Difäm Health Community (DHC)

Podcast:

Introduction to vaccines and their historical context

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My name is xxx, I am a member of the health team of the German Institute for Medical Mission, also called Difäm. With me is my colleague, xxx.

One thing we learn (and are still learning) from the Covid-19 pandemic is that people seem to refrain from being vaccinated, even if it saves their life and the lives of their beloved ones. Covid-19 is not the only disease people need to be vaccinated against; there are still polio, hepatitis, measles, and all the other diseases we know from childhood onwards.

Therefore, we decided to start a short series of podcasts on vaccination issues.

Today you will listen to some general information about vaccination and learn about milestones in the historical context of the development of vaccines.

Let us start with the question what vaccination is and why we want to vaccinate people. xxx, can you explain this to us?

Vaccination is the administration of a vaccine that helps our immune system to develop immunity against an infectious disease. A vaccine artificially activates the body's adaptive immune response by confronting the immune system with a disease agent or a component of a disease agent. This may be for example a virus, a bacteria or a parasite. In immunology, we call this an antigen. When later on the real infection happens, our immune system is prepared, reacts fast and prevents or at least lessens the symptoms of disease. The process of learning through the immune system and later be able to react quickly and in a specific way is called priming.

As a reminder: Last year we did a podcast about the activation of the immune system in the course of our COVID-19 podcasts.

Vaccinations play a crucial role not only for the personal health of a single person but also for public health. The aim is to achieve a high percentage of vaccination and immunity in a population, so that the infective agent has nowhere to go. Even if not everybody is immune, the whole group still has the protection. This is called herd immunity.

The big advantage of herd immunity is that it protects those who cannot get a vaccination due to their physical condition, like patients suffering from an immune deficiency and can therefore not receive a live vaccine or who cannot build antibodies. It also protects people who do not show a sufficient immune response like some elderly people.

What impact do vaccinations have on a population? Why are they so important?

In preventing the spread of infectious diseases, we have different tools at hand: hygiene and sanitation, condom use, facemasks, isolation of patients and many others. However, vaccination is considered the most powerful of these tools.

As late as in the twentieth century, an estimated 375 million deaths occurred worldwide due to smallpox until the eradication in 1978. Only with vaccination, we were able to eradicate smallpox and almost eliminate polio and tetanus.[1]

However, not only mortality is important: Ideally, a vaccination causes a sterilizing immunity in the person immunized. Sterilizing immunity means that the body has produced neutralizing antibodies, which prevent the pathogen from replicating. Thus, the person will no longer get the disease and not spread the pathogen. Besides, the person will not suffer from possible consequences of the disease like palsies in poliomyelitis. Life-long immunity is the result. Other vaccines temporarily lower the risk of severe disease and the risk of death like in COVID-19; therefore, they are called non-sterilizing vaccines.

What plays a major role in public health is that a vaccinated person is better able to care for the family, play a part in society, work and so make an economic impact. An unvaccinated person may need external help for him- or herself and the family in case of disease.

This can become an enormous financial burden to the extended family of the affected person.

Therefore, vaccines have a high economic benefit, which is called *Return of Investment* (ROI), especially in the long term. If you invest in vaccination, it will bring personal and national economic profit. The ratios of the benefits to the costs are estimated to range for example from 27:1 for diphtheria/pertussis to 13.5:1 for measles.[2] That means that one dollar invested in the vaccine for diphtheria/pertussis will bring back a 27fold revenue in terms of prevented disease. A dollar invested in the measles vaccination will bring 13.5 dollars in return because the medical cost and the long-term disability due to measles are prevented.

How a pandemic can affect a global economy, we have seen during the COVID-19 pandemic until now.

What are the different types of vaccinations?

First, we must distinguish passive and active vaccinations.

Passive immunization is not achieved by priming our immune system to react later. Rather, in passive immunization antibodies against a disease are given directly. In a natural way, this happens with many different types of antibodies through the placenta from mother to foetus and later with colostrum and breast milk to the baby. Artificially gained and administered antibodies, immunoglobulin or antiserum, can be given against the infective agent to help to get rid of a confirmed or suspected infection immediately.[3]

For example, when somebody is bitten by a rabid dog we inject immunoglobulin immediately around the wound. These antibodies will only work for a short period of weeks or months. Antibodies can also be called an antiserum, which is given in the case of a snakebite, for example.

Antiserum can consist of blood serum by a blood donor. These antibodies are polyclonal, which means that they are derived naturally from many different B-lymphocytes. For example, antiserum from Ebola survivors given to Ebola patients showed a treatment success rate of more than 85%.

We can also produce antibodies against infectious diseases in the laboratory, e.g. against the Respiratory Syncytial Virus or COVID-19. As these derive from one cell, we call them monoclonal antibodies or MAbs.[7]

Therefore, a passive immunization is less a vaccination but rather a treatment. Nevertheless, it also uses components of the immune system, the antibodies. The only difference is that antibodies do not come from the patient him- or herself, but are refined or artificial products in the form of a treatment from the outside. The patient's body plays a passive role. It receives the antibodies and does not have to produce them.

Let us now talk about active immunization. I suppose the patient's body is becoming more active now.

Yes, you are right. In active immunization or vaccination, a person's immune system becomes the major actor. We can subdivide active immunization into vaccination with dead or living vaccines.

A dead vaccine can consist of different antigens like weakened or slightly changed particles of a germ, e.g. the toxoid of clostridium tetanus, or proteins like the spike protein of COVID-19. In mRNA and vector based vaccines this is done in a more modern and sophisticated way by initiating the construction of an antigen in the body cells. As a reminder, in our podcast about vaccinations against COVID-19, we explained the different dead vaccines. Finally, also complete dead germs can be administered.

A living vaccine consists of a living infectious agent that can still multiply. Sometimes this living germ causes the infection but it is weakened by technical procedures, so that the infection will be very mild. Alternatively, it is a germ from the kingdom of animals that normally does not cause severe disease in humans. Later, we will see that this was the case with the first vaccine in history, the vaccine against smallpox. Stimulating the immune response with a live infectious agent is called immunization.

So this is the type of vaccination that is administered before an infection occurs in order to prevent infection or decrease the severity of disease. How do you administer these vaccines?

Many vaccines are given by intramuscular, subcutaneous or intradermal injection because absorption through the intestines is not sufficient. However, some attenuated living vaccines of diseases, which are spread by faecal oral transmission can be given orally like polio, rotavirus, typhoid and cholera vaccines.

Some vaccines are administered in early childhood, and they develop a lifelong immunity in the vaccinated person.

You might vaccination the magic bullet in the fight against disease. When in history did we first benefit from vaccinations?

The first attempts to prevent disease through vaccination are already quite old. It all started with the first records of so-called variolation in the 16th century in China. Variolation means that people were deliberately infected with a small dose of smallpox virus out of a skin lesion, a variola, to elicit an immune response without a full-blown infection. The use of non-attenuated live pathogens is called inoculation.[4] Inoculation reduced the risk of death from smallpox by more than ten times compared

to an infection without inoculation in which case mortality could be up to 35 %. Nevertheless, there was still a risk of death around 2% in a healthy person after inoculation.[5]

We see as early as that, that weighing the risks is a main principle for or against the administration of a vaccine. This has not changed since.

Basically the main question in vaccination is: Do I want to take the risk that my child or I myself fall ill from a disease, suffer, die or experience debilitating symptoms or do I want to reduce the risk considerably for my child or myself. The answer seems easy.

Please, tell us who developed the types of vaccines that we know today.

In 1796 Edward Jenner, a British physician, observed that some milkmaids were immune to smallpox without having had the disease. These milkmaids contracted cowpox during their work, a much milder disease, and were afterwards immune to smallpox. Jenner inoculated James Phipps with the cowpox-virus – this he called vaccination, coming from the Latin word vacca for cow. After the publication of his findings and experiments in the beginning of the 19th century, the Spanish king launched vaccination campaigns in America and other colonies.[6]

Interestingly, by that time viruses, bacteria and parasites were not yet discovered as pathogens causing infectious diseases. At this time, people thought that 'bad air' was causing disease; this is called the miasma theory.

While you could already detect microorganisms through the early microscopes in the 17th century, it took the work of many others scientists, like e.g. famous Louis Pasteur or the German Robert Koch in the 1880s to reveal the causal link between a microbe and the disease.

It seems that the history of vaccination has a lot to do with good observation, developing a theory and testing that theory in an experimental administration of a vaccine.

You are right. In 1885, Louis Pasteur was asked by a mother to help her son, who was bitten by a rabid dog. Rabies was and is usually fatal and she had heard that Pasteur was working on a cure for rabies. Pasteur inoculated the boy several times with an experimental rabies vaccine and the boy finally did not develop rabies. Until today, the rabies disease is one of few diseases that can be treated by vaccination, not only prevented. This is because rabies has a long incubation period from normally a few weeks to up to a year and active vaccination is working after approximately 2 weeks.

Another example for the treatment of a disease with a vaccine is tetanus. The incubation period here is about 10 days but may be up to several months if the site where the tetanus germ enters the body is far away from the central nervous system. The German physician Emil von Behring developed the first tetanus immunoglobulin in 1890. The antitoxin was applied to soldiers during the First World War and in 1924, a toxoid vaccine was developed. Behring also developed the first antitoxin against diphtheria in 1893.

Now we know how the vaccines against rabies, tetanus and diphtheria were developed. What about polio, measles and all the other dangerous diseases?

In the twentieth century poliomyelitis, a faecal-oral spread viral disease, infected millions of people, mainly children. In 1 in 200 cases, the disease progresses into a paralytic state that can even stop breathing. The American Jonas Edward Salk developed the first highly effective polio vaccine by the mid-1950s. Today this devastating disease is almost eradicated due to vaccination programmes.

A name that should also be mentioned in the context of vaccinations is Maurice Hilleman: The American was born in 1919, and until 2005 he developed not less than 40 vaccines against diseases

of animals and humans including measles, mumps, hepatitis A and B, chickenpox, meningococcal meningitis, pneumonia from streptococcus and infection by haemophilus influenza. He developed a mumps vaccine after taking a swab from the throat of his ill daughter Jeryl-Lynn. The Jeryl-Lynn strain is still used today in the MMR vaccine against measles, mumps and rubella, also developed by Hilleman. He was the first to develop combined vaccines against several diseases.

Thank you very much for giving us this extensive and historic overview of the importance of vaccines and vaccination. It casts a new light on the usefulness of vaccines and may help us to inform patients who are reluctant to be vaccinated for example against Covid-19.

In the upcoming podcasts, we will dig even deeper into the topic of vaccination. We will talk about childhood vaccination and vaccination in pregnancy, existing vaccines against HPV, Ebola, cholera, typhoid, influenza and tuberculosis. There will also be an update on COVID-19 vaccines. We will complete this series with vaccines in development against malaria and HIV.

We invite you to join us.

Be blessed and stay safe

Internet sources as of 16/05/2022

1 www.historyofvaccines.org/history/smallpox/overview

2 Executive Summary | Financing Vaccines in the 21st Century: Assuring Access and Availability |The National Academies Press - https://nap.nationalacademies.org/read/10782/chapter/2

3 https://historyofvaccines.org/vaccines-101/what-do-vaccines-do/passive-immunization

4 https://historyofvaccines.org/pioneers-0

5 https://web.archive.org/web/20070927032605/http:/www.semel.ucla.edu/biomedicalmodeling/pdf/Bernoulli%26Blower.pdf

6 www.nature.com/articles/s41541-017-0019-3#:~:text=With%20more%20than%2060%20recombinant,health%20concerns%2C%20as%20well%20as

7 www.astrazeneca.com/media-centre/press-releases/2022/evusheld-approved-in-the-eu-for-covid-19.html