Female scientists and vaccine research

My name is Elizabeth Wynn, I'm the Equality and Diversity Manager at the Babraham Institute, and today I'm going to be talking about female scientists and vaccine research. Obviously, the COVID vaccine, or COVID vaccines, have been on everyone's mind a lot recently, so I thought this would be a good time to look at the history of what female scientists, female researchers have contributed to vaccine research throughout the years, starting from the 1700s and going right the way up to today.

So, as I said, starting in the 1700s with Lady Mary Montagu and smallpox. Lady Montagu is actually the only person who isn't a scientist that I'm going to be talking about today. She was an English aristocrat and writer, but she had a big influence on the introduction of practices of inoculation, bringing that to the UK. Like everyone in this time period, Lady Montagu had personal experiences with smallpox. Her brother died of smallpox in 1713 and she also contracted and survived smallpox in 1715. Smallpox had a mortality rate of around 30% so pretty much everyone in this time period knew someone who had lost someone or had lost someone themselves due to this disease.

Her husband was an ambassador and she moved to the Ottoman Empire to be with him in 1716, and it was there that she came across the practice called variolation. The next slide has medical illustrations of smallpox. It's not too graphic, but I just wanted to give everyone a heads up that's coming on the next slide.

Variolation was a way of providing immunity to smallpox, a precursor to vaccination. The records are a bit unreliable sometimes to figure out where it developed and by whom. There are definitely verifiable records that a form of variolation was taking place in China as early as the 15th century. So there what they would do is take scabs from smallpox pox, grind it up and then inhale it, and that would produce an immune response and provide immunity to smallpox. In India, Sudan and the Ottoman Empire, by the 18th century, there were definitive proof that another form of variolation was taking place there, where you would make a cut on an individual who didn't have smallpox and then take a sample from the pox of someone who was suffering from it, inoculate it. And the idea there was that you would get a mild case of smallpox as opposed to a full blown disease. It's not quite clear if this originated several times independently, if there was some sort of communication going on between these different places, and if so, who came up with it first, which direction it went. But it was in the Ottoman Empire that Lady Mary Montagu came across the practice.

As I said, she had personal experience with smallpox and she was very keen to spare her children this. So she had one of her children inoculated with them with this variolation process, with the making a small incision, introducing smallpox that way. So she had one child go through that process while they were in the Ottoman Empire and the other after she had returned to the UK. She had a doctor do this in the presence of medical witnesses and this is the first recorded case of this procedure happening in the UK. Both of her children survived and they gained immunity to smallpox, they never contracted the disease. And so Lady Montague was a huge proponent of this and she was a real advocate for bringing this practice to the UK.

As I said, she had her own children inoculated. She also convinced an experiment to take place, which nowadays would be considered extremely unethical. So this was at Newgate Prison: seven prisoners who were due to be executed were given the choice instead to undergo this variolation to see if they survived. And they all took that opportunity and they did all survive. So these two public demonstrations, I guess, Lady Montagu's children and the Newgate Prison experiment did do a lot to convince people of the benefits of this practice. There were two high profile deaths associated with it though. The Princes Octavius and Alfred who were the 13th and 14th children of King George III both underwent variolation and both unfortunately died. So that was a publicity setback, as it were, for this. However, so this was happening at about the 1710s, 1720s, and until Jenner's vaccine was developed from cowpox, which was in 1798, this was the best the best preventative measure that existed against smallpox. It obviously wasn't without its risks, and when Jenner's vaccine became available, it was much safer and it was quickly replaced.

Jumping forward a bit now, I'm going to talk about Pearl Kendrick, Grace Eldering, Loney Gordon and pertussis. Pertussis is also known as whooping cough. And in this time period, so we're talking about the 1930s sort of time, it was one of the leading causes of childhood death in America. And Kendrick and Eldering were both researchers who worked at the Michigan Department of Health. They were actually both former school teachers who started working as researchers and as they worked at the Michigan Department of Health, they both also were working towards their PhDs, which they gained after already working at the Department of Health.

Female scientists and vaccine research

They both had a personal interest in whooping cough, both had contracted and survived as children. And at this time in the 1930s, there was a large outbreak going on in the city where they lived, Grand Rapids, Michigan, and they wanted to work on a vaccine. So by this time, there were a lot of vaccines to various infectious diseases, but pertussis is one that was causing researchers a bit of a headache, it was one that was difficult to crack. So Kendrick and Eldering's boss told them, "yes, you can you can work on this, you can use the lab resources after you've done all your normal work" and there was no salary for them with this. So basically, they were doing this research in their spare time.

They started working on a whooping cough vaccine in 1932. There was low funding, this was also during the Great Depression, so scientific funding in general was on the low end so they relied a lot on volunteers and community involvement. They had a huge network of doctors and nurses who volunteered, helping them collect samples and distribute vaccines. They had strong connections with the local communities. So these were poor neighbourhoods which were often very crowded. And so when a disease, infectious disease, started going through neighbourhood it would spread really quickly with very devastating results. So the community was very invested in helping them figure out a cure to this, or a preventative to this.

Even though they had such low funding, they were able to start small scale vaccine production in 1933 and this was quite targeted, like in response to a particular outbreak. And they were able to move on to larger, more generalised vaccine trials in 1934. So incredible what they were able to do so quickly. As well as developing the vaccine during this time, they were able to do a lot of really beneficial research into whooping cough, for example, incubation times, figuring out when people were at their most infectious, what was necessary in terms of quarantine times to prevent transmission. And also they developed a cough plate diagnostic technique where they would have someone cough onto an agar dish and they could develop it quickly to determine if they had whooping cough or not.

So after they'd had a proven track record with developing this vaccine, they were able to get more funding, they were able to expand their lab. One sort of unorthodox stream of funding they got, they invited the First Lady, who at the time was Eleanor Roosevelt, to come and tour their lab and explain what they were doing. And she accepted and became a big advocate for them and helped them secure funding.

So, as I said, they expanded their lab and one notable individual they recruited to their lab was Loney Clinton Gordon. So she was a chemist who joined their lab in 1944 and one of the big contributions she made was testing thousands of culture plates to discover the best medium for growing pertussis. So this was important for quickly developing large amounts of the organism so that they could use it for vaccine production.

In addition to developing the first working pertussis vaccine, this lab also went on to develop the first combined DTP vaccine, so diphtheria, tetanus and pertussis in 1949 and that's still commonly given as a triple vaccine dose.

One other thing I wanted to mention before I moved on, Kendrick and Eldering, neither of them married, and when I was doing research on this talk, I found a line that said “they formed a lifelong friendship and lived together until Kendrick's death” and, you know, draw whatever inferences you want from that, but I'm just going to say Happy Pride Month everyone.

Going forward just a little bit in time to look at Dorothy Horstmann, Isabel Morgan and polio. Unlike Kendrick and Eldering, they weren't collaborators, they didn't work together in the same lab or anything, but both of these scientists made huge contributions that enabled the development of polio vaccines.

So Dorothy Horstmann was a doctor. First of all, she specialized in internal medicine before switching to infectious diseases. She completed her medical degree in California and then moved out to the East Coast, where she joined a research group looking at polio. So at this time, it wasn't well understood how polio was transmitted and they were looking at that and the pathogenesis of it. And one of the most important discoveries that Horstmann made was she showed the poliovirus is present in the blood before the nervous system. It was common knowledge at this point that polio directly attacked the nervous system, but because Horstmann showed that it was present in the blood before moving into the nervous system, that was an important realization for that allowed the development of an oral vaccine.

After working on polio, she continued to research infectious diseases for the rest of her career, including rubella and measles. She became the first female professor at Yale School of Medicine and later the first woman in the entirety of Yale University to hold an endowed chair.

Isabel Morgan was another important female researcher in the story of the polio vaccine. She was actually the daughter of a Nobel Prize winner herself, so perhaps it's unsurprising she went into science, though she was a researcher rather than a doctor. She had a PhD in bacteriology. She worked at the Rockefeller Institute for a while before moving to John Hopkins, and there some of the key discoveries she made were identifying the three sereotypes of poliovirus, so it's necessary to have antibodies for all three types in order to have full immunity to poliovirus. And she also performed successful killed-virus vaccine trials in monkeys in 1948. Before this successful trial, researchers thought that for polio it was going to be necessary to have a live virus vaccine, but she showed it was possible to have an inactivated or killed-virus vaccine that successfully induced the immune response and provided immunity.

Morgan married in 1949 to become a homemaker. This is a sad reminder of the fact that for a long time it was thought that being a researcher was incompatible with being a wife and mother. A medical historian who wrote a book about polio and America[1], I can't remember his name right now, but he said that Morgan was on track, if she'd continued her research, to discover a polio vaccine about two years before Jonas Salk. So it's sad to think about the lives that could have been saved with this particular instance, thinking about polio, but also in a more general sense, all the potentially brilliant scientists that the world has missed out on because of this particular assumption about what women can and cannot do. Morgan did return to research, she retrained as a biostatistician in the 1960s, but she never went back to research on infectious diseases.

Smallpox remains the only human disease which has been completely eradicated but polio is another good candidate. And while I was doing this research, I came across the fact that 1988 there were about 350,000 reported cases of polio. And in 2018, thirty years later, there were 33 reported cases. So my main takeaway from this talk is just that vaccines are awesome.

[1] *Polio: An American Story* by David M. Oshinsky

Female scientists and vaccine research

Moving on now from historical examples to the present day. Obviously we're all aware of COVID-19 vaccines and there have been many incredible female researchers working on these. I've selected a few of them to talk about, some who I think are the most prominent, but this is in no way a comprehensive list of all the women who are working on COVID-19. There are also a couple of names in here that I had to look up the pronunciation for, and I am doing my best, but apologies if I don't get it quite right on some of these names.

I'm going to start with Kizzmekia Corbett, who's an American viral immunologist at the Vaccine Research Center in America, the National Vaccine Research Center. And she is the scientific lead on their coronavirus team. There she has been central to the development of the Moderna virus vaccine and the Eli Lilly therapeutic monoclonal antibody.

Sarah Gilbert, I think made a big splash over here, being an English vaccinologist working at Oxford University. She's co-founder of a company called Vaccitech and, of course, co-developed the Oxford-AstraZeneca COVID-19 vaccine. That's actually the one I got.

Kathrin Jansen is the head of vaccine research and development at Pfizer, so unsurprisingly, she worked on the Pfizer-BioNTech COVID-19 vaccine.

Katalin Karikó, the co-founder and former CEO of RNARx before becoming the senior vice president of BioNTech. Her patent on nucleoside modifications relating to RNA-mediated immune activation was licensed for both Moderna and the BioNTech vaccine. So her research has been fundamental to the development of a couple of vaccines.

Nita Patel, an Indian American physician and vaccinologist, and she leads vaccine development at Novavax. At Novavax she oversaw the development of their COVID-19 vaccine, and it was actually an all women team that worked on that one.

Finally, Özlem Türeci is the co-founder and chief medical officer of BioNTech. She's the third woman I mentioned in relation to the BioNTech vaccine so obviously she worked on that. But another thing I can say about her is that the profits they've made from this

vaccine, BioNTech plans to use to pursue its original goal, which was creating an mRNA-based cancer vaccine.

That was just a quick rundown of a few of the many female scientists who are working on current COVID-19 vaccines. But that isn't the only current day research which is going on around vaccination, and I would be completely remiss if I didn't mention Babraham Institute's own Michelle Linterman.

So Michelle gained her PhD in immunology at the Australian National University of Canberra. After that, she did postdoc work at the University of Cambridge before joining the Babraham Institute in 2013 as a tenure track group leader and then was awarded tenure in 2019. During her time here, Linterman was also recognized with some awards, for example, she became an EMBO young investigator in 2016 and in 2019 she also received the Lister Prize.

Her research all focuses around immune system response to vaccines and the effects of aging. So as we get older, there is a lower germinal centre response to vaccines, which results in them providing a lower immunity and that's what her research focuses on. So a couple of significant bits of research that have come out of her lab in recent years. In mice, they've shown that germinal centre response defects that occur with aging can be corrected. They've also looked at altering vaccine adjuvants to improve or enhance antibody response for long term immunity. And most recently, the Linterman lab has also worked on COVID-19. They did a preclinical trial in mice that demonstrated older mice have an impaired immune response to vaccine, but that a second dose corrects that.

Michelle isn't the only person in her lab. Throughout her career she has worked with many other female scientists. So I just want to share, finally, a list of all the female members of her team, past and present. So these are all incredible female scientists who are also working on vaccines. That was everything I wanted to talk about. I hope you've enjoyed this talk.