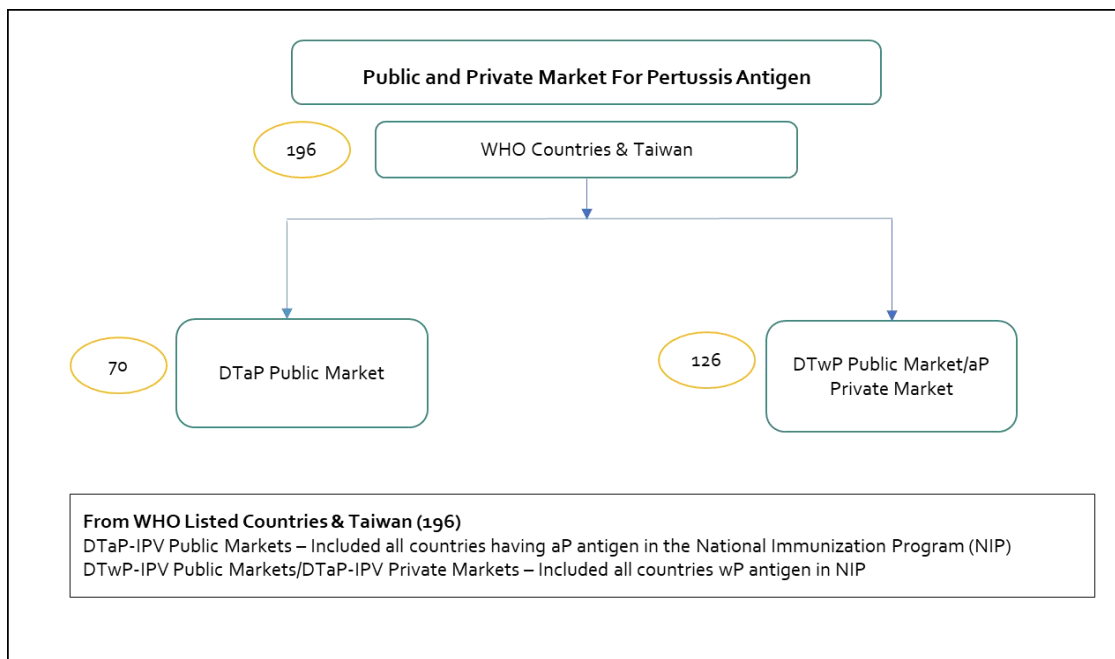


Fig 8: Public and private markets for pertussis antigen, 2022

A total of 196 countries were selected (195 from WHO Global Health Observatory (GHO) data and Taiwan). Public and private markets for vaccines are identified based on the inclusion or otherwise of the aP hexavalent and pentavalent combination vaccine in the government supply and the national immunization schedule of the country. The countries with an aP hexavalent and pentavalent combination vaccine in their national immunization schedule are designated public markets (70 countries) and countries with wP combination vaccine in their national immunization schedule are designated as private markets (126 countries). The government bears a part or all of the expenditure for immunization in the public markets whereas vaccine expenditure in most private markets is through out-of-pocket expenditure or reimbursement by private insurance payers.

All 196 countries selected are classified as HIC, UMIC, LMIC, and LIC based on the World Bank classification,^{lv} which is adopted by the WHO. China is included in the study, although it uses DTaP trivalent vaccine as a primary series vaccine, its private market is very large for pentavalent vaccines.

3. Research Methodology (Demand/Usage Approach)

This section includes the research methodology adopted to understand the market structure of the DTaP hexavalent and pentavalent vaccines market. The trivalent, tetravalent vaccines used globally and the copurified vaccines marketed in China and Japan are excluded from this study.

The study is based on the worldwide demand/usage estimates for aP hexavalent and pentavalent combination vaccines. The methodology includes four steps as below:

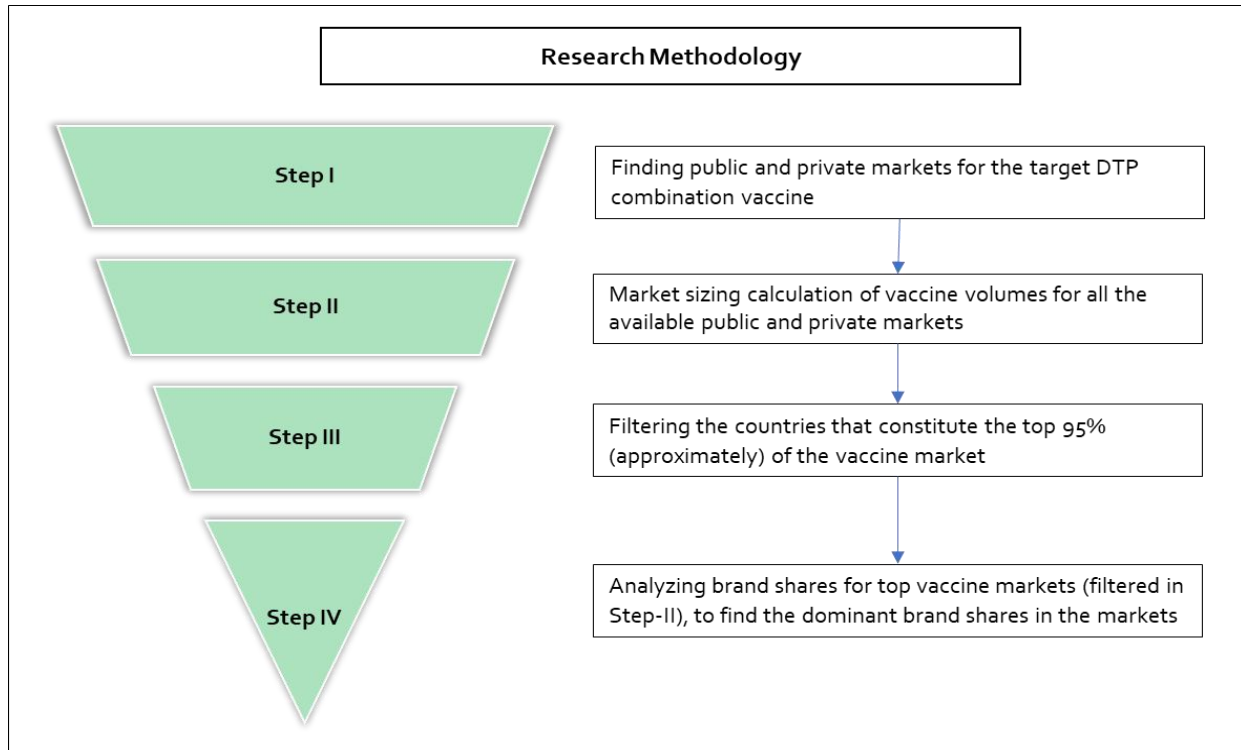


Fig 9: Research Methodology, 2022

Step-I: Finding public and private markets for the target vaccine

The potential size of the worldwide aP combination vaccine market is calculated for the hexavalent and pentavalent markets by including public and private markets.

A total of 196 countries were selected (195 from WHO data + Taiwan), and public and private markets for vaccines were identified based on the inclusion of the aP-based hexavalent and pentavalent combination vaccine in the national immunization schedule, and the government supply of the country. The countries with an aP-based combination vaccine in their national immunization schedule were designated public markets.

Among these WHO countries, 70 countries were using aP-based (DTaP) hexavalent and pentavalent combination vaccines in their national immunization schedules, which were designated public markets, whereas 126 countries using wP-based (DTwP) hexavalent and pentavalent combination vaccines in their national immunization schedules were designated as private markets.

Among the 70 public markets using aP combination vaccines, public markets for hexavalent and pentavalent vaccines were identified. The private markets for all combination vaccines are identified by including countries with wP based (DTwP) combination vaccines in their national immunization schedules, eliminating countries based on their income category, region, and filters specific to the individual vaccine market. (All 196 countries are classified based on income categories and regions).

Step-II — Market sizing calculation of vaccine volumes for all the available public and private markets

Three factors determine the potential size of the worldwide aP combination vaccine market — the annual surviving infant population, the proportion of children receiving these vaccines, and the number of doses of vaccine a child receives as per the recommended schedule.

The following parameters are used for the calculation of vaccine volumes for both the markets.

- a. Target population — Surviving Infants
- b. Immunization Rate — DTP₃
- c. Immunization Schedule — Number of doses of vaccine administered

Step-III— Filtering the countries that constitute the top 95% (approximately) of the vaccine market

The countries that constitute 95% of the market for each of the hexavalent and pentavalent were considered for further vaccine brand utilization analysis. As it is challenging to deduce the share of each brand of vaccine across all target countries (100%), we considered the statistically valid coverage of 95% of the market. Further, we assume that the brand that is dominant in 95% of the market will be a market leader.

Step-IV — Analyzing brand shares for top vaccine markets (filtered in Step-II), to find the dominant brand shares in the markets

For each market, brand shares were computed for the countries constituting the top 95% of the individual vaccine market.

The method by which vaccines are purchased and financed in each country influences the proportion of individual brands of vaccines used. In public markets, the government finances and procures vaccines in large quantities through tenders. In private markets, where individual consumers pay for the vaccine through out-of-pocket or private insurance, these vaccines are procured by either GP/ Pediatrician's offices or by pharmacies, directly from the manufacturer and/or through wholesalers.

The proportion of each of the brands used in a country is derived through extensive secondary research and expert insights. The usage patterns for each brand of vaccines across the target countries were obtained through information gathered from various sources as below-

- a) National and Regional Tenders
- b) MOH and National Health Authorities
- c) Expert Interviews with key members of NIP, medical advisors, university professors, UNICEF members, pediatricians, and immunization researchers.

We analyzed national tenders for available countries in the hexavalent and pentavalent market. Tendering information such as the number of doses of vaccines or the brand of vaccine procured in 2022 was used for market estimations. We also reviewed the MOH and National health authority sources in

each country to obtain information on specific brands of vaccines (among hexavalent and pentavalent) recommended in each country's national immunization schedule. Interviews were conducted with experts for the needed information for some countries with limited secondary information on vaccine procurement volumes and brand usage.

The methodology for estimating the volumes and shares of vaccine brands among each of the hexavalent and pentavalent markets is described below.

Hexavalent Vaccines Methodology

Step-I: Finding public and private markets for the hexavalent vaccines

The segregation and filtering of all the WHO countries into the public and private markets for the hexavalent vaccines are described below.

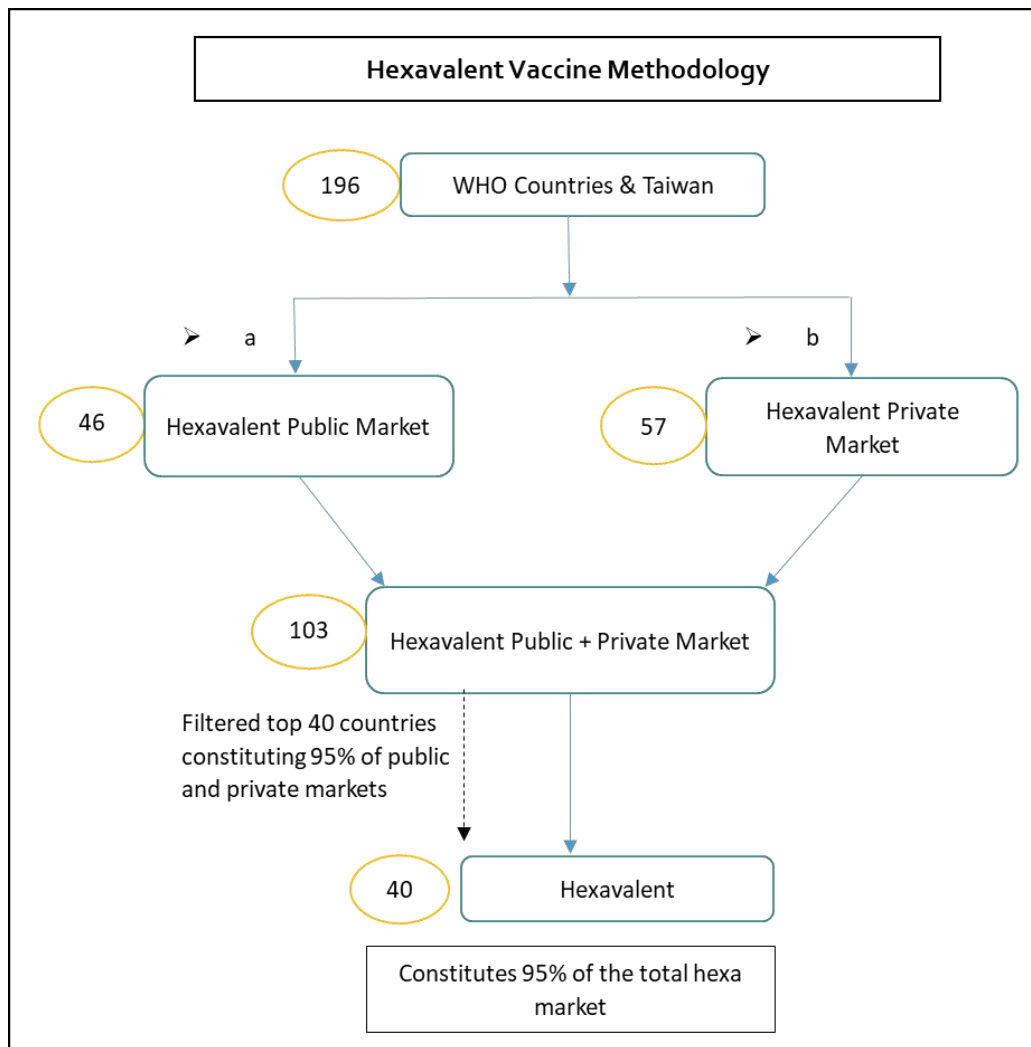


Fig 10: Methodology for hexavalent markets, 2022

The figure below mentions inclusion and exclusion criterion for hexavalent vaccine methodology:

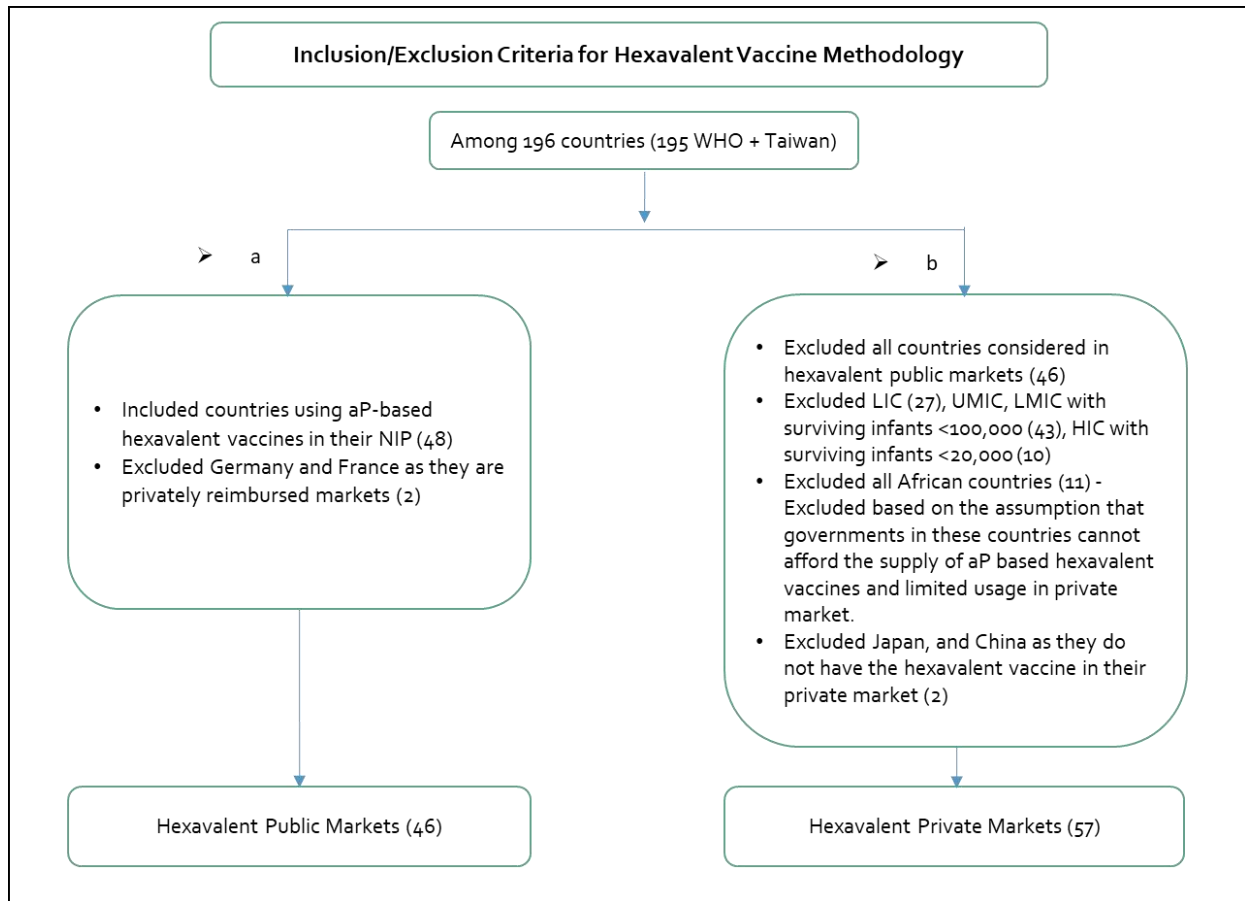


Fig 11: Inclusion/Exclusion Criterion for Hexavalent Vaccine Methodology, 2022

DTaP vaccine volumes were calculated for a total of 103 countries (46 public + 57 private) in the hexavalent market.

Step-II: Calculation of vaccine volumes for all 101 Step-1 filtered countries

For 103 countries filtered from Step-1, vaccine volumes are calculated using below mentioned parameters:

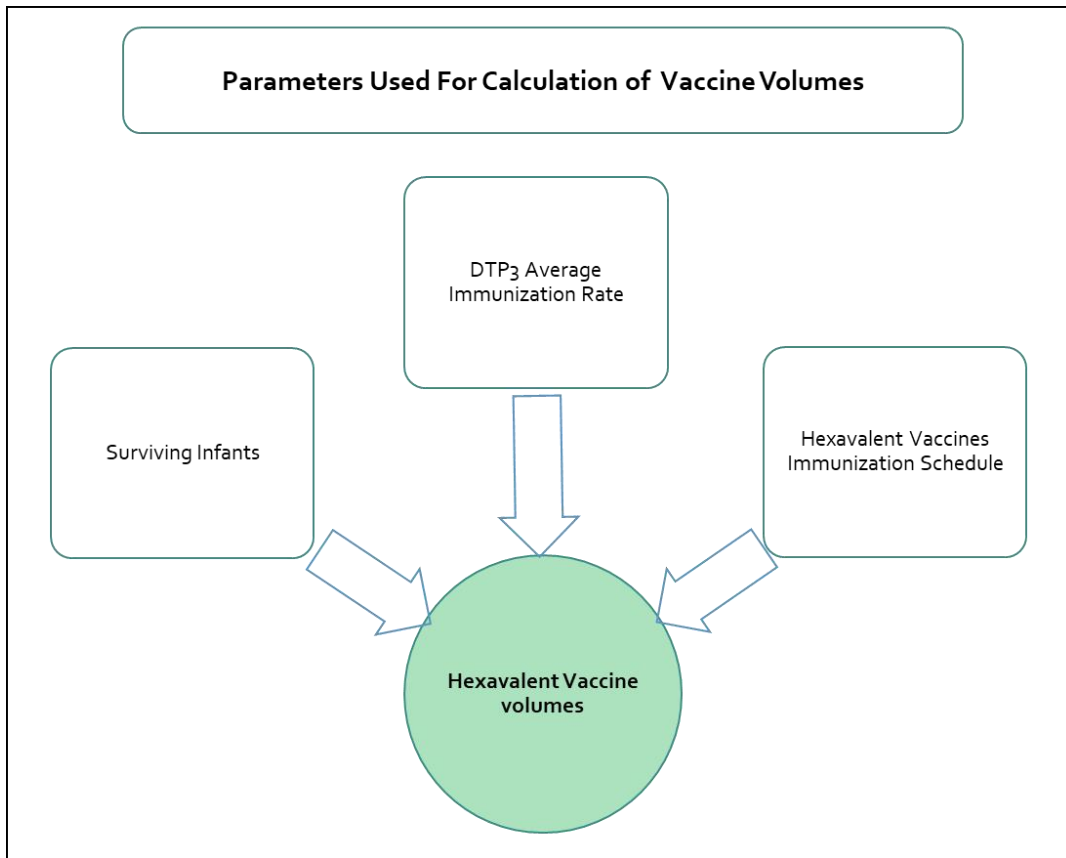


Fig 12: Parameters used for calculation of vaccine volumes, 2022

The figure below gives an overview of 3 parameters – surviving infant population, DTP3 average immunization rate and hexavalent vaccines immunization schedule

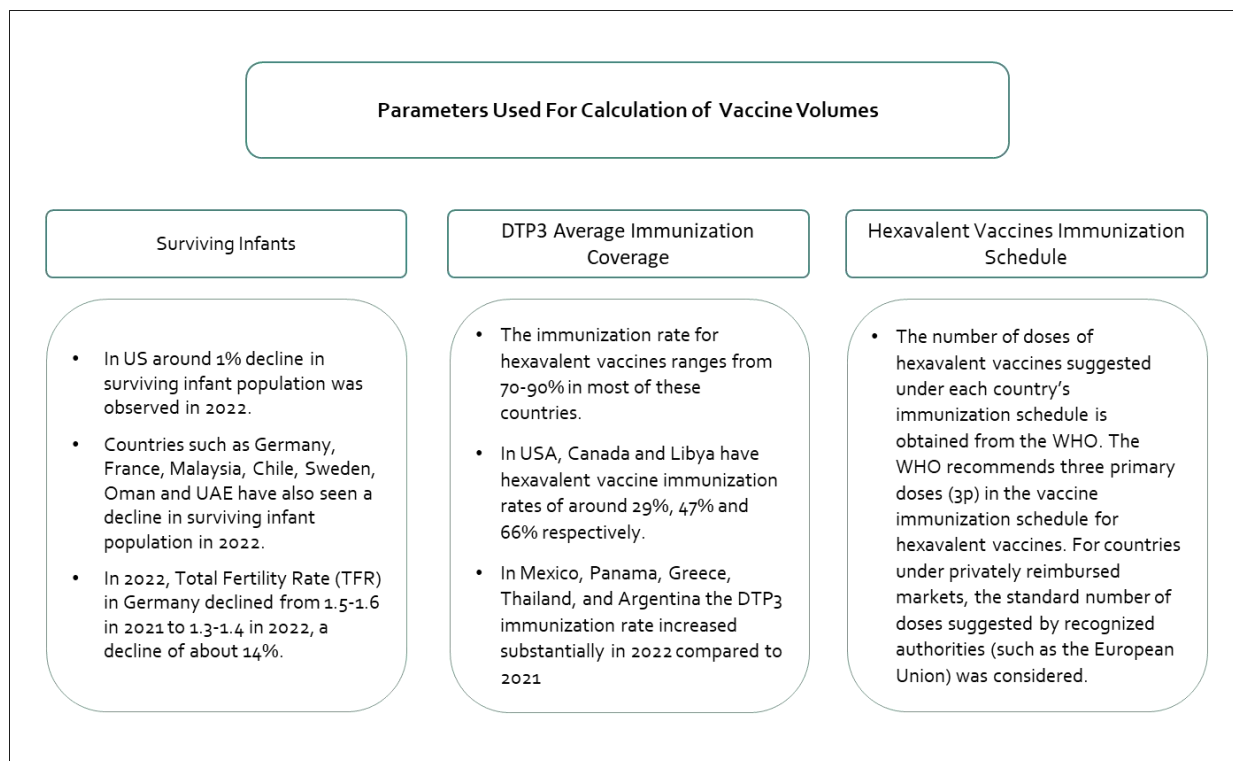


Fig 13: Parameters used for calculation of vaccine volumes, data, 2022

Surviving infants

The doses of hexavalent vaccines are administered to children less than 12 months of age. Hence the surviving infant population below 12 months of age is the target population for this study. The data on the surviving children (birth cohort) is obtained from the WHO, GAVI, UNICEF, UN population data, and national statistics from CIA Factbook.

UMIC and HIC have observed a significant decrease in surviving infant population in 2022. For example, according to analysis of Centre for Disease Control and Prevention, In US around 1% decline in surviving infant population was observed in 2022.^{lvi lvi} Other countries such as Germany, France, Malaysia, Chile, Sweden, Oman and UAE have also seen a decline in surviving infant population during the same period. In 2022, Total Fertility Rate (TFR) in Germany declined from 1.5-1.6 in 2021 to 1.3-1.4 in 2022, a decline of about 14%. And In Sweden the TFR dropped from about 1.7 in 2021 to 1.5-1.6 in 2022, a decline of almost 10%. This decline in fertility rate led to decline in surviving infant population in Germany and Sweden.^{lviii} According to the demographic statistics released by the Department of Statistics Malaysia (DOSM), the number of live births in Malaysia for the third quarter of 2022 decreased by 3.0 per cent to 109,397 from 112,776 births recorded in the third quarter of 2021.^{lix}

Immunization Rate (DTP3)

DTP3 immunization rate, the third dose immunization rate for diphtheria, tetanus, and pertussis, is considered for the hexavalent vaccine immunization rate.

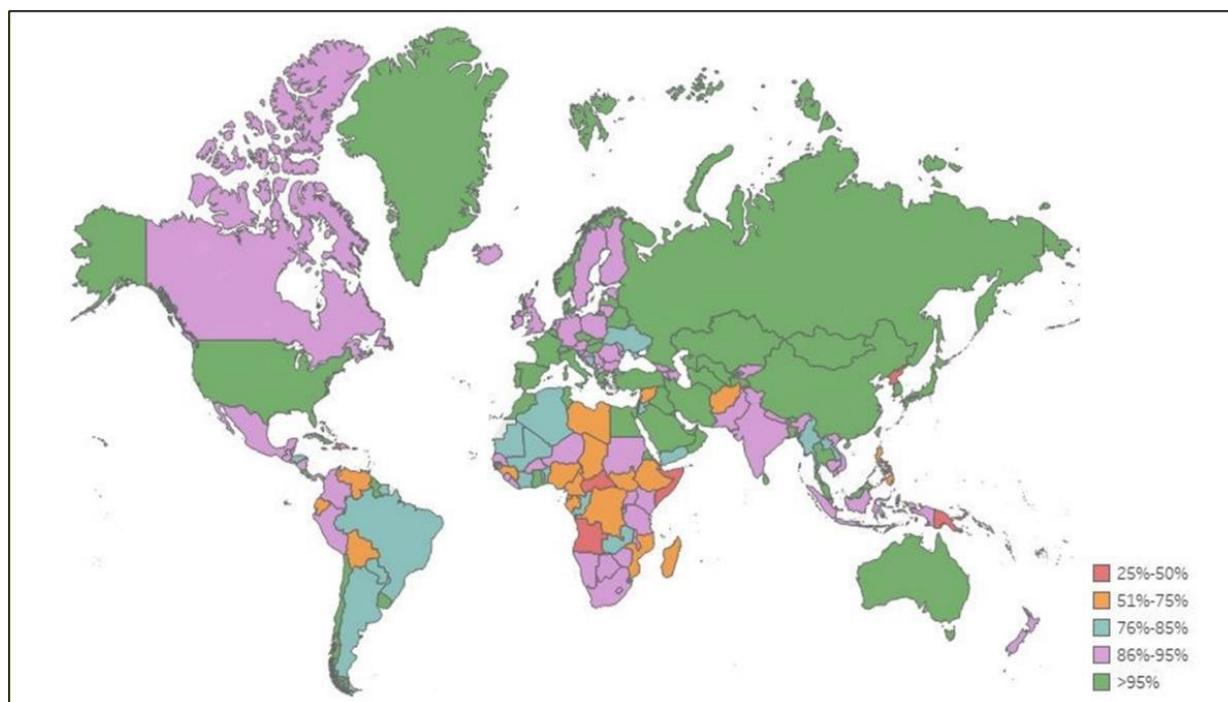


Fig 14: DTP₃ immunization rate (WHO Database), 2022

Globally, hexavalent vaccines are used more in public markets than in private markets. For public markets where hexavalent is the only vaccine supplied through the national immunization schedule, the immunization rate is high, ranging from 90-99% among those countries.

For public markets where both hexavalent and pentavalent vaccines are used, the immunization rate for hexavalent and pentavalent vaccines varies by country depending on specific factors such as geographical distribution, availability of vaccines within the country, targeted recommendations for specific populations and usage of these vaccines as a proportion of all the available multivalent vaccines.

The immunization rate for hexavalent vaccines ranges from 70-90% in most of these countries. However, the USA, Canada and Libya have hexavalent vaccine immunization rates of around 29%, 47% and 66% respectively. Although the overall immunization rate is high in the USA, Canada and Libya the use of hexavalent vaccines is low due to recommendations to limit the use of hexavalent vaccines to specific populations.

For private markets, the immunization rate for hexavalent vaccines is estimated, based on data collected from secondary sources such as WHO,^{lx} and the Center for Disease Control and Prevention (CDC).^{lxi} Parameters such as private healthcare vaccine trends and the income status of a country sourced from WHO were also considered for estimating private hexavalent vaccine market volumes for some countries. Private vaccine market shares obtained from WHO surveys^{lxii}, research publications, and from expert inputs were also used for estimating private market volumes for hexavalent vaccines.

In private markets, most HIC have hexavalent vaccine usage rates ranging from 40-95%, whereas UMIC and LMIC have hexavalent vaccine usage rates ranging from 1-12% and 1-10%, respectively.

The use of hexavalent vaccines is limited in private out-of-pocket (OOP) markets, whereas in private reimbursed markets such as France, and Germany, the usage of hexavalent vaccines is high.

In some of the UMIC and HIC, an increase in the DTP₃ immunization rate was observed. For instance, in Mexico, Panama, Greece, Thailand, and Argentina the DTP₃ immunization rate increased substantially in 2022 compared to 2021. In 2022, Government of Mexico have given strong emphasis on catchup vaccination program of Infants leading to rise in immunization rate from 78% in 2021 to 88% in 2022^{lxiii}. In Panama, the DTP₃ immunization rate increased from 74% in 2021 to 93% in 2022. In Greece, the DTP₃ immunization rate increased from 75% in 2021 to 99% in 2022. In 2022, Division of Vaccine Preventable Diseases, Ministry of Public Health, Thailand expanded immunization program in Thailand, as a result DTP₃ immunization rate in Thailand has increased from 14% in 2021 to 30% in 2022.^{lxiv}

Immunization Schedule

The number of doses of hexavalent vaccines suggested under each country's immunization schedule is obtained from the WHO. The WHO recommends three primary doses (3p) in the vaccine immunization schedule for hexavalent vaccines. For countries under privately reimbursed markets, the standard number of doses suggested by recognized authorities (such as the European Union) was considered.

Calculation Of Volumes Of Hexavalent Vaccine:

The hexavalent market volumes were calculated using these parameters— surviving infants' population, hexavalent vaccine immunization rate, and recommended vaccine dose schedule.

Market	Type of Market	Total Countries	Total Volume (Mn)
Hexavalent	Public	46	29.0
	Private	57	10.4

Table 5: Hexavalent Market, Total Countries and Volumes, 2022

Step-III: Filtering the top 95% (approximately) markets

The total Hexavalent Vaccine market of 103 countries constitutes 39.5 Mn. Among 103 countries, 40 countries (29 Public and 11 Private) constitute 95% of the total volumes, equaling 37.5 Mn. These 40 countries were considered for further brand analysis and to understand the brand usage trends of hexavalent vaccines.

Market	Type of Market	Top 95% Countries	Top 95% Volume (Mn)
Hexavalent	Public	29	28.3
	Private	11	9.2

Table 6: Hexavalent Vaccine Market, 95% by Volume, 2022

Step-IV: Analyzing brand shares for top vaccine markets

Several brands of hexavalent vaccines exist within each of the vaccine markets. Brand preference among the hexavalent brands is estimated for the top 40 countries that constitute 95% of the hexavalent market. The brand of vaccine that is used more in these 40 countries will be a market leader in the overall hexavalent vaccine market.

The first step in analyzing brand shares is to segregate the 40 countries into countries having only one brand or having multiple brands of hexavalent vaccine in their market. Among 40 countries, 19 countries have a single brand of vaccine, and only one brand will constitute a 100% share of the market. 21 countries have more than one brand of vaccines and the share of brands in these 21 countries has been analyzed through various approaches.

Market	Top 95% Countries	Single Brand	Multiple Brand
Hexavalent	40	19	21

Table 7: Countries with only one brand of vaccine and countries with multiple brands, 2022

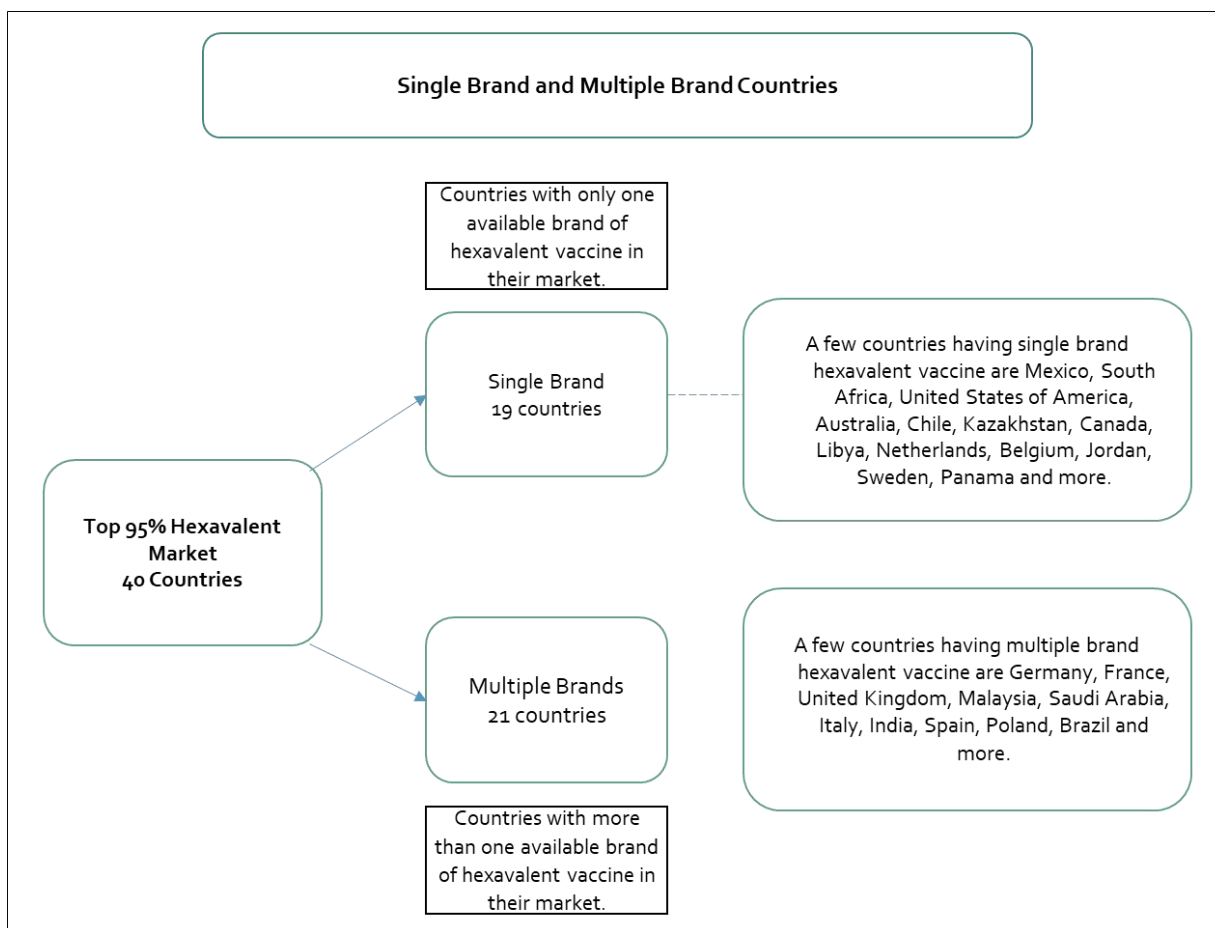


Fig 15: Single brand and multiple brand countries, Hexavalent Market, 2022

Single Brand – Countries with only one available brand of hexavalent vaccine in their market.

Multiple Brands – Countries with more than one available brand of hexavalent vaccine in their market.

In 19 public countries namely, Mexico, South Africa, United States of America, Australia, Chile, Kazakhstan, Canada, Libya, the Netherlands, Belgium, Jordan, Romania, Sweden, Panama, Austria, New Zealand, Ireland, Norway, and Oman only one brand of hexavalent vaccine is administered. For instance, in Mexico, South Africa, Chile, Kazakhstan, Libya, Belgium, Jordan, Sweden, Panama, Austria and Oman Hexaxim® is the only brand of hexavalent vaccine available and administered to all the target children.

Infanrix Hexa® is the only brand of hexavalent vaccine administered in five countries, namely the Australia, Canada, New Zealand, Ireland and Norway. In the United States of America and the Netherlands Vaxelis® is the only brand of hexavalent vaccine available and administered to all the target children.

National and Regional Tenders

Governmental vaccine procurement departments under the country’s MOH generally procure vaccines through national or regional tenders.

National tenders procure hexavalent vaccines in United States of America, Germany, France, United Kingdom of Great Britain and Northern Ireland, Vietnam, Malaysia, Saudi Arabia, Italy, Spain, Poland, Belgium, Romania, Czech Republic, Switzerland, and Austria. In United Kingdom, Department of Health and Social Care procures hexavalent vaccines.^{lxv}

The below table shows the agencies and department in respective countries responsible for procuring hexavalent vaccines.

Country	Agency/Department Procuring Hexavalent Vaccines
United States of America	U.S. Department of Health and Human Services ^{lxvi}
United Kingdom	Department of Health and Social Care ^{lxvii}
Vietnam	Department Of Drug Administration ^{lxviii lxix}
Malaysia	National Pharmaceutical Regulatory Agency (NPRA) ^{lxx lxxi}
Saudi Arabia	National Unified Procurement Company (NUPCO) ^{lxxii}
Spain	Department of Health of the Generalitat of Catalonia, Flemish Agency for Care and Health ^{lxxiii}
Poland	Independent Complex of Public Open Health Care Centers in Warsaw ^{lxxiv}
Belgium	Government of Belgium ^{lxxv}
Romania	Ministry of Health, Romania ^{lxxvi}
Czech Republic	Ministry of Health, Czech Republic ^{lxxvii}
Switzerland	Federal Department of Home Affairs ^{lxxviii}
Austria	Federal Government of Austria ^{lxxix}

Table 8: Countries and Agency/Department procuring Hexavalent Vaccine, 2022

In Germany, various regional and local authorities of German Government procured hexavalent vaccines.

In France and Italy, regional government authorities procured Hexaxim®, Infanrix-Hexa®, and Vaxelis® in 2022.

Qualitative Insights from MOH/NIP Resources

The information on brands of aP-based vaccines administered in national immunization schedules in the different countries was gathered through authentic secondary sources such as the MOH sites and publications by government health authorities, among related resources.

National Registries and MOH sites provided information on the brand usage of the aP-based hexavalent vaccines in Mexico, South Africa, United States of America, Germany, United Kingdom of Great Britain and Northern Ireland, Saudi Arabia, Italy, India, Australia, Spain, Chile, Kazakhstan, Poland, Canada, Libya, the Netherlands, Belgium, Jordan, Romania, Sweden, Panama, Thailand, Switzerland, Greece, Austria, New Zealand, Portugal, Ireland, Norway, Philippines, Oman, United Arab Emirates, and Argentina.

In the USA, US Food and Drug Administration have authorized use of Vaxelis® in the USA. ^{lxxx}

In Australia, the Australian Government Department of Health and Aged Care procured Infanrix-Hexa® as only Hexavalent vaccine in 2022. In Australia, Infanrix-Hexa® had 100% of the market share in 2022. Australian government decided to include Vaxelis® in Immunization schedule from year 2023 ^{lxxxi}

Expert Insights on Vaccine Usage Patterns

In some countries, especially in countries with private markets, data on vaccine procurement information is not publicly accessible. Expert interviews with key members of NIP, medical advisors, university professors, pediatricians, and immunization researchers were conducted for such countries to know the brand utilization.

For countries such as Brazil, Indonesia, Greece, Slovakia, Philippines, and United Arab Emirates where the availability of secondary information was limited, expert interviews and opinions were elicited to understand the brand usage for individual markets.

Pentavalent Vaccines Methodology

Step-I: Finding public and private markets for the pentavalent vaccines

The segregation and filtering of all the WHO countries into the public and private markets for the pentavalent vaccines are described below:

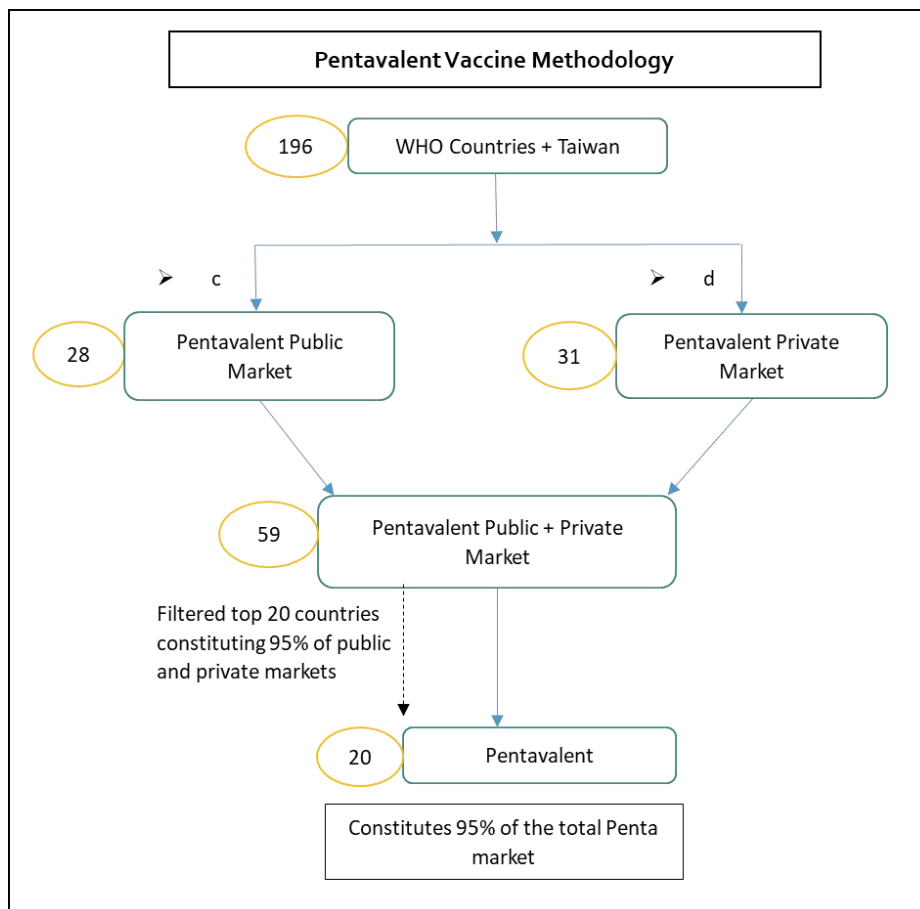


Fig 16: Methodology for pentavalent markets, 2022

The figure below mentions inclusion and exclusion criterion for pentavalent vaccine methodology:

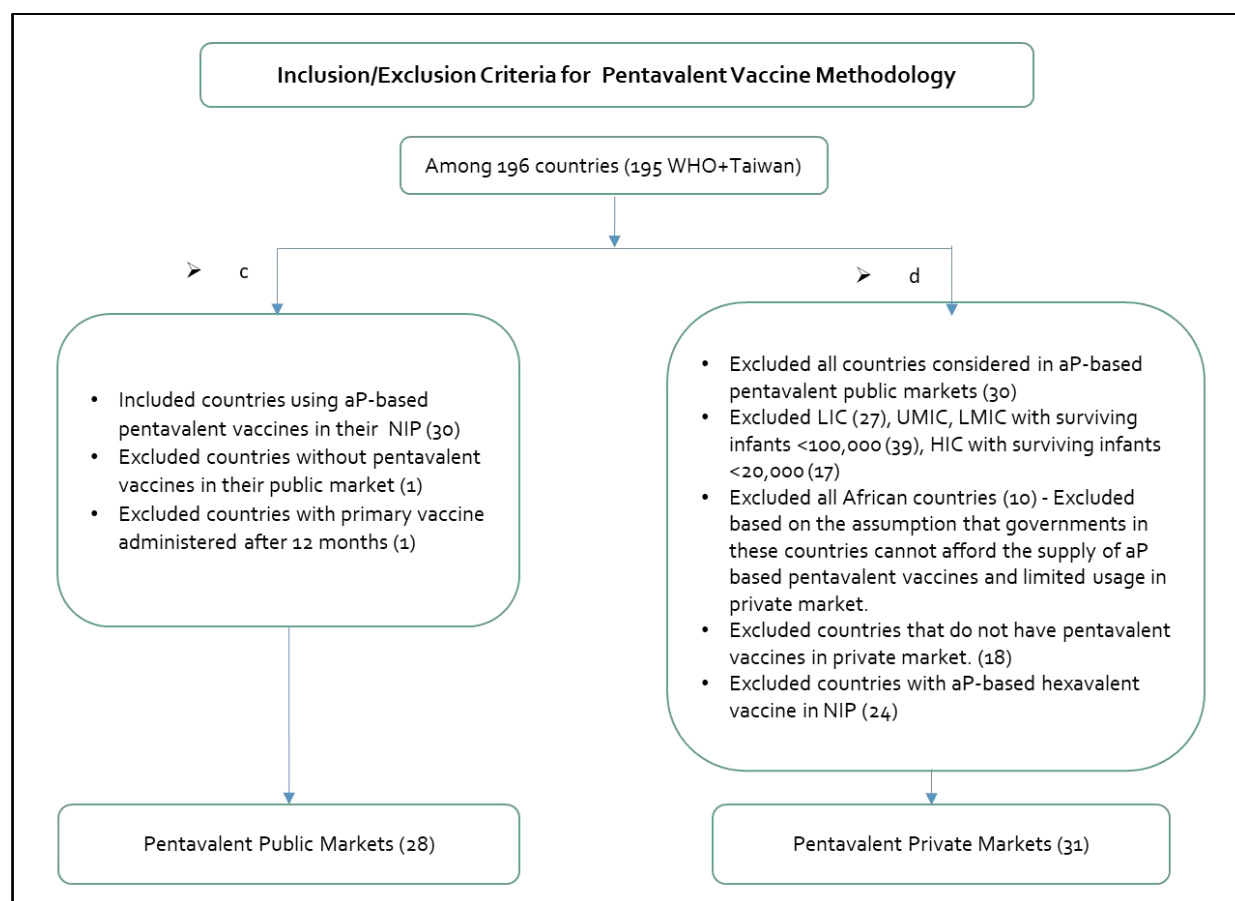


Fig 17: Inclusion/Exclusion Criterion for Pentavalent Vaccine Methodology, 2022

DTaP vaccine volumes were calculated for a total of 59 countries (28 public + 31 private) in the pentavalent market.

Step-II: Calculation of vaccine volumes for all 59 Step-I listed countries

The following parameters are used for the calculation of vaccine volumes

- Surviving Infants
- Immunization Rate
- Immunization Schedule

For 59 countries filtered from Step-1, vaccine volumes are calculated using below mentioned parameters:

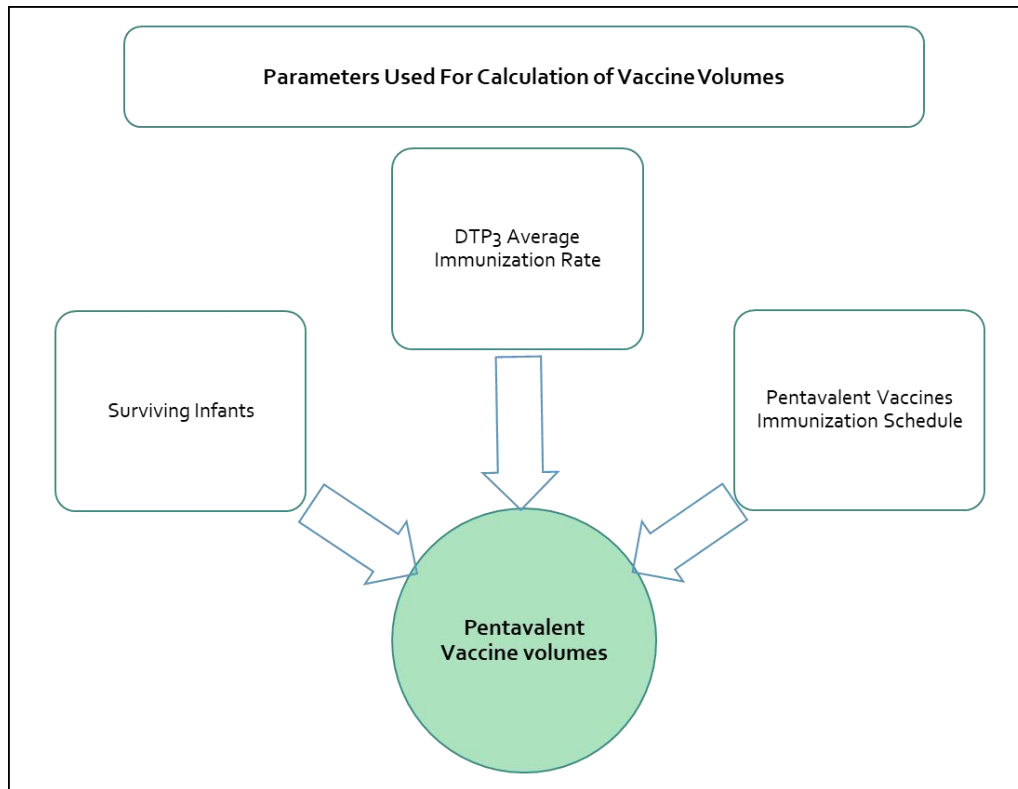


Fig 18: Parameters used for calculation of vaccine volumes, 2022

The figure below gives an overview of 3 parameters – surviving infant population, DTP3 average immunization rate and hexavalent vaccines immunization schedule

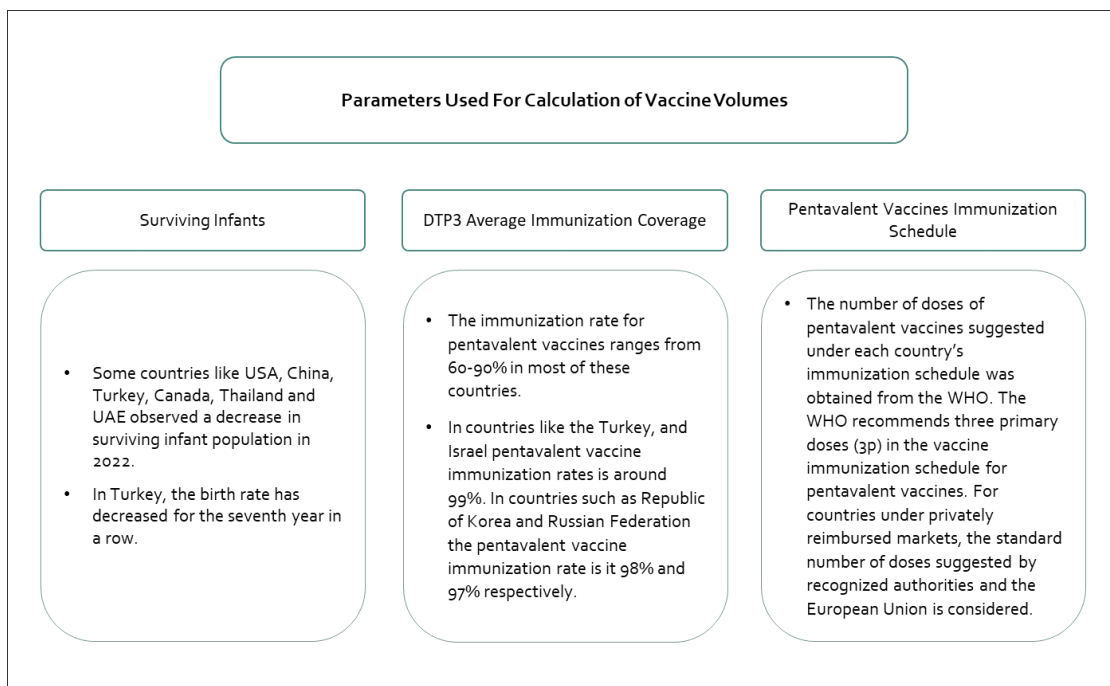


Fig 19: Parameters used for calculation of vaccine volumes, data, 2022

Surviving infants

The doses of pentavalent vaccines are administered to children less than 12 months of age. Hence the surviving infant population below 12 months of age is the target population for this study. The data on the surviving children (birth cohort) is obtained from the WHO, GAVI, UNICEF, UN population data, and national statistics from CIA Factbook.

Some countries like the USA, China, Turkey, Canada, Thailand and UAE observed a decrease in surviving infant population in 2022. For example, in United States of America decline in number of surviving infants is observed as compared to 2021.^{lxxxii} In 2022, according to Turkish Statistical Institute, the birth rate in Turkey decreased for the seventh year in a row, data for 2022 show, reaching 1.62 live births per woman. In 2022, the number of live births in Turkey is just over 1 million.^{lxxxiii}

Immunization Rate (DTP₃)

DTP₃ immunization rate, the third dose immunization rate for DTP was considered for the pentavalent and hexavalent vaccine immunization rate.

The immunization rate for pentavalent vaccines ranges from 60-90% in most of these countries. However, the USA, China, Canada, Vietnam and Brazil have pentavalent vaccine immunization rates of around 5%, 15%, 50%, 5% and 2% respectively. Although the overall immunization rate is high in the USA and Canada, the immunization rate of the pentavalent vaccine is low due to recommendations for targeted use of the pentavalent vaccine in specific populations.

For private markets, the immunization rate for pentavalent vaccines is estimated, based on data collected from secondary sources such as WHO,^{lxxxiv} and the CDC.^{lxxxv} Parameters such as private healthcare vaccine trends and the income status of a country sourced from WHO were also considered for estimating private pentavalent vaccine market volumes for some countries. Private vaccine market shares obtained from WHO surveys^{lxxxvi} and research publications, and from expert inputs were also used for estimating private market volumes for pentavalent vaccines.

Immunization Schedule

The number of doses of pentavalent vaccines suggested under each country's immunization schedule was obtained from the WHO. The WHO recommends three primary doses (3p) in the vaccine immunization schedule for pentavalent vaccines. For countries under privately reimbursed markets, the standard number of doses suggested by recognized authorities and the European Union is considered.

Calculation Of Volumes Of Pentavalent Combination Vaccine:

The pentavalent market volumes were calculated using these parameters—surviving infants' population, pentavalent vaccine immunization rate, and recommended vaccine dose schedule. The objective is to find the utilization of pentavalent vaccines by region, country, and by individual brand.

Market	Type of Market	Total Countries	Total Volume (Mn)
Pentavalent	Public	28	17.6
	Private	31	14.4

Table 9: Pentavalent Market, Total Countries and Volumes, 2022

Step-III: Filtering the top 95% (approximately) markets

The total pentavalent vaccine market of 59 countries constitutes 32.2 Mn. Among 59 countries, 20 countries (12 Public and 8 Private) constitute 95% of the total volumes, equaling 30.6 Mn. These 20 countries were considered for further brand analysis and to understand the brand usage trends of pentavalent vaccines.

Market	Type of Market	Top 95% Countries	Top 95% Volume (Mn)
Pentavalent	Public	12	17.1
	Private	8	13.5

Table 10: Pentavalent Vaccine Market, 95% by Volume, 2022

Step-IV: Analyzing brand shares for top vaccine markets

Pentavalent aP combination vaccines are used for the primary vaccination series. Brand preference among the pentavalent brands is estimated for the top 20 countries having 95% share of the market. The brand of vaccine used more in these 16 countries will be a market leader in the overall pentavalent vaccine market.

The usage patterns for each brand of vaccines across the target countries were obtained through information gathered from various sources as below-

- National and Regional Tenders
- MOH and National Health Authorities
- Expert Interviews with key members of NIP, medical advisors, university professors, UNICEF members, pediatricians, and immunization researchers.

The first step in analyzing brand shares is to segregate the 20 countries into countries having only one brand or having multiple brands of pentavalent vaccine in their market. 12 countries among 20 have the single brand of vaccine, and only one brand will constitute a 100% share of the market. Eight countries have more than one brand of vaccines and the share of brands in these countries has been analyzed through various approaches.

Market	Top 95% Countries	Single Brand	Multiple Brand
Pentavalent	20	12	8

Table 11: - Countries with only one brand of vaccine and countries with multiple brands, 2022

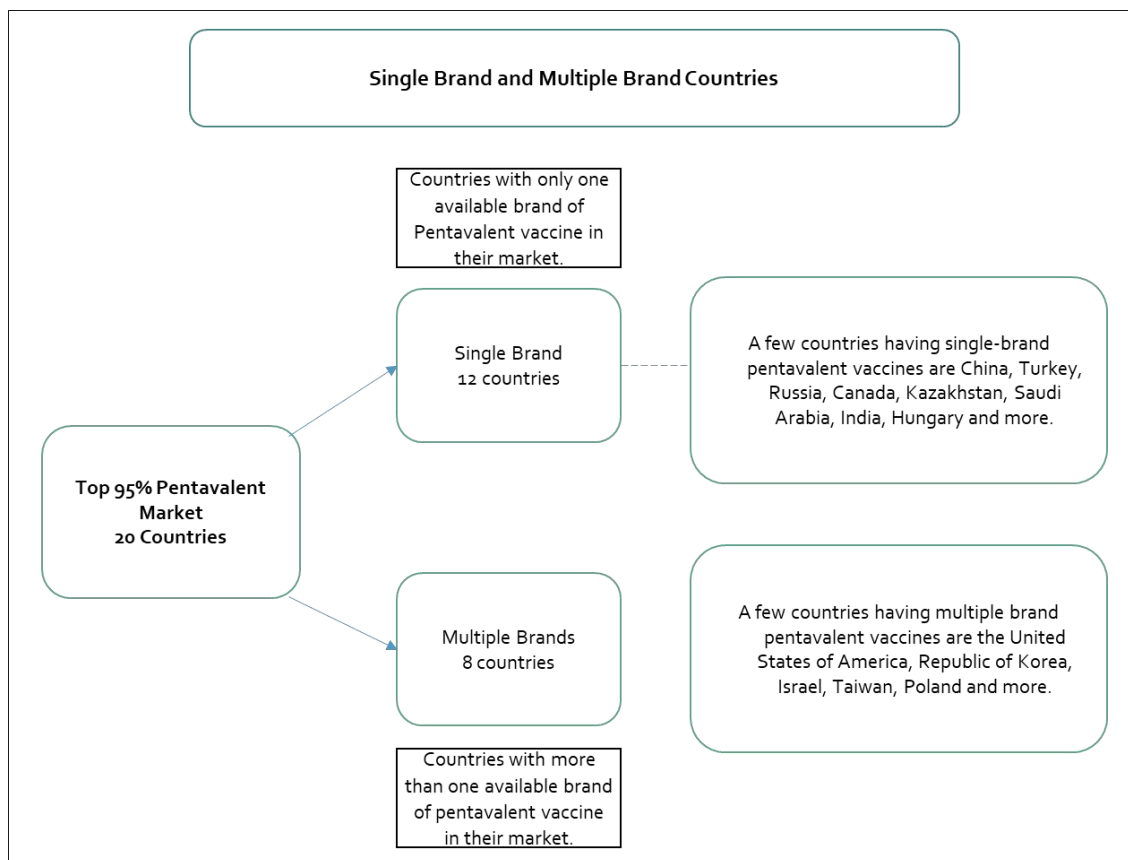


Fig 20: Single brand and multiple brand countries, Pentavalent Market, 2022

Single Brand – Countries with only one available brand of pentavalent vaccine in their market.

Multiple Brands – Countries with more than one available brand of pentavalent vaccine in their market.

In six public markets namely Turkey^{lxxxvii}, Kazakhstan^{lxxxviii}, Serbia^{lxxxix}, Costa Rica^{xc}, Denmark^{xc} and United Arab Emirates and in five private markets namely China^{xcii}, Russian Federation^{xciii}, Saudi Arabia^{xciv}, India^{xcv}, and Hungary^{xcvi} Pentaxim® is the only brand of pentavalent vaccine available and administered to all the target children. Pediacel® is the only brand of pentavalent vaccine available and administered in Canada^{xcvii}.

Five public markets namely United States of America, Republic of Korea, Israel, Taiwan and Portugal are having more than one pentavalent vaccine brand. United States of America is having Pediarix®, and Pentacel®. While, Republic of Korea, Israel, Taiwan, and Portugal are having Pentaxim, Infanrix Penta® as pentavalent vaccines in public market in 2022. In private market, three countries namely Poland, Thailand and Vietnam are using Pentaxim®, Infanrix Penta® as pentavalent vaccines in 2022.

National and Regional Tenders

Governmental vaccine procurement departments under the country's MOH generally procure vaccines through national or regional tenders.

The below table shows the agencies and department in respective countries responsible for procuring pentavalent vaccines.

Country	Agency/Department Procuring Pentavalent Vaccines
United States of America	U.S. Department of Health and Human Services ^{xcviii}
Taiwan	Ministry of Health and Welfare ^{xcix}
Hungary	National Center for Public Health ^c
Denmark	Ministry of Health, Denmark ^{ci}

Table 12: Countries and Agency/Department procuring Pentavalent Vaccine, 2022

Qualitative insights from MOH/NIP resources

The information on brands of aP-based vaccine administered in national immunization schedules in the different countries is gathered through authentic secondary sources such as the MOH sites and publications by government health authorities, among related resources.

National Registries and MOH sites provided information on the brand usage of the aP-based pentavalent vaccines in United States of America, Turkey, Canada, Republic of Korea, Israel, Kazakhstan, Taiwan, Saudi Arabia, Costa Rica and Vietnam.

Expert insights on vaccine usage patterns

In some countries, especially in countries with private markets, data on vaccine procurement by pharmacies or clinics, and or wholesaler sales data is not publicly accessible. Expert interviews with key members of NIP, medical advisors, university professors, pediatricians, and immunization researchers w

4. Pediatric Vaccination Trends

Increase in DTP₃ coverage

In 2022, according to the estimates of the World Health Organization (WHO) and The United Nations International Children's Emergency Fund (UNICEF), the global immunization coverage of a third dose of a vaccine protecting against diphtheria, tetanus, and pertussis (DTP₃) reached 84% in 2022, 3% up from 2021 which was 81%.^{cii} Thus, DTP₃ immunization serves as the standard indicator for immunization coverage worldwide.

The children who did not receive a single dose improved from 18.1 million in 2021 to 14.3 million in 2022, supporting the positive trend of increased immunization coverage.^{ciii}

Factors that contributed to the significant increase include recovery from COVID-19 pandemic, the introduction of pentavalent and hexavalent vaccines into the National Immunization Program (NIP) of some countries, the shift in income category from low-income to lower middle-income, inclusion into and exclusion of countries supported by Gavi, the vaccine alliance, and others.

In 2022, among the 57 lower-income countries, 46% of the countries have coverage rate of DTP₃ at or above 2019 levels, with 54% yet to return to pre-pandemic coverage levels.^{civ}

Backslide from a pandemic, immunization rates improved significantly in countries like Mexico, Malaysia, Saudi Arabia, Chile, and Kazakhstan, contributing to the overall rise in vaccine coverage in 2022. According to the data from the WHO and UNICEF, the DTP₃ immunization rate for Mexico increased from 78% to 83%;^{cv}, ^{cvi} Malaysia increased from 95% to 97%;^{cvi} Saudi Arabia increased from 97% to 98%;^{cvi} Chile increased from 95% to 96%;^{cix} and Kazakhstan increased from 95% to 99% in 2022.^{cx}

The shift of the country's economies to a higher income group positively impacts immunization coverage in the respective country, with the increased affordability of vaccines. For instance, according to the data published by, the World Bank, countries such as Panama and Romania moved from the upper-middle-income category in 2021 to the high-income category in 2022 and Belize moved from the lower-middle income to the upper-middle income in 2022.^{cx}

Countries in South-East Asia Region Created High Record DTP₃ Coverage

In 2022, according to the data published by WHO and UNICEF, the South-East Asia Region DTP immunization coverage rate recovered to pre-pandemic 91%, a significant increase from 82% in 2021.^{cxii} Member countries of the Southeast Asia Region were lauded by WHO for scaling up the childhood immunization coverage to pre-pandemic levels striving towards continued intensified efforts with a focus on reaching the 2.3 million un-vaccinated and 650,000 partially vaccinated children.^{cxiii}

India and Indonesia are the countries that contributed the best immunization recoveries among all WHO Regions.^{cxiv} India recorded an all-time high of 93% DTP₃ coverage in 2022, a sharp rapid increase from 85% recorded in 2021, surpassing an all-time high of 91% of the pre-pandemic levels in 2019. In this region, the number of zero-dose children improved from 4.6 million in 2021 to 2.3 million in 2022. In addition, the number of partially vaccinated children improved from 1.3 million in 2021 to 6,50,000 in 2022.^{cxv} Indonesia recorded a DTP₃ coverage rate of 85% in 2022, a significant increase from 67% in 2021.^{cxvi}

Immunization Agenda 2030

Vaccines and immunizations are responsible for saving over 4 million lives, every year. With these life-saving tools to achieve much betterment in human health is the shared ambition of countries and partners all over the world.

The World Health Assembly (WHA), with the support of countries and partners, has endorsed a new global vision and strategy, called the Immunization Agenda 2030 (IA2030), for addressing these challenges over the next decade and saving over 50 million lives by 2030.^{cxvii} The IA2030 reports provide the status of immunization programs across the world and progress being made to implement the IA2030 strategy, designed to achieve resilient, impactful, accessible, and responsive programs.^{cxviii}

To achieve the IA2030 vision, IA2030 Framework for Action describes four critical operational elements that enable a successful translation of the strategy into its implementation phase. The elements include regional and national strategies that prioritize actions for operational planning; mechanisms to ensure appropriate Ownership and Accountability (O&A); Monitoring and Evaluation (M&E) frameworks to guide and monitor country implementation; communication and advocacy to create the necessary messaging and reinforce the required actions by all stakeholders throughout the decade.^{cxix}

In 2022, in response to new data from WHO and UNICEF on 2022 immunization coverage the members of the Immunization Agenda 2030 Partnership Council together made the statement that the figures released by WHO and UNICEF underline the power of acting together and also that they must redouble efforts to ensure a more equitable and faster recovery from the pandemic as well as reach those that were missed during the pandemic.^{cxx}

Shift from Whole Cell Pertussis to Acellular Pertussis Vaccine (wP to aP)

In 2022, according to the vaccine schedule published by WHO, Angola shifted to the aP pentavalent vaccine (DTaP-Hib-HepB) from wP pentavalent vaccine.^{cxxicxxii} Due to the safety profile of the aP vaccine, they can be offered to wider population groups.^{cxxiii} The selection of vaccines is weighed against the reactogenicity, effectiveness, and cost-effectiveness. Determining the right vaccination approach depends on immunization program infrastructure, financial considerations, adverse event monitoring, and pertussis surveillance in the community.^{cxxiv}

Shift to Hexavalent Vaccine

HICs are completely shifting from pentavalent to hexavalent vaccines by removing pentavalent vaccines from their national immunization schedule. For instance, Monaco, Switzerland, Slovenia, Malaysia, and Malta have shifted completely to hexavalent vaccines. According to the immunization schedule published by WHO, the Monaco country shifted from pentavalent to hexavalent vaccine in 2022.^{cxxv}^{cxxvi}. In 2020, Malaysia implemented the hexavalent vaccine to reduce side effects and consider the milder adverse effects of these vaccines.^{cxxvii} The USA and Algeria have included the hexavalent vaccine in their national immunization program in 2021.

Recommendations by CDC

Centers for Disease Control and Prevention (CDC) recommends diphtheria, tetanus, and whooping cough (pertussis) vaccination for everyone. 3 shots of DTaP are recommended for babies to build up high levels of protection against diphtheria, tetanus, and whooping cough, and the 2 booster shots for maintaining it through early childhood. CDC recommends shots at the age of 2 months, 4 months, 6 months, 15 through 18 months, and 4 through 6 years.

In 2022, a summary of CDC recommendations includes giving infants and children 5 doses of DTaP, giving adolescents a single dose of TDaP, preferably at 11 to 12 years of age, giving women a single dose of TDaP during every pregnancy, preferably during the early part of gestational weeks 27 through 36.^{cxxviii}

New Vaccine Introductions

Vaccine introductions have played an important role in increasing the 2022 coverage. According to WHO and UNICEF, in 2022, the average coverage for vaccines targeting 11 diseases stood at 72% compared with 8% in 1980. The breadth of protection is a cross-sectional program performance indicator, the average global coverage achieved across multiple age ranges for a set of globally recommended antigens including polio, measles, rubella, diphtheria, tetanus, pertussis (DTP), hepatitis B (Hep-B), Haemophilus influenzae type B (Hib), Pneumococcal vaccine, Rotavirus Vaccine, Inactivated Polio Vaccine (IPV), and Human Papilloma Virus vaccine (HPV).

The rate of vaccine introductions declined during a pandemic and improved with 47 introductions in 2022, as 17 countries introduced a second dose of Inactivated Polio Vaccine, 9 introduced the Human papillomavirus vaccine, 6 introduced a second dose of Measles, 3 introduced Pneumococcal Conjugate Vaccine, 2 introduced Rotavirus Vaccine. The introduction of vaccines into country programs, are largely attributable to gains in 2022 in comparison to 2019.^{cxxix}

In 2022, the UK Health Security Agency (UKHSA) introduced and started supplying the vaccine, Vaxelis® in addition to Infanrix-Hexa® for use in the primary immunization schedule. Vaxelis® is a hexavalent vaccine and it protects against the same diseases as Infanrix-Hexa® (diphtheria, tetanus, pertussis, polio, Hib, and hepatitis B).^{cxxx}

Vaccination Coverage In Fragile States And Those Affected By Russia-Ukraine Conflict

Immunization coverage is not improved in fragile states as they have characteristics that substantially impair their economic and social performance^{cxxxi} and in the countries affected by the Russia-Ukraine war, which disrupted global trade that was still recovering from the pandemic.

In 2022, the number of countries with DTP₃ coverage of 50 percent or less increased to seven (Angola, the Central African Republic, the Democratic People's Republic of Korea, Guinea, Papua New Guinea, Somalia, and the Syrian Arab Republic) from five in 2019. Five of these seven countries are either fragile states or affected by conflict.^{cxxxii} It is essential to prioritize efforts in countries with the highest numbers of unvaccinated children to elevate global immunization levels.

Future Strategies

Economically improving countries are planning to include and exclude vaccines from their immunization program for the next year to improve the health of the population and to achieve a better coverage rate. Most possible changes include a shift from pentavalent to hexavalent vaccine and a shift from wP vaccine to aP vaccine in the immunization schedule. Due to the safety profile of the aP vaccine, they can be offered to wider population groups.^{cxxxiii} In Barbados, aP hexavalent vaccine is currently given to children of HIV-positive mothers and is given to premature babies in Argentina. Argentina plans to extend the aP hexavalent vaccine to its general population. Paraguay and El Salvador plan to introduce the aP hexavalent vaccine in the immunization schedule in 2023.^{cxxxiv}

5. Findings and Discussions

This section enumerates the findings and provides an in-depth analysis of the DTaP hexavalent and pentavalent global vaccine study.

DTP Vaccine Market Analysis

The global DTP-based combination vaccine market includes volume usage of the DTP vaccine. DTP vaccines include a wP (DTwP) or aP antigen (DTaP). These DTP-based vaccines serve as the backbone of several other combination vaccines such as tetravalent, pentavalent, and hexavalent vaccines.

The DTP vaccine usage volume was analyzed by estimating the three indicators, namely vaccine immunization schedules, immunization rate, and population of surviving infants and preschool age (three to seven years), for all the target countries, across the globe, in 2022.

DTP Vaccine Market and Volume

The DTP vaccines market consists of DTwP and DTaP vaccines. The figure below represents the split of the DTwP and DTaP vaccines by country.

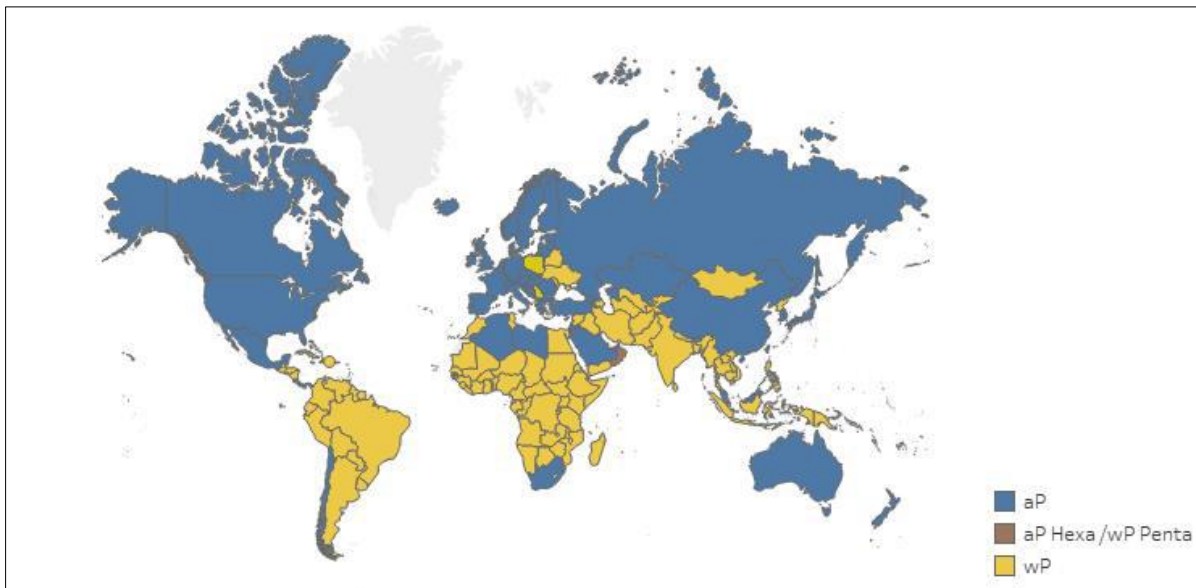


Fig 21: Countries including aP and wP vaccines in their national immunization schedule, 2022

Among the 196 countries (195 WHO countries + Taiwan), 126 countries have DTwP hexavalent and pentavalent combination vaccines and 70 countries have DTaP hexavalent and pentavalent combination vaccines in their national immunization schedule.

Among the 70 countries using DTaP hexavalent and pentavalent combination vaccines in their national immunization schedules, 49 are HIC, 18 are UMIC and only three are LMIC (Angola, Jordan, and Micronesia).

Most of the EUR countries use aP vaccines. For instance, in Europe, among 53 countries (according to WHO classification) 41 countries are using DTaP combination vaccines in their national immunization schedule. Only Angola and South Africa among the African countries, use DTaP vaccines in public immunization.

DTaP-based combination vaccines are more expensive than DTwP vaccines. Pooled procurement agencies such as UNICEF supported by GAVI funding procures pentavalent vaccines with wP components for supply to LIC and MIC. Also, developing countries that procure by self-financing methods procure wP-based DTP combination vaccines for supply in their countries.

DTaP vaccines are supplied to the public by governments of UMIC and HIC or administered in private markets in some HIC and MIC funded through out-of-pocket expenditure.

The above reasons explain the usage of higher volumes of DTwP vaccines than DTaP combination vaccines. There is increasing adoption of DTaP-based combination vaccines, especially hexavalent vaccines in high income countries. This can be attributed to low reactogenicity and the ease of use of these vaccines.

Although, the initial cost of implementing hexavalent vaccines through NIP are high, however, there are significant cost savings through the implementation of these vaccines in NIP.

In 2022, of the total DTP combination vaccines market was estimated to be 441.7 Mn doses. The DTwP combination vaccines market was estimated for 126 WHO countries using these vaccines. The volume was calculated using the demand side approach considering the three indicators namely surviving infant population, immunization rate and the number of doses of vaccine administered as per the immunization schedule of each country.

DTwP and DTaP combination vaccines had a share of 70.34% (310.7 Mn doses) and 29.6% (131.0 Mn doses) respectively.

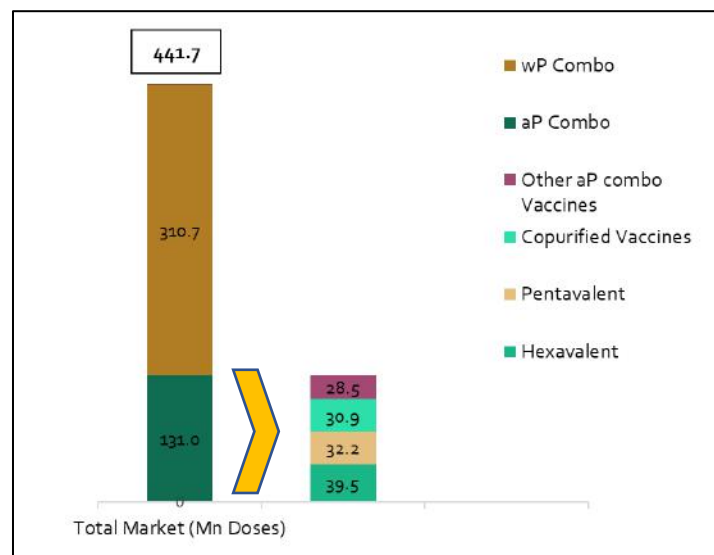


Fig 22: Global DTP vaccine split, 2022

Among the 131 Mn DTaP vaccines, in 2022, the global demand for the hexavalent vaccine was 39.5 Mn doses, pentavalent vaccines were 32.2 Mn doses, other aP combination vaccines were 28.5 Mn doses and the copurified vaccines was 30.9 Mn doses. The other aP combo vaccines include trivalent and tetravalent primary and booster series vaccines. The other aP combo vaccines including the trivalent and tetravalent vaccines and the copurified vaccines marketed exclusively in China and Japan are excluded from this

study. The high share of hexavalent vaccines among DTaP-based vaccines can be attributed to the increased adoption of hexavalent vaccines by HIC, particularly European countries in their NIPs.

Hexavalent Vaccine Market Analysis

A hexavalent vaccine (DTaP-IPV- HepB-Hib) is a six-in-one vaccine that protects infants against diphtheria, tetanus, pertussis, poliomyelitis, Haemophilus influenza type b and hepatitis B. The section below enumerates the findings by volume analysis and brand analysis for type of market, region, and country.

Brand Shares

The brand share of the three brands of hexavalent vaccine is given in Figure 23. In 2022, Hexaxim® has the highest share of the hexavalent vaccines market by volume with 62.8% (23.6 Mn), followed by Infanrix Hexa® with 23.2% (8.7 Mn), and Vaxelis® with 14.0% (5.2 Mn).

The brand share of the three brands of hexavalent vaccine for the preterm market is given in Figure 24. In 2022, Hexaxim® has the highest share of the hexavalent vaccines preterm market by volume with 67.9% (2.0 Mn), followed by Infanrix Hexa® with 16.1% (0.5 Mn), and Vaxelis® with 16.0% (0.48 Mn).

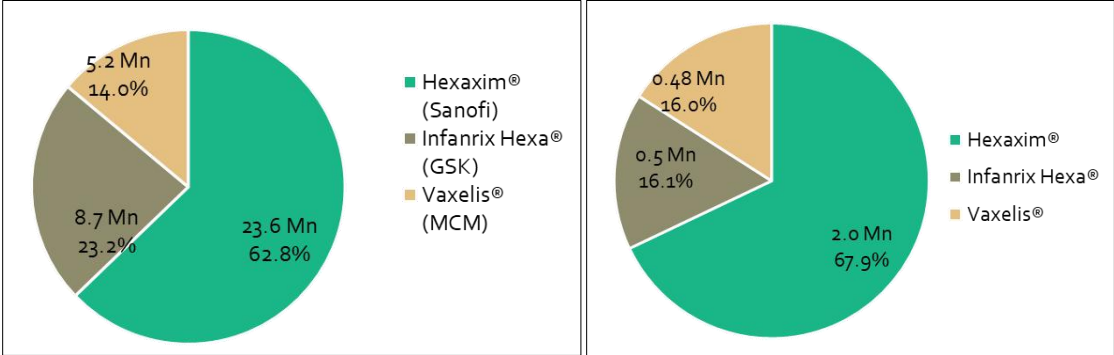


Fig 23: Brand proportion of hexavalent vaccines, 2022

Fig 24: Brand proportion of hexavalent vaccines, preterm market, 2022

Volume Analysis

By Public And Private Markets

The administration of the hexavalent vaccines is split into public and private markets based on their inclusion in the immunization schedule of the country and government supply. The countries with an aP-based hexavalent vaccine in their national immunization schedule were designated public markets whereas countries, where hexavalent vaccines are given by private practitioners and not included in the national immunization, were designated as private markets.

Hexavalent vaccines were included in the NIP of many HIC and UMIC, due to the strong public immunization financing in these countries. The higher cost of hexavalent vaccines is a hindrance to the supply of these vaccines in some LIC and MIC.

Of the 40 countries using hexavalent vaccines, 29 countries are public markets and 11 countries are private markets. In 2022, of the 37.5 Mn doses of hexavalent vaccines administered, 28.3 Mn doses (75.5%) of hexavalent vaccines were administered in public markets and 9.2 Mn doses (24.5%) were administered in private markets. (See Figure 25).

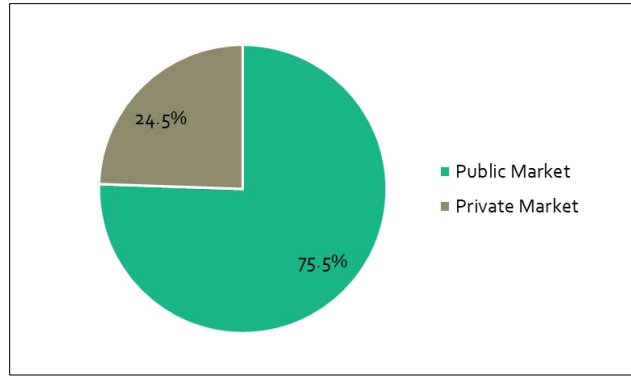


Fig 25: Volume split by public and private market, 2022

By Region

This section enumerates the vaccine volume analysis by region. Regions mentioned according to the WHO countries' classification used for analysis by region are enumerated in Table 13.

In 2022, the EUR accounted for major share of the hexavalent vaccines market by volume at 33.6% (12.6 Mn), followed by the AMR with 31.8% (11.9 Mn), the WPR with 12.6% (4.7 Mn), the AFR with 10.4% (3.9 Mn), the EMR with 6.9% (2.6 Mn), and the SEAR with 4.6% (1.7 Mn) of the hexavalent vaccine market.

The high share of hexavalent vaccine used in the EUR can be attributed to the increased approval and adoption of these vaccines since 2001. In 2022, Germany and France each used around two million doses of the hexavalent vaccine. The UK and Italy, each used more than one million doses of the hexavalent vaccine.

Some EUR countries, such as Italy, France, Spain, Poland and Belgium adopted policy changes and enforced mandatory vaccination to protect the community when vaccination coverage levels were at risk.^{CXXXV} In France, the use of hexavalent vaccines is mandatory for children born on January 1st, 2018.

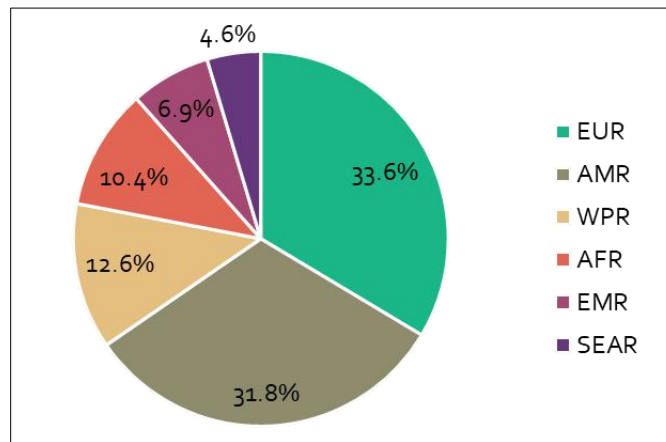


Fig 26: Hexavalent vaccine volume analysis, by region, 2022

Abbreviation	EUR	AMR	WPR	AFR	EMR	SEAR

Region	European Region	American Region	Western-Pacific Region	African Region	Eastern Mediterranean Region	South-East-Asia Region
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Table 13: Abbreviations of regions classified as per WHO, 2022 (Refer to Table 26 in Appendix for countries included in each region)

In the AMR, five countries, namely Mexico, Chile, the USA, Canada, and Panama have included hexavalent vaccines in their national immunization schedules. The low use of hexavalent vaccines in the AMR compared to the EUR can be attributed to the use of hexavalent vaccines only in special situations in some countries. In 2022, 6.8 Mn doses of hexavalent vaccines were used in Mexico, and around 3.2 Mn hexavalent vaccine doses were used in the USA. while Chile and Canada used 0.7 and 0.5 Mn doses of hexavalent vaccines respectively.

In the WPR, five countries namely Vietnam, Malaysia, Australia, New Zealand, and Philippines have hexavalent vaccines in their immunization schedule. In 2022, Vietnam and Malaysia were major countries in WPR region, each used more than 1.7 Mn doses of hexavalent vaccines.

In the AFR, South Africa was the first country to switch to hexavalent vaccines in 2015, replacing the pentavalent and HepB vaccines in its immunization schedule.^{xxxxvi} More than 95% (3.9 Mn) of hexavalent vaccine volumes used in Africa are in South Africa. The other countries in the region such as Congo, Guinea, Zambia, and Algeria contribute to less than 5% (0.18 Mn) usage of the hexavalent vaccine.

In the EMR, Saudi Arabia, Jordan, and Libya are the major countries using hexavalent vaccines. In 2022, around 1.3 Mn doses of hexavalent vaccines were used in Saudi Arabia, while Libya and Jordan used 0.5 and 0.4 Mn doses of hexavalent vaccines respectively.

By Country

In 2022, 37.5 Mn doses of hexavalent vaccines were used by 40 countries, of which Mexico had the highest usage of hexavalent vaccines 17.8% (6.8 Mn doses), while Argentina had the lowest usage of 0.34% (0.13 Mn doses).

In public markets, the top three countries with high volumes of hexavalent vaccines include Mexico, South Africa, and United States of America.

In private markets, the top three countries with high volumes of hexavalent vaccine usage include Germany, France, and Vietnam.

Although Germany and France have high immunization rates, they are included in the private market because of the need for healthcare professional (HCP) prescriptions for administering vaccines. In Germany, the vaccines are reimbursed under the social security reimbursement program, whereas in France, the vaccines are reimbursed by the primary health insurance fund (CPAM- Caisse Primaire d'Assurances Maladie).

Brand Analysis

By Public And Private Markets

There are three hexavalent vaccine preparations commercially available for administration to infants; namely Hexaxim®/Hexyon®/Hexacima® (Sanofi), Infanrix Hexa® (GSK), and Vaxelis® (MCM). The hexavalent vaccine volumes were analyzed in both public and private markets for these three brands.

Hexaxim® (23.6 Mn doses) is the most-used hexavalent vaccine in public and private markets, followed by Infanrix Hexa® (8.7 Mn doses), and Vaxelis® (5.2 Mn doses) the least-used brand in the public and private market of hexavalent vaccines.

Hexavalent Vaccine	Public Market (Volume, Mn)	Private Market (Volume, Mn)
Hexaxim®	18.9	4.7
Infanrix Hexa®	4.7	4.0
Vaxelis®	4.7	0.5

Table 14: Brand analysis of hexavalent vaccines, by public and private markets, 2022

By Region

Analysis of the brand proportion by region are detailed below. Regions mentioned according to the WHO countries' classification used for analysis by region are enumerated in Table 15.

The brand proportion for Hexaxim®, Infanrix Hexa®, and Vaxelis® by region is given below in Figure 27.

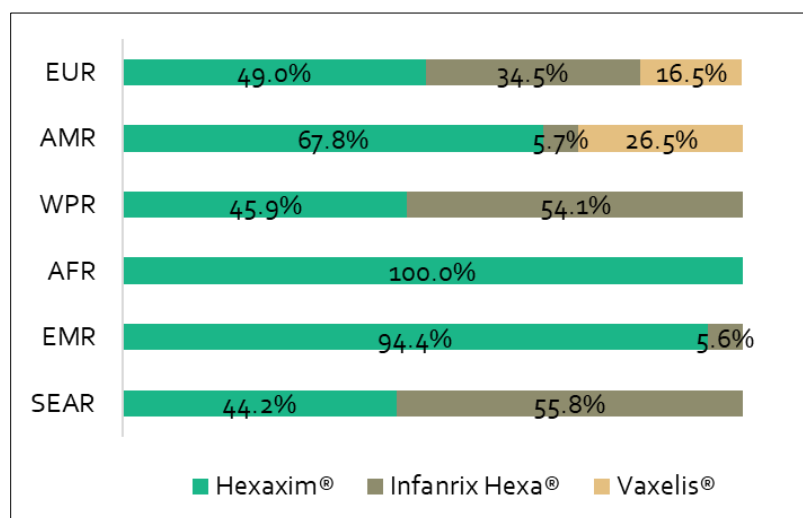


Fig 27: Brand proportion of hexavalent vaccine, by region, 2022

Abbreviation	EUR	AMR	WPR	AFR	EMR	SEAR
Region	European Region	American Region	Western-Pacific Region	African Region	Eastern Mediterranean Region	South-East-Asia Region

Table 15: Abbreviations of regions classified as per WHO, 2022 (Refer to Table 26 in Appendix for countries included in each region)

In 2022, 19 countries in the EUR used 12.6 Mn doses of hexavalent vaccines. Among these hexavalent vaccine doses, 49% are Hexaxim®, 34.5% are Infanrix Hexa®, and 16.5% are Vaxelis®.

In 2022, seven countries in the AMR (Mexico, the USA, Chile, Canada, Brazil, Panama, and Argentina) used 11.9 Mn doses of hexavalent vaccine in which Hexaxim® is the most used hexavalent vaccine (67.8%) followed by Vaxelis® (26.5%) and Infanrix Hexa® (5.7%).

In 2022, five countries in the WPR (Vietnam, Malaysia, Australia, New Zealand, and Philippines) used 4.7 Mn doses of hexavalent vaccines in which Infanrix Hexa® (54.1%) is the most used vaccine followed by Hexaxim® (45.9%).

In 2022, in the AFR, South Africa is the only country using the Hexavalent vaccine. The AFR used 3.9 Mn hexavalent vaccine doses in which Hexaxim® is the only vaccine being used under South Africa's national immunization schedule.

In 2022, five countries in the EMR (Saudi Arabia, Libya, Jordan, Oman, and UAE) used 2.6 Mn doses of the hexavalent vaccine in which Hexaxim® (94.4%) is the most used hexavalent vaccine followed by Infanrix Hexa® (5.6%).

In 2022, three countries in the SEAR (India, Indonesia, and Thailand) used 1.7 Mn doses of hexavalent vaccines of which Infanrix Hexa® (55.8%) is the most used vaccine, followed by Hexaxim® (44.2%).

By Country

This section enumerates the analysis of the vaccine brands by country.

In 12 public markets, namely Mexico, South Africa, Chile, Kazakhstan, Libya, Belgium, Romania, Jordan, Sweden, Panama, Austria, and Oman, Hexaxim® is the only brand used in their national immunization program.

In five public markets, namely the Australia, Canada, New Zealand, Ireland, and Norway, Infanrix Hexa® is the only brand used in their national immunization program.

Vaxelis® was approved in the EU in 2016 and was launched in eight European countries: Germany, France, United Kingdom of Great Britain and Northern Ireland, Italy, Spain, the Netherlands, Switzerland, and Greece. In the USA and the Netherlands, Vaxelis® is the only hexavalent vaccine for vaccination. In 2022, the UK Health Security Agency (UKHSA) started supplying the vaccine, Vaxelis® in United Kingdom in addition to Infanrix hexa® for use in the primary immunization schedule.^{cxvii} While in other European countries of the total hexavalent vaccine doses used is respective countries, Vaxelis® is used 50% in Switzerland, 10% in United Kingdom, 30% in Italy, 13% in Germany, 12% in France, 47% in Spain and 10% in Greece, in 2022.

In preterm infants, Hexaxim® is the only vaccine used in 12 countries, including 5 countries in Europe: Kazakhstan, Belgium, Sweden, Romania and Austria.^{cxviii}

Market Share By Manufacturer

Sanofi and GSK are the major manufacturers of hexavalent vaccines. Sanofi's hexavalent vaccines include Hexaxim® Hexyon®/Hexacima® (DTaP-Hib-HepB-IPV). GSK's hexavalent vaccine is Infanrix Hexa® (DTaP-Hib-HepB-IPV), while Vaxelis® (DTaP-Hib-HepB-IPV) is manufactured by MCM.

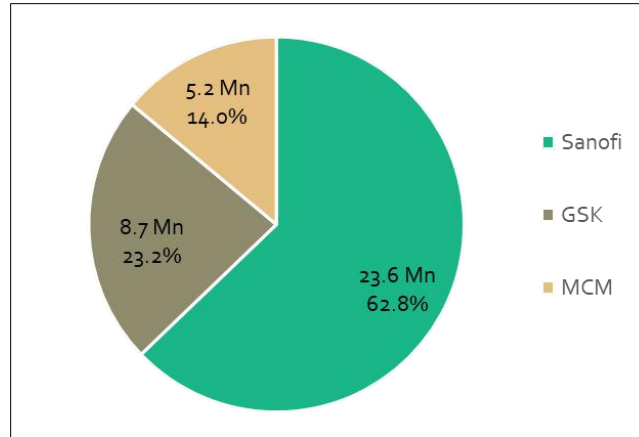


Fig 28: Hexavalent vaccine market share by manufacturer, 2022

Among the 40 countries, Sanofi has a 62.8% market share in the hexavalent vaccines market, whereas GSK has a 23.2% market share and MCM has an 14% share of the market. The high market share for Sanofi can be attributed to the sole use of Hexaxim® in many public markets such as Mexico, South Africa, Chile, Kazakhstan, Libya, Belgium, Jordan, Romania, Sweden, Panama, Austria, Oman.

Pentavalent Vaccine Market Analysis

A pentavalent vaccine (DTaP- IPV-Hib) is a five-in-one vaccine that protects infants against diphtheria, tetanus, pertussis, poliomyelitis, and Haemophilus influenza type b. The section below enumerates the findings by type of market, region, and country for the pentavalent vaccine volumes and brand proportions.

Brand Shares

The brand share of five brands of pentavalent vaccine is given in Figure 29.

In 2022, Pentaxim® has the highest share of the pentavalent vaccines market by volume with 66.5% (20.4 Mn), followed by Pentacel® with 15.8% (4.8 Mn), Pediarix® with 11.5% (3.5 Mn), Infanrix Penta® with 3.2% (1 Mn), and Pediacel® with 3.1% (0.9 Mn).

The brand share of the five brands of pentavalent vaccine for the preterm market is given in Figure 30. In 2022, Pentaxim® has the highest share of the pentavalent vaccines preterm market by volume with 48.4% (1.26 Mn), followed by Pentacel® with 34.4% (0.89 Mn), Infanrix Penta® with 15.9% (0.41 Mn), and Pediacel® with 1.3% (0.03 Mn).

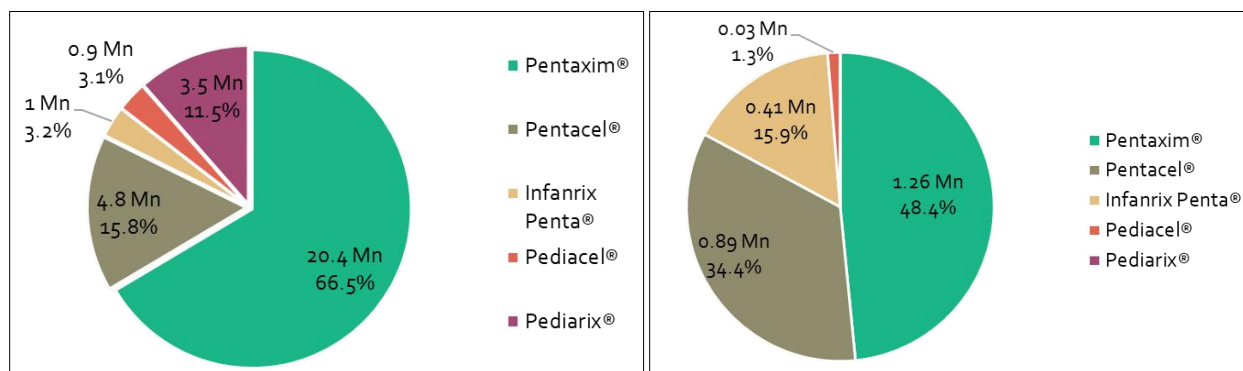


Fig 29: Brand proportion of pentavalent vaccines, 2022

Fig 30: Brand proportion of pentavalent vaccines, preterm market, 2022

Volume Analysis

By Public And Private Markets

The usage of the pentavalent vaccines is split into public and private markets based on their inclusion in the immunization schedule of the country and government supply. The countries with an aP-based pentavalent vaccine in their national immunization schedule were designated public markets whereas countries, where pentavalent vaccines are given by private practitioners and not included in the national immunization, were designated as private markets.

Of the 20 countries using the pentavalent vaccines, 12 countries are public markets and 8 countries are private markets. **In 2022, of the 30.6 Mn doses of pentavalent vaccines administered, 55.8% (17.1 Mn doses) were administered in public markets, and 44.2% (13.5 Mn doses) were administered in private markets** (see Figure 31).

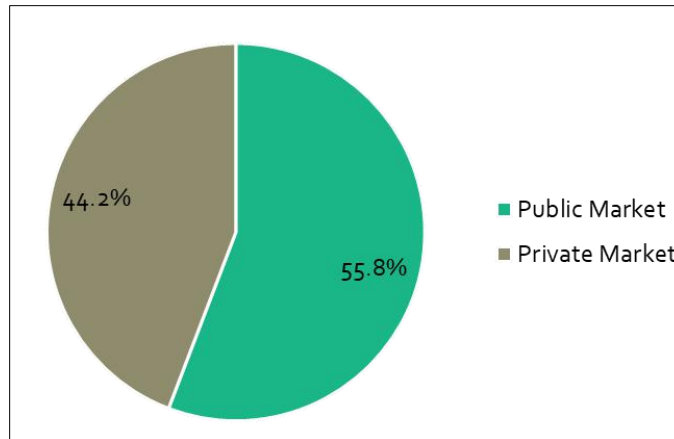


Fig 31: Volume split by public and private Markets, 2022

By Region

This section enumerates the vaccine volume analysis by region. Regions mentioned according to the WHO countries' classification used for analysis by region are enumerated in Table 16.

In 2022, the EUR accounted for the major share of the pentavalent vaccine market by volume with 39.1% (12.0 Mn), followed by the AMR with 31% (9.5 Mn), the WPR with 25.5% (7.8 Mn), the EMR with 2.3% (0.7 Mn) and the SEAR with 2.1% (0.6 Mn). The high share in both the EUR and the AMR is due to most European and American countries' early approval and adoption of pentavalent vaccines.

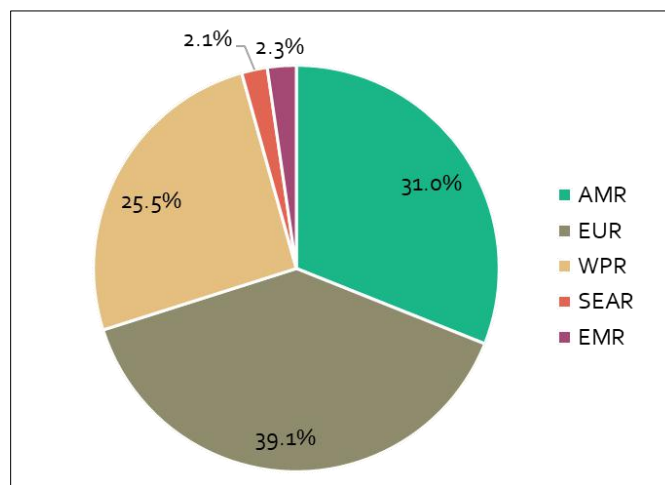


Fig 32: Pentavalent vaccine volume analysis by region, 2022

Abbreviation	AMR	EUR	WPR	SEAR	EMR
Region	American Region	European Region	Western-Pacific Region	South-East-Asia Region	Eastern Mediterranean Region

Table 16: Abbreviations of regions classified as per WHO, 2022 (Refer to Table 26 in Appendix for countries included in each region)

In the EUR, 2022, Turkey, Israel, Kazakhstan, Serbia, Denmark and Portugal have included pentavalent vaccines in their national immunization schedules. Turkey and Israel each used around 4.1 Mn and 0.8

Mn doses respectively, and Kazakhstan have used more than 0.6 Mn doses of pentavalent vaccines. Serbia and Denmark used 0.2 Mn and 0.18 Mn doses respectively.

In the AMR, the USA, Canada, and Costa Rica have included pentavalent vaccines in their national immunization schedules. The high usage of pentavalent vaccines in the AMR can be attributed to the use of aP-based pentavalent vaccines in the USA. In 2022, 8.4 Mn doses of pentavalent vaccines were administered in the USA.

In the WPR, Republic of Korea and Taiwan have pentavalent vaccines in their immunization schedule. Republic of Korea and Taiwan each used more than 0.7 Mn and 0.5 Mn doses of the pentavalent vaccine respectively.

In the EMR, pentavalent vaccines are available in private markets of countries such as Saudi Arabia and United Arab Emirates. Saudi Arabia have used more than 0.5 Mn doses of pentavalent vaccines.

In the SEAR, pentavalent vaccines are available only through private markets. Among those private markets in this region, India used 0.39 Mn doses of pentavalent vaccine in 2022.

By Country

In 2022, 30.6 Mn doses of pentavalent vaccines were used by 20 countries, of which the USA had the highest usage of pentavalent vaccines 26.9% (8.4 Mn doses) while Thailand had the lowest usage of (0.48%) 0.15 Mn doses of the global pentavalent vaccines used.

In public markets, the top three countries with high volumes of pentavalent vaccines include the USA, Turkey, and Canada.

The top three countries with high volumes of pentavalent vaccine usage in private markets include China, Russian Federation and Saudi Arabia. Although China has an aP-based trivalent vaccine for the primary series in its immunization schedule, pentavalent vaccines have high demand in their private market. In 2022, China used 6.2 Mn doses of pentavalent vaccines through private channels.

Brand Analysis

By Public And Private Markets

There are five aP based pentavalent vaccine preparations commercially available for administration to children; namely Pentaxim®, Pentacel®, Pediacel® (Sanofi), Infanrix Penta®, and Pediarix® (GSK). They are all DTaP-IPV-Hib vaccines except Pediarix® DTaP-IPV-HepB. The pentavalent vaccine volumes are analyzed in both public and private markets for these brands.

Pentaxim® (20.4 Mn doses) is the most used pentavalent vaccine, followed by Pentacel® (4.8 Mn doses), Infanrix Penta® (1.0 Mn doses), Pediacel® (0.9 Mn doses), and Pediarix® (3.5 Mn doses). Pentacel®, Pediarix®, and Pediacel® are available only in the public market whereas Pentaxim® and Infanrix Penta® are available in both public and private markets.

Pentavalent Vaccine	Public Market (Volume, Mn)	Private Market (Volume, Mn)
Pentaxim®	7.0	13.4
Pentacel®	4.8	0.0
Infanrix Penta®	0.8	0.2

Pediacel®	0.9	0.0
Pediarix®	3.5	0.0

Table 17: Brand analysis by public and private markets, 2022

By Region

Analysis of the brand proportion by region are detailed below. Regions mentioned according to the WHO countries' classification used for analysis by region are enumerated in Table 18.

The brand proportion for Pentaxim®, Pentacel®, Infanrix Penta®, Pediacel®, and Pediarix® by regions is given in Figure 33.

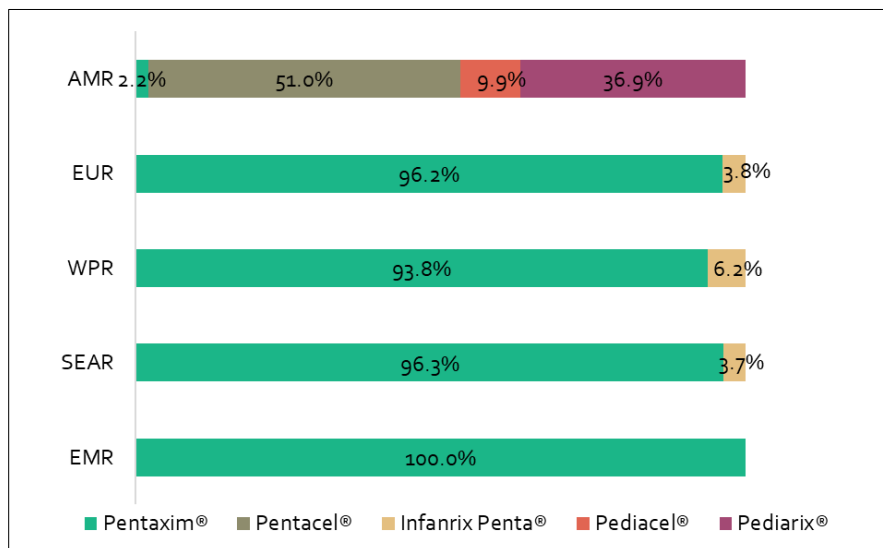


Fig 33: Brand proportion by region, 2022

Abbreviation	AMR	EUR	WPR	SEAR	EMR
Region	American Region	European Region	Western-Pacific Region	South-East-Asia Region	Eastern Mediterranean Region

Table 18: Abbreviations of regions classified as per WHO, 2022 (Refer to Table 26 in Appendix for countries included in each region)

In 2022, three countries in the AMR (the USA, Canada, and Costa Rica) used 9.5 Mn pentavalent vaccine doses in which Pentacel® (51.0%) is the most used pentavalent vaccine, followed by Pediarix® (36.9%), Pediacel® (9.9%), and Pentaxim® (2.2%).

In 2022, nine countries in the EUR (Turkey, Russian Federation, Kazakhstan, Israel, Hungary, Poland, Serbia, Denmark and Portugal) used 12 Mn doses of pentavalent vaccines. Among these pentavalent vaccine doses, 96.2% are Pentaxim® and 3.8% are Infanrix Penta®.

In 2022, four countries in the WPR (China, Republic of Korea, Taiwan, and Vietnam) used 7.8 Mn doses of pentavalent vaccines, of which Pentaxim® (93.8%) is the most used vaccine, followed by Infanrix Penta® (6.2%). The high share of Pentaxim® in this region can be attributed to China using only Pentaxim® in their national immunization schedule and Taiwan majorly using Pentaxim® in national immunization schedule.

In 2022, two countries in the SEAR (India and Thailand) used 0.6 Mn doses of pentavalent vaccines, of which Pentaxim® (96.3%) was the most used vaccine, followed by Infanrix Penta® (3.7%). This can be attributed to India using solely Pentaxim® in their private market.

By Country

This section enumerates the analysis of the vaccine brands by country.

In 11 markets (6 public and 5 private), namely those of Turkey, Kazakhstan, Serbia, Costa Rica, Denmark and United Arab Emirates Pentaxim® is the only brand used in their national immunization schedule.

In Canada, Pediacel® is the only brand used in their national immunization schedule. Pentacel® and Pediarix® vaccines are used in the USA. In the USA, although Pentacel® and Pediarix® are recommended to use in pre-term infants as per the national immunization program, only Pentacel® is used in preterm infants (according to the CDC).^{cxxxix}

Market Share By Manufacturer

Sanofi and GSK are the major manufacturers of pentavalent vaccines. Sanofi's pentavalent vaccines include Pentaxim® (DTaP-Hib-IPV), Pentacel® (DTaP-Hib-IPV), and Pediacel® (DTaP-Hib-IPV). GSK's pentavalent vaccines include Infanrix Penta® (DTaP-Hib B-IPV) and Pediarix® (DTaP-HepB-IPV).

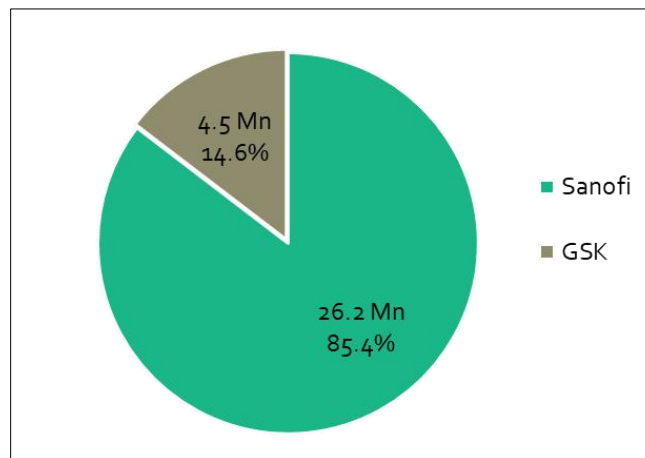


Fig 34: Pentavalent vaccine market share by manufacturer, 2022

Among the 20 countries, Sanofi has an 85.4% market share in the pentavalent vaccines market, whereas GSK has a share of 14.6%. The high market share for Sanofi can be attributed to the use of Pentaxim® in many public markets.

aP Based Hexavalent and Pentavalent Combination Vaccine Market Dominance

Our analysis shows that aP-based hexavalent and pentavalent vaccine brands offered by Sanofi are market leaders in the DTaP hexavalent and pentavalent combination vaccines market.

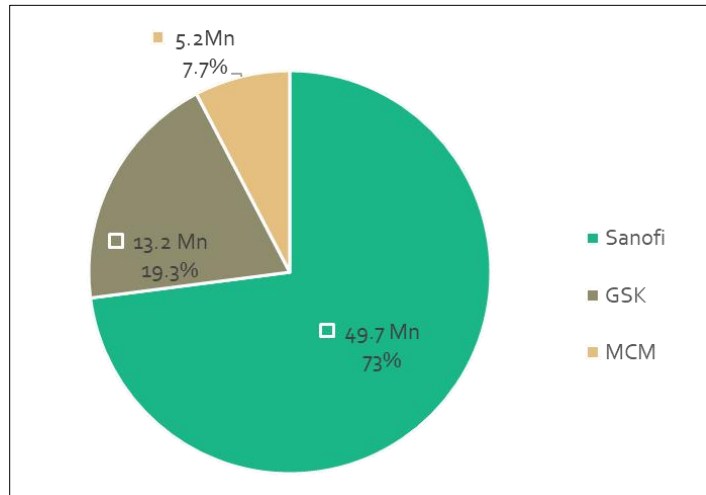


Fig 35: Brand Share In aP Based hexavalent and pentavalent Combination Vaccine Market, 2022

In 2022, around 49.7 Mn doses of Sanofi’s pertussis-based vaccines were used (Hexaxim®, Pentaxim®, Pentacel®, and Pediacel®) whereas 13.2 Mn doses of GSK’s pertussis-based vaccines were used (Infanrix-Hexa®, Pediarix®, and Infanrix-Penta®).

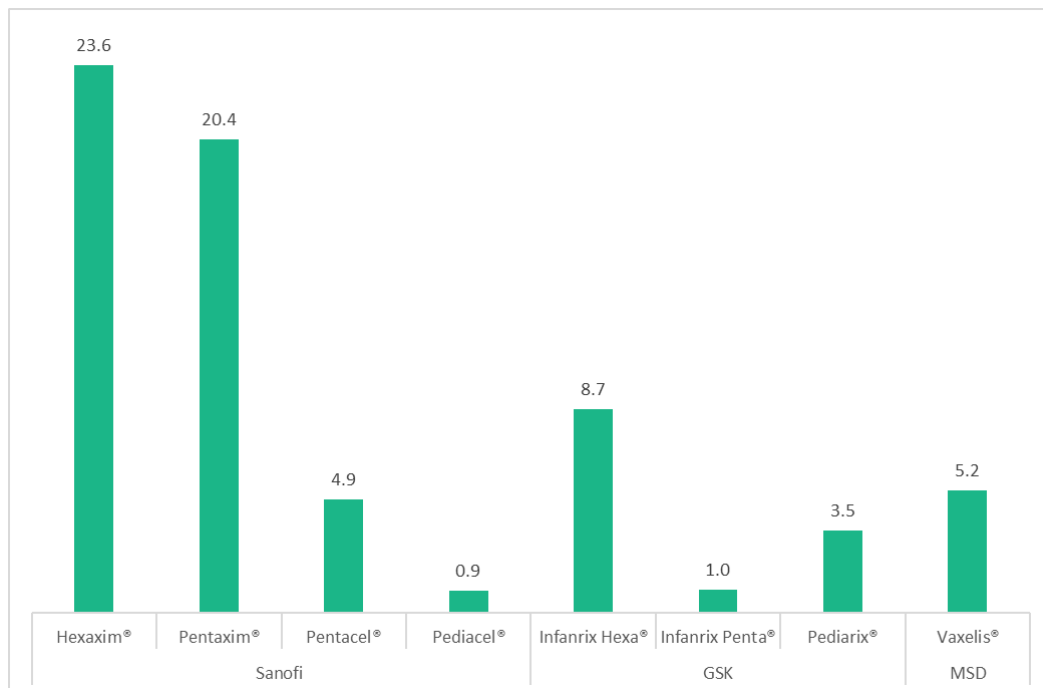


Fig 36: aP based hexavalent and pentavalent vaccine volumes used (Mn doses), 2022

In 2022, Sanofi’s Hexaxim® and Pentaxim® are the major brands with usage of more than 20 Mn doses each. During the same period around 8.7 Mn doses of GSK’s Infanrix-Hexa®, and 3.5 Mn doses of Pediarix® were used.

Value of the Study

The current study evaluates the volumes of aP-based hexavalent and pentavalent combination vaccines administered across the globe. Utilization trends of aP-based combination vaccines (including Hexavalent and Pentavalent) by region, by country, and by individual brands were also analyzed indicating market leadership by the manufacturer.

Major indicators that drive the demand for aP-based hexavalent and pentavalent combination vaccines, such as immunization rate, surviving infants' population, and the immunization schedule, were studied. The correlation between these indicators and the vaccine volumes is described. These indicators directly affect the volumes of aP-based hexavalent and pentavalent combination vaccines administered.

Conclusions

Different factors drive the demand for aP-based hexavalent and pentavalent combination vaccines among the public and private markets. Government financing and inclusion of the hexavalent/pentavalent vaccine in the immunization schedule drive vaccine usage in public markets, whereas availability and affordability of the vaccines drive the vaccine usage in private markets.

In 2022, DTaP combination vaccines accounted for a 29.6% (131 Mn doses) share of the DTP combination vaccines market (441.7 Mn doses).

Most public markets occur in HIC and UMIC and most private markets in LMIC and LIC. The study summarizes that aP-based combination vaccines were administered more in private markets than in public markets in 2022.

Europe accounts for the major share of the aP-based combination vaccines market by volume at 33.6% for hexavalent vaccines, and 40% for pentavalent vaccines. In 2022, the top 40 countries used 37.5 Mn doses of hexavalent vaccines, which is 95% of global usage. During the same period top 20 pentavalent markets used around 30.6 Mn doses (95% of the global pentavalent vaccine market).

Among the commercially available brands of aP hexavalent and pentavalent combination vaccines, Hexaxim® is most administered among hexavalent vaccines, followed by Pentaxim® in pentavalent vaccine markets. In 2022, around 23.6 Mn doses of Hexaxim®, and 20.4 Mn doses of Pentaxim® were administered.

Among hexavalent vaccines, Hexaxim® (Sanofi) had a market share of 62.8%, followed by Infanrix Hexa® with a market share of 23.2% (GSK). Among pentavalent vaccines, Pentaxim® (Sanofi) had a market share of 66.5%, followed by Pentacel® (Sanofi) and Infanrix-Penta® (GSK) with 15.8% and 3.2%, respectively.

Sanofi's vaccine brands were market leaders in each market investigated category, namely hexavalent vaccines, and pentavalent vaccines. **The research concludes Sanofi as the market leader in the aP-based pediatric hexavalent and pentavalent combination vaccines market with a global share of 73% in 2022.**

Appendix

Table 19 - Abbreviations

The table below shows abbreviations across the report

S. No	Abbreviation	Description
1	DTP	Diphtheria Tetanus Pertussis
2	IPV	Poliomyelitis
3	Hib	Haemophilus influenza type b
4	Hep B	Hepatitis B
5	aP	Acellular Pertussis Antigen
6	Wp	Whole-cell Pertussis Antigen
7	NIP	National Immunization Program
8	MOH	Ministry of Health
9	NPRA	National Pharmaceutical Regulatory Agency
10	NUPCO	National Unified Procurement Company
11	CIA	Central Intelligence Agency
12	WHO	World Health Organization
13	CDC	Center for Disease Control and Prevention
14	GAVI	Global Alliance for Vaccine and Immunization
15	UNICEF	United Nations Children's Fund
16	UN	United Nations
17	HIC	HIC- High Income Countries
18	UMIC	UMIC- Upper middle income
19	LMIC	LMIC- Lower middle income
20	SAGE	Strategic Advisory Group of Experts
21	PAHO	Pan American Health Organization
22	VCR	Vaccination Coverage Rate
23	GHO	Global Health Observatory
24	EUR	European Region
25	AMR	American Region
26	AFR	African Region
27	WPR	Western Pacific Region
28	EMR	Eastern Mediterranean Region
29	SEAR	South-East Asia Region
30	WHA	World Health Assembly
31	O&A	Ownership and Accountability
32	M&E	Monitoring and Evaluation
33	PT	Pertussis Toxoid
34	FHA	Filamentous Haemagglutinin
35	TFR	Total Fertility Rate

36	DOSM	Department of Statistics Malaysia
37	OOP	Out-of-pocket
38	UKHSA	UK Health Security Agency

Table 20 - Hexavalent Vaccine Public Markets

The table below shows the parameters considered for hexavalent vaccine volume estimation in the public market

Sr. No.	Country Name	Income Status	Region	Hexavalent Vaccine Immunization Rate in Public Market	Surviving Infant Population	Schedule
1	United States of America	HI	AMRO	29%	3,661,220	3
2	Mexico	UMI	AMRO	88%	1,920,957	4
3	South Africa	UMI	AFRO	86%	1,139,382	4
4	United Kingdom of Great Britain	HI	EURO	95%	684,808	3
5	Saudi Arabia	HI	EMRO	98%	456,564	3
6	Malaysia	UMI	WPRO	98%	439,744	4
7	Italy	HI	EURO	97%	400,613	3
8	Canada	HI	AMRO	47%	368,792	3
9	Kazakhstan	UMI	EURO	99%	340,549	2
10	Spain	HI	EURO	86%	322,165	3
11	Australia	HI	WPRO	96%	300,521	3
12	Libya	UMI	EMRO	66%	254,588	3
13	Chile	HI	AMRO	98%	187,736	4
14	Jordan	LMI	EMRO	78%	185,818	3
15	Netherlands	HI	EURO	95%	171,732	3
16	Romania	HI	EURO	87%	140,440	3
17	Belgium	HI	EURO	98%	113,600	4
18	Sweden	HI	EURO	95%	104,734	3
19	Czech Republic	HI	EURO	96%	101,350	3
20	Panama	HI	AMRO	93%	87,733	4
21	Austria	HI	EURO	88%	85,753	3
22	Portugal	HI	EURO	99%	83,671	2
23	Switzerland	HI	EURO	97%	82,371	3
24	United Arab Emirates	HI	EMRO	97%	81,000	2
25	Oman	HI	EMRO	99%	79,945	2
26	New Zealand	HI	WPRO	91.5%	62,978	3
27	Ireland	HI	EURO	95%	57,147	3
28	Slovakia	HI	EURO	97%	56,765	3
29	Bulgaria	UMI	EURO	79%	54,864	2
30	Norway	HI	EURO	98%	54,731	3
31	Georgia	UMI	EURO	90%	40,667	3
32	Croatia	HI	EURO	76%	37,258	3
33	Armenia	UMI	EURO	95%	33,339	3
34	Qatar	HI	EMRO	82.2%	26,781	2

35	Macedonia (North)	UMI	EURO	88%	19,929	2
36	Slovenia	HI	EURO	91%	17,400	3
37	Bahrain	HI	EMRO	97%	17,293	2
38	Latvia	HI	EURO	97%	16,480	4
39	Estonia	HI	EURO	86%	13,343	4
40	Luxembourg	HI	EURO	99%	7,309	3
41	Brunei Darussalam	HI	WPRO	99%	6,819	3
42	Malta	HI	EURO	99%	4,552	4
43	San Marino	HI	EURO	93%	239	3
44	Niue	UMI	WPRO	99%	15	3
45	Andorra	HI	EURO	99%	426	3
46	Monaco	HI	EURO	99%	323	3

1. Income Status: Data for the type of country income classification, such as High Income (HI), Upper middle income (UMIC), and Lower middle income (LMIC) country were collected from World Bank (WHO follows World Bank classification).
2. #Vaccines: Number of DTP vaccines within the national immunization schedule followed in each country
3. The immunization rates for the public market are taken from WHO (having only hexavalent in the immunization schedule). In some countries, the immunization rates are taken from sources such as country-specific MOH sites, News articles, and other secondary sources. For instance, in Argentina, children weighing <1500 grams should be administered a hexavalent vaccine, these children are around 1.1% of the total surviving infant population. Hence the hexavalent immunization rate is considered 1.1% for Argentina. In Canada, hexavalent vaccines are used only in 6 provinces out of 10 provinces. In Latvia infants who receive HepB mono vaccine due to HepB risk exposure from mothers will use the pentavalent vaccine, all others are given Hexavalent vaccines.
4. WHO vaccine-preventable diseases: monitoring system (Global summary 2020), GAVI-Country Hub, The World Factbook 2020, UNICEF child survival, and sustainable development goals (SGD), United Nations (UN) Population data.

Table 21 - Hexavalent Vaccine Private Markets

The table below shows the parameters considered for hexavalent vaccine volume estimation in the private market.

Sr. No.	Country Name	Income Status	Region	Hexavalent Vaccine Immunization Rate in Private Market	Surviving Infant Population	Schedule
1	India	LMI	SEARO	1%	2,6403,088	3
2	Pakistan	LMI	EMRO	0%	7,021,879	3
3	Indonesia	UMI	SEARO	2%	4,136,626	4
4	Bangladesh	LMI	SEARO	1%	3,345,170	3
5	Brazil	UMI	AMRO	4%	2,730,050	3
6	Philippines	LMI	WPRO	3%	2,131,496	3
7	Egypt	LMI	EMRO	2%	2,130,278	3
8	Vietnam	LMI	WPRO	45%	1,341,593	3
9	Russian Federation	UMI	EURO	2%	1,328,223	3
10	Iraq	UMI	EMRO	2%	1,067,290	3
11	Iran (Islamic Republic of)	LMI	EMRO	1%	1,064,612	3
12	Turkey	UMI	EURO	0%	1,029,883	3
13	Algeria	LMI	AFRO	1%	981,834	3
14	Myanmar	LMI	SEARO	0%	888,436	3
15	Uzbekistan	LMI	EURO	1%	866,476	3
16	Zambia	LMI	AFRO	1%	824,726	3
17	Germany	HI	EURO	95%	739,000	3
18	France	HI	EURO	98%	683,000	3
19	Colombia	UMI	AMRO	4%	648,575	3
20	Morocco	LMI	EMRO	2%	639,245	3
21	Argentina	UMI	AMRO	13%	530,360	2
22	Nepal	LMI	SEARO	1%	520,049	3
23	Peru	UMI	AMRO	3%	494,595	3
24	Guinea	LMI	AFRO	5%	477,419	3
25	Poland	HI	EURO	41%	393,588	4
26	Guatemala	UMI	AMRO	2%	344,746	3
27	Cambodia	LMI	WPRO	3%	341,920	3
28	Ecuador	UMI	AMRO	1%	330,105	3
29	PaPua New Guinea	LMI	WPRO	3%	314,650	3
30	Thailand	UMI	SEARO	30%	309,455	3
31	Sri Lanka	LMI	SEARO	1%	273,056	3
32	Haiti	LMI	AMRO	2%	269,554	3
33	Republic of Korea	HI	WPRO	1%	265,192	4
34	Ukraine	LMI	EURO	15%	251,057	3

35	Congo	LMI	AFRO	10%	246,769	3
36	Tajikistan	LMI	EURO	1%	242,234	3
37	Bolivia (Plurinational State of)	LMI	AMRO	0%	238,494	5
38	Honduras	LMI	AMRO	1%	200,136	3
39	Israel	HI	EURO	1%	190,560	5
40	Dominican Republic	UMI	AMRO	3%	186,546	3
41	Tunisia	LMI	EMRO	3%	159,215	3
42	Lao People's Democratic Republic	LMI	WPRO	8%	149,733	3
43	Kyrgyzstan	LMI	EURO	5%	144,783	3
44	Paraguay	UMI	AMRO	2%	142,312	3
45	State of Palestine	LMI	EMRO	1%	141,241	3
46	Taiwan	HI	WPRO	1%	138,990	3
47	Turkmenistan	UMI	EURO	2%	131,770	3
48	Nicaragua	LMI	AMRO	4%	127,530	3
49	Azerbaijan	UMI	EURO	7%	114,812	3
50	Hungary	HI	EURO	1%	91,947	4
51	Greece	HI	EURO	99%	76,918	3
52	Denmark	HI	EURO	15%	63,248	4
53	Kuwait	HI	EMRO	1%	47,445	4
54	Finland	HI	EURO	3%	44,951	4
55	Uruguay	HI	AMRO	8%	32,492	4
56	Singapore	HI	WPRO	25%	31,040	4
57	Lithuania	HI	EURO	4%	23,952	5

1. Income Status: Data for the type of country income classification, such as High Income, Upper middle income, Lower middle income & Low-income countries were collected from World Bank (WHO follows the World Bank classification).
2. Hexavalent Vaccine Private Market Share: The share of hexavalent vaccine in these countries of total DTP immunization rate. Data taken from WHO private vaccine shares, expert interviews
3. WHO vaccine-preventable diseases: monitoring system (Global summary 2020), GAVI-Country Hub, The World Factbook 2020, UNICEF child survival, and sustainable development goals (SGD), United Nations (UN) Population data.

Table 22 - Preterm Hexavalent Vaccine Volumes

The table below shows the estimated preterm hexavalent vaccine volumes in the top 33 countries

Sr. No.	Country Name	Preterm Births, 2022	Preterm Hexavalent Vaccine Volumes
1	South Africa	148,090	509,429
2	Mexico	129,860	457,108
3	United States of America	390,291	337,212
4	Malaysia	62,498	244,991
5	Germany	58,828	223,547
6	United Kingdom of Great Britain and Northern Ireland	53,000	150,255
7	Saudi Arabia	40,221	118,249
8	France	35,672	104,876
9	Austria	27,088	71,105
10	Australia	24,658	71,015
11	Chile	16,516	64,413
12	Italy	22,117	64,029
13	Spain	24,041	62,313
14	Jordan	26,495	61,602
15	Kazakhstan	25,905	51,292
16	Romania	17,439	45,517
17	Poland	24,996	40,993
18	Canada	29,363	40,962
19	Belgium	9,204	36,080
20	Libya	16,518	32,780
21	Panama	8,363	27,074
22	Netherlands	9,041	25,767
23	Czech Republic	7,093	20,427
24	Switzerland	6,268	18,147
25	Sweden	6,300	17,955
26	Oman	7,674	15,195
27	New Zealand	5,059	13,886
28	Greece	4,305	12,786
29	Portugal	6,270	12,414
30	Slovakia	3,994	11,623
31	Ireland	4,070	11,599
32	United Arab Emirates	5,953	11,549
33	Norway	3,032	8,870

*The estimation of these preterm volumes is not robust but based on multiple parameters such as WHO preterm birth rate, surviving infant's population, similar immunization rates used for term babies, private market share of hexavalent vaccines used for term infants. However, we did extensive secondary research to find specific countries that use different brands of vaccines for preterm to estimate the brand proportions split.

a) Global preterm birth estimates - WHO

- 2) World Bank/UN Population Estimates and Projections
- 3) WHO vaccine-preventable diseases: monitoring system. 2020 global summary
- 4) HEXYON/HEXACIMA – Use in preterm infants in EU countries with exclusive use (up to end DEC-2020)

Table 23 - Pentavalent Vaccine Public Markets

The table below shows the parameters considered for pentavalent vaccine volume estimation in the public market.

Sr. No.	Country Name	Income Status	Region	Pentavalent Vaccine Immunization Rate in Public Market	Surviving Infant Population	Schedule
1	United States of America	HI	AMRO	67%	3,661,220	3
2	Turkey	UMI	EURO	99%	1,029,883	4
3	Canada	HI	AMRO	47%	368,792	3
4	Kazakhstan	UMI	EURO	99%	340,549	2
5	Republic of Korea	HI	WPRO	98%	265,192	3
6	Libya	UMI	EMRO	7%	254,588	1
7	Israel	HI	EURO	99%	190,560	4
8	Taiwan	HI	WPRO	99%	138,990	4
9	Portugal	HI	EURO	99%	83,671	2
10	United Arab Emirates	HI	EMRO	97%	81,000	2
11	Denmark	HI	EURO	98%	63,248	3
12	Serbia	UMI	EURO	95%	62,950	4
13	Bulgaria	UMI	EURO	21%	54,864	3
14	Costa Rica	UMI	AMRO	97%	53,435	4
15	Finland	HI	EURO	94%	44,951	3
16	Croatia	HI	EURO	19%	37,258	1
17	Singapore	HI	WPRO	98%	31,040	4
18	Qatar	HI	EMRO	25%	26,781	1
19	Bosnia and Herzegovina	UMI	EURO	80%	26,024	4
20	Lithuania	HI	EURO	92%	23,952	4
21	North Macedonia	UMI	EURO	88%	19,929	2
22	Luxembourg	HI	EURO	99%	7,309	1
23	Montenegro	UMI	EURO	87%	7,128	4
24	Iceland	HI	EURO	94%	5,040	3
25	Micronesia (Federated States of)	Lower Middle Income	WPRO	81%	4,016	3
26	Marshall Islands	UMI	WPRO	91%	1,006	4
27	Palau	UMI	WPRO	97%	310	2
28	Cook Islands	HI	WPRO	82%	225	3

1. Income Status: Data for the type of country income classification, such as High Income (HI), Upper middle income (UMIC), and Lower middle income (LMIC) countries were collected from World Bank (WHO follows the World Bank classification).
2. #Vaccines: Number of DTP vaccines within the national immunization schedule followed in each country

3. The immunization rates are taken from WHO, country-specific MOH sites, News articles, and other secondary sources. In Latvia infants who receive HepB mono vaccine due to HepB risk exposure from mothers will use the pentavalent vaccine, all others are given Hexavalent vaccines.

4. WHO vaccine-preventable diseases: monitoring system (Global summary 2020), GAVI-Country Hub, The World Factbook 2019, UNICEF child survival, and sustainable development goals (SDG), United Nations (UN) Population data.

Table 24 - Pentavalent Vaccine Private Markets

The table below shows the parameters considered for pentavalent vaccine volume estimation in the private market.

Sr. No.	Country Name	Income Status	Region	Pentavalent Vaccine Immunization Rate in Private Market	Surviving Infant Population	Schedule
1	India	LMI	SEARO	1%	26,403,088	3
2	China	UMI	WPRO	23%	9,321,196	3
3	Pakistan	LMI	EMRO	0%	7,021,879	3
4	Indonesia	UMI	SEARO	0%	4,136,626	4
5	Bangladesh	LMI	SEARO	1%	3,345,170	3
6	Brazil	UMI	AMRO	2%	2,730,050	3
7	Philippines	LMI	WPRO	1%	2,131,496	3
8	Vietnam	LMI	WPRO	5%	1,341,593	3
9	Russian Federation	UMI	EURO	97%	1,328,223	4
10	Algeria	LMI	AFRO	1%	981,834	3
11	Myanmar	LMI	SEARO	1%	888,436	3
12	Uzbekistan	LMI	EURO	1%	866,477	3
13	Japan	HI	WPRO	1%	845,750	4
14	Zambia	LMI	AFRO	1%	824,726	3
15	Colombia	UMI	AMRO	1%	648,575	3
16	Morocco	LMI	EMRO	1%	639,245	3
17	Nepal	LMI	SEARO	8%	520,049	3
18	Peru	UMI	AMRO	1%	494,595	3
19	Saudi Arabia	HI	EMRO	40%	456,564	3
20	Poland	HI	EURO	30%	393,588	3
21	Guatemala	UMI	AMRO	1%	344,746	3
22	Ecuador	UMI	AMRO	1%	330,105	3
23	Thailand	UMI	SEARO	25%	309,455	3
24	Ukraine	LMI	EURO	25%	251,057	1
25	Congo	LMI	AFRO	2%	246,769	3
26	Tajikistan	LMI	EURO	3%	242,234	3
27	Tunisia	LMI	EMRO	5%	159,215	3
28	Paraguay	UMI	AMRO	25%	142,312	3
29	State of Palestine	LMI	EMRO	2%	141,241	3
30	Hungary	HI	EURO	99%	91,947	4
31	Kuwait	HI	EMRO	6%	47,445	4

1. Income Status: Data for the type of country income classification, such as High Income (HI), Upper middle income (UMIC), and Lower middle income (LMIC) countries were collected from World Bank (WHO follows the World Bank classification).
2. Hexavalent Vaccine Private Market Share: The share of hexavalent vaccine in these countries of total DTP immunization rate. Data taken from WHO private vaccine shares, expert interviews
3. WHO vaccine-preventable diseases: monitoring system (Global summary 2020), GAVI-Country Hub, The World Factbook 2019, UNICEF child survival, and sustainable development goals (SDG), United Nations (UN) Population data.

Table 25 - Preterm Pentavalent Vaccine Volumes

The table below shows the estimated preterm pentavalent vaccine volumes in the top 14 countries

Sr. No.	Country Name	Preterm Births, 2022	Preterm Pentavalent Vaccine Volumes
1	United States of America	390,291	891,738
2	Taiwan	198,315	785,328
3	Turkey	147,551	584,303
4	Republic of Korea	26,437	77,726
5	Kazakhstan	25,905	51,292
6	Saudi Arabia	40,221	36,199
7	Canada	29,363	34,135
8	Hungary	8,271	32,753
9	Israel	6,971	27,605
10	Costa Rica	5,951	23,091
11	Serbia	4,005	15,219
12	Portugal	6,270	12,414
13	United Arab Emirates	5,953	11,549
14	Denmark	3,842	11,296

*The estimation of these preterm volumes is not robust but based on multiple parameters such as WHO preterm birth rate, surviving infant's population, similar immunization rates used for term babies, private market share of hexavalent vaccines used for term infants. However, we did extensive secondary research to find specific countries that use different brands of vaccines for preterm to estimate the brand proportions split.

1) Global preterm birth estimates - WHO

2) World Bank/UN Population Estimates and Projections

3) WHO vaccine-preventable diseases: monitoring system. 2020 global summary

Table 26- WHO countries classification by region

Sr. No	Region	Abbreviation	Countries
1	EUR	European Region	United Kingdom, Italy, Spain, Kazakhstan, Netherlands, Romania, Poland, Belgium, Sweden, Czech Republic, Switzerland, Greece, Austria, Ireland, Slovakia, Norway, Ukraine, Portugal, Georgia, Turkey, Serbia, Israel, Hungary, Russian Federation (the), Germany, France,
2	AMR	American Region	Mexico, Chile, United States of America, Canada, Brazil, Panama, Costa Rica, Peru, Argentina, Colombia, Guatemala
3	WPR	Western Pacific Region	Malaysia, Vietnam, Australia, Philippines, New Zealand, China, Republic of Korea, Taiwan
4	AFR	African Region	South Africa
5	EMR	Eastern Mediterranean Region	Saudi Arabia, Jordan, Libya, United Arab Emirates (the), Oman
6	SEAR	South-East-Asia Region	India, Indonesia, Thailand

Table 27 - Expert Inputs

The table below shows the expert respondents' information.

Sr. No	Designation	University/ Organization	Country
1	Public Health Expert	Technical Officer- New Vaccine Introduction	India
2	Course Coordinator Immunisation (Nurse Immuniser)	Melbourne Medical School	Australia
3	Medica pediatra	Hospital Santa Marcelina	Brazil
4	Technical Director (Past- Pediatrician)	Salute Clinica Médica Ltd	Brazil
5	Health Consultant in Cannabis	Self-employed	Brazil
6	Researcher at Epidemiology, Public Health, Impact Unit.	International Vaccine Institute	Brazil
7	Consultant	World Health Organization	Brazil
8	Pediatrician at NEXTCLINICS Czech a.s.	MediClinic, a.s.	Czech Republic
9	Allergist GP Peadiatrician	Medicare UK	United Kingdom of Great Britain and Northern Ireland
10	Public Health Consultant	PT Cipta Nalar Semesta	Indonesia
11	Department of Paediatric, Faculty of Medicine,	Universitas Trisakti	Indonesia
12	EPI Health officer	World Health Organization	Germany
13	Pharmacist	Flora Apotheke Dachau	Germany
14	Pediatrician and Researcher	University of Crete	Greece
15	Specialist Pediatrics	Prime Healthcare Group LLC	United Arab Emirates
16	Pediatrician	Burjeel Oasis Medical Centre	United Arab Emirates
17	Senior Analyst, Policy – Consultant	Gavi, the Vaccine Alliance	Italy
18	Medical Doctor	Global Care	Italy
19	Head of Business Division - Health and Pharmaceuticals	Adda	Sweden
20	Pediatrician	Medical Center Manila	Philippines
21	Epidemiologist	Haute Autorité de Santé	France
22	Pediatrician, neonatologist	Groupe hospitalier Nord-Essonne	France
23	Pediater	MEDANTE- poliklinika celostnej medicíny	Slovakia
24	Pediatrician	Medped s.r.o	Slovakia
25	Pediatricians		Slovakia
26	Pediater	MEDANTE- poliklinika celostnej medicíny	Slovakia
27	Pediatrician	Rosana Medical	Romania
28	Autoryzowany Trener STRUCTOGRAM	Agnieszka Sawicka	Poland
29	Vaccine Customer Specialist	MSD Polska Sp. z o.o.	Poland
30	Hospital Pharmacist	Hospital Clínic de Barcelona	Spain
31	Medica Pediatra	Grupo Pediatrico	Argentina
32	Pediatrician	Grupo OSDE	Argentina

Table 28 - Characteristics of Hexavalent Vaccine Brands

The table below shows the characteristics of different hexavalent brands

Vaccine Characteristics	Infanrix Hexa®	Hexaxim®	Vaxelis®
Diphtheria toxoid	Not less than 30 UI	Not less than 20 UI	Not less than 20 UI
Tetanus toxoid	Not less than 40 UI	Not less than 40 UI	Not less than 40 UI
Pertussis	PT 25 µg	PT 25 µg	PT 20 µg
	FHA 25 µg	FHA 25 µg	FHA 20 µg;
	PRN 8 µg	-	PRN ₃ µg
	-	-	FIM type 2,3: 5 µg
Hepatitis B – HbsAg	Saccharomyces cerevisiae	Hansenula polymorpha	Saccharomyces cerevisiae
Hib -PRP	10 µg Conjugated to Tetanus toxoid	12 µg Conjugated to Tetanus toxoid	3 µg Conjugated to Meningococcal protein
IPV Polio	Poliovirus inactivated type 1, 2, 3	Poliovirus inactivated type 1, 2, 3	Poliovirus inactivated type 1, 2, 3

Table 29 - Characteristics of Pentavalent Vaccine Brands

The table below shows the characteristics of different pentavalent brands

Vaccine Characteristics	Pentaxim®	Pentacel®	Pediacel®	Infanrix Penta®	Pediarix®
Diphtheria toxoid	Greater than 30 UI	15Lf	15Lf	Not less than 30 UI	25 Lf
Tetanus toxoid	Greater than 40 UI	5Lf	5Lf	Not less than 40 UI	10 Lf
Pertussis	PT 25 µg	PT 20 µg	PT 20 µg	PT 25 µg	PT 25 µg
	FHA 25 µg	FHA 20 µg	FHA 20 µg	FHA 25 µg	FHA 25 µg
	-	PRN 3 µg	PRN 3 µg	PRN 8 µg	PRN 8 µg
	-	FIM 5 µg	FIM 5 µg	-	-
Hepatitis B – HbsAg	-	-	-	Saccharomyces cerevisiae	Saccharomyces cerevisiae
Hib -PRP	10 µg Conjugated to Tetanus toxoid	10 µg Conjugated to Tetanus toxoid	10 µg Conjugated to Tetanus toxoid	-	-
IPV Polio	Poliovirus inactivated type 1, 2, 3	Poliovirus inactivated type 1, 2, 3	Poliovirus inactivated type 1, 2, 3	Poliovirus inactivated type 1, 2, 3	Poliovirus inactivated type 1, 2, 3

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