NCIRS National Centre for Immunisation Research and Surveillance

FactSheet

Vaccine types and their components

Vaccines contain an active component – the antigen, which induces the immune response – and additional components present in small quantities – such as preservatives, additives, adjuvants and traces of other components. This fact sheet provides information about the types of vaccines and their components, including why each component is present and what (if any) risks these components may pose to vaccine recipients.

More general information on vaccine components is available at the links under ‘Further reading’.

Types of vaccines

All vaccines fall into two categories: live attenuated vaccines and non-live vaccines. The different components in these vaccines aim to elicit an immune response to a virus or bacteria, without the consequences of a natural infection.

Live attenuated vaccines

These vaccines contain a weakened (attenuated) version of the virus that most closely mimics natural infection. This generates strong lifelong immunity without causing serious disease in people with healthy immune systems. Because these vaccines resemble natural infection, they are more likely to cause side effects than non-live vaccines many people experience more side effects than they would with non-live vaccines. These reactions are usually mild, and either go away on their own or can be relieved with simple pain relief like paracetamol. Examples of live attenuated vaccines available in Australia are measles-mumps-rubella (MMR) vaccine, varicella (chickenpox) vaccine, herpes zoster vaccine, yellow fever vaccine, rotavirus vaccine, BCG vaccine, Japanese encephalitis vaccine (Imojev only) and oral typhoid vaccine.

Live attenuated vaccines have the potential to replicate in people with weakened immune systems (i.e. immunocompromised people) and in unborn babies, so they are usually not suitable for people who are immunocompromised, very young or pregnant.

Non-live vaccines

All vaccines other than live attenuated vaccines are considered ‘non-live’. Non-live vaccines cannot replicate in the body so do not cause disease, even in people with weakened immune systems. This means they can be safely given to most people, including those who are immunocompromised. Often, multiple doses and booster doses of non-live vaccines are necessary to achieve high effectiveness and long-lasting immunity. However, for some non-live vaccines, only one or two doses provide long-lasting protection.

Non-live vaccines fall broadly into two categories: whole-cell and subunit vaccines. Whole-cell vaccines contain an inactivated version of the entire pathogen (virus or bacteria). Subunit vaccines include only parts of the virus or bacteria that contain the antigens needed to stimulate an immune response, but do not include all the other molecules in the virus or bacteria.

The table below provides more information about the different types of non-live vaccines.

Vaccine type	Examples	Description
Whole-cell inactivated vaccines	Hepatitis A, polio, influenza, rabies, Japanese encephalitis (JEspect)	These vaccines contain an inactivated version of a virus or bacteria. The viruses in these vaccines are inactivated or split, and bacteria are killed.
Protein subunit vaccines	Pertussis (whooping cough), Novavax COVID-19 vaccine (Nuvaxovid)	These vaccines contain specific isolated proteins from viral or bacterial pathogens that stimulate an immune response.
Recombinant vaccines	Hepatitis B, HPV, meningococcal B	These vaccines are engineered by inserting a small piece of the virus or bacterium into cells used to manufacture the vaccine.
Polysaccharide and conjugate vaccines	*Haemophilus influenzae* type B, meningococcal ACWY, pneumococcal conjugate vaccine, pneumococcal polysaccharide vaccine	Polysaccharide vaccines include only the sugar (carbohydrate) molecules found on the outside of some bacteria. Conjugate vaccines are those where the polysaccharide is attached (conjugated) to another protein that creates a stronger immune response. Diphtheria and tetanus toxoids are common conjugate proteins used in vaccines.
Nucleic acid-based vaccines (mRNA vaccines)	Pfizer COVID-19 vaccine (Comirnaty), Moderna COVID-19 vaccine (Spikevax)	These vaccines use genetic material (either DNA or RNA) from the virus or bacterium to stimulate an immune response. The DNA or RNA provides the instructions for making a specific protein (the antigen). When a person is vaccinated, the DNA or RNA starts producing antigens, which are detected by the immune system, triggering an immune response. The DNA or RNA from the vaccine breaks down quickly in the body.
Viral vector vaccines	AstraZeneca COVID-19 vaccine (Vaxzevria)	These vaccines include an unrelated harmless virus (a vector) that is engineered to deliver the genetic code of the vaccine antigens to the cells in the body, which then produce protein antigens to stimulate an immune response.
Toxoid vaccines	Diphtheria, tetanus	These vaccines contain weakened versions of toxins (poisons) produced by certain bacteria. These weakened toxins (called toxoids) trigger the immune system to generate a response against the toxin.

Vaccine components

Many components of vaccines are found naturally in our bodies (such as salts like sodium and potassium) or in common household and food items. However, a small number of people may be severely allergic to a particular vaccine component (see below).

Active components

The active component of a vaccine – the antigen – is a modified or partial form of the virus, bacterium or toxin that causes the disease against which the vaccine protects. The vaccine antigen is altered from its original form so it no longer causes disease but can stimulate an immune response.

Additional components

These components are added to vaccines to enhance their effectiveness and ensure they remain sterile and stable. They include:

- Adjuvants: These are substances added to vaccines to strengthen and lengthen the immune response to the vaccine, reducing the number of vaccines needed to provide protection. They include additives like aluminium salts and conjugate proteins.
- Excipients: These are substances other than the active ingredients in vaccines. They are used during the manufacturing process or in the finished product to maintain the vaccine's quality and safety. They include stabilisers, preservatives, buffers, surfactants and diluents. They also include 'residuals', which are the remaining minute quantities of substances used during the manufacturing or production process.

Aluminium salts, in small amounts, have been added to certain vaccines for over 60 years, and have a well-established body of evidence demonstrating no serious or long-term adverse events.[1,2] Our exposure to aluminium from vaccines is far less than that from our diet or medications. For example, DTPa vaccines contain only 0.8 mg of aluminium, which is similar to the amount in several slices of white bread. In Australia, most adults consume an average of 3.7 mg of aluminium daily in their food,[3] while children consume between 2.1 and 3.3 mg daily. Over-the-counter antacid medications contain over 100 times more aluminium (usually approximately 200 mg of aluminium hydroxide). Aluminium-containing vaccines have been associated with some short-term local reactions, such as nodules (lumps) under the skin at the injection site. But, overall, fewer reactions are reported after aluminium-containing vaccines than after vaccines without aluminium.

MF59 is a mixture of oil, water and squalene used in some influenza vaccines to enhance the immune response to the vaccine. Squalene is a naturally occurring organic compound found in many plant, animal and human cells, and has been proven safe in numerous clinical studies.

None of the vaccines used in Australia contain mercury. Thiomersal is an ethylmercury-containing compound that is substantially different to free mercury. Thiomersal was commonly used as a preservative in vaccines in the past, but is now only rarely used because new technologies and more affordable packaging have made it unnecessary. It is discussed in detail in the National Centre for Immunisation Research and Surveillance (NCIRS) Thiomersal fact sheet.

Component	What they are	Examples
Adjuvants	These are substances added to improve the immune response to vaccines. By enhancing the immune response, they reduce the amount of antigen required and reduce the number of vaccine doses required to provide protection. Substances used as adjuvants are also commonly found in household and food products like tap water, infant formula, and consumer products like antacids, deodorants and cosmetics.	Aluminium hydroxide, aluminium phosphate, potassium aluminium sulphate (alum), MF59/squalene (oil and water mix)
Conjugate proteins	These are proteins that are attached (conjugated) to the antigen to create a stronger immune response to the vaccine, reducing the number of vaccine doses required to provide protection.	Diphtheria and tetanus toxoid
Stabilisers	These substances help keep the vaccine stable and maintain vaccine effectiveness by stopping chemical reactions occurring in the vaccine, and preventing components from separating from each other or sticking to the vaccine vial during transportation and storage. Stabilisers used in vaccines are commonly found in food products like cheese, tomatoes, vegemite and confectionary items (like marshmallows and gummy bears).	Sugars (lactose and sucrose), glycine, monosodium glutamate (MSG), albumin (human or bovine), gelatin (bovine or porcine)
Preservatives and antibiotics	These substances prevent vaccines from losing their potency, and prevent fungal and bacterial contamination of vaccines after they are opened. Most single-dose vaccine vials do not contain preservatives because they are only used once and there is minimal chances of contamination. Preservatives are mostly used in vaccines supplied in multidose vials. Preservatives and antibiotics are used in household products like cosmetic products, green tea, antiseptics and eye drops.	Thiomersal (with ethylmercury), phenoxyethanol, phenol, antibiotics (neomycin, polymyxin, gentamicin)
Buffers	These substances prevent changes in the pH (acidity) of the vaccine. These substances are found in common items like food additives, laundry detergents and medicines. The most commonly used buffer substance, sodium chloride, is table salt.	Monopotassium phosphate, sodium borate, sodium chloride, disodium adipate, succinic acid, sodium hydroxide and hydrochloric acid (which react together to form water and salt), histidine, trometamol
Surfactants or emulsifiers	These substances help particles remain suspended in liquid, preventing them from settling and clumping. Surfactants and emulsifiers are commonly used in household items like shampoos, toothpastes, fabric softeners, and as food additives. A commonly used surfactant in vaccines, polysorbate 80, is made from sorbitol (sugar alcohol) and oleic acid (a natural omega-9 fatty acid), and is a common food additive in foods like ice cream. Food items usually contain a much greater amount of polysorbate 80 than vaccines do.	Polysorbate 80, sorbitan trioleate (made from oleic acid), sorbitol
Diluents	Diluents are liquids used to dilute vaccines to the proper concentration immediately before they are administered.	Sterile water, saline
Solvents	These are substances that dissolve another substance to create a solution. The most common solvent used in vaccine manufacture is water.	Water, ethanol

Component	What they are	Examples
Residuals and other trace components	These are the leftover ingredients used to manufacture or produce individual vaccines. They are typically present in minute quantities, and the components present depend on the process used to produce the vaccine. Trace components that are typically found in vaccines are also usually consumed in a person's diet, such as in fruits, vegetables, eggs and bread.	Formaldehyde, egg proteins, yeast
Latex	Latex is used in the packaging of some vaccines. This may be a risk for people who have a severe allergy to latex. People who have a less severe latex allergy are usually not at risk from latex in vaccine packaging.	Latex bung

Allergies to vaccine components

Anaphylaxis (a rapid and serious form of allergic reaction) after vaccination is extraordinarily rare. Overall, the total risk of anaphylaxis in children and adults after vaccination has been reported as approximately 1.3 per 1 million doses.[4]

It is important that immunisation providers assess each person for a history of allergies and previous reactions to vaccines before giving any dose of vaccine. People with certain allergies can safely receive some vaccines; for example, people with an egg allergy can safely receive influenza vaccines and those with gluten intolerance can receive HPV vaccine. For those people who have a strong suspicion of an allergy to a vaccine component, advice from an allergy specialist or immunologist should be sought before administering further vaccines. Providers can also check the relevant chapter in the Australian Immunisation Handbook, where the precautions and contraindications to specific vaccines are detailed.

Immunisation providers should consult the product information sheet for each vaccine being administered if a person has a history of allergies to any of the components listed in the table below. Any person with severe allergies should be vaccinated in a medical setting and be supervised by a healthcare professional who can recognise and manage severe allergic reactions.

Examples of ingredients in vaccines that are often implicated in allergies

Note that this list is not exhaustive – if an allergy is suspected, immunisation providers should check the list of vaccine components in the relevant vaccine product information.

Ingredient	Examples of vaccines containing ingredient
Gelatin	MMR, MMRV, typhoid, herpes zoster and rabies vaccines
Yeast	Hepatitis A, hepatitis B, HPV and combination DTPa vaccines
Antibiotics like neomycin, polymyxin B and gentamicin	Influenza, hepatitis A and combination DTPa vaccines
Egg proteins	Influenza, Q fever, rabies and yellow fever vaccines
Natural rubber latex	Some hepatitis A, hepatitis B, meningococcal ACWY and combination DT vaccines
Thiomersal	Q fever vaccine

Traces of animal-derived ingredients

Islam, Judaism and the Seventh-day Adventist Church all permit their followers to receive vaccines containing porcine gelatin or bovine albumin. Scholars of these religions have pronounced various exceptions or rulings that allow the 'ingestion' of porcine or porcine-derived products in this context.

Historical use of fetal tissue in vaccine production

Viruses cannot reproduce themselves (replicate) outside of a human or animal cell. For researchers to study viruses, and to weaken them and develop vaccines for humans, viruses need to be in living cells so they can replicate. The best cell types to grow human viruses originally came from human cells, as it is very difficult to grow some viruses in any other type of cell. The cells used in virus and vaccine research are known as 'cell lines', which can be grown continuously in the laboratory. Once established, the cell lines have an unlimited lifespan, so scientists can continue using cell lines established in the past to grow viruses for modern day vaccine research.

The cell lines (also called human diploid cell lines) used to produce vaccines (cell lines WI-38 and MRC-5) were originally derived from human fetal tissue. The tissue came from three abortions performed for medical reasons in the 1960s. Since then, no new fetal tissue has been taken for cell lines.

These particular cell lines have proven over several decades to be the most suitable for researching vaccines for humans without introducing further animal components into vaccine production and where other cells have proven unsuitable. Even though fetal cells are used to grow viruses, the vaccines themselves do not contain these cells or any intact pieces of them.

The world's major religions (Bahá'í Faith, Buddhism, the major denominations of Christianity, Confucianism, Daoism, Hinduism, Islam, Jainism, Judaism, Shinto and Sikhism) consider that the use of vaccines with remote fetal origins is permitted and ethical when there are no alternative products available. For Catholics who are concerned about the use of these cell lines, an expert report from the Vatican in 2005 said that the use of vaccines with remote fetal origins was acceptable to protect the health of children and pregnant women. The Pontifical Academy for Life released a declaration in 2005 noting that parents should vaccinate their children for the good of their children and the community, and they can do so with a "clear conscience" that "the use of such vaccines does not signify some sort of cooperation in voluntary abortion".

Further reading

Australian Immunisation Handbook: Fundamentals of immunisation

Australian Immunisation Handbook: Vaccination for people who are immunocompromised

NCIRS: Vaccine platforms

Immunisation Advisory Centre (New Zealand): Vaccine development

GAVI The Vaccine Alliance: Types of COVID-19 vaccines and how they work

University of Oxford, Vaccine Knowledge Project: Types of vaccines

University of Oxford, Vaccine Knowledge Project: Vaccine ingredients

Australian Government Department of Health and Aged Care: Questions about vaccination

SKAI Sharing Knowledge about Immunisation: Talking about immunisation

Johns Hopkins Bloomberg School of Public Health: Religion and vaccines

World Health Organization (WHO) Regional Office for the Eastern Mediterranean: Statement arising from a seminar held by the Islamic Organization for Medical Sciences on 'The judicially prohibited and impure substances in foodstuff and drugs

References

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2. Löffler P. Review: Vaccine myth-buster – cleaning up with prejudices and dangerous misinformation. *Frontiers in Immunology* 2021;12:663280.
3. Food Standards Australia New Zealand. 24th Australian Total Diet Study. Canberra: FSANZ; 2014. Available from: https://www.foodstandards.gov.au/publications/Documents/1778-FSANZ_AustDietStudy-web.pdf (Accessed 8 June 2022).
4. McNeil MM, Weintraub ES, Duffy J, et al. Risk of anaphylaxis after vaccination in children and adults. *Journal of Allergy and Clinical Immunology* 2016;137:868-78.