00:06 Sarah Crespi: Welcome to the Science Podcast for August 7th, 2020. I'm Sarah Crespi. First up this week, staff writer Meredith Wadman talks about why COVID-19 poses a special risk during pregnancy. Next, Gianluca Roscioli describes the microscopic mechanism for how body hair damages razor blades. First up this week, we have staff writer Meredith Wadman. She wrote about coronavirus and pregnancy. Hi, Meredith.

00:38 Meredith Wadman: Hi, Sarah.

00:39 SC: Okay, as it seems to be always the case these days, there are a lot of open questions about coronavirus and something else, and in this case, it's pregnant women. Are these women at greater risk for more severe infections? Can the virus infect a fetus? How likely is transmission at birth from an infected mother? Meredith, I know you don't have answers to all these questions, but let's start with what are some solid trends at this point? For example, are pregnant women more at risk if they're infected?

01:12 MW: It seems to be the case that they are, although the data is very incomplete. Given, though, what the consequences are from a severe infection, it's really better to err on the side of caution and assume that, yes, they are at increased risk. And that wouldn't be totally surprising because it's known from our understanding of other respiratory viruses that women can get much more severe infections and have worse outcomes. That's particularly well established for influenza, and it's thought to be the case for SARS, the Severe Acute Respiratory Syndrome that's caused by a similar virus that's a close cousin of the new coronavirus.

01:56 SC: There are a couple of biological factors that point to why this might be the case, particularly how the immune system changes during pregnancy. How might that contribute to more severe infections?

02:09 MW: The immune system in pregnancy is like a moving target, it's constantly adjusting. It has to hit this tricky balance of still repelling foreign invaders but not rejecting the fetus, which after all, half of the fetus is not from Mom, and it might look foreign to the immune system. And what can happen is that things get out of whack. Perhaps there are worse infections than might have otherwise been the case. At the same time, we know that the new coronavirus causes really severe inflammation in particularly serious cases of infection. And if the mother's immune system is also active as it is in pregnancy, it's possible, some experts think, that this piles on with additional inflammation and that you get a worse situation than you would have had had Mom not been pregnant. So it's not well understood, but it's thought that there can be an unhealthy interplay.

03:17 SC: Pregnancy also puts stress on the lungs and the cardiovascular system. These are both two targets of COVID-19. How is the body affected by pregnancy in such a way that the lungs and cardiovascular system are harmed, and how does COVID-19 affect the lungs and the cardiovascular
03:36 MW: Sure. Well, you can imagine if the woman, particularly as she goes into later pregnancy and the fetus is larger and larger, has decreased breathing room. That is gonna make any respiratory infection in which your breathing capacity is being affected by the infection itself, that's gonna double down and make it even tougher to adequately oxygenate your blood.

04:00 SC: You basically have less room to breathe.

04:02 MW: Right, and that's a serious impediment. If you're already breathing at that reduced level and then you have a virus causing an infection that is filling some of your breathing space with fluid, you can imagine how you could get into serious trouble quite quickly.

04:19 SC: What about the cardiovascular issues, and how does that interact with the new coronavirus?

04:25 MW: Well, there's a couple of things. One, just the amount of work. The body's so amazing. Women pump, by the time they're in late pregnancy, 50% more blood than they normally have, so there's a ton of blood circulating and that can lead to lots of fluid exiting into the lungs and making a bad problem worse. And then we know that the virus can and does have bad effects on the heart and blood vessels, which are already under strain because of the pregnancy. So again, the virus is potentiating and making worse this part that's punching at the top of its weight already. There's a final effect that's not fully understood and not fully pinned down, but it's known that the coronavirus causes increased clotting in some patients, the blood has more of a tendency to clot. Well, guess what? In pregnancy, the blood already has more of a tendency to clot. So now you layer an increased tendency to clot on top of an increased tendency to clot, and you can see where women can also get into trouble with clotting, which has independently been a problem in serious cases of COVID-19.

05:34 SC: We just talked about how the virus and pregnancy might interact in a negative way. What is the evidence for the fact that women fare worse when pregnant and infected with the new coronavirus?

05:47 MW: Well, there was a much-noticed study that came out of the US Centers for Disease Control and Prevention late in June that showed that pregnant women with COVID were up to 50% more likely to end up in intensive care and 70% more likely to end up needing a breathing machine than their infected but non-pregnant peers. Now, there's some caveats to that study. Number one, they were not more likely to die, which is reassuring.

06:20 MW: Number two, even though this was a lot of pregnant women that CDC looked at, about 91,000, it was only 28% of all the women of reproductive age that have had COVID, and have had their COVID reported to CDC through early June. Why is that? Because these reports have a box that say, "checked pregnancy status: Yes, pregnant; no, not pregnant", and many, many, basically 72% of the reports that CDC received, came in without either box checked, and so they couldn't use that data, and that makes this study quite incomplete.
07:00 MW: There's a more comprehensive but much smaller study that was published by the Public Health Agency of Sweden in July, and it found that the women who were pregnant were landing in ICUs at six times the rate of non-pregnant women. What's unique about this study is it captured all ICU admissions in Sweden, and it used as a denominator all non-pregnant and all pregnant women of reproductive age in Sweden. This study was very small, however. In the end, only 13 coronavirus-infected pregnant women and 40 non-pregnant infected women were admitted to Swedish ICUs in the timeframe of the study.

07:44 SC: So we have two studies that show strong trends, but they both leave something to be desired.

07:49 MW: Yeah, one's incomplete, and one is small.

07:52 SC: Right. Turning to the fetus, there is some good news here. Unlike other viral infections we know about, like Rubella or Zika, this novel coronavirus doesn't appear to cause birth defects so far. What evidence do we have that that is not a problem?

08:11 MW: Really, we're in a kind of wait-and-see game. If you think back, the pandemic really took hold in China in January. And the time when fetuses are most susceptible to having their development really affected by a virus so that they're born blind or deaf or with those small skulls that we saw in Zika babies is during the first trimester. That's when the fetus is particularly vulnerable. So we're just beginning now to get, say, the births to Chinese women who were eight weeks pregnant in January. We don't have the evidence yet, but what seems clear is that if there was a major problem, and you have now dozens, or hundreds, or even thousands of Chinese babies being born affected profoundly by this virus in a first trimester sort of way, then you would be getting at least case reports out of China that this is happening, and we're not getting that.

09:16 MW: We contacted several Chinese obstetricians. Now, granted, they cautioned us that their numbers are small, and this is by no means comprehensive, but they were cautiously optimistic that this is not happening. You also need to think about in the United States, say you were eight weeks pregnant on April 1st. Well, now your baby is certainly big enough to be having imaging by ultrasound scan that would pick up a very shrunken skull, for instance. We're not getting those reports in this country.

09:49 SC: What might protect the fetus in this case?

09:52 MW: Yeah, and I should qualify that by saying "as far as we know", and there's a couple of posited reasons. One is that Rubella, Zika and cytomegalovirus, another virus that commonly hurts fetuses early in pregnancy, are blood-born. They travel around the human body in the blood a lot. And during the first trimester the placenta is just forming, and it is not that formidable a barrier to blood-born infections. That's why fetuses are so vulnerable in the first trimester. But with coronavirus it seems that it rarely travels via the blood, that it might have moments of doing so and there are certainly isolated cases of it doing so, but it's not invading the blood for the length of time and at the level that these other fetus-damaging viruses do. So that is somewhat reassuring.
10:44 MW: A second piece is that the coronavirus needs certain molecules in order to invade cells. And there was a new study out of the National Institute on Child Health and Human Development published just earlier this month that found that the two enzymes that coronavirus commonly uses in tandem to invade cells are not present at the same time in placental cells. These scientists looked from beginning to end and found negligible simultaneous expression presence of these two enzymes in placental cells. So that too is reassuring.

11:27 SC: One thing researchers are concerned about is fetal growth when the pregnant woman has coronavirus. Why is that a worry?

11:36 MW: Several studies have been done of placentas after delivery from women who were infected with coronavirus. There was one from a subset in a very large series of women who were admitted for labor and delivery at three New York hospitals in March and April. And the scientists there looked at 29 placentas from COVID-infected mothers and found that nearly half of them, 14, showed signs of clots on the fetal side of the placenta, so possibly stopping maternal nutrients and oxygen from getting in to feed the fetus and support it.

12:16 MW: At the same time, an examination of 16 placentas by researchers at Northwestern University found that fully 15 of them had damage to the blood vessels and maternal blood supply on the maternal side of the placenta, so again possibly stopping nutrients and oxygen from getting to the fetus. So both of these groups of scientists advise that when there's a COVID infection in pregnancy, obstetricians should follow very carefully the rate of fetal growth and make sure through ultrasound scanning that it's proceeding as it should.

12:54 SC: What about when the baby is born? Is there a big risk that an infected mother could infect the baby during birth or soon after?

13:07 MW: There is a lot of attention on this issue. The good news is that fetal infection at or around the time of birth seems to be rare. The one study I mentioned of women who were infected with COVID who were admitted to New York hospitals, there were 70 women who gave birth to 71 babies, and just one of those babies became infected. That being said, it's under debate right now, "How do you gauge infection in a newborn?" For instance, if they've just popped out and you're giving them a nasal swab, well, they're not gonna have breathed in coronavirus. If they're infected, it's gonna have come through the placenta, and so of course a nasal swab is not gonna turn it up. Then there's questions around, "Now, do you separate mother and baby? Does she breastfeed? What about infection during the birth process?" All those things are being closely examined, and I think it's a state of uncertainty that's reflected in the fact that depending on which advisory body you talk to or look at their recommendations, some say mother and baby should be separated. Others say no. It's something that's in process.

14:22 SC: Not a good thing to be uncertain about.

14:24 MW: Yeah, exactly.
14:25 SC: After the baby is out, postpartum, the mother's body goes through a lot of changes. Does her risk for severe illness from coronavirus infection go down really quickly?

14:38 MW: Actually, no. And this is something I was surprised and interested to learn and think it's really important for doctors and women to be paying attention to, is that in the immediate time after birth... Again, I'm going back to this big New York study, it found that women who had COVID infection in fact were more likely to have complications, including hospital readmission and decreased blood oxygen and fever in the period immediately after birth. So it's important. Don't just send these women home on their merry way. Observe them, check on them. And women themselves should be attentive to if they're feeling poorly in those immediate few days after birth.

15:24 SC: Meredith, there's so much that we need to know about this. What kinds of studies are you keeping an eye on now?

15:30 MW: I'm really looking for several registries that are accruing pregnant and non-pregnant women and following them during pregnancy and for their outcomes. We need thousands of women. Without participation and large numbers of women, we're not gonna have solid answers to these questions even six or eight months or two years from now.

15:55 SC: Well, Meredith, before we wrap-up, I wanna remind people who may be very disturbed by this information that the best thing to do is to avoid contracting coronavirus. We know how to do that, we know how to keep ourself safe, and that's probably the best advice you can have at this point for anybody who is worried about COVID during pregnancy.

16:17 MW: Absolutely. David Baud, who's an expert at Lausanne University Hospital, said to me, "The first ones who need the masks are pregnant women. The first to avoid social contact should be pregnant women." And I just don't think folks can take that too much to heart.

16:32 SC: Alright, thank you so much, Meredith.

16:34 MW: Thanks a lot, Sarah. It's been great talking to you.

16:36 SC: Meredith Wadman is a staff writer for Science. You can find a link to her story and all of our coronavirus coverage at sciencemag.org/podcasts. Stay tuned for an interview with Gianluca Roscioli. We talk about how sharp blades are damaged by soft things, like cheese and potatoes.

[music]

17:00 SC: Why do sharp blades become dull even when they only cut soft things, like cheese or potatoes? It seems like a simple question. We've been making sharp cutting blades for a very long time, and of course we've been sharpening them as they get dull. But the precise interaction between a sharpened edge and a softer surface has been very difficult to analyze. Gianluca Roscioli and colleagues write this week in Science about the microscopic meetings that make it possible for hair to deform steel. Hi, Gianluca.
17:34 Gianluca Roscioli: Hi, Sarah.

17:35 SC: Are you trying to figure out how something wears down over time, or are you asking a more specific question?

17:44 GR: This research was born as a case study on a wear process. Everybody can think of razor blades or knives getting dull over time due to wear processes. But then we realized during the experiments that was not the case, and in fact blades get dull by several chips forming along the sharp edge that makes this sharp edge become less and less sharp.

18:10 SC: People have been making sharp blades for a really long time. Why has this been so difficult to study?

18:17 GR: We have been making blades for more than 2000 years, so we are experts in producing blades. The difficult part is actually to study why they fail and what is happening at the micro scale during the cutting operation. And this is one of the big challenges for this study since it is difficult to usually visualize during a cutting process what is happening in the material of the blade when it is cutting small objects like a single hair. And that is why in our experiments we had to use a scanning electron microscope and perform the shaving experiment in situ.

19:01 SC: Right. So this is a really neat setup, and the images and videos that come out of it showing the close-up interaction between hair and blade are just amazing. But one of the things you can see from this is that the angle matters. What was different about cutting straight across the hair versus matching an angle that a razor is designed to take?

19:22 GR: The difference is that if you hold the hair perpendicular with respect to the blade, we notice no chipping and no failure of the blade. Instead, the problem comes when you go to a more realistic scenario and the hairs are free to bend. This free bending is what can impart the stress on the blade along different directions. And depending on the direction of the applied stress, you can get different modes.

19:53 SC: Modes are these different angles, the way the blade is stressed by the hair, the plane that the stress occurs at in this interaction between the blade and the hair. And so of all these modes, you found one that was most likely to cause chipping in the blade.

20:10 GR: This was an insight that was not happening for every hair at that particular angle. So this is what pushed us to dive more into the details because it meant that there was something more, some other factors taking place.

20:28 SC: So in addition to the fact that the hair is free to bend and can change its angle and how it exerts pressure on the blade, what other factors are important for this chipping process?

20:41 GR: There are two main other factors. The first is the presence of asperities along the sharp edge.
20:48 SC: What are asperities?

20:50 GR: Roughness. If you zoom in at the microscopic scale, you can see that this edge is actually rough. We show the notch where the stress shows the highest intensification is the notch that corresponds to the edge of the hair being cut. Only some asperities present the highest stress during the shaving operation, but as you can imagine, this is a parameter that is not controllable from an engineering point of view, because during shaving, subsequent hairs will be on different positions along the sharp edge. And so if you have asperities, those asperities over time will for sure experience side stresses. And the second factor that affects blade failure is the presence of heterogeneity in the material itself.

21:45 SC: Commercial blades are made up of several different materials. To the eye it looks like one thing, but at the microscopic level there are these important differences because of this blend of materials.

21:58 GR: Yes, the mechanical properties are different from point to point inside the material. The more you go into the details, the more heterogeneous the properties become.

22:11 SC: So when I look at the pictures in the paper, it really does look very much like, I don't know, confetti. There's just so many different materials all packed into this blade.

22:23 GR: Yes.

22:24 SC: Yeah, it doesn't look like one solid thing anymore once you start to look at the individual components in this fine structure.

22:30 GR: And in fact, what we showed from our experiments is that if you have a heterogeneous material ahead of one of the notch, specifically ahead of the notch that shows the highest stress, and in addition, if the load due to the cutting of the hair is applied on the more compliant face next to the stiff one, then the crack is more likely to propagate. And what we have shown with these experiments is that you form these chips when the combination of three factors is met, and in order to meet three factors all together, the probabilities are very low. But when we're cutting several thousand of hair, when you shave, also this low probability becomes more likely, and this is why your blades don't fail right away, but they fail over time. And this is when you need to resharpen it or throw it away if you're talking about disposable razor blades.

23:34 SC: Right. There are many places where blades are used in manufacturing and cutting your lawn, all kinds of places like that. How can what you've learned here in this study be used to improve blades more generally? Is this something where you can say, "Oh, cut at a different angle," or, "Use less heterogeneous materials," those kinds of things?

23:57 GR: The parameters that you can play with are the roughness along the sharp edge, for sure, but that usually depends on the material the blade is made of. This roughness along the sharp edge is intrinsically linked to the heterogeneity in the material. And therefore, the suggestion would simply be to find a more homogeneous material or at least a material where this heterogeneity is
such a small scale that it looks homogeneous from the point of view of the sharp edge.

24:32 SC: Does it really make sense to change the material that we're using for razor blades or should we just keep throwing them out because it would cost a lot more money to make them from something more homogeneous?

24:44 GR: Of course, from the point of view of a company producing blades, it is better for consumers to throw away their blades so that they can make more money, but if you think about it from an environmental point of view, it has consequences. In 1990, the Environmental Protection Agency estimated the waste to be over two billion razors thrown out. This causes big problems because this waste is of course sharp objects. When you shave, it can also produce biological waste.

25:19 SC: What other improvements could you see in making blades in the future?

25:23 MW: What we thought could be the best way is to actually modify the process of producing blades. At the moment, sharp edges are produced by honing. Instead, we thought of a different way to produce sharp edges where you can simply deform your material into having an almost wedge shape, push it until you obtain the sharp edges. So you are not removing material anymore, but you are compressing it. This allows you also to use different kinds of materials.

26:01 SC: Very interesting. And this has been an interesting conversation where things that we all think we know, like how to make something sharp that are described in these highly technical terms, it makes you realize that you don't really know how it happens. So this has been great.

26:17 GR: Yes, there are tools that we use every day and most of the people don't realize how much thinking there is behind these tools, how much they are engineered in order for us to use them in an easy way.

26:33 SC: Yeah, for sure. Thank you so much, Gianluca.

26:36 MW: Thanks, Sarah.

26:37 SC: Gianluca Roscioli is a PhD student in the Tasan Group in the Department of Material Science and Engineering at MIT. You can find a link to his Science paper at sciencemag.org/podcast. And that concludes this edition of the Science Podcast. If you have any comments or suggestions for the show, write to us at sciencepodcast@aaas.org. You can listen to the show on the Science website at sciencemag.org/podcast. On the site, you'll find links to the research and news discussed in the episode, and of course, you can subscribe anywhere you get your podcasts. The show was edited and produced by Sarah Crespi with production help from Podigy, Meagan Cantwell, and Joel Goldberg. Jeffrey Cook composed the music. On behalf of Science Magazine and its publisher, AAAS, thanks for joining us.