Step 3.8 How can vaccines help?

Professor Elizabeth Miller describes how vaccines can help in outbreaks, and what is needed to develop a new vaccine (recorded on 2nd March 2020). She shares below more information and technical details on the specific approaches for vaccines for COVID-19. As you watch and read the material consider that vaccines are frequently described as the single most important and successful public health intervention, after clean water. Do you agree? And what are the particular challenges for COVID-19 vaccines?

To develop a successful vaccine for COVID-19 it is necessary to understand the immune response to the virus and which of its outer proteins are involved in generating protective antibodies, i.e. are the antigens involved in protection. The aim of vaccination is to deliver these antigens to the body in a way that doesn't cause harm but does generate a protective immune response.

There are a number of ways of doing this. One approach is to use inactivated whole virus particles (as done with inactivated polio vaccine) or live strains that were derived from a wild virus but have been attenuated (i.e. lost their ability to cause disease) by growing them under laboratory conditions (as done with oral polio virus vaccine). Both these approaches are being tried for COVID-19 but require large amounts of virus to be grown in the laboratory which can be a rate limiting step.

Other approaches involve generating the protective antigens via recombinant techniques. This involves inserting the part of the coronavirus genome that codes for the protective antigen into another organism so that it is expresses the antigen.

The recombinant proteins can be delivered in different ways. They can be administered on their own or with an adjuvant (substance that enhances the immune response). Such vaccines are termed subunit vaccines. Another approach is to incorporate the genetic code for the protective antigen into another harmless virus which then expresses the coronavirus protective antigen. The host virus therefore acts as a vector for introducing the coronavirus antigen into the body and is termed a viral vector vaccine. A third approach is to embed the protective antigens in a spherical membrane that acts as an artificial virus like particle (called a virosome) and can stimulate an immune response similar to that of a live virus. All these vaccine approaches are being explored for COVID-19 and have been successfully developed for other vaccines.

Another approach being tried for COVID-19 is to introduce the genes of the virus that code for the protective antigen directly into the body so that it is taken up by human cells which then produce viral antigen – this is called a genetic vaccine. So far no genetic vaccine has been licensed for human use.

There are many vaccine candidates under development to protect against COVID-19 – a list can be found on the WHO website here. For a more personal story, read about Sarah Gilbert's path towards a COVID-19 vaccine, a perspectives article included in the See Also section alongside the more technical pieces.

Video transcript:

ELIZABETH MILLER: I'm going to be talking about vaccines and their potential for use in this COVID-19 outbreak.

Along with public health interventions like clean water and sanitation, vaccines have been one of the most important ways of protecting people against infectious diseases, preventing both illness and death. Now, vaccines can be used in two ways. You can either give it to somebody after they've been infected or before they have been exposed to prevent them ever getting infected.

Now, if you give a vaccine after somebody who's been infected-- a common vaccine that is used in this way is rabies. It's-- you have to give it for a disease where there's quite a long interval between being exposed and developing symptoms so the vaccine has time to work and protect that individual. But most vaccines are given to prevent an individual becoming infected in the first place. And they can be used in different ways. So, for instance, with the Ebola outbreak the cases were very obvious and contacts of those cases could be vaccinated and so were health care workers.

Sometimes if there's an outbreak in a very defined population like meningitis in a school, you can vaccinate the school population. In the case of smallpox, again, where cases were very obvious, it was possible to vaccinate everybody in the locality-- what's called ring vaccination-- to prevent the smallpox virus escaping into the rest of the population. Mostly vaccines are used-- the common vaccines are used to vaccinate those in the population who are both susceptible but most likely to transmit the disease. And the idea behind this use of the vaccine is that you can actually interrupt transmission of the infection in the population and, thereby, protect people who themselves haven't been vaccinated.

Well, as I mentioned before, vaccines protect in two ways. They can protect an individual directly by giving them immunity to the infection, but they can also indirectly protect other individuals through something called herd immunity. If enough individuals are vaccinated, then transmission of the infection in the population can be reduced or even eliminated. In order to-- for a vaccine to interrupt transmission, you have to make sure that the reproduction number is less than one-- that is every infectious individual has a probability less than one of infecting another individual. Under those circumstances, the disease will die out as a result of the vaccination programme.

Despite the huge protection and benefit from vaccination, there is no vaccine that gives 100% protection to all individuals for their entire life. In fact, some diseases--natural diseases can recur and you can get reinfections. So we talk about vaccine efficacy and by this we mean how much protection an individual who has been vaccinated will get if they are exposed? And most vaccines that are used give well over 90% protection.

Well, there's a huge amount of effort by scientists around the world to develop vaccines very rapidly and the approach generally is to look for the viral proteins on the outside of the virus that are responsible for the virus attaching to and entering the human cell. And if you can make protective immune responses against these viral proteins, that would be the basis of a vaccine. So a lot of candidate vaccines are being developed based on this out of viral proteins. And it is possible to generate them in the laboratory without having to extract them from the virus.

After that, the candidate vaccine composed of these viral proteins has to undergo very stringent testing before it can be used at a population level. You would like to have evidence that they actually protect humans in the field, but under emergency circumstances like Ebola and COVID-19, it would be possible to proceed to its field use without having done a large study to demonstrate that it works. Under those circumstances, it would, of course, be important to monitor as carefully as possible the safety and effectiveness of the vaccine under field use.

Now, while the scientists are busily developing the vaccine and trying it out in small studies in humans, it is also necessary to find a way of scaling up vaccine production so you can make millions of doses that will be needed to really affect transmission or protect a large number of vulnerable people. It's very unlikely that all of these stages are going to be completed in time to interrupt transmission or protect vulnerable individuals as the COVID-19 virus takes off in the next few months. But coronaviruses generally are seasonal and it may be that we will see a peak and then a drop off in infections with a return and a second wave or subsequent waves in future years.

Now, under those circumstances, if vaccine is available at that time, then it could be used and the issue is who would it be used on? Has the virus changed its structure so that the vaccine last year looks a bit different from this year? We'll need a lot of information to understand what is the most effective and efficient way of using a vaccine if COVID-19 is still being transmitted at the time it's available.

See Also

First in Human: Covid-19 Vaccines & Tales of Phase 1 Clinical Trials Past

https://absolutelymaybe.plos.org/2020/03/16/first-in-human-covid-19-vaccines-tales-of-phase-1-clinical-trials-past/

Regulatory focus COVID-19 tracker

https://www.raps.org/news-and-articles/news-articles/2020/3/covid-19-vaccine-tracker

Nature – News updates on COVID-19

https://www.nature.com/articles/d41586-020-00154-w

Sarah Gilbert: carving a path towards a COVID-19 vaccine

https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(20)30796-0/fulltext

Developing Covid-19 Vaccines at Pandemic Speed

https://www.nejm.org/doi/full/10.1056/NEJMp2005630