

Making a Simple Respiratory Mask

[Announcer] This program is presented by the Centers for Disease Control and Prevention.

[Sarah Gregory] Hi, I'm Sarah Gregory, and today I'm talking with Dr. Virginia Dato. She's a physician, board certified in public health and general preventive medicine, and past president of the American Association of Public Health Physicians. We'll be discussing how to construct a simple face mask with easily available materials. We're in the middle of the COVID-19 outbreak and so situations have changed a bit. I'm calling from home, Dr. Dato's calling from home, and our sound engineer is in the studio. So there might be a slightly different quality to this podcast.

Welcome, Dr. Dato.

[Virginia Dato] Thank you for having me.

[Sarah Gregory] You wrote this article in 2006, what was going on at that time that led to you begin researching how to make a face mask?

[Virginia Dato] Well, the article was published in 2006, but the work actually began in 2002 in response to the first SARS outbreak, and continued through H5N2 and the return of H1N1, with my first submission to the *Emerging Infectious Disease* journal in November of 2005. I was one of the public health physicians on call for the Commonwealth of Pennsylvania responding to outbreaks and individual cases of communicable diseases. And when I was not responding to outbreaks I saw my job to be a pessimist—to think of the worst case scenarios and figure out how to prevent them.

And one day riding the bus, which I love the bus, it occurred to me that we could never have enough N95 masks for every bus rider if we had a pandemic. I had attended a lecture which described how battle dress uniform t-shirts had been tested for protective masks against ricin and saxitoxin in mouse experiments and I thought “Why not see if we can use nonmilitary t-shirts for humans?”

I did not do the actual designs at work. I was the mother of two teenagers and, you know, doing science at home was being a good role model. After I came up with two designs that were effective on initial testing with Bitrix, which is a little fit test solution that's used in...that you can just purchase online, in my home, my coauthors volunteered their time to test them using a quantitative fit test. Because it was not a funded large-scale study, we did not have the data or designs that I would like. This was a study I hoped we would never need.

[Sarah Gregory] Well, this article has become, at this point in time, March of 2020, EID journal's most viewed article. What do you think about that?

[Virginia Dato] I think the problem is that we're facing a virus that has many challenging characteristics. In some settings, there is little or no transmission and then in others you get these documented superspreader events.

When originally submitted in November of 2005, I wrote in the letter that I sent that I believed other researchers would be able to innovate upon this design and develop country-specific solutions. It's my sincere hope that it's true. I also wrote “My initial motivation for this work was simple. I enjoy commuting to work by bus and in a pandemic I want to continue to do that. Although I have fit-tested N95 masks, I must save them for official high-risk investigations.

More important, as a public servant, I would not feel comfortable having a higher level of protection in social settings than the citizens I'm duty bound to protect.

My only solution was develop a respiratory protective mask that could be made by the average risk-averse citizen. You notice I said risk-averse citizen. This brings me to both risk communication and harm reduction. Nothing in life is risk free and I often would discuss with our citizens their options in circumstances where experts might disagree—things like whether to get a rabies post-exposure prophylaxis for a low-risk exposure. In some cases the individuals absolutely should get it; in other cases, absolutely should not. But there were circumstances that were borderline where experts disagree. In a rabies post-exposure treatment paper I coauthored in 1993, we called that recommendation “indeterminate.” I explained the risks and the benefits and let the individual decide. I believe we're in an indeterminate situation where the risks and benefits are highly dependent upon the individual situations. More important, those of us who are risk adverse certainly do not want to take N95 masks from healthcare providers. So having a mask you can make with a t-shirt and scissor is suddenly a good option. So I guess this is my 15 minutes of fame.

[Sarah Gregory] What kinds of masks are there out there and what are they used for? You just mentioned an N95, which I'm sure everyone has heard of by now, but I know there's all kinds of variations on the theme at this point.

[Virginia Dato] Well, I assume you mean respiratory masks and not Halloween masks. Masks have three main purposes: The first is **courtesy/contagion**. This keeps droplets from an individual infected individual from straying as far in the air or onto surfaces. This protects others, but not the wearer. **Barrier**: This protects the wearer from body fluid, including drops that are shot directly at their face and mouth. And then there are the **protective masks**. These masks filter out harmful bacteria, virus, and particles that the individual would otherwise breathe in.

The most protective masks are powered air-purifying respirators which use an external power source to filter the air for you. The reason that these must be powered by external sources is because it's too difficult for humans to breathe through the materials that can filter out the smallest of particles.

The next most protective masks are the N99 and N95 respirators, which allow you breathe in and out to filter 99 and 95% of very small, that's 0.3 micron test particles, respectively. Although many individuals can breathe through these masks, individuals with compromised respiratory tracts or other disabilities cannot.

And then there are surgical masks were not designed as protective masks. Surgical masks were intended as barriers and courtesy masks to keep the surgeon's droplets from falling directly on you during surgery and protect the surgeon from splashes. However, if the masks are fitted closely to the face, then they likely provide filtration in addition to their function as a barrier and courtesy mask to protect others. Of course, even the best mask does no good if not fitted properly, if not put on and off properly, if not used with other protective practices that are needed—for example, eye protection and hand hygiene, and if left sitting around where it can spread virus to the wearer and other individuals if touched.

[Sarah Gregory] If a mask prevents germs from being spread, why is there some guidance that says a mask doesn't protect the germs from being breathed in? If nothing else, it stops people from touching their mouth and nose.

[Virginia Dato] Well, the Sars-COV-2 virus is so tiny so no mask that humans can breathe through can absolutely protect against the tiniest droplets. But that may not matter, in individual cases since the virus usually travels in larger droplets. And I do not know what percentage of infections are from airborne tiny droplets, larger droplets, and touching. I do not know if anybody knows. There appears to be great variability in the number of people a single individual can infect. We do not have randomized controlled studies of people who wear masks versus those who are in identical situations for SARS-COV-2, but we do know that eye protection, gowns, gloves, hats, masks were associated with little or no healthcare provider transmission in certain countries.

And perhaps more important, for those who are risk adverse, dose, or the quantity of infectious virus droplet, almost certainly matters. So even if we just drop the number of virus particles inhaled, we give our bodies more time to develop an immune response. And if we're infected but asymptomatic, we likely drop the virus particles that we're spreading to others by using a mask—again, harm reduction. But it may be all for naught if significant quantities of the virus is transmitted to you by touching your eye, nose, or mouth. And maybe the masks will make you touch your eyes more as you adjust it. As time goes on, we get better data or we get better traditional mask supplies, vaccines, post-exposure and post-symptomatic treatments, the differences in opinion may start to resolve. This is a rapidly changing situation. I believe brilliant individuals all over the world are literally working on this as we speak.

[Sarah Gregory] Okay, well, tell us about the mask you created. What's it made of and how does it work?

[Virginia Dato] I had volunteered very, very briefly in Haiti and Jamaica, so I was acutely aware of the needs in other parts of the world. I wanted a design to be something that could be used anywhere in the world and so I choose 100% cotton t-shirts because I believed they were available everywhere, *not* because they're the most effective material. I first boiled the t-shirts for two reasons: It was a method of sterilization that was available everywhere and, by shrinking the fiber, it might make the mask more effective. I did not use anything else other than a ruler and a scissor because those are available everywhere in the world. Plus, I'm lousy at sewing.

Ideally, the mask works by having material filter out all of the breathable air both in and out of the nose and mouth so that none goes around the mask. I say ideally because...a good fit is needed to do that. After all, air follows the path of least resistance. And ideally it filters out all of the droplets. I say ideally because the filtration ability depends upon the material. Ordinary t-shirts do not filter out all of the droplets. Even 9 layers do not. However, with most infectious diseases, as I noted, even decreasing the dose allows your body more time to develop an effective immunity—again, harm reduction.

[Sarah Gregory] I know you've been experimenting with improving your design. What do you suggest doing differently now?

[Virginia Dato] Well, the first big change I made is the "slit" that's in the paper. Two different people have asked me what I meant by the slit. In addition, I found that making the slit is fine the first time, but after you wash it and rewash it and rewind it over and over, the slit is a little off to

the side or the slit is a little...it takes time to line up. So now I'm not making the slit and just stuffing extra leftover cotton material between the nose and the cheek bone, inside the roll or outside the roll, if needed, until no air escapes and there is a good seal. By a good seal, you can see the fabric move back and forth as you breathe or if you put your hand one-half inch in front of the mask, you can feel the air coming in and out. By good seal I mean your glasses are not fogging up and you cannot feel any air coming in from around the sides.

The 9 layers also makes it very difficult to put on and off and carry. So I just tried 4 layers of a thicker-fiber flannel fabric. I essentially just took a 7 inch by 28 piece of flannel, cut it into two 7 by 14 pieces, folded them in half and put them in...put the 4 layers in, some facing vertical, some facing horizontal and under the original top t-shirt layer. It felt soft, was easier, and it felt like it was filtering the same degree. I tried this because there are a number of articles out there about face masks using high density cotton. They may indeed be improvement over there...over this, especially if you have a good fit, however not everyone has flannel at home. For harm reduction, we need the right balance between the ability of the material to allow us to filter and the ability to breath. Any commercial products clearly need to be fully tested using traditional methods. This paper is about do-it-yourself for low-risk situations.

[Sarah Gregory] Do you use this mask yourself?

[Virginia Dato] Yes, but I do not work in a clinical healthcare setting at this time. I put it on carefully. I check for air coming in and out the sides and either tighten the ties or add filler if I detect air leakage. I hold my hand in front of the mask to make sure air is coming in and out of the front. I try not to touch the front of the mask during or after wearing it. I also use eye protection, good hand hygiene and consider the mask contaminated after use if I'm using it for communicable disease harm reduction. I only touch the mask ties and either place the outside layer down on a clean isolated surface when I take it off, and then consider that area contaminated once touched, or I put it in a metal pot for reboiling after taking it off. Prior to COVID-19, I used N95 masks I purchased at hardware stores for protection against allergens like pollen and dust mites, in addition to my neti pot, antihistamine, asthma medicines, etc. Obviously, I no longer use new N95 masks for my allergy control and I'm now using homemade cotton masks for this purpose.

[Sarah Gregory] Dr. Dato, you just mentioned something that I think is extremely important and, frankly, I haven't been reading anything about. That's the bit you just talked about, about taking it off, where to put it, washing it, or disposing of it. Would you just sort of reiterate the high points of that again?

[Virginia Dato] Yeah. In fact, at one point I had the right words: donning, doffing, decontaminating, and disposing of it all properly. But what *donning* means is how to put it on. And if you're putting a brand new one on, that's not so important, except that you put on whatever mask you're using so that it meets the purpose you're using it for, and this is true even for an N95 mask. Because those of us who were appropriately fit-tested for N95 masks know that those masks are supposed to be tight against our face, if they're not, they're not serving that full purpose. So putting it on means that, before you go into a risk environment, where you're going to discover it's leaking, and you have to go touching it and then you wind up touching your eyes, is that you make sure that it's properly fit and it's properly fit doing the things you're gonna do. A true fit test has people moving around in...to make sure that that mask still fits as they move around, so, so you put the mask on and you make sure there is no air around it and

that's the time where...for N95 masks you've the little metal thing or some of these masks that you see online where they use a little metal, so that's the time to make sure there's no air blowing around. That's donning.

Doffing is taking the mask off. Now, if this mask really helped you, if this mask really protected you, then guess what? This virus is on the front of that mask. It was just a filter. Think about a colander or anything else that you use to filter material, it's got all the gunk in it. So, you don't want to be touching the front of it and then taking off your mask with your hands and then picking up your food and eating it. You're essentially giving yourself a high dose of virus.

So, that's why depending upon the risk situation I'm using a mask for, if I'm using a mask just for my allergy control, and there is just dust on the outside, then yeah, I'll put it down, sounds like, but I'll keep the practice and put it down, straight down on the table, and I don't touch the front of it, just to keep the habit. If, though, I actually wore it someplace that there might be some COVID 19, I can take it off and put it right in the big metal pot and then, when all the masks are ready, I throw water in and boil them. And then I wash my hands, proper hand hygiene, before I go and do anything else. So that's the doffing.

And that's what I meant about the *disinfecting* and the *disposal*. Because again, after you use...if it's like the N95 mask that are not going to be reused or reesterilized—and I know that that science is changing rapidly, so anything I say there is going to be changing—but anything that's contaminated, that we're throwing out, it goes right into the garbage. It doesn't go anywhere that anyone is going to touch it. It's not sitting around on the table where your child can come up to and play with and pretend it's their Halloween mask. So that's what I mean by donning, doffing, disinfecting, and disposal.

[Sarah Gregory] That's such a really very saliable point, I hadn't even considered myself, that the mask itself is a...is a little carrier of virus if you've used it around the virus. Gosh. Okay.

Well, tell us a little bit about yourself.

[Virginia Dato] Although I'm not currently working in public health. I'm 62. I have over 20 years of experience in two state health departments, New Jersey and Pennsylvania. In addition, I did a pediatric residence at Bellevue Hospital in New York City, a pediatric infectious disease fellowship at Children's Hospital of Michigan in Detroit, a public health residency at the New Jersey Department of Health, I got my MPH at Columbia University, and I was a faculty member of the University of Pittsburgh School of Public Health, a biomedical informatics fellow at the University of Pittsburgh Medical School, and that's also where I also got my MD degree. I have cared for patients with and/or investigated outbreaks related to AIDS, resistant TB, rabies, measles, hepatitis A, LCMV, Lyme, Salmonella, norovirus, and influenza in both humans and animals. I have served on the Region 13 Preparedness Task Force, and I'm a current member of the Minority Emergency Preparedness Task Force, ServPA, an honorary advisory board member of the One Health Initiative, and a current officer of the American Association of Public Health Physicians.

[Sarah Gregory] Wow, that's quite an impressive background! What do you do for fun?

[Virginia Dato] [laughter] Make masks. [laughter] Other people make soup, I boil my masks. [laughter] I have always been the little kid doing science. Well, I'm not the little kid anymore, but when I was the little kid, I was doing science.

[Sarah Gregory] Well, you've obviously found your niche.

Well, thank you so much for taking the time to talk with us today and explaining about this important face mask issue right now.

[Virginia Dato] And I want to thank everyone for their work in these difficult times. It truly takes a village. We need everyone's talents and I hope that everybody takes care.

[Sarah Gregory] Listeners can read the June 2006 article, Simple Respiratory Mask, online at cdc.gov/eid.

I'm Sarah Gregory for *Emerging Infectious Diseases*.

[Announcer] For the most accurate health information, visit cdc.gov or call 1-800-CDC-INFO.