

Wednesday, 11 September 2024

1
2 (10.00 am)
3 **LADY HALLETT:** Mr Scott.
4 **MR SCOTT:** Good morning, my Lady. May we please call
5 Catherine Todd, who can be sworn.
6 **MS CATHERINE TODD (affirmed)**
7 **(Evidence via videolink)**
8 **Questions from COUNSEL TO THE INQUIRY**
9 **LADY HALLETT:** Ms Todd, thank you so much for joining us
10 this morning. I know how difficult this must be for
11 you, it's probably something you don't want to relive,
12 but it is so important that we do hear from you, so
13 I'm really grateful to you.
14 **THE WITNESS:** Thanks.
15 **MR SCOTT:** Ms Todd, I would like to ask you some questions
16 about the experiences of you and your partner TJ around
17 the very sad death of your son Ziggy on 21 July 2021,
18 a few hours after he was born.
19 It's right that Ziggy was your first child?
20 **A.** Yeah, he was.
21 **Q.** And are you happy if I refer to him as Ziggy throughout?
22 **A.** Yeah, that's fine.
23 **Q.** On 12 July 2021, you were approaching 28 weeks pregnant;
24 is that right?
25 **A.** Yeah, that's correct.

1

1 sorry, maybe, to say that I had Covid, and then up until
2 Ziggy was born, so up until the 20th. I had
3 an ambulance out as well to our house in between the
4 phone calls.
5 **LADY HALLETT:** Mr Scott, can you pause there, I'm not sure
6 if anybody else is having some problems following the
7 audio. Is it just me? Looks like it's just me, nobody
8 else is nodding, so I'll look at the transcript.
9 **MR SCOTT:** Well, you're quite important, my Lady, so if
10 there's anything we can do to make it better --
11 **LADY HALLETT:** As long as the stenographer can hear
12 properly, that's fine. So sorry to have interrupted,
13 Ms Todd.
14 **MR SCOTT:** What advice were you being given in those first
15 few days, so the 12th, 13th, 14th, when you were calling
16 the maternity unit?
17 **A.** Every time it was really the same, just lie on my side
18 and to phone back if I had any other concerns.
19 **Q.** Did you ask for Ziggy to be checked?
20 **A.** Yeah.
21 **Q.** And what did they say?
22 **A.** They told me that they wouldn't bring me in at the time
23 because they wanted to reduce the risk of spreading
24 Covid.
25 **Q.** How did that make you feel?

3

1 **Q.** You'd been due to attend a routine scan, but you'd
2 tested positive for Covid, so you called the hospital's
3 maternity unit. What did they do as a result of that
4 call?
5 **A.** When I first phoned and reported to maternity that I was
6 Covid positive, they had cancelled a scan that was
7 upcoming.
8 **Q.** Did they give you any guidance or advice about what to
9 do or things to look out for as a pregnant lady with
10 Covid?
11 **A.** No, not at that time.
12 **Q.** You started to feel very unwell but you also became
13 aware that Ziggy wasn't moving the way that he had been.
14 What did you do as a result of that?
15 **A.** I phoned maternity, both the EOU and the advice line
16 multiple times. Their advice really at the time was
17 just to take paracetamol and lie on my side for
18 two hours, and drink a fizzy drink.
19 **Q.** That seems fairly normal advice you'd get for a pregnant
20 lady who is suffering from reduced foetal movement.
21 Were you being told anything above and beyond that
22 because you had Covid?
23 **A.** No.
24 **Q.** For how many days did you call?
25 **A.** I think I first phoned maybe on the 12th -- or the 13th,

2

1 **A.** Not reassured at all.
2 **Q.** Do you think that you should have been examined sooner
3 than you were?
4 **A.** Yeah, definitely.
5 **Q.** Do you think that you would have been seen earlier if
6 you didn't have Covid?
7 **A.** Yeah.
8 **Q.** It came to the point that you took yourself to hospital
9 on 16 July; is that right?
10 **A.** The -- no, I had phoned them a few times on the 16th.
11 Again they gave me the same advice: just lie on the
12 side, drink a fizzy drink, take paracetamol. But a few
13 hours later nothing had changed, so I phoned back again
14 and said that I was coming up for the hospital to check
15 Ziggy.
16 **Q.** What made you take the decision to go up?
17 **A.** I just felt at that time that it had gone on too long,
18 and I was just getting the same advice and nothing was
19 changing every time I was phoning.
20 **Q.** When you went up, it's right that you were 27 weeks and
21 six days pregnant that day; is that right?
22 **A.** Yeah.
23 **Q.** When you went up -- you have a partner TJ; that's right?
24 **A.** Yeah.
25 **Q.** Did TJ go with you?

4

1 A. He was not allowed into the hospital, he had to park
2 outside, and they brought me through an ambulance bay
3 just to be seen.
4 Q. Were you told when at any point TJ may be allowed in
5 while you were in there?
6 A. I was told that he wasn't allowed in at all.
7 Q. When you were in, you didn't receive a full -- I'm going
8 to call it a CTG scan, but you received a Doppler scan,
9 so just a normal scan to listen to the baby's heartbeat;
10 is that right?
11 A. Just a Doppler.
12 Q. Was the midwife who carried out that scan wearing PPE?
13 A. I think she was. It was the sister that had seen me,
14 although after she had done the Doppler, she had told me
15 to go back and wait in the car, that she needed to do
16 a handover, she'd been there from half 7 that morning,
17 and that I was fine and Ziggy was fine, and while I was
18 waiting in the car for my notes to be brought out, she
19 actually came out in her own clothes.
20 Q. How long were you waiting in your car for?
21 A. Maybe about five minutes after my Doppler was done.
22 Q. How did you feel being asked to leave the maternity
23 unity and go and wait in your car before you got your
24 notes?
25 A. Like I was just rushed in and out the door, no one

5

1 A. (Unclear) reduced and then I had also noticed my bump
2 getting quite a lot smaller.
3 LADY HALLETT: I don't think the stenographer heard. What
4 reduced? Was that the movement of the baby? Was it
5 Ziggy's movement?
6 A. (Witness nods).
7 LADY HALLETT: So Ziggy's movement reduced and you thought
8 your bump was smaller, so you thought he was smaller?
9 A. Yeah, yeah.
10 MR SCOTT: When you went in on 16 July, for how many days
11 had you been concerned about reduced movements from
12 Ziggy?
13 A. Maybe from the 14th onwards.
14 Q. Just if I can come back to the review about that in
15 relation to the scan, it's also noted that:
16 "The impact of maternal Covid-19 was not fully
17 understood and led to this not being recognised as
18 an independent risk factor when assessing reduced foetal
19 movement; this resulted in [you] not having a CTG
20 recording when [you] attended ... on 16th July 2021."
21 It continued:
22 "At the time the review, limited information was
23 available about the effects of Covid-19 during
24 pregnancy, particularly the strain of virus which was
25 prevalent in Northern Ireland during the summer months

7

1 really wanted to see me.
2 Q. You provided a review of the circumstances of Ziggy's
3 death. One of the points that's considered in that
4 review is about the decision not to give you a CTG scan.
5 A. Yeah.
6 Q. And please do correct me if I'm wrong, but is it right
7 that the guidance that was in place at the time for the
8 hospital was that assessment of foetal heart rate by CTG
9 was from 28 weeks onwards?
10 A. That's correct.
11 Q. And because you were 27 weeks and six days, a CTG was
12 not performed?
13 A. Yep.
14 Q. Were you asked to come back the next day, when you would
15 have been at 28 weeks?
16 A. No. I was just sent home and told that I was fine and
17 that Ziggy was fine.
18 Q. Were you told what to do if you still had concerns about
19 Ziggy's movements or lack of them?
20 A. No.
21 LADY HALLETT: Sorry to interrupt again.
22 Ms Todd, what was it about Ziggy that made you feel
23 that you had had to go to hospital? What was it about
24 the baby that made you think that something might be
25 wrong?

6

1 of 2021."
2 They:
3 "... were not obvious within the Obstetric teams in
4 Northern Ireland until late August/early
5 September 2021."
6 How did you feel about that finding when you read
7 it?
8 A. Very let down. I don't know why it took even past
9 a year into the pandemic for them to have anything
10 really in place for maternity.
11 Q. In July 2021, had you heard there being concerns about
12 risks associated with Covid during pregnancy?
13 A. Not really, no.
14 Q. What's your thoughts about not being offered a CTG scan?
15 How has that had a lasting impact upon you?
16 A. I think that if they had have done the CTG they possibly
17 would have picked things up and things could have been
18 completely different.
19 Q. Do you feel that you were able to ask or insist or press
20 for a CTG scan?
21 A. No. As I say, I felt like I was rushed in and out,
22 no one really wanted me in the hospital for a start,
23 obviously because I was Covid positive, so I think at
24 the time they were just trying to get me out as quick as
25 they could.

8

1 Q. Do you think the situation might have been different if
2 you had been allowed to have TJ or anyone else in with
3 you?
4 A. Yeah.
5 Q. So, moving ahead about three days later, you were having
6 difficulty breathing and you were having heart
7 palpitations. How concerned at that point were you for
8 both yourself and for Ziggy?
9 A. Extremely concerned. I actually ended up phoning my GP
10 the following day from having the ambulance out, because
11 when the ambulance did come out they just checked me but
12 not Ziggy, and I was kind of -- at the time I was kind
13 of up and down, one minute I was okay breathing-wise and
14 then next minute breathing wasn't great. I think maybe
15 it had taken the ambulance about five hours or so to
16 come out, but the following day my breathing had got
17 worse and I just felt like the hospital, and when the
18 ambulance came out they hadn't really done much, so the
19 following days, whenever I'd phoned my GP --
20 Q. Can I just take those in steps. So what were you
21 concerned about with Ziggy that led to, I think it was
22 TJ who called the ambulance, wasn't it?
23 A. Yeah.
24 Q. So what were your concerns about Ziggy that led to the
25 ambulance being called?

9

1 checked you?
2 A. Yeah.
3 Q. This was on 16 July, so you'd already been in this for
4 a few days at this point, four or five days. What was
5 your state of mind at that time when the paramedics
6 left?
7 A. I think being checked by both the sister in EOU and the
8 ambulance, I was kind of thinking at the time maybe
9 everything was okay, as that's what they were telling
10 me, and just to kind of -- to trust them when I know now
11 that I shouldn't have, you know, I should have kind of
12 pushed it further.
13 Q. Did you feel looked after?
14 A. No.
15 Q. So you said earlier on that you called the GP about
16 midday, so that's about 11 hours or so after the
17 ambulance had arrived. Could you tell us, please, what
18 the GP said to you?
19 A. She said to go straight to A&E and that she was going to
20 fax over that I was coming so that they definitely had
21 to see me.
22 Q. Did she think that you might not be seen if she hadn't
23 informed them that you were coming?
24 A. I think so. I think so. I think she also had faxed it
25 over, so I kind of wouldn't have been waiting as long,

11

1 A. Well, I'd obviously noticed his movements reducing and
2 then the sicker I was feeling, it was concerning me more
3 that the two of us were really unwell at that point.
4 Q. I think you said it was five hours?
5 A. Yeah, I think it was around there.
6 Q. That was for the ambulance to arrive from the time it
7 was called?
8 A. Mm-hm.
9 Q. It arrived about 1.00 or 2.00 am; is that right?
10 A. That's right.
11 Q. You said earlier on that when the ambulance arrived they
12 didn't check the baby. Do you remember anything about
13 why the paramedics didn't check on Ziggy?
14 A. No, they didn't tell me why. They just basically done
15 my oxygen levels and blood pressure, and that was it.
16 Q. Did you tell them about your concerns about Ziggy's lack
17 of movements?
18 A. Yeah. I was more so phoning for him than me at that
19 point.
20 Q. Again, were you given any advice or guidance about what
21 you should do?
22 A. No, just the same thing again, take paracetamol and lie
23 down.
24 Q. So you were told to lie down, that was from the
25 paramedics you were told to lie down when they'd just

10

1 but I don't think really it would have made a difference
2 because obviously I was in A&E then waiting for maybe
3 about ten hours.
4 Q. You said you went to A&E and you just said you were
5 waiting in A&E for ten hours; was that ten hours until
6 you were seen or ten hours until you left, or ...
7 A. Ten hours in A&E in total, until I was moved over to
8 maternity. I think at about five hours in, obstetrics
9 came down and scanned me. They -- I could see Ziggy and
10 stuff moving then at the time --
11 Q. Sorry, Ms Todd, I don't want to jump ahead too quickly,
12 I will definitely get there with you. I just want to
13 talk about your waiting experience in A&E. You say that
14 you were placed in what seemed to be a waiting area for
15 people with Covid but it also seemed to be used for
16 people with suspected Covid.
17 A. Yeah.
18 Q. What made you think that?
19 A. There was a man who was shouting everywhere about how he
20 wasn't Covid positive. I think he was maybe like
21 an asthmatic, probably, and they had just grouped his
22 symptoms together basically and put him in the Covid
23 area of A&E.
24 Q. So it was July 2021, was there any kind of funnelling
25 system or areas for people to wait depending on any kind

12

1 of Covid status?

2 **A.** They, at the A&E that I was in, they had -- so the

3 normal waiting room of A&E was people that they didn't

4 suspect to have Covid. Then they had a door that was

5 like locked and security and beyond that door was just

6 everyone that was either Covid positive or they had

7 Covid symptoms.

8 **Q.** Was that where you were because you'd had the positive

9 test?

10 **A.** Yeah.

11 **Q.** Okay.

12 So you just said in A&E that they scanned Ziggy and

13 that you could see him moving; were you given the

14 results of that scan?

15 **A.** No.

16 **Q.** What were you told?

17 **A.** That he was fine but their concern at the time was

18 they'd arranged a liver function test that was done on

19 me but they had no concerns really for Ziggy.

20 **Q.** You talk about how you thought that the staff were all

21 called into a meeting?

22 **A.** Yeah.

23 **Q.** Did you feel that everything was fine with Ziggy at that

24 point?

25 **A.** I did, yeah.

13

1 **A.** No. No one came in at all.

2 **Q.** How did you feel about being left in that situation?

3 **A.** Really unsafe.

4 **Q.** Why do you think that there was a delay in carrying out

5 that emergency C section?

6 **A.** We had a meeting, maybe December time, with a few of the

7 staff and they had told me the delay was because there

8 was another baby that had, I think, an 80% survival

9 rate, whereas at the time Ziggy only had 10, so they

10 chose basically to go in with the other baby.

11 **Q.** Do you think that there was enough staff there to be

12 able to treat you and to give Ziggy an early C-section?

13 **A.** No, not at all.

14 **Q.** Did anybody contact TJ to tell him what was happening at

15 this time?

16 **A.** No, he actually contacted the hospital a few times

17 himself. The first time I think he was told if I needed

18 him that I would phone him, to which he replied "If

19 she's in having a section she'll not have her phone",

20 and then he phoned another two times, I think, and they

21 told him to stop ringing and that it wasn't his

22 information to know.

23 **Q.** Did anybody else try and contact?

24 **A.** Yeah, my mum and my elder sister, and they were told the

25 same thing.

15

1 **Q.** So were you taken from A&E round to the maternity ward?

2 **A.** Yeah, a midwife, she came down with a wheelchair to take

3 me round to maternity from A&E, but that was another

4 five hours after he was scanned.

5 **Q.** Was TJ with you at any point in this?

6 **A.** No, he wasn't allowed in.

7 **Q.** Where was he, was he in the car park or somewhere else,

8 or ...

9 **A.** At home. We only live maybe like five minutes from the

10 hospital, so he stayed at home.

11 **Q.** When you were scanned, round in the maternity ward, how

12 many people were at that scan?

13 **A.** Maybe about four or five.

14 **Q.** What were you told were the results of that scan?

15 **A.** That Ziggy had very little amniotic fluid around him and

16 they were going to take me for an emergency section.

17 **Q.** Did you have a chance to talk to TJ at that time?

18 **A.** No, I just text him really quickly and then they had

19 prepped me for the section.

20 **Q.** Just before you go on, Ms Todd, because you talk about

21 the alarms going off.

22 **A.** Yeah.

23 **Q.** How long were you left after the alarms went off?

24 **A.** An hour.

25 **Q.** Were you told what was happening?

14

1 **Q.** So did anybody know when you actually went in to have

2 the C-section?

3 **A.** No.

4 **Q.** When was TJ allowed in?

5 **A.** I had had the section and then brought back up to

6 a room, so it wasn't until later that night, a few hours

7 maybe after Ziggy was born.

8 **Q.** How did TJ feel in that time between when he found out

9 that you were having a C-section and when he was

10 actually allowed to see you?

11 **A.** I think he was very anxious. He was at home with no

12 information of what was going on. He was completely

13 left in the dark.

14 **Q.** What happened to Ziggy after you had had the C-section?

15 **A.** I know when he was first born, he had a low Apgar score,

16 so they had him basically in the corner with the team

17 within NICU. They had done CPR and then taken him up to

18 neonatal intensive care.

19 **Q.** Did you have a chance to see him?

20 **A.** No.

21 **Q.** So when he was in the neonatal unit, did you have

22 an opportunity or, put that a different way, did the

23 nursing staff try and help you and TJ see Ziggy over

24 that night?

25 **A.** They tried to bring us round a few times during the

16

1 night but they didn't explain that they were bringing us
 2 round, they were just kind of putting me in full PPE and
 3 then into a wheelchair, and then the next minute I was
 4 back, they were getting me back out of the wheelchair
 5 and the PPE was off again.

6 **Q.** Were you in a room or were you in the ward at that time?

7 **A.** I was in a private -- like a side room. I think it's
 8 actually the bereavement room that's in the hospital.

9 **Q.** So you didn't have to be in PPE in there?

10 **A.** No.

11 **Q.** Was TJ allowed to be in with you there?

12 **A.** Yeah.

13 **Q.** Was he allowed to be in there with you all night or did
 14 he have to leave?

15 **A.** He -- as soon as he came into the hospital, he stayed
 16 with me then in the room. We actually had a midwife who
 17 came in and sat -- and this was after Ziggy had
 18 passed -- sat on the floor and told him that he wasn't
 19 allowed to leave. He basically said he hadn't left, and
 20 she said, "That's fine, you shouldn't even be here,
 21 we've already bent over backwards for you, you shouldn't
 22 even be here."

23 **Q.** How did it help you to have TJ with you that night
 24 before Ziggy passed away?

25 **A.** I think it was more so the support because I hadn't been

17

1 **Q.** What did you think Ziggy's condition was before you saw
 2 him?

3 **A.** As I say, the midwife had stated that his obs were
 4 starting to pick up, so we thought we were being brought
 5 round to meet him as he was getting better. We weren't
 6 told at the time that he was palliative care or
 7 anything.

8 **Q.** What did you find was -- how was Ziggy when you went in?

9 **A.** He was basically in an incubator, in a private NICU room
 10 that actually overlooked the main neonatal. There was
 11 a window so people could see in and we could see him
 12 there, but he had all the medical equipment on basically
 13 and when we came in they had taken him off everything
 14 and, again, we thought that he was getting a lot better
 15 at that point, that they were able to remove everything.

16 **Q.** When did you find out that wasn't the case?

17 **A.** They took everything off and then handed Ziggy over to
 18 me, and then they just left the room, and then he passed
 19 away, and they didn't come back for maybe about another
 20 two hours.

21 **Q.** Was that the first time that you had been with Ziggy
 22 since he was born?

23 **A.** Yeah.

24 **Q.** Was that the only time that TJ got to see Ziggy?

25 **A.** Yeah.

19

1 given that option the whole time that, you know, Ziggy's
 2 movements reducing, he wasn't allowed into any scans and
 3 then again in A&E. So I think it was more so the
 4 support and he obviously was in the same boat that I was
 5 at the time, no one was telling us anything, so it was
 6 just the two of us kind of talking with each other.

7 **Q.** Did you know how unwell Ziggy was that night?

8 **A.** At the start they'd said that he was really unwell but
 9 then later on one of the midwives had made a comment
 10 that his obs had been picking up, that was just before
 11 we were brought round to meet him, so we actually
 12 thought he was getting better, a good bit better, before
 13 we were being brought round to see him the next day.

14 **Q.** Do you think the fact that you were Covid positive had
 15 anything to do with the amount of information that you
 16 were being given about Ziggy's condition overnight?

17 **A.** Yeah, I think they were trying not to come in and out of
 18 the room as much as probably what they would have if
 19 I wasn't Covid positive.

20 **Q.** Were you or TJ receiving any food and drink, for
 21 example?

22 **A.** Yeah.

23 **Q.** You went round and saw Ziggy, was it about 8.30, 9.00
 24 the following morning?

25 **A.** Yeah.

18

1 **Q.** Were you having to wear full PPE when you were with him?

2 **A.** Yeah, we had to show PPE. We had hairnets, masks,
 3 a visor, a full apron, gloves and I think shoe -- like,
 4 shoe coverings.

5 **Q.** What did you think about being asked to wear PPE to
 6 visit Ziggy?

7 **A.** I thought it was unnecessary, especially at the time
 8 they knew how unwell he was, we didn't. So now looking
 9 at it, I'm a bit confused as to why we were in full PPE,
 10 because, you know, if they knew that he was being taken
 11 off life support, I don't understand who the PPE was
 12 protecting. Also he was in a private, like, infection
 13 room, so again, I don't think it was necessary to have
 14 full PPE.

15 **Q.** Wearing PPE, does that have a lasting impact upon your
 16 memories of your time with Ziggy?

17 **A.** Yeah. All of our photos that we have with him are in
 18 full PPE.

19 **Q.** How long were you with Ziggy for?

20 **A.** We were -- after he had passed, as I say, they left us
 21 in that room for about two hours, before they came back
 22 and then they brought us back to the bereavement room.
 23 I think -- I'm not sure but I think they possibly had
 24 like washed him and stuff, we weren't given the option
 25 again to do that, and then they brought him round to the

20

1 bereavement room.

2 **Q.** In those two hours did anyone come in and see you?

3 **A.** No.

4 **Q.** You said earlier on that in the room that Ziggy was in

5 you could be seen from the outside?

6 **A.** Yeah.

7 **Q.** Was there a curtain or a screen or anything that was put

8 up?

9 **A.** Nothing. I think only after the SAI was done, because

10 it was something that I highlighted, as there was

11 another baby that was on the opposite side of the window

12 and his -- the baby's dad -- what I assume was the

13 baby's dad was able to watch everything.

14 **Q.** You stayed in the hospital for some days afterwards.

15 How much time was TJ able to spend with you?

16 **A.** He stayed with me the whole time then in that room.

17 **Q.** How beneficial was that for both of you, that you were

18 able to spend time together?

19 **A.** Really important. I think also it was really the only

20 time that we got with Ziggy, so it was very important.

21 **Q.** You had mentioned earlier on about the midwife coming

22 over and saying, "You can't be leaving this room, we've

23 bent over backwards for you". Was that two days after

24 Ziggy had passed away?

25 **A.** Yeah, he was actually on my chest at the time.

21

1 **A.** Yeah, that's right.

2 **Q.** Do you know the reason for that?

3 **A.** No. No.

4 **Q.** Had anyone ever told you whether there was anyone

5 actually in Northern Ireland capable of carrying out

6 a postmortem on a child at that time?

7 **A.** No, that was really our only option, was that he went to

8 Alder Hey and in the bereavement room they brought round

9 like a DVD to watch of stages, basically, and what would

10 happen, from timeframes to like who would be with him

11 and -- but obviously that didn't happen either.

12 **Q.** How important was it to you to know where Ziggy was at

13 all times in that trip to and from Liverpool?

14 **A.** Extremely important.

15 **Q.** Were you kept informed about where he was?

16 **A.** No, not at all. We were told that he would be picked up

17 from the Ulster on the Monday and back on the Wednesday.

18 When in turn it came to the Monday, I had heard nothing

19 at all, so I contacted the hospital themselves, and they

20 basically said they didn't know where he was, he wasn't

21 there. They suggested that I contact the Royal

22 mortuary, so when I done that they weren't sure where he

23 was either, and they told me to maybe phone Liverpool.

24 So I'd phoned Liverpool maybe that night and, again,

25 I got a guy on the phone who wasn't too sure. He said

23

1 **Q.** What was your overall view of the compassion that you,

2 TJ and Ziggy received from the staff at that time?

3 **A.** I don't think -- I don't think there was any, at all.

4 I don't think anyone cared. I think they were too busy.

5 They were rushing in and out of the room and just didn't

6 really care.

7 **Q.** Do you think they knew what to do, how to cope with

8 Covid and pregnant people at that time?

9 **A.** Not at all.

10 **Q.** Do you think there was enough staff to be able to look

11 after everyone in the maternity unit at that time?

12 **A.** No.

13 **Q.** Were you offered any help with bereavement or grief

14 while you were in hospital?

15 **A.** I later learned that leaving the hospital we were

16 supposed to have a bereavement midwife, as we were

17 leaving, which we didn't hear from until I think it was

18 two weeks later, and she actually contacted TJ to tell

19 him funeral arrangements that we had made.

20 **Q.** You were told that Ziggy was to be sent for

21 a postmortem?

22 **A.** Yeah.

23 **Q.** Do you know that -- well, his body was going to have to

24 be collected to be taken to a hospital in Liverpool for

25 a postmortem; is that right?

22

1 he didn't think there was any babies that had come over

2 from Belfast. Until the next morning, a lady from the

3 Snowflakes team had contacted me to let me know that he

4 wasn't there and she didn't -- she had stayed in contact

5 with me but then she phoned me again on the Wednesday

6 morning. But on Tuesday night she had told me that

7 there was two babies coming from Belfast but they didn't

8 know their names until they got there. So she phoned me

9 maybe at about 6.00 Wednesday morning to let me know

10 that he had arrived in Liverpool. So he had basically

11 been in the Ulster the entire time.

12 **Q.** So is it right that it was about two days where you

13 didn't know where Ziggy was?

14 **A.** Yeah.

15 **Q.** What did you think of the level of contacts that you had

16 had from the hospital in Northern Ireland?

17 **A.** I thought it was appalling.

18 **Q.** Were you able to have an open coffin for Ziggy?

19 **A.** In the end but very nearly no. The Ulster had put on

20 "maternal Covid" on his death certificate and, as

21 a result, the funeral directors' policy was that they

22 wouldn't then be able to manage his body, and it was

23 only from the lady actually that was working in the

24 Snowflakes team over in Liverpool, she had phoned me

25 just to see if we had a CuddleCot and, at the time,

24

1 I didn't even know what that was.

2 **Q.** Could you just explain quickly what a CuddleCot is?

3 **A.** It's like a small Moses basket type shape, a device that

4 keeps the baby cold, so you can spend more time with

5 them.

6 **Q.** How important was it to you at that time to spend time

7 with Ziggy?

8 **A.** Extremely important, especially --

9 **Q.** How long -- sorry.

10 **A.** Sorry, just because we'd even been told that it was

11 going to be a closed coffin, you know, it was really

12 important to us that we got to make memories that were

13 good.

14 **Q.** How long did it take for you to be given a CuddleCot?

15 **A.** When he came home, he was due to be home with the

16 funeral directors, and because the lady from Snowflakes

17 team had phoned, everything kind of had to be delayed,

18 so we could arrange with the hospital to collect the

19 CuddleCot. And I think, if I remember correctly,

20 I think TJ actually had to go up and collect it himself.

21 **Q.** You were talking about an open coffin. Is it right that

22 it was only when the funeral home were told that Ziggy

23 had had a negative PCR test that you were able to have

24 an open coffin?

25 **A.** Yeah. So the lady from Snowflakes team is the one who

25

1 but if it helps her sleep then, you know, what's the

2 issue that she's given them?" And basically then we

3 were given half, we weren't given the full -- the full

4 medical notes, we were only given half of them, and

5 I think it was a few days even for them to photocopy

6 that out. We'd never actually received our own -- the

7 green file, it's just been a photocopy.

8 **Q.** Do you think it was a battle to get those notes?

9 **A.** Yeah.

10 **Q.** I just want to ask about your overall impressions,

11 Ms Todd. When you look back on all of your experiences

12 in that period in July 2021, do you think that there

13 were enough staff to treat you at that time?

14 **A.** No.

15 **Q.** Do you think that the staff knew how to treat a pregnant

16 woman with Covid back in 2021?

17 **A.** No.

18 **Q.** Did you feel safe as a pregnant lady in Northern

19 Ireland?

20 **A.** Not at all, no.

21 **Q.** It's right that you're pregnant now, is it?

22 **A.** Yeah.

23 **Q.** Do you feel safe as a pregnant lady in Northern Ireland

24 now?

25 **A.** No.

27

1 organised it all. She phoned round the Ulster from

2 Liverpool to ask if he had a PCR. Now, we were never

3 asked or gave consent for him to have a PCR done, but

4 basically that's -- that's the only reason why, is she

5 then obtained it from the Ulster. And then she

6 contacted the funeral directors as well, to let them

7 know that Ziggy's PCR was done by the hospital and it

8 was negative.

9 **Q.** This was a Snowflakes team, this is in Liverpool, it's

10 not a Northern Ireland service; is that right?

11 **A.** Yeah.

12 **Q.** How did you feel about the level of communication that

13 you'd received about the CuddleCot, about the PCR that

14 would allow you to have an open coffin?

15 **A.** There wasn't any. There wasn't any communication.

16 You know, it was -- everything was done either by us or

17 from another service that's not in Northern Ireland.

18 **Q.** Is it right that after Ziggy's death and after the

19 funeral arrangements you'd tried to get access to the

20 records that were held about you and about Ziggy? How

21 easy was it to get access to those records?

22 **A.** Extremely difficult. We phoned and phoned, and a lady

23 actually told TJ she wasn't so sure why -- why I wanted

24 them, even to begin with, and he said -- he had replied

25 to her, saying "It doesn't matter why she wants them,

26

1 **Q.** Did you feel listened to by medical staff in 2021?

2 **A.** No.

3 **Q.** You have since given birth, as you say. Is it right

4 that some of those who had been involved in your time

5 with Ziggy arrived at your bedside at the time when your

6 child was born?

7 **A.** Yeah.

8 **Q.** How did that impact upon your experience with her?

9 **A.** I don't think it was necessary at all. I also was

10 admitted the majority of my pregnancy with my second,

11 and had people that were dealing with the SAI with Ziggy

12 at the time come round to see me while I was admitted

13 with my second, which again I don't think there was any

14 need for.

15 **Q.** How have your experiences made you feel towards the

16 healthcare system in Northern Ireland?

17 **A.** I don't have much hope in it.

18 **Q.** Just finally, how are you now?

19 **A.** Not -- not great. It's obviously something that's

20 completely impacted the rest of our lives, and I think

21 we have just been left to deal with it ourselves. We're

22 kind of away from the hospital now and that's all,

23 you know, that matters to them, we're out the door, and

24 we're the ones left with this for the rest of our lives,

25 basically.

28

1 **MR SCOTT:** Thank you, Ms Todd.
 2 My Lady, I've no further questions.
 3 **LADY HALLETT:** Thank you very much indeed, Ms Todd, I hope
 4 we have not added to your trauma and grief. No one can
 5 ever replace Ziggy and I know that you and his father
 6 will never forget him and you will always miss him.
 7 I just hope that the new baby and your daughter can help
 8 you come to terms with the grief that I'm afraid is
 9 going to be with you forever. But thank you so much and
 10 best of luck with the new baby.

11 **THE WITNESS:** Thank you.

12 **LADY HALLETT:** Right. I think we'll take a break now,
 13 Ms Todd, I think there are some people who may wish to
 14 speak with you, so Ms Campbell and others may just come
 15 and say -- repeat the thanks, I suspect, that I have
 16 already given. And we will take a short break and then
 17 we will come back to the next witness. Thank you again.

18 **(The witness withdrew)**

19 **(10.45 am)**

20 **(A short break)**

21 **(10.56 am)**

22 **LADY HALLETT:** Ms Carey.

23 **MS CAREY:** My Lady, before we call the next witness, can
 24 I deal with one matter. You have just heard, now, from
 25 four witnesses who are giving evidence from the bereaved
 29

1 Covid transmission, and its implication for infection
 2 prevention and control in healthcare settings?
 3 **A.** Yes, that's the case.
 4 **Q.** It has the formal INQ ending 474276 and we will be going
 5 through a number of pages and paragraphs in it. I hope
 6 you have a copy in front of you.
 7 **A.** I have, yes.
 8 **Q.** Before we delve into the science, can I start with you,
 9 please, and a little bit about your background. It's
 10 set out at pages 4 and 5 of your report, but does it
 11 come to this: that you are a bioengineer and
 12 a physiologist and an emeritus professor of applied
 13 physiology at Leeds Beckett University?
 14 **A.** I am, yes.
 15 **Q.** I think you are a multidisciplinary scientist, with more
 16 than 25 years researching the transmission of infection
 17 in hospitals, and you have worked in neurology as well?
 18 **A.** Yes, I have, yes.
 19 **Q.** You specialise in what is termed interdisciplinary
 20 research and you have particular expertise in the
 21 transmission of infectious diseases in hospitals?
 22 **A.** Yes.
 23 **Q.** And you also have particular expertise in ventilation
 24 and the behaviour of aerosols in the air, biophysics and
 25 the application of engineering interventions to mitigate
 31

1 groups across the UK, and in addition to publishing
 2 their statements the Inquiry also obtained statements
 3 from four other individuals: Seema Bhalla,
 4 Sam Smith-Higgins, Margaret Waterton and Fidelma Mallon.
 5 Can I invite you, please, to publish both the four
 6 people that we have heard from and indeed those four
 7 additional statements onto the Inquiry website.

8 **LADY HALLETT:** Certainly. I should say I was re-reading the
 9 statements of the four bereaved that you are about to
 10 publish earlier today and they are all as moving as the
 11 evidence we have heard over the last few hours.

12 Also I should say that you mentioned I think in your
 13 opening about documents being published. The default
 14 setting will be publication unless there is a reason not
 15 to.

16 **MS CAREY:** Thank you very much, we are very grateful.
 17 Can I invite now, please, Professor Clive Beggs to
 18 be sworn.

19 **PROFESSOR CLIVE BEGGS (affirmed)**

20 **Questions from LEAD COUNSEL TO THE INQUIRY for MODULE 3**

21 **MS CAREY:** Thank you, sit down.

22 Professor, your full name, please?

23 **A.** My name is Clive Barron Beggs.

24 **Q.** You have provided, I think, a 132-page report to
 25 Module 3 dealing with the physical science underpinning
 30

1 the transmission of infection?

2 **A.** Yes, those are all areas of my expertise.

3 **Q.** Before entering academia, is it right that you worked as
 4 a professional engineer designing ventilation and air
 5 conditioning systems for buildings, and as such you have
 6 knowledge, indeed intimate knowledge, of hospital
 7 ventilation systems?

8 **A.** Yes, that was the first part of my career.

9 **Q.** I think during the Covid pandemic, you worked and served
 10 on the Royal Society Rapid Assistance in Modelling the
 11 Pandemic working group?

12 **A.** I did, yes.

13 **Q.** If it's not clear from what I've just said, you are
 14 a research scientist but not a clinician?

15 **A.** That is absolutely the case.

16 **Q.** I think though that you know that the Inquiry has
 17 instructed a trio of experts with clinical background
 18 who can help in relation to that matter?

19 **A.** Yes.

20 **Q.** All right.

21 Can we take down, please, the screen, thank you very
 22 much.

23 Can we at the outset, please, try to ensure that
 24 when giving your evidence and -- people reading your
 25 report understand the language and understand the
 32

1 science about the way that the Covid is transmitted.
 2 All right?
 3 **A.** Yes.
 4 **Q.** We're going to look, firstly, at the language, and
 5 I think, Professor, you may have heard me explain that
 6 although obviously we're dealing with SARS-CoV-2, for
 7 ease I'm going to try to just refer to it as Covid-19?
 8 **A.** Yes, and I will try to use the same but I probably will
 9 slip into SARS-CoV-2, please forgive me, but -- and
 10 I'll probably say SARS or SARS-CoV-1 for the other
 11 one --
 12 **Q.** For the other -- all right. If there is any confusion
 13 we will do our best to clarify.
 14 **A.** But I will also talk about the spread of Covid as well.
 15 **Q.** Thank you.
 16 **LADY HALLETT:** When we're talking about confusion,
 17 Professor Beggs, I was having a conversation with
 18 a doctor at the weekend, and of course "ventilation"
 19 gets used in two different ways in this context, doesn't
 20 it?
 21 **A.** Yes.
 22 **LADY HALLETT:** There's the ventilation which is opening the
 23 windows and you've got ventilating a patient.
 24 **A.** Oh, right, yes, absolutely. In fact I've had this
 25 happen in my professional life when we have been talking

33

1 diseases are either hospital doctors, microbiologists,
 2 virologists or infection control nurses. They're not
 3 necessarily -- in fact they're not trained in
 4 engineering generally, and so we have had a kind of two
 5 parallel universes come up with one group of people who
 6 are on the clinical side of things and mostly in the
 7 medical and infection prevention and control -- which
 8 I'm going to call IPC after that -- who have gone down
 9 one route and used one set of terminology, whereas those
 10 working in physics, engineering and aerosol science,
 11 I suppose, have used another terminology, and I'm from
 12 that camp, although I cross over into them.
 13 So I will use -- I'm afraid that's the more correct
 14 terminology, by the way, from the physics, so I'm going
 15 to go with the physics. So that's -- there has been
 16 a lot of confusion, that's all I'm saying.
 17 **Q.** We're going to look at perhaps some of the ways that
 18 confusion plays out as we go through your evidence but
 19 can I start, please, with in your report you use the
 20 phrase "large droplets". What is a large droplet,
 21 please?
 22 **A.** Right, first of all, to say droplets/large droplets, I'm
 23 using that term here, it's my term for this inquiry
 24 because people, especially from a lay background, need
 25 to know this -- we're talking the upper end of things

35

1 to clinicians and there's been crossed wires.
 2 Yes, you ventilate patients who are having problems
 3 with breathing in intensive care units and places like
 4 that, but in this occasion we're not talking about that.
 5 I have done work on bits and pieces on that but in this
 6 case we're talking about the ventilation of room spaces
 7 like this room here and air movement in rooms.
 8 **LADY HALLETT:** Thank you.
 9 **MS CAREY:** Thank you.
 10 All right, some basic terminology, please, and
 11 I think it starts on page 7 of --
 12 **A.** Yeah.
 13 **Q.** -- your report but I just want to ask you about the
 14 language that you have used in the report because, as
 15 I think you are aware, there is not necessarily
 16 consensus about the terminology and we're going to just
 17 be clear about what you mean by things and then we'll
 18 look perhaps at what some other people say about the
 19 terminology. All right?
 20 **A.** Yes.
 21 **Q.** Can you help us, as a general starting point though, why
 22 does the terminology matter?
 23 **A.** Well, the reason it matters is because, historically,
 24 there has been an awful lot of confusion and, if you
 25 think about it, most people involved in infectious

34

1 and they're above 100 microns, that's micrometres, I'll
 2 use the term "micrometres" or "microns". It's the same
 3 thing.
 4 **Q.** Is that the size of the particle?
 5 **A.** That's the diameter of the particle but we abbreviate
 6 that to 100 microns. And there is a very good reason
 7 we'll explain in a minute.
 8 **Q.** All right. So a larger droplet, in your terminology for
 9 this report --
 10 **A.** Is that, yes.
 11 **Q.** -- is a particle greater than 100 microns?
 12 **A.** Yes.
 13 **Q.** All right. Just help the layperson, can we see
 14 a micron?
 15 **A.** A micron is a thousandth of a millimetre, so we can just
 16 about see those. You know, it's about the thickness of
 17 a hair, I think. I think I read 50 microns is the
 18 thickness of a hair but it's that type of order of
 19 magnitude. Yes, you can actually feel those droplets --
 20 **Q.** You can feel a larger droplet?
 21 **A.** You can feel a larger droplet, you know, when someone
 22 coughs on you or something.
 23 **Q.** In a nutshell, help us, how does a larger droplet behave
 24 once it's in the air?
 25 **A.** Right. So from an engineering point of view and

36

1 a physics point of view, it behaves ballistically and
 2 that means it's like -- "ballistic" means it's got some
 3 mass, it's got weight and, when you throw it -- so it's
 4 like throwing a stone. So it has a trajectory. So it's
 5 got some velocity and mass. And if we're talking in the
 6 context of respiratory aerosols, someone's exhaled it,
 7 either coughed it or whatever, these are so large that
 8 they will fall rapidly to the floor, and they can't go
 9 more than about 1 metre, 1.5 metres before they hit the
 10 floor. There's something to do with evaporation but I'm
 11 sure we'll come to that later.

12 **Q.** I'll cover that. All right, so the larger droplets
 13 behave ballistically, either they --

14 **A.** Yes, ballistically, like a stone being thrown, that's
 15 the way to look at it. They've got a trajectory.

16 **Q.** Thank you. Aerosol particles, please.

17 **A.** Yeah.

18 **Q.** How have you defined them in your report?

19 **A.** I've defined them and used the general understanding
 20 which has been around since the 1930s, really, in
 21 engineering and physics, with relation to the
 22 respiratory particles. They're the particles that are
 23 less than 100 microns. Any particle of that size in
 24 this context is that. There's not a strict actual --
 25 any demarcation for aerosols. It's -- the definition is

37

1 therefore you can be interchangeable. Anything that's
 2 aerosol transmission is airborne transmission, the two
 3 are --

4 **Q.** Pause there. We have a stenographer who is taking
 5 a note and you're also covering some quite
 6 complicated --

7 **A.** Yes.

8 **Q.** So I just want to try and break the answers down
 9 a little, if I may, and perhaps give slightly shorter
 10 answers and then we can ask for more information if it
 11 helps.

12 **A.** Absolutely.

13 **Q.** So larger droplets behave ballistically, they are
 14 100 microns or greater; aerosol particles are less than
 15 100 and they float in the air, in short.

16 **A.** Yes.

17 **Q.** Right. Okay.

18 You spoke about the 100 microns being, effectively,
 19 the dividing line between larger droplets and aerosols.
 20 Is that a general agreement about that dividing line at
 21 100 microns?

22 **A.** This is where the historical confusion comes in.
 23 Amongst physicists and people from my background,
 24 physicists and engineers, there's a fairly -- agreement
 25 from back in the 1930s, when this work was done. Shall

39

1 to do with the behaviour and the characteristics.

2 **Q.** Right.

3 **A.** I'm sure we'll talk about that in a minute.

4 **Q.** So you told us how the larger droplets behave. What
 5 about the aerosol particles, how do they behave in air?

6 **A.** Right, so the aerosol particles, as I -- just to
 7 reiterate, are below 100 microns, right, and they can be
 8 various sizes down to very small sizes. The thing about
 9 an aerosol, by definition an aerosol is a suspension,
 10 a mixture of particles, and they can be liquid or solid
 11 or a bit of both, which is what you have with
 12 respiratory particles in air, in a gas, in air, and the
 13 really key thing is they float, they're suspended,
 14 they're floating in the air and the really important
 15 point is that they take on the -- air is a fluid
 16 actually, you don't think of it like that but it is, it
 17 flows.

18 They take on the fluid mechanics, the fluid dynamics
 19 of the overall fluid. So, in other words, wherever the
 20 air goes, the particles go if they're an aerosol.

21 That's the definition.

22 **Q.** Right.

23 **A.** All right?

24 **Q.** So, in short, they float?

25 **A.** They float in the air, while they're in that air, and

38

1 I explain the -- why the division is there at 100?

2 **Q.** Yes.

3 **A.** Yep. The reason that's a division is that, as soon
 4 as -- when you exhale particles, right -- so I'm just
 5 going to call them particles, respiratory particles,
 6 both aerosols and droplets -- they evaporate. There's
 7 a lot of water in them so they immediately start to
 8 evaporate and they shrink down to about a third of their
 9 size and, basically -- so if they're less than say
 10 a 90-micron particle, that will end up at 30. In fact,
 11 there's very little in that upper range, they're down at
 12 30 and below.

13 However, the particles that are larger than 100,
 14 they're so big that what happens is they don't have
 15 a chance to evaporate before they hit the ground, so
 16 that's why the divide happens.

17 So this lot are kind of going down onto the floor,
 18 whereas the ones smaller, they can kind of evaporate and
 19 they then are wafting round the room on the air
 20 currents, basically, and they're aerosols.

21 **Q.** I think you said there that, where you used the phrase
 22 "respiratory particles", you're using it as a term that
 23 covers both the larger droplets and the aerosol
 24 particles; is that right?

25 **A.** Yes, and the reason I -- I'm just -- to clarify that,

40

1 when writing this report, I had to -- as we will go on
2 to explain, there's a lot of confusion. I had to set
3 out a framework and so it was extremely helpful just to
4 refer to them as "respiratory particles" and that's what
5 I'm doing here, referring to them all as that, including
6 everything.

7 **Q.** We are going to come on to look at the way in which
8 viral infections are transmitted, and obviously Covid in
9 particular, but I want to just stand back for a moment
10 and just get an overview of where we were at the start
11 of the pandemic and where we are now in 2024.

12 If I ask you now in 2024 how is Covid transmitted,
13 by which route I mean, what's your answer?

14 **A.** My personal answer and my personal opinion,
15 predominantly by an airborne route.

16 **Q.** Right, by an airborne route, by which you mean by
17 aerosol particles?

18 **A.** By aerosol particles, although obviously I'm not
19 excluding other routes as well, droplets and other
20 things involved, yeah.

21 **Q.** So --

22 **A.** That's my belief.

23 **Q.** -- it transmits via airborne but it does also transmit
24 via the droplets?

25 **A.** Oh, yes, and contact.

41

1 **Q.** What about those who were advising, preparing papers,
2 preparing IPC guidance, are you able to tell us what
3 their view was back in 2020 as to how Covid was
4 transmitted?

5 **A.** Not the same as mine. The answer there is -- I should
6 have said, sorry -- qualified my own belief --
7 I believed it was airborne but I believed it was likely
8 to be airborne, that there was a strong component. So
9 when I say that, I'm not being exclusive, I'm saying
10 that my belief is probably that it was airborne.

11 No, the general belief was that it was by droplets
12 and contact and fomite transmission. That's something
13 which we'll come on to. That was the general consensus
14 at the beginning of the pandemic, which is why so much
15 emphasis was on washing hands, and things like that.

16 **Q.** So the position has, in fact, evolved from droplet being
17 thought of as to be predominant in 2020 to now
18 certainly, by 2024, if not earlier, the role of airborne
19 transmission is now perhaps considered to be different
20 and more important --

21 **A.** Yes, the World Health Organisation is -- realises now
22 that airborne is -- and the CDC -- that it makes
23 a significant contribution. There's still argument over
24 which is the predominant route, in various quarters but,
25 you know, it's shifted, the consensus has shifted

43

1 **Q.** Right, and then we're going to come onto contact. In
2 a nutshell, what is contact transmission?

3 **A.** That's where we start to talk about hand-to-hand
4 contact, you know, someone, you know, coughing into
5 their hands, shaking hands with someone, and then the
6 other contacts are, for example, you cough, you touch
7 a door handle, something we call a fomite, it's
8 an inanimate object, and then someone else touches that
9 and touches their mouth or their eye or something.
10 There's a route of solid contacts in --

11 **Q.** We'll look at that in a bit more detail but they're the
12 three predominant routes that are in play for the
13 purposes of transmission?

14 **A.** Yeah, some people divide them up into subgroups -- into
15 different names but --

16 **Q.** Don't worry about that.

17 **A.** Basically, that's what we're talking about: the
18 aerosols, the droplets and then the contact routes,
19 which include fomite transmission.

20 **Q.** That is your opinion of how Covid is transmitted now in
21 2024. What was your opinion back in 2020 when the
22 opinion started?

23 **A.** It was airborne.

24 **Q.** Fine.

25 **A.** That was my opinion personally.

42

1 considerably.

2 **Q.** Okay. A little bit more background, please, about how
3 respiratory viral infections transmit, and I think you
4 say at your paragraph 14, as is probably obvious, that
5 in order for an infection to spread --

6 **A.** Yeah.

7 **Q.** -- the infectious individual must shed virus particles
8 into the environment in such numbers thought generally
9 to range from several hundred to many thousands,
10 depending on the virus, such that a few eventually reach
11 the target receptors of a susceptible host.

12 Can we put that into perhaps more easily explicable
13 language?

14 **A.** Yeah, I can easily do that, it's a numbers game really.
15 So we've got two ways of looking at this. The first one
16 is a mechanistic thing. This is what we do as engineers
17 and bioengineers, things have to get from A to B to
18 cause an infection. So you can look at it in terms of
19 the transmission route or routes. Someone's got to
20 produce some virus that's viable that's going to
21 transmit through the environment somehow. This could be
22 in the air, or it could be in the hands or whatever.
23 Then it's got to get to the target and the targets in
24 this case are receptors, which I'm sure we'll talk about
25 later on --

44

1 Q. Pause there. Just help us: in relation to Covid what
2 are the main receptors?
3 A. The main receptor with Covid is ACE2 receptors.
4 Q. Where are they in the body?
5 A. Predominantly the ones we're most interested in are in
6 the nasal cavity and also in the upper respiratory
7 tract, the lining of the mouth, throat, but they do go
8 down into the lungs. They're also on the eyes, and
9 I'm not so sure but I think also possibly on the lips as
10 well, maybe there.
11 Q. Pausing there, that's, in short --
12 A. But to a lesser extent, you know.
13 Q. Pausing there, that's in short as to how the virus Covid
14 gets into the body, mouth, down the tract, in through
15 the nose or in through the eyes?
16 A. Yes, there's got to be. It doesn't do it by magic.
17 Things have to move from one place to the other and they
18 have to have some kind of vector, some transport. But
19 on top of that, I think you asked me earlier on -- if
20 this is okay, or shall we leave this for later -- the
21 numbers game --
22 Q. We'll come to the numbers in a minute. I just want to
23 set out some basics and then we can descend to the
24 detail as we go through your evidence.
25 A. Which -- sorry, just to clarify, I think that was in
45

1 say later but, at the moment, we're -- that's where the
2 infection occurs.
3 Q. Right, exactly, let's just stick with the infected
4 person then. You can see there that we've got there
5 lungs and, indeed, you've highlighted -- or the figure
6 has highlighted the alveolar; is that deep into the
7 lungs, in short?
8 A. The alveolar are right at the bottom end, right at the
9 far end of the lungs, that's where the oxygen transfer
10 goes on.
11 Q. Right. We go up, effectively, through the bronchial,
12 laryngeal --
13 A. Yeah, the bronchial is the larger --
14 Q. -- into the person's mouth.
15 A. Yeah.
16 Q. They may be sneezing or coughing here, it matters not,
17 and out come the aerosols and the droplets?
18 A. Yeah. We basically call -- the kind of lower
19 respiratory tract is basically anything below where the
20 kind of mouth and nose is --
21 Q. Right.
22 A. -- down into the lungs; and the upper respiratory tract
23 is up from the larynx upwards. But, yeah, so this is
24 where all the droplets come from. There's a lot of
25 fluid there basically in all that and, even when people
47

1 there as well about the hundreds, and things like that.
2 We'll talk about that later, yeah.
3 Q. All right. Can I ask, please, about one of the diagrams
4 in your report and could we call up, please, page 10 of
5 the report and figure 1, which might help bring this
6 together. I think you've set out there how effectively
7 the virus transmits. You've spoken there about aerosols
8 and droplets and there's various size of droplets on
9 there.
10 Can you just help us, please, what are we looking at
11 here with the person on the left, the infected person?
12 A. Yeah, this is an excellent diagram which I use in my own
13 lectures, but it's not one I produced, it's from a paper
14 that sums up everything.
15 So just to -- if you can see on the far left-hand
16 side, you can see aerosols and droplets, and that
17 basically tells you everything we've said already, the
18 division, and they -- it highlights that the droplets
19 are not really inhalable and they're larger than
20 100 microns, whereas the aerosols are inhalable.
21 So if we see the infected person.
22 Q. Yes.
23 A. Now, we're actually seeing the whole respiratory tract
24 there, the lungs and the upper respiratory tract and
25 everything. That's useful for maybe things we want to
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1 are breathing, they're producing aerosols. So I'm sure
2 we'll talk about that later on but that's where they
3 come from or originate. And if they're infected,
4 there's a virus in there, and that's going to come out,
5 and once they leave the mouth or the nose, they're in
6 the room space and in the environment, which is the next
7 part.
8 Q. Pause there.
9 A. Yeah.
10 Q. We can see then that the infected person has coughed or
11 sneezed or exhaled --
12 A. Yeah.
13 Q. -- and the size of the droplets -- and does the arrow
14 pointing down to the bottom or the middle of the page
15 indicate there effectively the ballistic way --
16 A. Yes, that's --
17 Q. Can I finish?
18 A. Yep, sorry, my mistake.
19 Q. All right. Can we see there the ballistic nature of the
20 droplets falling to the ground?
21 A. Yes, we can.
22 Q. All right. Can we also see there the aerosols, the
23 smaller dots on the screen, floating across to the
24 potential host, over a distance of about 1 metre, and
25 then potentially going into the receptors on the
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1 potential host?

2 **A.** Broadly speaking, yes, you're right. At various sizes
3 there's aerosols. They are actually going more than
4 1 metre in this diagram.

5 **Q.** Yes, they can keep going on the bottom.

6 **A.** They can go a lot further than 1 metre, I can assure
7 you.

8 **Q.** Thank you.

9 **A.** They are -- yeah, they are then going into the receptors
10 in the susceptible person, in the host.

11 **Q.** All right. Help us, please, the aerosols, the smaller
12 particles, where do they tend to end up in the potential
13 host?

14 **A.** They, what happens is that those aerosols are floating
15 in the air. They're various sizes, right, and they are
16 inhaled if they come into the -- in front of the face,
17 they're inhaled through the nose and through the mouth,
18 depending on whether you're mouth breathing or nose
19 breathing, and what actually happens during respiration
20 is you exhale out and so, when you're exhaling out
21 there's actually a jet of air coming out and it's
22 blowing away little aerosols, and then when you inhale,
23 which we call aspiration, we take a breath, through the
24 nose, actually the air velocities can be quite large,
25 they can be between 10 cm to -- up to 40 cm per second

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1 called a film burst, when you breathe out, and that's
2 just even in breathing, and you produce these tiny
3 aerosols and these are kind of like 1, 2-micron size,
4 they're really small.

5 The other place where you get smaller aerosols are
6 often around the vocal chords there as well. They
7 produce slightly bigger but they're also 5 micron, maybe
8 below 10 micron, they can be a range of sizes, so the
9 fluid there.

10 The largest particles are generated in the actual
11 mouth and they're saliva, that's where the big ones, the
12 over 100 microns.

13 So actually the particle size reflects where they're
14 generated and now we know also that the microbes, if
15 they're bacterial or viruses, in them tend to reflect
16 where they're generated, so --

17 **Q.** So the question I asked you was --

18 **A.** Sorry.

19 **Q.** -- where in relation to Covid were the infectious
20 particles generated?

21 **A.** Good question. The answer is not 100% clear cut but
22 I would say mostly in the lungs, deep in the lungs and
23 in the vocal chords, although we can't exclude that some
24 other virus might be in the larger droplets as well.

25 **Q.** Understood, thank you very much.

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1 and these capture the aerosols that are in that area,
2 that's both through the mouth or the nose, depending on
3 the rate of breathing, right, and how wide your mouth
4 is, and those capture them and the air sucks in and the
5 aerosols go in and then they impact in various parts.
6 The smaller ones tend to go deep into the lungs, into
7 the lower respiratory tract, whereas the larger
8 particles, over 10 microns, definitely stick around up
9 here.

10 **Q.** All right. So we've just looked there at how the
11 infection gets into the potential host. I just want to
12 ask you this: where, in relation to Covid, is it your
13 view that infectious particles are generated in the
14 infected person? If it helps you, I'm at paragraph 26
15 in your report on page 13.

16 **A.** Well, I think I can probably answer it anyway but --
17 without looking to it. I think I'm just going to fly
18 blind.

19 Particle sizes -- it used to be thought that it
20 didn't matter where the particles were generated. Now
21 we understand that the particle sizes in the aerosols
22 actually reflect where they're generated in the human
23 body. So the smallest particles are actually generated
24 deep in the lungs because there's a kind of fluid lining
25 to the lungs, and something called -- a technical thing

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1 **A.** But in the lungs and the vocal chords, those are key
2 areas, as I'm sure we'll talk about later on, the
3 vocalisation, yeah.

4 **Q.** Can you help us with whether it's the droplets or the
5 aerosols that are more likely to contain Covid or not,
6 which of the two?

7 **A.** It's the aerosols that are more likely. There's
8 a reason for this, and it goes back to -- it's a change
9 in thinking, but we'll talk about that, I'm sure, later
10 on when we talk about this stuff.

11 **Q.** Now, how one --

12 **A.** It's in the small droplets, that's it -- no, small
13 aerosols. Small aerosols.

14 **Q.** Thank you, all right. So deep in the lungs, small
15 aerosols, that's where the Covid --

16 **A.** And the vocal chords.

17 **Q.** And the vocal chords, all right, thank you.

18 Help us with how people generate the respiratory
19 particles. Obviously with breathing, what about
20 coughing or sneezing?

21 **A.** Yeah, right, so we get -- let's go from the kind of
22 least violent, the breathing. So people didn't realise
23 this before but we are emitting -- I'll give you
24 a figure -- over 100 small aerosols per second in just
25 breathing. You can't see them but every one of us is

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1 producing that now. Right? So they're not
2 insubstantial. So even with just breathing, you produce
3 thousands of these things and hundreds of thousands of
4 them in an hour.

5 The next level up, talking. You're bringing in the
6 vocal chords now and they vibrate, they produce
7 aerosols. Off the top of my head, I can't remember
8 the --

9 **Q.** Don't worry.

10 **A.** But it comes, it's an appreciable increase. But the
11 louder you talk, shouting, more gets produced. So if
12 you're in a loud noisy situation, you raise your voice:
13 more aerosols.

14 Singing particularly lots of aerosols. There are
15 nearly up to -- I think a figure sticks in my head of
16 about 900 aerosols per second.

17 Then we go to the things that we -- the kind of
18 symptomatic coughing and sneezing.

19 **Q.** Yes.

20 **A.** They're slightly different in the sense that when you
21 have a cough and especially a sneeze you get a violent
22 action and that brings in the whole of the system and
23 that strips out more -- so you get a wider range, you
24 get larger droplets produced in those things and a lot
25 of droplets in -- a lot of particles in between. That's

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1 they're losing them even faster, so they're going right
2 down. They've got moisture in there -- they've also got
3 proteins and other solids in there -- so they evaporate
4 down into these things, right? Whereas the larger
5 droplets, they've got a small surface area in comparison
6 to their mass, so the evaporation is less with the
7 larger droplets, hence why they struggle to evaporate
8 before they hit the ground. But, generally speaking,
9 the kind of rule of thumb -- and that's why we -- to
10 make sense of this, around about a third of their size,
11 that's a good rule of thumb.

12 **Q.** Can I just see if I've understood this correctly: is it
13 the case that the aerosols evaporate quickly?

14 **A.** Rapidly, yes, within --

15 **Q.** Right, but the larger particles don't evaporate before
16 they hit the floor?

17 **A.** Yeah, simple, that's the general overall thing, and the
18 ones that evaporate go to about a third of their size.

19 **Q.** Right, understood. But the smaller particles, the ones
20 less than 100 microns, presumably they can become still
21 suspended in the air and float around?

22 **A.** Absolutely, yes, I mean, just to clarify one point, just
23 to give an illustration --

24 **Q.** Please do.

25 **A.** -- if you produce an aerosol, so say you had,

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1 the -- how it works.

2 **Q.** Can I just touch on evaporation, because you've told us
3 about the respiratory particles being made up of water,
4 which clearly evaporates. If it helps you, Professor,
5 I'm around paragraph 30 on page 15 of your report, but
6 I think so you say this:

7 "... no matter [what] their size, all respiratory
8 particles comprise mainly of water, because they're
9 formed in the lungs, throat and mouth ...

10 "... as soon as the particles exit the mouth or nose
11 and enter drier air, they immediately start to lose
12 water due to evaporation and dramatically shrink in size
13 to about a third of their original diameter."

14 Help us with the droplet and the aerosols and how
15 they evaporate?

16 **A.** Right. You know, I've done plenty of modelling of this
17 over the years in my own work. You've got to understand
18 that a small particle has a small mass for a very large
19 surface area, you know, think of a small -- you know,
20 we're talking balls, from like football, the large one,
21 going down to kind of like, you know, marble size or
22 whatever. So the relationship, as you get smaller, the
23 surface area is much greater to the mass. So you
24 evaporate through the surface area.

25 So these poor small aerosols, small particles,

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1 you know -- it doesn't mean that you're at 100,
2 you know, it's a whole gradation of things coming out of
3 the mouth, you can have something at 10, something at
4 20, so if you had a 15-micron particle, that is so
5 small, in comparison to its large surface area, it's
6 going to have evaporated down within, you know, a few
7 centimetres from the mouth. It's done its evaporation
8 and it's a small particle moving around, so it's very
9 rapid.

10 **Q.** I think you said in your report at page 16,
11 paragraph 37, that historically many people concluded
12 wrongly that the vast majority of exhaled viruses would
13 be contained in the larger droplets, which were assumed
14 to travel no further than about 1.5 metres but, over the
15 years, that assumption has been shown to be incorrect.

16 **A.** The answer is yes. Shall I elucidate on it?

17 **Q.** Yes, what I want to try and understand is why that's
18 important for us to be aware of that historical
19 misunderstanding, if that be the right phrase, and how
20 it affects Covid and the transmission of Covid.

21 **A.** It's absolutely fundamental because it's a bit like
22 a house of cards: once that goes, everything else goes,
23 so it's crucial -- that's a crucial and important
24 factor.

25 Can I just elucidate on it?

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1 Q. Please do.

2 A. Right, so, and it's a perfectly logical position to hold
3 this, by the way, and I used to believe it myself,
4 right? That was my understanding, so it's reasonable to
5 appreciate this.

6 So when you look at all those droplets and aerosols,
7 all the respiratory particles that come out of the mouth
8 during, let's say, a cough, for example, right,
9 an exhalation event, a cough. So if you added them all
10 together, you would have a bulk of fluid, right, and we
11 know that the virus is in that fluid, right?

12 But, actually, if we looked at the quantity of the
13 fluid, if you think about it, the actual volume of the
14 fluid, most of that fluid, kind of 90% of it, is
15 actually in particles that are over 10 microns in
16 diameter. The bulk of the fluid is in the big droplets,
17 right, which you think, well, what's the point of that,
18 until you go to the next stage.

19 So where's the virus likely to be? And we thought
20 that the fluid was all the same and we thought -- we
21 didn't understand completely that the virus reflected
22 where the sites -- where they were generated. We
23 thought that it was just evenly distributed through the
24 whole of the fluid. So that meant if most of the fluid
25 was in the large droplets then most of the virus must be

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1 A. No.

2 Q. No. When we think about Covid, can I ask you, please,
3 about what you've termed "virus shedding", and I'm at
4 paragraph 38 in your report on page 17. Just in
5 layman's terms, what's virus shedding?

6 A. Right, so in the context of that diagram we've just seen
7 there, so if it's not clear, the latest science is that
8 the bulk of the virus is in the smaller aerosols, right,
9 the under 5 microns, I'm sure we'll mention that later,
10 but that's the case, the bulk of the virus is in the
11 smaller aerosols, not in the big droplets. That's the
12 evidence now. That goes for both influenza and Covid.

13 Q. All right.

14 A. Right, so now virologists talk about virus shedding,
15 what they're meaning is -- this is getting back to the
16 numbers game -- it's the quantity of virus that's shed
17 by any route. So this could be, for example -- well, it
18 comes out of somewhere, out of the mouth or the nose,
19 but they don't just mean in the aerosols, they mean you
20 can cough in your hands and then touch something, the
21 virus can be wherever it is.

22 So when they talk about virus shedding, they're
23 talking about the number of, rather confusingly, virus
24 particles which are even smaller, viruses, and these are
25 viruses -- they look to see -- they do it by various

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1 in the large droplets.

2 So, historically, those involved in infection
3 prevention and control and public health, and you will
4 see it as we'll talk in other documents, made the
5 assumption, and many scientific papers made the
6 assumption, that the bulk of the virus was in those
7 large droplets that don't travel very far. Now, that is
8 not the case.

9 Q. Right.

10 A. But that's only been discovered in the last ten years or
11 so, 10/12 years, right, as the science improved. But we
12 will I'm sure talk about that.

13 Q. Right. My Lady, can I interpose at this point to say
14 this: Professor Beggs has very helpfully in his report
15 set out key findings which summarise a number of
16 paragraphs and pages, so if anyone is either struggling
17 to follow or wants to have a quick easy reference guide,
18 the key finding boxes are very helpful in drawing all of
19 this together. So can I just put that advert out there,
20 if I may, in an attempt, I hope, to help anyone who is
21 following online in particular.

22 Can I just ask you this, please, Professor: is there
23 any scenario or situation in which someone could produce
24 a droplet without also generating significant amounts of
25 aerosols?

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1 means but, anyway, virus shedding is basically just the
2 number of viruses that are just kind of released by
3 an infectious person, by whatever means.

4 Q. Now, in relation to Covid, obviously there may be
5 a period of time where you are infectious but you don't
6 know that you are. Right?

7 A. Absolutely.

8 Q. Asymptomatic, as it's sometimes called. There's also
9 the presymptomatic period.

10 A. Well --

11 Q. Help us with those and what you say at paragraph 38,
12 please, in your report.

13 A. Absolutely. You've led me nicely to the right point
14 there. Right, when you come into contact with someone
15 who is infectious, so they may not appear infectious,
16 they may not be coughing, that's, you know, they may be
17 perfectly all right, they don't realise they're
18 infectious, and that's what we call asymptomatic. They
19 don't show any symptoms, right, but they're still
20 infectious.

21 However, when you meet them, you don't know whether
22 they're -- they're not showing any symptoms but in two
23 or three days' time, they may get very, very ill and
24 feel really unwell and stay at home. Actually, they're
25 asymptomatic at that time but they go on to develop

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1 symptoms, so we say they are presymptomatic.
 2 So, strictly speaking, "asymptomatic" refers to
 3 people who never show any symptoms but it's a kind of
 4 loose thing, it overlaps with presymptomatic. It's
 5 a working term for -- it can include presymptomatic
 6 people, I would use it in that way. So, in other words,
 7 I would say it is people who appear to have no symptoms
 8 and are still infectious.

9 **Q.** Right. So that period of time when you don't know
 10 you've got it, in short, because you feel all right --

11 **A.** Yeah.

12 **Q.** -- help us there, please. I think that's when you say
 13 in your report that that's when the individual is most
 14 contagious?

15 **A.** Yeah, the most contagious period is shortly before they
 16 become symptomatic, if they do become symptomatic, and
 17 for that two to three days beforehand and shortly
 18 afterwards, I think is also fair to say. It then starts
 19 to subside, the infectivity, after their symptoms
 20 develop. Is that -- is that all right?

21 **Q.** Yes, thank you. So it's a dangerous situation where
 22 people are walking around, feeling well but could in
 23 fact be transmitting the virus?

24 **A.** Yes.

25 **Q.** All right. I think you said in your report that the

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1 you certainly will have exactly the same -- you'll have
 2 a presymptomatic period where you're not showing
 3 symptoms and you're still shedding.

4 **Q.** So whatever time you're incubating the virus for, there
 5 is a period of time, potentially, where you are
 6 contagious and you don't know you're ill and, therefore
 7 may not be wearing a mask, may not be hand washing, may
 8 be in close contact with people, all of the ways in
 9 which the virus could easily spread?

10 **A.** Yes, and you may be singing, which --

11 **Q.** Right.

12 **A.** -- you know, is not a good situation.

13 **Q.** Can I just deal with a few more questions, please, about
 14 asymptomatic transmission and then perhaps we'll take
 15 a break, if we may, my Lady. Thank you.

16 It helps you, Professor, Can I turn you please to
 17 page 22 of your report. Your "Key findings" box at the
 18 top of that page may be the easy way into this. Thank
 19 you very much. It may be the easy way into these few
 20 questions.

21 I think you set out there that:

22 "A third to half of all Covid-19 cases are
 23 asymptomatic ..."

24 **A.** Yeah, my understanding -- in fact it varies by age
 25 group. So in children it's even higher than that, and

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1 virus was able to spread for maybe two to three days
 2 before any symptoms develop but with Covid there were
 3 variations between the various strains in how long
 4 people were incubating the virus for?

5 **A.** Yeah, I think -- right, so in that paragraph there,
 6 I use the term "incubation". So incubation is not quite
 7 the same as shedding. Incubation is from the minute you
 8 first get infected. At that point, you're not shedding
 9 that much virus because you're not that infected. You
 10 know, you are infected but it hasn't had a chance to
 11 replicate in your body but, as it starts to replicate,
 12 then you become infectious.

13 So for -- I think the original figure that I've got
 14 down here, the figure that sticks in my head is four to
 15 seven days, I think that's for the original strain, the
 16 Wuhan strain of the virus.

17 **Q.** So you've got 4.6 to 6.4 days --

18 **A.** Yes, four to seven days, it sits there. But for the
 19 subsequent waves, the delta, the omicron, they've found
 20 the incubation periods were shorter, so it came on
 21 quicker.

22 Presumably then, also that would mean that the --
 23 a similar type of period of asymptomatic or
 24 presymptomatic infection, but I'm not an expert on that
 25 so I'm going to say that I'm on dodgy ground there. But

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1 young people. But in older people and elderly people,
 2 it's much less than that. So it kind of balances out.
 3 About 30 to 40% is the kind of figures that I see are
 4 asymptomatic. Yeah, that's, I think that's reasonable
 5 to say.

6 **Q.** Then you go on to say there that:

7 "Although asymptomatic transmission of [SARS or
 8 Covid] is a widespread phenomenon, early in the pandemic
 9 it was not known to what extent it occurred. SAGE
 10 regularly reported on the gradually strengthening
 11 evidence base and by September 2020 confirmed
 12 definitively that it was occurring."

13 **A.** Yeah, it's a really tricky one, this, in the sense that,
 14 you know, what do we mean by "asymptomatic
 15 transmission", is this people who were asymptomatic all
 16 the way through or presymptomatic and that was
 17 a blurring line, so it makes it very difficult, but they
 18 were aware early -- you know, in the SAGE minutes that
 19 I've seen, they were discussing it and they were aware
 20 that this was a potential problem. But they didn't know
 21 the extent to it, and there's a BMJ article, I think, in
 22 December of that year, that is saying we still don't
 23 know the magnitude of it. But, certainly by the minutes
 24 of the meeting in the September, this was becoming --
 25 you know, it was firming up.

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- 1 **Q.** I think it's important to point out, isn't it, that
2 asymptomatic infection does not necessarily lead to
3 asymptomatic transmission; is that correct?
- 4 **A.** Yes, except for, of course, we've got the problem of
5 presymptomatic is asymptomatic at the time, so it's how
6 you define it. So it doesn't always -- there is some
7 evidence that some people who never develop symptoms
8 have a lower viral load, so they're less infectious but,
9 of course, that person who you meet at work or whatever,
10 who doesn't show any symptoms but has Covid, you don't
11 know whether they're presymptomatic or asymptomatic, so
12 it's a very blurry boundary, that's what I'm saying.
- 13 **Q.** Finally, in those key findings, asymptomatic
14 transmission of Covid accounts for many of the
15 infections acquired in hospitals, and we'll probably
16 hear more of that, my Lady, with the IPC trio next week.
- 17 **A.** Yeah. I was going to mention that, because not being
18 a clinician and, you know, I read the papers and I'm
19 aware of this and I was asked to comment on it, but the
20 clear evidence from what others have reported is that
21 asymptomatic transmission, both amongst healthcare
22 workers and patients, made a major contribution to
23 transmission in hospitals and other healthcare
24 environment --
- 25 **Q.** Just the final bullet point there, before we take our
65

- 1 drawing parallels with the flu planning might therefore
2 have thought more quickly, "Ah, well, asymptomatic
3 transmission could also be a route in relation to
4 Covid"?
- 5 **A.** That is a very, very obvious and logical and reasonable
6 stance to take. I think, you know, when I looked at the
7 evidence for asymptomatic transmission of influenza,
8 I very quickly dug up papers that were showing quite
9 large similar types of levels to Covid and then, as
10 I looked at them, I suddenly realised there was a large
11 controversy about this and that some people were
12 criticising the methodology. And when you actually
13 looked at the methodologies and trying to decide what
14 was presymptomatic and what's asymptomatic, that's the
15 big problem, it came down to a figure -- I'm sorry, off
16 the top of my head I can't say, it's in the report, but
17 15% sticks in my head. But I don't know whether that is
18 the case, right, so without looking, reading it --
- 19 **LADY HALLETT:** You said that a consensus developed that flu
20 can be asymptomatic; when did that consensus develop, it
21 having been controversial?
- 22 **A.** Right, have we -- let's just --
- 23 **LADY HALLETT:** Very rapidly.
- 24 **A.** I've got it --
- 25 **LADY HALLETT:** Is it before the pandemic or not?
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- 1 break: you reference there that there is some evidence
2 that flu can also be transmitted by asymptomatic people
3 who are infectious. Why have you made reference there
4 to flu when predominantly we're talking about Covid?
- 5 **A.** Right, throughout this, I was given a brief to look at
6 the transmission of infection and you can't -- if you're
7 looking at pandemic preparedness, it was all around
8 influenza. Influenza and I would also put RSV, another
9 respiratory infection, the mechanisms of transmission
10 are all very similar. The viral agent's different, so
11 it makes sense to look at them, so I have looked also at
12 influenza, I was asked to look at influenza and, as
13 I was doing that, I was asked by the Inquiry to look at
14 the asymptomatic transmission of influenza, which I have
15 to confess I'd never looked at, and so I dug down into
16 the information.
- 17 So I don't claim to be an expert on asymptomatic
18 transmission of influenza but I looked into the evidence
19 base and it was interesting because there were some
20 contrasting views but the overall consensus was that,
21 yes, it does occur but not to the same extent as with
22 Covid, right? So that's why I looked at it.
- 23 **Q.** Is the point there perhaps being made that, if the
24 planning was based about flu and flu could transmit
25 asymptotically, those that were looking at Covid and
66

- 1 **A.** Oh yes, before the pandemic, I think it is anyway.
- 2 **LADY HALLETT:** Don't worry. That's --
- 3 **A.** Sorry, I'm searching through my text here.
- 4 **MS CAREY:** May I make a suggestion, that we take a break?
- 5 **LADY HALLETT:** Yes, we'll take a break and you can confirm
6 after the break.
- 7 **A.** Yes, I can certainly do that, yeah.
- 8 **LADY HALLETT:** Right, we'll take ten minutes.
- 9 **MS CAREY:** Thank you very much, my Lady.
- 10 (11.50 am)
- 11 (A short break)
- 12 (12.00 pm)
- 13 **LADY HALLETT:** Ms Carey.
- 14 **MS CAREY:** Thank you.
- 15 Before we had our break, I think, Professor, you
16 were just answering some questions, indeed one from
17 her Ladyship, about the evidence that flu can be
18 transmitted by asymptomatic -- and we left it on
19 a cliffhanger, that you were going to go and look it up.
- 20 **A.** Yeah.
- 21 **Q.** Could we turn, please, to paragraph 53 --
- 22 **A.** Yeah.
- 23 **Q.** -- within your report.
- 24 **A.** Right, well, I said 15%, it was 16%, so I wasn't far
25 off.
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1 **LADY HALLETT:** I'll let you off.

2 **A.** But I think the first point there is it's not clear-cut

3 by any means. Difficulties are because, frankly, how do

4 you know who's truly asymptomatic and how much are

5 presymptomatic. But you can see the dates here, right

6 at the top, the first sentence, it says:

7 "Most cases of seasonal influenza are thought to be

8 asymptomatic."

9 And that was someone -- Hayward in 2014. However,

10 that's disputed by various people and various things and

11 methodologies and everything. And this comprehensive --

12 so we're down at about line 5 or 6 -- a comprehensive

13 meta-analysis in 2015 said really that's 16%. And

14 that's Leung in 2015. So it was definitely there.

15 But the key point, at the bottom, just to get it

16 over, is of course those people, if they're lower

17 infectious and fewer symptoms, they mix more, so whether

18 they were transmitting more depends on not only how ill

19 they were but also how much they mixed, shall we say.

20 Sorry, I've added that on.

21 **MS CAREY:** No, don't worry, because I think what I just

22 wanted to try to be clear, and I know this will

23 resonate, my Lady, with evidence you've heard,

24 I suspect, in Modules 1 and 2, I think there was

25 a pre-pandemic flu strategy in 2011, and we're going to

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1 it helps you, we're at page 24 -- and I'd like to

2 examine with you, please, the movement of infectious

3 particles through the air.

4 Now, we've probably touched on it a little bit by

5 looking at the ballistic way that the droplets behave in

6 contrast to the way that the aerosols float through the

7 air -- my paraphrasing, I appreciate -- but there we

8 have, I hope, at the top, a little summary of that:

9 "Exhaled respiratory droplets [greater than

10 100 microns] behave ballistically ... fall ... to the

11 floor ...

12 "Smaller ... particles ... shrink ... due to

13 evaporation ..."

14 As we've looked at:

15 "... and become [even smaller] aerosol particles

16 which can float in [the] air."

17 Now, help us, please, you say:

18 "These small aerosol particles can take many minutes

19 (even hours) to settle out of the air and therefore can

20 be transported long distances around [the] rooms by air

21 currents."

22 **A.** Can I direct you -- can we put it up? -- direct you to

23 paragraph -- table 1 in paragraph 59.

24 **Q.** Yes, I'm going to come on to that, but if it helps you

25 to answer the questions, please do. Because what

71

1 perhaps look at that little later with Professor Beggs,

2 so there is the underpinning document in 2011 and then

3 these various studies in 2014, 2017, 2015, et cetera,

4 albeit not consensus on that either, that suggested

5 though that flu was thought to be asymptomatic. So

6 we'll just keep that chronology, if we may, in our minds

7 as we go through.

8 **A.** Can I just clarify --

9 **Q.** Yes.

10 **A.** -- what I'm saying here? It was known that some

11 influenza transmission was asymptomatic before the

12 pandemic.

13 **Q.** Yes?

14 **LADY HALLETT:** And the dispute was on how many?

15 **A.** How many.

16 **LADY HALLETT:** Yes.

17 **A.** And it was to do with methodology.

18 **LADY HALLETT:** So I can confidently say that it was known

19 that some cases of flu are asymptomatic?

20 **A.** All I've reported is what was in the papers, and that's

21 what was said --

22 **LADY HALLETT:** Thank you?

23 **A.** The references are all there.

24 **MS CAREY:** Thank you very much, Professor.

25 New topic if I may, please -- and in your report, if

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1 I really wanted to know was: how long does it take? How

2 far can they go?

3 **A.** That's what I was going to do.

4 **Q.** All right.

5 **A.** That's where the table would be -- that's it, thank you.

6 Right. Back in 1851 a guy called Stokes developed

7 a whole load of laws to do with -- basically it was

8 understood how aerosols behave, right, and how particles

9 in air behave, and we use them in engineering to predict

10 how aerosols behave, and basically Stokes' law can be

11 applied both to moving particles but also to particles

12 in still air.

13 And here, what we have here is a table for various

14 sizes, and I just did it for illustrative purposes,

15 a range of sizes, and I'm assuming 2 metres, which is

16 the height of a tall person, producing -- but it's an

17 approximate height -- and you can see there that -- say

18 we take a 5-micron particle.

19 **Q.** Yes.

20 **A.** That actually takes -- descends at about -- well, it

21 takes 32 minutes to fall to the floor.

22 **Q.** Right. So if someone were 2 metres tall --

23 **A.** Yeah, it's a bit high, but height of a --

24 **Q.** Yeah.

25 **A.** 32 minutes, right? So we can set the clock and we can

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1 wait until half past and it's still falling. And that's
 2 in an absolutely still room. This room and every other
 3 room that you will be in has movement, because basically
 4 if you have a mechanical system -- we've got lots of
 5 movements in here, but when people move -- walk around
 6 -- and we're each producing what's called a thermal
 7 plume, because we've got -- we're warm and we have
 8 a convective -- so there is lots of air movement, so
 9 they will stay airborne for a lot longer than this.

10 **LADY HALLETT:** Can I just interrupt to say the transcriber's
 11 software has crashed, but they will catch up on the
 12 transcript.

13 **MS CAREY:** Thank you very much.
 14 So you mentioned there the thermal plume. Help us,
 15 where is it? What is it? How does it work?

16 **A.** Oh, right, yeah, it's been overlooked a lot.
 17 Yeah, thermal plume, basically your skin is at
 18 about, I don't know, 36, 37 -- 37 degrees, the air's at
 19 20 degrees, when it comes into touch -- into contact
 20 with you, you're warm and you get -- you've got -- every
 21 one of us here has got a rising current of air,
 22 convective current of air, passes over the face, round
 23 the back of the head, and you've got a big plume -- and
 24 we can actually visualise this --

25 **Q.** Pause there, because there may be a diagram that helps

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1 heavy particles fall out. But it can also go for
 2 radiators, you know --

3 **Q.** I was going to ask, yes?

4 **A.** -- they can do the same thing, it's an area that's
 5 not -- it's the big difference between indoor
 6 transmission and outdoor transmission. It's one of the
 7 key differences.

8 **Q.** Right.

9 **A.** Outdoor it just goes up and it's distributed.

10 **Q.** Right. So the virus can go up in the particles, up
 11 through the -- upwards through the thermal plume, and
 12 then into, presumably, any current of air that is within
 13 the room?

14 **A.** Well, in fact, here we've got what we call four-ways
 15 movement diffusers, they're -- something called a Coanda
 16 effect, they're shooting air underneath the ceiling, so
 17 if someone is producing a thermal plume that then mixes
 18 with that and there's particles in it, they will be
 19 distributed around.

20 So this idea -- it's very complex, it's complex
 21 fluid mechanics, and it's different in every space, but
 22 this idea that we can just say a particle falls out of
 23 the air very quickly, you know, by its size, it depends
 24 what it comes into contact with. And this is the
 25 problem.

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1 you.

2 Could I call up, please, figure 7 on page 26 of the
 3 report, because I think this will demonstrate what
 4 you're -- so there's a person at the bottom?

5 **A.** Yeah, this is my colleague at Queen Mary's in London.

6 **Q.** Right. And the halo, for want of a better phrase, is
 7 that the thermal plume?

8 **A.** It is, yeah. What we did there, this is something
 9 called Schlieren photography, which is a very specialist
 10 type of photography which is useful in this situation.
 11 The horizontal line, by the way, in this particular --
 12 is us trying to simulate a ceiling, right?

13 **Q.** Okay.

14 **A.** So what actually happens, and we've got a video of this
 15 online, you can see that we had this constant flow of
 16 streams of air going up. They get to the ceiling and
 17 then they spill out across the ceiling, depending on the
 18 height of the ceiling of course, and you can see -- it
 19 really is quite -- they could be kind of moving at the
 20 highest above the head at about, you know,
 21 30 centimetres, a foot, a second, and that can transport
 22 quite large aerosols up.

23 What we think is happening, anything that gets
 24 entrained into that goes up to the ceiling, then fans
 25 out and then after a while it gets slowed down and the

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1 **Q.** Can I see if I understand this correctly. Your thermal
 2 plume sitting there will travel upwards?

3 **A.** Yeah.

4 **Q.** And on a current could, therefore, flow in the direction
 5 of her Ladyship, me, everyone else --

6 **A.** Yeah, it could do. Obviously the smaller particle --
 7 the heavier the particle -- the point about the aerosol
 8 is that it will only -- the particles will only stay
 9 suspended in the air until the air current drops in its
 10 strength, at which point they start to descend, but they
 11 then fall into the next -- they kind of do
 12 that (**indicated**), you know, but they go a lot further.

13 So the table in table 1 is an ideal situation in
 14 still air.

15 **Q.** Yeah.

16 **A.** And unfortunately I've seen in lots of literature people
 17 saying -- the worst case is they say, like, a 5-micron
 18 particle can't go more than a metre, which is just
 19 wrong, but people sometimes take a value off here, but
 20 rooms are not still, that's the whole point. That's the
 21 bit that I'm trying to get over.

22 **Q.** Are you able to help us with how far, in metres or
 23 whatever metric you wish to use, an aerosol can travel?
 24 In a room like this perhaps, might be the easier way of
 25 thinking about it.

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1 A. Yeah, they can travel a long way, much further than
2 2 metres. Right? That's from the social distancing
3 point of view, and where we -- we'll talk about near
4 field and far field. But if we could look at figure 8,
5 please.

6 Q. I thought you were going to turn to that.
7 My Lady, it is behind tab 8 and it is INQ000497038.
8 This is going to be, when we get it on screen -- there
9 we are.

10 A. Oh, right, yeah, that's -- I didn't think that was
11 figure 8, actually, but it doesn't matter, this is good
12 as well.

13 Q. Just do it with this -- well, this one is in the context
14 of a six-bed bay --

15 A. Yeah, this is very good. Figure 8 in the report was
16 actually also computational fluid dynamics.
17 CFD stands for computational fluid dynamics and its'
18 a tool that we use, physicists and engineers use, to
19 simulate complex flows of air and particles and fluids
20 in various environments.
21 And this is actually work that we had done at
22 Addenbrooke's, I worked with the Addenbrooke's team
23 there, at Addenbrooke's Hospital, and this is --
24 similar -- is one of the wards there, where you have
25 a classic six-bedded bay. And what happens is we used

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1 Sorry, you said a simulation there. This is
2 a simulation --

3 Q. Yes.

4 A. -- but in fact, just to clarify that and -- we also did
5 measurements, we had particle counters throughout the
6 whole ward -- now, these are not looking at bioaerosols,
7 they're just looking at particulates -- throughout the
8 whole ward. And in an earlier study we actually
9 measured the transport, and we've published this in the
10 Journal of Hospital Infection, and what we found was,
11 for example, when the ward round came round, we saw the
12 particles go up in one part of the ward, you know, 10,
13 15 metres away at the far end, and then those particles
14 just migrated all the way through -- as with the ward
15 round, as the doctors went round, but also as the air
16 currents moved. Which is exactly what we're seeing
17 here.

18 Q. Thank you.

19 A. It's not just simulation.

20 Q. No. Understood.
21 Perhaps if we just take that diagram down, please,
22 because it brings me on to inhalation and the risk of
23 inhalation.
24 And if it helps you, Professor, I'm at paragraphs 65
25 onwards in your report, which is at page 28.

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1 some -- a team of aerodynamicists used computational
2 fluid dynamics to simulate the transmission of aerosol
3 particles.
4 And there we have a bed -- the dark bed on the
5 right-hand side in the middle of the six-bedded bay is
6 a patient who is infectious. We can't see the thermal
7 plume here -- they're lying in bed, they're exhaling
8 out -- and this is actually 2.5-micron particles, and we
9 built in the thermal plume. And what you see is the
10 density of the particles after ten minutes in that space
11 of regular breathing out and exhaling particles, and you
12 can see them migrating all the way through.
13 And in fact as part of the studies we did at
14 Addenbrooke's, we looked at the particles and we could
15 see them migrating throughout the whole ward within
16 minutes. You know, it takes time, that's what
17 I'm trying to say. They can transmit 10 metres easily.

18 Q. So although this is a simulation of a six-bedded bay,
19 one can see there that not only is there the infection
20 concentrated around the infectious patient but the two
21 beds either side of the infectious patient, and indeed
22 the aerosol beginning to spread out to the other three
23 patients and up to the top of the bay --

24 A. Into the corridor, that's the corridor towards the
25 nurses' station.

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1 A. Yep.

2 Q. Just give me a moment to turn that up.
3 (Pause)
4 It's probably evident, just looking at the key
5 findings first of all, that when aerosols are inhaled
6 the different size particles land in different places
7 within the respiratory system. Right?

8 A. Mm.

9 Q. The smallest particles, which as you told us before the
10 break are more likely to contain the virus, they tend to
11 travel deep into the lungs, while the larger aerosol
12 particles land in the mouth and throat?

13 A. Yes. But -- yes, shall I --

14 Q. Do you have a caveat to that?

15 A. Yeah. There is no clear cut-off, right. So
16 historically, the kind of -- which comes back from
17 almost the end of the Spanish flu in the First World
18 War, you know, the early part of the 20th century, so
19 it's pretty old science, but it was realised then that
20 particles that were less than 5 microns tended to travel
21 into the lower respiratory tract. What that means is
22 that they went deep into the lungs.
23 Particles above that size that were inhaled tended
24 to stick in the nasal cavity, in the upper respiratory
25 tract.

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1 And clinicians use that as a demarcation to do with
2 TB, it was -- TB went down in the lungs, they thought
3 that was small microns, whereas things like influenza,
4 which predominantly infects the upper respiratory tract
5 first and foremost, they thought: well, that must be in
6 particles bigger than 5 microns. And we'll come on to
7 that later.

8 But the truth of the matter is it's a gradation.
9 It's roughly around there but it's kind of 10 to
10 5 microns. 10 microns can go deep into the lungs as
11 well, and some 5 microns can stay up in the upper
12 respiratory tract, but the important point there is that
13 particles in inhalation up to 100 microns can be inhaled
14 if the air's strong enough to -- if they're in the
15 region, they can -- but they don't go deep, they just
16 stay up here.

17 But most of the particles that are being inhaled and
18 tend to end up somewhere in the system are under
19 20 microns, that's the general rule. But it's not hard
20 and fast.

21 **Q.** No, understood, all right.

22 Now, I think you said, though, in your report at
23 paragraph 66 that:

24 "Aerosol particles tend to be light and slow moving,
25 and as such are easily inhaled."

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1 land on -- that's trickier. In my opinion it's
2 trickier, but traditionally it's thought --

3 **Q.** Pausing there, if we just think about it --

4 **A.** That's the droplets, not the aerosol.

5 **Q.** I know. If we just pause there and think about it in
6 the context of a nurse taking a vital sign, blood
7 pressure or temperature in the ear, essentially what
8 you're saying there is that the droplet, the larger
9 particle, can easily, if they're up close to them, end
10 up in the eye, or in the mouth, albeit that you're --

11 **A.** Absolutely. Well, I personally find it harder to see
12 how it gets up the nose, because what's happening is
13 these droplets are tending to fall away, and they're
14 large so they can't really be inhaled very easily, so
15 they're moving away, they've got momentum, so they're
16 not being drawn in. But certainly on the eyes. But
17 they could land on the lips.

18 **Q.** So if the nurse --

19 **A.** Maybe on the nose and someone could touch them and then
20 pass it on, rub their eye or something.

21 **Q.** So if the nurse is not wearing a goggle or a visor,
22 that's an easy route --

23 **A.** That's an easy route for that -- I've got to say, sorry,
24 it's a route, but the epidemiology supporting this is
25 not actually that strong. Because when I looked at it,

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1 **A.** Yes.

2 **Q.** "... if a susceptible person is close to an infectious
3 person then there is the potential for droplets
4 transmission via the eyes ... or mucus membranes of the
5 nose and mouth ..."

6 Is that correct?

7 **A.** Yeah. Yeah. I'm just trying to see this. Yeah.

8 So the -- this is about droplet transmission, the
9 larger droplets, right?

10 **Q.** It is.

11 **A.** So we're talking about larger than 100 microns. They
12 can't travel very far. So if someone's in close
13 proximity to someone else, within a metre, say, and
14 someone coughs or sneezes and they're infectious,
15 they're going to produce a whole load of aerosols and
16 droplets but those droplets have got a trajectory and
17 they're ballistic, and they can land -- we all know it,
18 we've all experienced it when someone's coughed or
19 spoken, you can feel the spit, you know, on your
20 forehead -- that's a very large droplet, but they could
21 land on your eye, and there's some ACE2 receptors there,
22 or sialic receptors with influenza. And that could
23 cause an infection, a route of -- what we call a portal
24 of entry. Or, and it's a bit more ambiguous on this
25 one, it could land on your lips, for example. It could

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1 this is what is supposed to happen, and it's plausible,
2 definitely.

3 **Q.** Now, let's look at the aerosol particles and your
4 paragraph 67, and you say that because they are
5 suspended in the air, the quantity that will be inhaled
6 is directly proportional to the concentration of the
7 particles in the air and the volume of the air that is
8 inhaled.

9 So take a slightly different example now, the nurse
10 is not taking blood pressure or the temperature but is
11 on the other side of the room dealing with another
12 patient, help us please with what you say there and the
13 level of risk to the nurse.

14 **A.** Yes, I will, but I want to just say one thing in
15 relation --

16 **Q.** Of course.

17 **A.** -- because it's important to do this.

18 So let's make the nurse, again taking blood pressure
19 in the same position as the droplets, you can't have
20 droplets without aerosols. So if that patient -- if
21 that nurse has got no mask on, for example, they may
22 receive a droplet in the eye, it's a fairly small
23 target, but they're more likely to get a face full of
24 aerosols and inhale those into the things. In my
25 opinion, that's a higher likelihood. So in that near

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1 field they can get that. But of course aerosols don't
 2 just stop there, they pass on further. So now we go to
 3 the longer range thing that you've just described.
 4 So --
 5 **Q.** We're going to look at near field and far field, so it
 6 is as well to deal with it now.
 7 **A.** Right, so going back to the concentration of the
 8 particles, it's irrespective, from the aerosol point of
 9 view, of whether it's in the near field or the far
 10 field, near or further away, you breathe in some air
 11 which has some virus in it, viral particles. So it's
 12 actually -- just the number of viral particles is -- the
 13 risk is related to the -- this is the numbers game: the
 14 more viral particles you inhale, the more likelihood
 15 that one's going to hit one of those receptors and cause
 16 the infection.
 17 So you can -- it's to do with the volume of air
 18 inhaled, wherever you are in the room, and the
 19 concentration of particles in that. And obviously if
 20 you're close up, the concentration's likely to be
 21 greater than if you're further away. And the volume of
 22 air inhaled, that's the total volume, depends on how
 23 fast you're breathing, how much you take in, but also
 24 how long you are. So we now have --
 25 **Q.** As in how long you are exposed?

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1 **A.** Yes.
 2 **Q.** All else being equal?
 3 **A.** All else being equal, yes.
 4 **Q.** But of course one has to bear in mind then how close you
 5 are to the infectious person?
 6 **A.** Yes. So you -- all right?
 7 **Q.** Go on, you can carry on.
 8 **A.** So we could have, for example, someone who is close to
 9 a person for a short period of time inhaling a certain
 10 infectious dose. They're got a high concentration but
 11 they've taken in for a short time. Or in a café,
 12 for example -- or someone on the other side of the café
 13 is working there for four hours or -- you know, with
 14 a computer, and they're breathing in infectious air,
 15 they're breathing in a smaller concentration but for
 16 longer, and so they can actually get the same infectious
 17 dose, actually a greater infectious dose, even though
 18 the concentration is lower in the far field.
 19 **Q.** So for the infection to occur, is this right, you need
 20 to have inhaled a respiratory aerosol that contains the
 21 virus?
 22 **A.** Yes.
 23 **Q.** The aerosol must come into contact with a receptor,
 24 nose, mouth?
 25 **A.** Wherever, yeah.

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1 **A.** Exposed.
 2 **Q.** Right. Can we hive that off, if we may, and deal with
 3 that slightly later --
 4 **A.** So the volume and the concentration. The concentration
 5 changes where you are in the space, but it's dependent
 6 also on how much air you breathe in, and that's
 7 dependent on time.
 8 **Q.** Can I see if I --
 9 **LADY HALLETT:** Professor, can I interrupt to say, I know how
 10 careful you are trying to be and it really is very
 11 helpful information, but Ms Carey's an expert at getting
 12 what she needs and what I'm going to need, so if you
 13 could just try to shorten your answers. And if she
 14 wants more, she'll ask for more?
 15 **A.** I will, yes, certainly.
 16 **LADY HALLETT:** Because we have limited time. I'm sorry
 17 to --
 18 **A.** No, that's okay, it's very understandable.
 19 **MS CAREY:** Thank you, my Lady.
 20 Can I ask you, to see if I understand this correctly
 21 from your report, if the susceptible individual spends
 22 two hours in the room with an infectious person, they're
 23 going to be at much greater risk of acquiring the
 24 infection compared to someone who's only in there for
 25 five minutes?

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1 **Q.** The virus in the aerosol must be fit enough to bind on
 2 to the receptor?
 3 **A.** Yes, it's got to be viable to get in and there's got to
 4 be enough of it to get into it, basically, yeah.
 5 **Q.** Then once inside the receptor or the cell, the virus
 6 must overcome any of our own immune system in order for
 7 the infection to take hold?
 8 **A.** Yes, so what actually happens is that most virus
 9 particles either miss receptors or get knocked out by
 10 the defence, the host defences, or they're not fit
 11 enough, and it's just that few that get through. It's
 12 a numbers game.
 13 **Q.** Right. Does that generally mean, therefore, that
 14 a large number of virus particles need to be inhaled in
 15 order for an infection to be established?
 16 **A.** The figure that sticks in my head from, I think it's the
 17 Skagit choir analysis, or is it -- that's another
 18 paper -- is 600, I think, in this particular case, for
 19 a kind of ratio of 600 to 1, the expected dose to be
 20 inhaled.
 21 **Q.** Right.
 22 **A.** But that, again, is an estimate that I -- that's in --
 23 **Q.** In short, you've got to get a large number of --
 24 **A.** You've got to get a large number, but that is always the
 25 case with viruses, you know.

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1 Q. All right. If I understand your evidence correctly,
2 therefore exposure time and concentration of the virus
3 in the air are critical when we're looking at how the
4 infection gets in and spreads?
5 A. Absolutely, yes, the longer you spend in a space, even
6 if the concentration is not that high, you're at risk.
7 Q. Can I ask you about an example that you refer to in your
8 report, please, at paragraph 74 on page 30 of your
9 report, which might highlight the importance of exposure
10 time and indeed concentration of the virus in the air.
11 A. Sorry, which is it? Yes. I've got it, yep.
12 Q. Yes. I think you looked there at situations where the
13 viral load is allowed to accumulate, let's say in
14 a poorly ventilated room --
15 A. Yes, right.
16 Q. -- even short exposure times can result in significant
17 risk?
18 A. Yes.
19 Q. So actually -- let me just finish -- and this is
20 especially in the case where individuals may be
21 shouting, singing or just talking, and then you go on to
22 refer to a study by Alsved. Help us with this
23 paragraph, please?
24 A. Yes, no problem. Right, so two things happen, really.
25 When you exhale a virus -- exhale aerosols which contain

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1 a classic one.
2 Q. Yes.
3 A. So they're producing lots of aerosols into the space and
4 the concentration builds up and everyone's breathing it
5 in. In that situation, Alsved calculated quite a short
6 period of time, even within 37 minutes. It depended on
7 the ventilation rate and all the rest of it.
8 Q. So is it fair to say that healthcare workers treating
9 patients who are generally in the near field, in that
10 1 to 2-metre range, or potentially right up close to
11 them, are more generally exposed to the near-field risk?
12 A. In that specific situation, yes and no. They're in the
13 near-field risk when they're treating that patient and
14 caring for that patient, they're in the far-field risk
15 when they're at the nurses' station or it's a cleaner or
16 someone who is working around about, and other patients
17 maybe in the near and in the far field, depending on the
18 situation.
19 Q. So it's not just nurses, non-clinical staff like the
20 cleaners, the porters, some --
21 A. Non-clinical staff are also exposed to it in offices of
22 hospitals, and things like that as well.
23 Q. I think you said in your report -- I won't take you to
24 it, Professor -- that when considering the near field
25 direction is important, clearly face-to-face poses more

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1 virus, so you imagine someone in the near field, they're
2 going to get a waft of this thing through their -- past
3 them.
4 Q. In their near field, 1 to 2 metres, roughly?
5 A. 1 to 2 metres, yeah, I'd call it that kind of region.
6 They'll get the first waft, which is a high
7 concentration, and that could occur indoors or outdoors.
8 But those aerosols then, assuming they're not inhaled,
9 progress into the room and mix, and then the air
10 currents in the room take them and take them around, and
11 this is where it differs from indoors and outdoors.
12 So outdoors there's a progressive dilution but what
13 happens indoors is, because we've got an enclosed space,
14 these aerosols start to waft around and build up in
15 concentration in the space. So someone in the far
16 field, who's some distance from the infected person,
17 they can be breathing a kind of soup of aerosols if the
18 virus is in there, if it's a poorly ventilated space, of
19 a fairly high concentration over quite a long period of
20 time and it's made even worse if you're in
21 an environment like the Skagit choir, which we may come
22 on to later where people were singing, if it's noisy,
23 a nightclub or a church or something, where lots of
24 superspreading events have occurred, where we generally
25 have got people raising their voices: singing is

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1 of a risk?
2 A. Yeah.
3 Q. Side to side, a risk, but not --
4 A. Yeah. Near field definitely. If you're in front of
5 that -- what we call the exhalation plume, you're going
6 to get a higher dose. Actually, there is a slight
7 caveat to that in the clinical scenario, because
8 patients are often in bed and so the thermal plume rises
9 up from them, as their exhalation does as well, and so
10 clinical staff are often above the patient. So I would
11 include both the exhalation plume and the thermal plume.
12 So if you've got a patient and you're taking blood
13 pressure or something and they're lying down, you can be
14 leaning over them and getting both the exhalation and
15 the thermal plume. So, yes.
16 Q. Understood. There is a number of variables there as to
17 how you end up getting infected but can I look at
18 a different form of transmission now briefly and come on
19 to what you've termed "Fomite and contact transmission".
20 It's at page 36 in your report, Professor. Again,
21 terminology may be important here, so actually -- thank
22 you -- the key findings may be a helpful way in to this
23 evidence.

24 I think you said in your report that historically
25 flu and other respiratory viruses have been assumed to

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1 be transmitted by droplet transmission, the larger
 2 particles, and by contact.
 3 **A.** Yes --
 4 **Q.** Is that right?
 5 **A.** -- and fomite as a --
 6 **Q.** Yes.
 7 **A.** -- subgroup.
 8 **Q.** Yes. There is direct contact, indirect contact, there
 9 is also the phrase "fomite", so let's deal with those,
 10 if we may please.
 11 Can I just deal with contact. Direct contacts: help
 12 us, please, what is meant by the phrase direct contact?
 13 If it helps you, it's paragraph 91 on page 37.
 14 **A.** Yeah, right, so I'm not actually saying contact, I'm
 15 talking about direct routes and indirect routes there,
 16 and it's important in the thing, so shall I explain?
 17 **Q.** Yes, please do.
 18 **A.** I was asked by the Inquiry to examine all the routes,
 19 right, and I have done quite a bit on hand washing in my
 20 time but mostly on things like MRSA. So I wanted to set
 21 it alongside the airborne and the droplet as well, so
 22 we're looking at the whole picture because it's really
 23 important that the number of intermediary steps, the
 24 virus can get diluted basically, right? So I wanted to
 25 introduce, talk about direct routes, so in this

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1 and someone touches it and then rubs their eye. That
 2 would be an intermediary step.
 3 **Q.** Or a droplet falls onto a bed handle on a patient's
 4 bed --
 5 **A.** Yeah, yeah, classic. There's a bed rail or it drops
 6 onto a surface, a patient's surface, so the patient does
 7 that, or on to a medical instrument or something.
 8 **Q.** Understood.
 9 **A.** The nurse touches it and then rubs their eye, for
 10 example, or whatever.
 11 **Q.** So there is contamination effectively via some kind of
 12 intermediary surface --
 13 **A.** An intermediary step and the classic one is, you know,
 14 the handshake, is that.
 15 **Q.** Well, I wanted to ask you about that because handshaking
 16 is sometimes given as an example of direct but, if
 17 I understand you correctly, it isn't because it's got to
 18 go onto my hand, I shake the other person's hand and
 19 they then have to transmit it to a receptor; is that
 20 right?
 21 **A.** Yes. In the textbooks, when they're talking about hand
 22 contact, they say that's the direct route. I'm doing
 23 this for this report because I'm trying to make sense
 24 for everybody that there are intermediary steps, and
 25 that's really rather important. So the direct contact,

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1 report -- it's confusing because they talk about direct
 2 contact and indirect contact, so I'm talking about
 3 direct routes in this report and in this paragraph, as
 4 meaning there's no intermediary stage. So that could be
 5 a droplet going from coughing and landing on someone's
 6 eye or it could be an aerosol going out, flowing round
 7 and going up someone's nose. That's direct. There's --
 8 **Q.** Pause.
 9 **A.** Yep.
 10 **Q.** Thank you. I just want to make sure I understand that
 11 right: the virus travels from the infected person to the
 12 receptor without touching anything in between?
 13 **A.** Yeah, so whatever is in the virus that left the mouth,
 14 and we're talking in those situations, certainly in the
 15 short -- in the near field, within, you know, seconds;
 16 in the case of the droplet, within minutes. So there's
 17 nothing in the way to interfere.
 18 **Q.** Understood. Indirect may be obvious now, but help us,
 19 please, looking at paragraph 91, I think you said that
 20 indirect routes involve one or more intermediary steps.
 21 **A.** Yes, so --
 22 **Q.** So the context of respiratory transmission, help us with
 23 that, please.
 24 **A.** I suppose that could be with the intermediary step there
 25 is the droplet when it lands on the outside of the nose

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1 say, touching someone's hand or touching something,
 2 I suppose if someone kissed someone that could be a very
 3 direct route, you know, but that's a very intimate --
 4 I don't know where to go with that one, really. We'll
 5 leave that at this moment.
 6 **Q.** Yes.
 7 **A.** I'm blushing now, I can see this here.
 8 **LADY HALLETT:** I don't think kissing got banned, did it?
 9 **A.** I don't know. What happened in the home stays in the
 10 home, I suppose, yes.
 11 You know, but the point is it's the idea that the
 12 classic of -- the textbooks would say the classic of the
 13 indirect and -- two indirect routes as I've classified
 14 here, with the hands. The classic one would be,
 15 "Hello", you cough into your hand, you shake hands with
 16 someone else, they then take it and they rub their eye
 17 or their nose or something. Or with a fomite that would
 18 be you cough into your hand, you touch the door handle
 19 you walk away, someone else then touches the door
 20 handle, then they do that.
 21 **MS CAREY:** So that is what is meant by fomite?
 22 **A.** That's fomite, yes.
 23 **Q.** Can I take it that where you're dealing with indirect
 24 transmission, viral material is lost through
 25 degradation?

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1 **A.** Yes, every time you touch, so let's take the door
2 handle, that's a great one to do.
3 **Q.** Yes.
4 **A.** So even when you cough and you cover your hands, not all
5 the virus went onto your hands and the hands actually
6 aren't very good at -- porous surfaces and hands tend to
7 kill the virus, it doesn't last for very long. So
8 whatever goes onto the hands, then it has to be
9 transferred to the -- it's lost something there. It
10 goes to the door handle, it's lost some more.
11 Then the next person to touch the door handle
12 doesn't necessarily touch them straightaway, they might
13 wait an hour and, in that time, it's degraded over time.
14 The person touches it, it loses them, and in fact
15 I think it was Raymond Tellier did some analysis and
16 reckoned that only about 1% of it eventually gets to the
17 target, if it does get to the target. So it really is
18 degraded.
19 So time is a very key important thing in there.
20 **Q.** Now, clearly, though, when you're talking about direct
21 contact, it goes -- you cough in my face, effectively?
22 **A.** Very short.
23 **Q.** Yes, exactly, that's the point.
24 **A.** So the virus is fitter, and it hasn't been through any
25 intermediary steps.

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1 that plays a role is not known but the IPC people -- by
2 which you mean those drafting the guidance -- and public
3 health assumed it to play a greater contribution whilst
4 airborne, certainly initially, was considered to be
5 an unlikely --
6 **A.** Yeah. Well, I always like to kind of quote higher
7 authorities than myself, right, and the PIP report,
8 which is the Pandemic Influenza Preparedness report from
9 2011, there was two of them, and there you see it in
10 105, it's:
11 "Since the role of hands in the transmission has
12 actually never been demonstrated epidemiologically, one
13 may hesitate to attribute great proportion to this
14 pathway."
15 The epidemiological evidence is not that strong, to
16 be honest.
17 **Q.** Perhaps before we break for lunch, I want to deal with
18 one other topic, if I may, my Lady, and it's to look at
19 some of the other terminology that is used and then
20 perhaps, after lunch, we can look at some of the
21 historical controversy and assumptions that played out
22 in particular in the IPC guidance.
23 So, Professor, can I ask you this: I think you were
24 shown a statement by Lisa Ritchie, and it will be in
25 your bundle behind tab 3. Now, she was the chair of the

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1 **Q.** Okay, so survival time depends on the surfaces, how
2 porous, all of the other ways in which could --
3 **A.** Yeah, that was fully understood initially, but later on
4 many studies have shown that the porous hands and
5 things, it doesn't survive that well on it. But hand
6 washing is really good by the way, so don't, you know
7 ...
8 **Q.** Well, that actually was going to bring me onto --
9 I think you've said in your report that the fomite
10 transmission, touching the inanimate object, and indeed
11 contact transfer plays a role but the precise proportion
12 of that is not yet known; is that correct?
13 **A.** Yes, in my opinion. At the beginning of the pandemic,
14 it was thought to be much more important than later on
15 but I'm sure clinical witnesses will tell you the same
16 thing. As it went on, it got downplayed and --
17 certainly the fomite and the contact -- and so less
18 emphasis was on that and more was on the droplet.
19 So I think it does make a contribution but I don't
20 think we understand how much of a contribution. But
21 I would say it's a significant but minor contribution.
22 That's my personal opinion.
23 **Q.** Fine. I think you did say in your report at
24 paragraph 105, though, and you made the point that the
25 precise proportion of fomite and contact transmission

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1 IPC cell made up of a number of individuals, and
2 obviously it wasn't proportionate for the Inquiry to
3 speak to all of them.
4 **A.** Yep.
5 **Q.** So, although she is the front person, I want it to be
6 made abundantly clear that she's often speaking on
7 behave of the cell's position. Occasionally she speaks
8 to her own position and we'll deal with that when we
9 hear from her, but can I just ask you about some of the
10 terminology that she uses, whether you agree with it,
11 and see where we end up just before our lunch break.
12 Could you turn, please, to page 13, and if we put it
13 on screen, it's INQ000421939_13. We're, I hope, a bit
14 more familiar now with some of the language, and there
15 may be a divergence here, and if we look at "Droplet
16 transmission", there the statement sets out that:
17 "Droplet transmission involved droplets ([of
18 5 microns to about 200] in diameter) from an infected
19 person's respiratory tract reaching the eyes, nose or
20 mouth of another person."
21 Then it sets out:
22 "Large droplets [greater than 20 microns] typically
23 fall to the [floor] within 1 metre ...
24 "Large droplets [she says at the bottom of
25 paragraph 43] fall to the ground within seconds, while

100

1 smaller droplets [5 to 20] can stay airborne for several
2 minutes."

3 Now, just pause. You have told us about the
4 distinction between 100 microns and now we're
5 introducing much smaller figures, and I want to try and
6 understand what you say about droplet transmission
7 firstly involving droplets of 5 microns to about
8 200 microns in diameter; is that a range of diameter
9 with which you're familiar and with which you would
10 agree?

11 **A.** I disagree with it, but I am familiar with it, if that
12 makes sense. May I just elucidate one thing?

13 **Q.** Yes, of course.

14 **A.** Earlier on in your questioning, earlier on in the first
15 session, you asked me about the 100 microns and I said
16 there was two schools of thought, and I went down the
17 engineering/physics, which are my -- which I believe is
18 the correct one because it's dealing with the physics,
19 which is well established and has been established for
20 about 150 years, certainly 100 years, in this situation
21 since the 1930s. The other branch is the medics and the
22 IPC branch, and this represents that, and they -- we
23 will see it in the next session -- they had this
24 5-micron demarcation. They didn't actually say
25 200 microns but that's a good upper limit, it's not bad.

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1 factually incorrect, that will take about one -- to fall
2 out of the air, about 1.3 minutes, from a height of
3 a standing height, and remember that is still air not in
4 air. That has a descending velocity, according to
5 Stoke's law of 2.5 centimetres per second, bear in mind
6 that the average air velocity in this room is in the
7 region of 15 to 25 centimetres per second, that type of
8 order.

9 These particles in that one minute, they will travel
10 much further -- can potentially travel further than
11 a metre, especially if they're --

12 **Q.** So there is a divergence here between physicists, if
13 I put it like that --

14 **A.** Yeah.

15 **Q.** -- and the clinicians and I want to try to understand
16 why is it important in terms of infection prevention and
17 control measures?

18 **A.** Well, if you feel that a particle, so say most particles
19 are in that kind of smaller range, if you feel that --
20 but above 5 microns, if you think that that's a droplet
21 and doesn't go more than 1 metre, which is the classic
22 viewpoint, I'm not saying that's here necessarily said
23 quite like this, but the classic textbook says that
24 a particle greater than 5 microns doesn't go more than
25 a metre, then, if you stand 1.5/2 metres away, socially

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1 But that 5 microns, they said anything bigger than that
2 was a droplet.

3 So I am familiar, I've seen this many times in many
4 things but, as far as I'm concerned, that has no basis
5 in physics, it's completely arbitrary, that first
6 statement there. Certainly, they do go up to
7 200 microns and they certainly are in the 500 microns
8 but they're not droplets, those are -- below 100, those
9 are aerosols.

10 **Q.** Right. So --

11 **A.** But, you know, they can reach the eyes and --

12 **Q.** Yes, that bit there is no dispute with but, from your
13 evidence, if I understand you correctly, "droplet" is
14 referring to microns 100 plus?

15 **A.** Yes.

16 **Q.** Aerosols lower than 100?

17 **A.** As in that diagram, which we saw earlier on, Wang's
18 diagram.

19 **Q.** Do we need to look at the paragraph 43 referencing large
20 droplets greater than 20 microns now being introduced,
21 typically falling to the ground?

22 **A.** It's just not true.

23 **Q.** Right.

24 **A.** It's not true. In fact, I can tell you what a 25-micron
25 particle, which is larger than that, right, it's

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1 distanced, you think, well, all the droplets will fall
2 on the floor and you're not taking into account that the
3 aerosol will be inhaled, especially both in the near
4 field and in the far field.

5 So you're completely -- you don't think the aerosols
6 are important, basically, especially if you don't
7 believe that the virus is in them, which we now know the
8 virus is in those things.

9 Also, I should say, you would be recommending
10 a surgical mask --

11 **Q.** Right.

12 **A.** -- because you would be trying to stop droplets and not
13 being too concerned about the aerosols, if that was the
14 case.

15 **Q.** So I understand this correctly, the size of the droplet
16 can determine not only how far -- sorry, the size of the
17 particle can determine not only how far it can go but
18 the type of IPC measure that might be required by the
19 healthcare worker in terms of masks and other bits of
20 PPE they might need to wear to help protect them?

21 **A.** Yes.

22 **Q.** All right, okay.

23 If we briefly turn to the next page in the statement
24 and just deal with airborne, and there set out is, for
25 the purposes of Ms Ritchie's statement, what she says

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1 about airborne transmission:
 2 "... involves infectious particles ... in
 3 a respirable size range that can remain suspended in the
 4 air for long periods and be dispersed by air currents
 5 over distances greater than 1 metre."
 6 **A.** Right, can I just say --
 7 **Q.** Yes.
 8 **A.** -- to clarify, a respirable size actually has a strict
 9 definition in the --
 10 **Q.** Right.
 11 **A.** Well, it's interpreted as less than 5 microns generally,
 12 right, that's the demarcation.
 13 **Q.** Thank you.
 14 **A.** Certainly in the PIP report, that's there. It's the
 15 demarcation between the particles that go deeper into
 16 the lungs and stay higher up, so 5 microns is
 17 generally -- it's not stated here but that would be the
 18 kind of size there.
 19 **Q.** Right.
 20 **A.** So, sorry.
 21 **Q.** It's all right.
 22 **A.** Are we --
 23 **Q.** So, I'm sorry, I lost my train of thought there:
 24 "Airborne transmission involves infectious particles
 25 ... in the respirable size range that can remain
 105

1 less than 10 microns are going to obviously travel short
 2 distances but they'll travel a lot further than the
 3 short distances. So I think this says "can spread over
 4 short distance less than that", the implication being
 5 there that it can only travel over less than short
 6 distances. No, it can't, it can travel over short
 7 distances and long distances. In fact, that's been
 8 known about for years. I'm sorry, you know, back in
 9 Wells' work in the 1930s on TB they were talking about
 10 that going ...
 11 **Q.** Long-range transmission, I suspect you've just dealt
 12 with, and there is set out at paragraph 49, it's her
 13 view that the distinction between a respiratory aerosol
 14 and a droplet in terms of size is:
 15 "... an academic consideration that cannot usefully
 16 be applied in national guidance."
 17 Now, can I make it clear this is not a them and us?
 18 **A.** No, I know.
 19 **Q.** There is a genuine divergence here between the
 20 physicists and perhaps the clinicians, so please don't
 21 misunderstand --
 22 **A.** Yeah.
 23 **Q.** -- the position but I just want you to help us with your
 24 view about some of these terms and indeed some of the
 25 IPC measures that might flow from the terminology.
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1 suspended in the air for long periods and be dispersed
 2 by air currents over distances greater ..."
 3 Do you agree with that summary in that paragraph?
 4 **(Pause)**
 5 Put another way, do you think it accurately
 6 reflects?
 7 **A.** Yeah, no, I agree with it but I would say that particles
 8 over 5 microns can also do that as well and go further
 9 than --
 10 **Q.** Fine. Now, she refers in the statement to short range
 11 transmission and long range. You've told us about near
 12 field and far field. So, again, the terminology not
 13 necessarily being on all fours. Set out here is:
 14 "Short-range aerosol transmission involves tiny
 15 respiratory droplets (less than [10 microns]) that can
 16 spread over short distances (less than 2 metres)."
 17 Do you agree with that?
 18 **A.** I disagree with that.
 19 **Q.** Why?
 20 **A.** Right. Because particle -- a 10-micron particle in
 21 still air will take 8 minutes to drop 2 metres, right,
 22 to fall out of the air. Sorry, 8 metres -- minutes,
 23 I should have said. So 8 minutes, that's in still air,
 24 it can move a lot further.
 25 So a 10-micron particle -- so particles that are
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1 **A.** Right. Yeah, I will. I'm not trying to do a them and
 2 us at all, you know, I'm really trying to help here.
 3 I'm smiling because it highlights the difference of
 4 opinions, right?
 5 **Q.** Exactly.
 6 **A.** Right, so I want to say straight up: I work with
 7 clinicians but I am not a clinician, you know that, but
 8 I have utter respect for clinicians and I see how they
 9 deal with patients all the time. So from an infection
 10 prevention and control background, which this person is
 11 talking from, they're having to deal with a whole load
 12 of practical things. My answer to this is it's not
 13 an academic --
 14 **Q.** Why?
 15 **A.** Because it's really important to understand how
 16 infection is transmitted, how viruses are transmitted
 17 because, if you want to develop interventions you need
 18 to know how it's transmitted and you need to know kind
 19 of the relative importance of various routes, and then
 20 you can decide, develop optimum strategies to minimise
 21 that, to mitigate that, and sometimes you might say, you
 22 know, we don't have to measure the particles, you know,
 23 we don't have to measure the sizes or, you know, the
 24 things that are put down here. What we need to do is
 25 understand it, then we can take measures that help to
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1 mitigate transmission, that's why it's important to
2 understand, so I don't believe it is an academic issue.

3 **MS CAREY:** My Lady, may we pause there?
4 I referred to her as "Ms Ritchie"; she is
5 Dr Ritchie. I meant no disrespect, I'm sorry about
6 that.

7 But would that be a convenient moment?

8 **LADY HALLETT:** Of course. 1.55.

9 **MS CAREY:** Thank you.

10 (12.54 pm)

11 (The short adjournment)

12 (1.55 pm)

13 **LADY HALLETT:** Ms Carey.

14 **MS CAREY:** Thank you.

15 Professor, we've got a number of topics to deal with
16 this afternoon, and can I just try and deal with your
17 evidence in relation to the historical controversy.
18 I suspect we've got a flavour of it already from the
19 evidence that you've already given, but where things
20 have gone wrong or have been assumed to be the position,
21 what I really want to understand is what impact that had
22 on IPC guidance and IPC measures.

23 So can I just deal with the first and perhaps one of
24 the main areas of controversy, which is that Covid was
25 not airborne. Now, I gather from all the evidence that
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1 You set that out in your report and I won't take you
2 through it:

3 "... indicates that by the end of September 2020
4 there was enough moderate certainty evidence to strongly
5 suggest that [SARS or Covid] could be transmitted via
6 the airborne route ..."

7 Pause there. The reference in there to "enough
8 moderate certainty", is that your terminology?

9 **A.** Yes, it is my terminology. I'm referring to -- I'm kind
10 of trying to look at it in the whole. I was convinced
11 it was airborne but, if you're looking for -- there's
12 a range of evidence from a lot of different angles,
13 which we may go into, I don't know, but I was pretty --
14 I was -- felt that it was a good certainty, moderate
15 certainty, there's not beyond absolute doubt but it was
16 definitely a strong possibility. That's the kind of
17 thing that I'm --
18 **Q.** All right, that's what you were trying to convey there?
19 **A.** That's what I'm trying to convey there. You know, I was
20 convinced and many of my colleagues from my background
21 will be utterly convinced that it was, by that time.

22 **Q.** Can I summarise it this way: you thought there were
23 a number of sources that pointed, by September 2020, to
24 it being airborne?

25 **A.** Yes, yes.

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1 you've given that you disagree with that --

2 **A.** Yes.

3 **Q.** -- and indeed believed at the outset that it was
4 airborne, and indeed now in 2024 have firmed up that
5 belief?

6 **A.** Absolutely.

7 **Q.** All right. The World Health Organisation's position
8 requires just a moment's examination. In March 2020, is
9 it right that the WHO, World Health Organisation,
10 position on transmission of Covid was that it was not
11 airborne?

12 **A.** Absolutely, they even Tweeted about it.

13 **Q.** Right. By April 2021 there was partial acceptance by
14 the WHO that Covid was airborne?

15 **A.** Yes.

16 **Q.** And it was December 2021 that they stated that Covid-19
17 could be transmitted via aerosols?

18 **A.** Yes.

19 **Q.** Right. Your position is, if I may summarise it, that by
20 September 2020 -- and if it helps you I'm at
21 a paragraph 139 in your report on page 53.

22 **A.** Yep.

23 **Q.** Thank you. It's helpfully highlighted there. You
24 consider that:

25 "... the weight of the evidence presented ..."
110

1 **Q.** All right. That was obviously 15 months or so before
2 the WHO, in December 2021 --

3 **A.** Yes.

4 **Q.** -- stated that it was transmitted via aerosols?

5 **A.** Yes. Yes.

6 **Q.** Now, we have alluded this morning to the fact that there
7 has been a shift in the scientific consensus from the
8 position in 2020 by those writing the guidance, those
9 advisers and the like, to where we are in 2024. Do
10 I understand it correctly that you consider that that
11 shift in consensus was largely driven by scientists?

12 **A.** Yes.

13 **Q.** Okay. In your report, if you could just take down the
14 insert --

15 **LADY HALLETT:** Sorry to interrupt. You're distinguishing
16 between clinicians and your kind of scientist or are you
17 saying virologists?

18 **A.** It was driven by people from a multidisciplinary
19 background, predominantly very much influenced by people
20 from physics, people like Lidia Morawska, Cath Noakes,
21 engineers, myself and others, but there were clinicians
22 involved in that. There was a letter of I think about
23 230-odd eminent scientists/clinicians to the WHO saying,
24 "Look, it's airborne", and I can't remember the date,
25 I'd have to look at --

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1 **LADY HALLETT:** So it was across the board?
 2 **A.** Yeah.
 3 **MS CAREY:** Thank you very much.
 4 **A.** But they were absolutely influential in that.
 5 **Q.** Underpinning that evolution from the position at the
 6 start of the pandemic to at the end were obviously
 7 a number of scientific papers, and you've set them out
 8 in your report, and I'm not going to go through them
 9 all, save for one that you considered to be of some
 10 import in moving the shift towards people accepting
 11 airborne transmission.
 12 Can I ask you, please, about paragraph 132 in your
 13 report, and if we'd like to put it on the screen, there
 14 is a summary of it on page 55, and it's the Skagit
 15 Valley superspreading event, and on the screen it's the
 16 entry of 26 September 2020.
 17 **A.** Yeah.
 18 **Q.** Just, in a nutshell, tell us what happened at the Skagit
 19 Valley superspreading event and then why you consider it
 20 to be so important?
 21 **A.** Right. I just want to set it in context, if it's all
 22 right, just very briefly.
 23 **Q.** Briefly, thank you.
 24 **A.** Prior to that, right from March, there was evidence
 25 that -- of people sampling the air in hospitals and

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1 contact or droplets; it was far field aerosol
 2 transmission, and that really was epidemiological
 3 evidence that confirmed what we had suspected from all
 4 the other studies that were coming through.
 5 **Q.** Fine, and they set out in that little --
 6 **A.** So that's why that was a key thing.
 7 **Q.** Thank you. I think, in addition to concluding there was
 8 overwhelming evidence of long-range or far-field
 9 airborne transmission, it perhaps matters not for these
 10 purposes, that fomite or ballistic droplet transmission
 11 was unlikely to explain a substantial fraction of those
 12 53 cases?
 13 **A.** Absolutely.
 14 **Q.** All right, and you'd, in your report, said that this
 15 study or event gave wider traction to the notion that
 16 Covid might be airborne?
 17 **A.** Yes, those of us who were working behind the scenes to
 18 try to understand this, and were convinced it was
 19 airborne, we were -- this was really helpful, because
 20 this was further evidence to that. But also people were
 21 starting to take notice, and that's when it gained
 22 traction further afield because of that.
 23 **Q.** To help root this in the pandemic, this is now probably
 24 just before the second wave, my Lady, and we're around
 25 September 2020, going into the second wave later that

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1 finding RNAs, so that was around. There was evidence
 2 from lab work that the virus could stay viable in the
 3 air for long periods of time, this is all evidence
 4 leading up to that, people have cultured live virus from
 5 the air, and people realised that this was in the
 6 aerosols and everything. This led up -- so the evidence
 7 was building, that's what I'm saying, that's why this is
 8 all part of the same picture, and this was the kind of
 9 icing on the cake.
 10 This was when -- it's a horrendous event which some
 11 of you may know of, which was a choir had a practice in
 12 the Skagit Valley Chorale and 61 people were in this
 13 practice, and I forget how many hours it was but it was
 14 a number of hours, and I think in a fairly large
 15 building as well, a large space, and so they weren't all
 16 in close contact with each other, they weren't
 17 necessarily socially distanced or anything, as far as
 18 I can remember.
 19 And 53 of those people became infected, 53 of 61
 20 became infected and, unfortunately, two people died and
 21 this was reported -- first reported, I think, probably
 22 in August but not -- the analysis was done with
 23 something called the Wells-Riley equation and looking at
 24 the whole route of transmission and the authors came to
 25 the absolute conclusion this could not have been by hand

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1 year.
 2 Now, we just briefly touched on the WHO position.
 3 I want to ask you about the position in the UK, and
 4 I think you say at paragraph 140 in your report that
 5 Professor Noakes -- who my Lady heard from I think in
 6 Module 2 -- certainly was aware that, from 14 April,
 7 transmission of Covid might be occurring through the
 8 airborne route, and she then went on to form the
 9 Environmental Modelling Group, and that group, as
 10 my Lady knows, produced a number of documents in 2020
 11 and into 2021, which showed the change from Covid-19 is
 12 not airborne to Covid-19 is airborne. Is that,
 13 generally speaking, correct?
 14 **A.** Yes, that's what I'm saying here. I'm using the Covid
 15 is not airborne to Covid is airborne as a vehicle to try
 16 and convey the change of consensus.
 17 **LADY HALLETT:** Just before you move on, you said the Skagit
 18 Valley Chorale was September 2020, second wave. When
 19 I Googled it I thought it was March 2020.
 20 **A.** Ah, right.
 21 **MS CAREY:** Can you help?
 22 **A.** Yes, I can clarify. The first outbreak was reported in
 23 *Emerging Infectious Diseases*, which is a CDC publication
 24 and it reported the outbreak but didn't do the analysis.
 25 **LADY HALLETT:** Oh, I see, so this --

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- 1 A. But then the group, it didn't mention airborne, so group
2 came together with Professor Noakes, Shelly Miller --
- 3 **LADY HALLETT:** It's all right, I don't need to go into more
4 detail. So the event took place in March, analysis
5 later?
- 6 A. They did the analysis -- the epidemiological analysis
7 and this is showing that that could not have been --
8 highly unlikely it would have been by that route.
- 9 **MS CAREY:** Thank you for that.
- 10 A. That took several months, obviously.
- 11 **LADY HALLETT:** Thank you.
- 12 **MS CAREY:** I think I should add that, although the
13 Environmental Modelling Group shifted its position from
14 Covid-19 isn't airborne to is, again, I think you set
15 out in your report at paragraph 143, not all scientists
16 agree with that shift. I won't go into that but it's
17 just to allude to the fact that there isn't always
18 consensus about this.
- 19 A. It was gradual, it was in steps.
- 20 Q. I suppose, really, the question comes down to this: can
21 you help us as to why you think it was assumed at the
22 start of the pandemic that Covid was not airborne? Your
23 paragraph 125 might help you, Professor. It's at
24 page 49 in your report.
- 25 A. 125?

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- 1 that you can't tell whether the near-field transmission
2 is by droplets or aerosols. It could be either, from
3 the epidemiological and the animal study data.
- 4 But because you take the **a priori** position, which
5 seemed reasonable at the time, that most of the virus is
6 going to be in the largest droplets, therefore that
7 would explain that these results would be -- it's
8 plausible it's in the large droplets.
- 9 In the fine aerosols there's -- after all there's
10 hardly any virus, at that time, and the PIP report says
11 that in 2011. That's the justification for the whole
12 thing, they actually set that out quite clearly.
13 Because they assume it's in the large ones, therefore
14 all the epidemiological evidence and all the animal
15 studies are interpreted as being droplet borne, then
16 people come along afterwards, they report it, yes, it's
17 been shown that it's droplet borne, but it was all on
18 this assumption.
- 19 If you flip the assumption, if you knew that they
20 were in the smaller particles you'd say, "Well, it was
21 all airborne" and suddenly all the evidence would show
22 it was airborne. So it's an **a priori** assumption that
23 was reasonable at the time that in the last 10, 12 years
24 has been challenged. But whether people are aware of
25 that --

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- 1 Q. Yes. Essentially, why was it assumed at the beginning
2 that Covid wasn't airborne?
- 3 A. Quite simply, it was assumed it was droplet borne, was
4 the main route. Droplet borne, don't travel, the large
5 droplets is where it was assumed, in my opinion,
6 wrongly, as it's transpired, that most of the virus was
7 in the large droplets and these do not travel more than
8 about 1 metre, 1.5, therefore the only people who can
9 get infected are the people who are in close range,
10 therefore it is droplet borne. So where the virus is in
11 the particles is hugely important because it --
12 everything -- it's kind of house of cards, everything
13 rests on that.
- 14 **LADY HALLETT:** Was there any basis for that assumption? Why
15 would you not work on the basis that we don't yet know
16 the route of transmission --
- 17 A. That's an excellent answer -- sorry, an excellent
18 question. It's an **a priori** position. So when you look
19 at trying to -- this is what people don't realise. When
20 you're trying to interpret epidemiological data of
21 outbreaks, and indeed animal experiments, you canvass it
22 with an **a priori** position, you say: does it fit with
23 this or what we expect? The problem there is that
24 the -- when you actually drill down into the evidence,
25 and it's going back to the '40s, and things like this,

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- 1 **LADY HALLETT:** Well, that's what I'm questioning. Is it
2 reasonable, if you don't know the route of transmission,
3 surely you should be preparing for and guarding
4 against -- I think some core participants have called it
5 the precautionary principle, though I'm wary of that
6 because I've heard it has different meanings to
7 different people, but surely you should guarding against
8 every possible route of transmission until you know?
- 9 A. You're absolutely correct. I -- sorry, another of my
10 hats is doing statistics and I spent a lot of time
11 looking at that, and one of the problems with stats is,
12 generally, medical statistics we're trying to eliminate
13 what's called a type 1 error, which is we're trying to
14 say something is -- we want absolute proof to show that
15 that drug makes a difference, and we're not so worried
16 about when we get it wrong on the other side, the type 2
17 error, when we say -- basically, which is with the
18 pandemic, it's not airborne and it is airborne, we're
19 not too worried about that generally. But in a pandemic
20 that's exactly what you don't want, you want to be
21 precautionary.
- 22 So one of the problems was I think there was
23 a mindset there that followed through -- sorry,
24 I'm waxing on a bit too much there --
- 25 **LADY HALLETT:** Sorry, it was my fault, I interrupted.

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1 **MS CAREY:** Not at all, because in fact that's where I was
2 going to get to, because if in reality there is no clear
3 evidence at the beginning of a pandemic about what route
4 of transmission is adopted, do you think it would be
5 wise for recommendations to cover all modes until you
6 know more?

7 **A.** I certainly would do, and this is one of the big
8 complaints that myself and others have is that people
9 have a kind of confirmation bias, in the sense that they
10 confirmed what they thought and they read that into it.

11 And I'm not saying that there isn't droplet
12 transmission, but to rule it out when -- just take the
13 simple fact that you always have aerosols with droplets.
14 That's been known about for many, many years. If you're
15 going to be precautionary, what you see in many of the
16 randomised controlled trials are people are going to
17 a very high bar of proof to jump over, when in fact, as
18 we've seen, there's very little evidence for the
19 hand-borne route, and then they don't apply that high
20 bar of proof for that because that's the *a priori*
21 received position, it's in the textbooks and that. So
22 that's one of the weaknesses I see of the whole thing.

23 **Q.** Thank you.

24 Can I deal with one other or two other matters in
25 this vein. I think you say at your paragraph 150 that

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1 **Q.** -- but do you consider that the physical science
2 suggests that many so-called AGPs actually produce fewer
3 aerosols than normal activities such as coughing?

4 **A.** Yes.

5 **Q.** That's not to say that some AGPs don't produce a lot of
6 aerosols but there are some on there that actually
7 produce fewer?

8 **A.** I always -- I've got to be a bit careful not being
9 a clinician, so I -- but from the evidence that I have
10 seen, and there has been quite, quite serious studies
11 and meta-analysis done, quite a lot of the AGPs which
12 were thought to produce a lot of aerosols don't produce
13 that many aerosols.

14 **LADY HALLETT:** AGP again?

15 **MS CAREY:** Aerosol-generating --

16 **A.** Aerosol-generating -- it's a medical procedure, so
17 bronchoscopy, for example, would be one, where you stick
18 an endoscope down --

19 **Q.** Now, I should add there is not always consensus about
20 what should or shouldn't be on the AGP list. But in
21 general terms is this the position: there may appear to
22 be an overconcentration on AGPs and the role they play
23 to the detriment of us just talking and breathing?

24 **A.** Yeah. I'll add -- if I can add --

25 **Q.** Yes, of course.

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1 there was an important shift in the thinking concerning
2 vocalisation, ie speaking, shouting, singing. I just
3 want to ask you about that.

4 I think you are of the view that breathing and
5 talking was overlooked as a way of producing aerosols;
6 is that right?

7 **A.** Yes. And I'd include singing as well, and shouting.

8 If you think about it, all the emphasis, certainly
9 at the beginning of the pandemic, was on symptomatic
10 situations, so coughing and sneezes. You know, people
11 can see people are infectious: distance yourselves,
12 cover your mouth, wash your hands, all the rest of it.
13 But nobody was talking about just being next to someone
14 who was breathing.

15 You know, think about a patient in bed, and if you
16 think about presymptomatic patients, say in that
17 six-bedded bay, an open bay, the other patients are with
18 them, next to them, all day long. If that person is
19 infectious, just talking and breathing, they may not be
20 showing any symptoms but they still could be spreading
21 the virus. So it's a hugely important issue.

22 **Q.** One other allied topic is that of aerosol-generating
23 procedures (AGPs). Can I summarise your position. If
24 I've got it wrong, please let me know --

25 **A.** Yes.

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1 **A.** Yes, and in my opinion, yes, when you look at the IPC
2 guidelines, the national IPC manual, there's lots and
3 lots on aerosol-generating procedures and nothing on
4 just aerosols produced -- natural aerosols produced
5 through exhalation, including coughing actually and
6 including that -- unless it's classified as an airborne
7 disease. And the only thing that's classified as that
8 are measles and TB -- are the two, yes, basically.

9 **Q.** Just finally on dealing with assumptions, can I ask,
10 please, that we put up page 45 of Professor Beggs'
11 report and I hope maybe segue into the Pandemic
12 Influenza Preparedness (PIP) 2011 report.

13 Professor Beggs sets out fully in his report the
14 impact of that, but I just want to look at the two
15 finite bullet points to bring it together.

16 You consider that:

17 "The 2011 Pandemic Influenza Preparedness (PIP)
18 report was well-conducted and correctly identified the
19 significant remaining uncertainty about [flu]."

20 But it has:

21 "... several problems. Unlike many other studies it
22 did acknowledge the risk of airborne transmission, but
23 only at close range ..."

24 Does that mean in the near field?

25 **A.** Yes, yes yeah.

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- 1 **Q.** "... and made an important flawed assumption about large
2 droplets conferring most of the infection ..."
3 Whereas you are telling us in fact it is the
4 aerosols?
- 5 **A.** Yes, that's the -- that's that fundamental assumption,
6 and if I may just take a minute -- I like this report.
7 I was really pleased that, when I read it, they'd gone
8 into depth, they'd justified why things were there,
9 they'd gone through things and they were looking at it.
10 But they made the assumption that the -- which was
11 definitely prevalent, the first study actually found
12 influenza virus in small aerosols, less than 5 microns
13 in size, only occurred in 2010, and they spotted that as
14 well, but they made this assumption that most of the
15 virus was in the large droplets and therefore very
16 little would be in the aerosols. Therefore aerosol
17 transmission probably wasn't occurring, certainly not in
18 the long range, possibly however it might be occurring
19 in the short range, in the near field. That was their
20 assumption. But they did say that the droplet was the
21 main route.
- 22 **Q.** Thank you.
- 23 **A.** There is another flawed assumption but I think we're
24 dealing with that one in the next -- is it in the next
25 one?

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- 1 in, that was just completely missed in the PIP report.
2 So those two assumptions I felt were flaws in that
3 report.
4 Going back to this here, they had raised -- what
5 I did like was they raised the possibility that
6 short-range aerosol transmission was occurring for the
7 first time, which I thought was good, but they were
8 mainly concerned about aerosol-generating procedures, as
9 you say, and this is why it influenced future IPC
10 guidance.
- 11 **Q.** Understood.
- 12 **A.** So it was influential. But there was no -- again, there
13 was no epidemiological evidence so far as I could see
14 relating to the aerosols in the aerosol-generating
15 procedures. I may be wrong, but I can't --
- 16 **Q.** That's your position, all right. I can take that down.
17 And let me just deal with this. I've obviously
18 asked you a number of questions and given examples
19 relating to hospital bays and nurses attending to
20 patients in that context, non-clinical staff going in
21 and cleaning and the like. Can I ask you, what
22 implications does the significance of aerosol
23 transmission have for IPC in smaller settings, clinics,
24 pharmacies, GPs? Is there any difference if we're
25 looking at a smaller setting?

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- 1 **Q.** I hope so. Can we look at the final bullet point
2 please.
- 3 **A.** If not, I will then --
- 4 **Q.** All right. The reason it's important, my Lady, is
5 because the PIP report, many of the findings and
6 assumptions in that then underpinned various guidelines
7 for use during a flu pandemic and, by extension
8 therefore, other respiratory virus pandemics. And it
9 restricted respirators to only staff conducting AGPs on
10 flu patients. And you say there:
11 "Newer evidence that large amounts of virus could be
12 naturally exhaled by infectious patients did not shift
13 this initial policy choice during the Covid-19
14 pandemic."
- 15 **A.** Right. Before I do that --
- 16 **Q.** Yes.
- 17 **A.** -- I don't want to forget the other point, which is not
18 here but it's in the text.
19 The other flaw in the PIP report was that they
20 assumed that once aerosols as they went out they fanned
21 out and you got less and less concentration. That's
22 what happens outdoors. But indoors, because they're
23 confined, the concentration over time will build up, and
24 so people in the far field, even though the
25 concentration will become more and they can breathe that

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- 1 **A.** Right. No, the physics is the same, but -- it's exactly
2 the same principles. Basically the aerosols will build
3 up in a space that's poorly ventilated. So in a smaller
4 setting, you might be looking at a hospital --
5 a doctor's waiting room, you might have quite a tight,
6 confined space with -- maybe not well ventilated -- with
7 a lot of people there. You may also find that the same
8 things apply: the longer you spend in the presence of
9 someone who's infected and the closer you are to them,
10 you're probably going to get a higher load of aerosols.
- 11 **Q.** So across the healthcare settings it's important to get
12 right at the outset, or at least not get wrong at the
13 outset, the mode of transmission?
- 14 **A.** Yeah, physics doesn't change whether you're in a big
15 hospital or a little clinic.
- 16 **Q.** Can I move topic completely to face masks, respirators
17 and, to the extent we need to, visors.
18 Now, Professor, we've already seen an example of
19 an FRSM, and if we want one there is in your report.
20 And I think perhaps if we could call up page 73 and
21 a very helpful diagram there.
22 In short, FRSMs protect against droplets; is that
23 right?
- 24 **A.** Yeah, well, it's fluid-resistant surgical masks,
25 right --

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1 Q. But they can't prevent inhalation of aerosols due to
2 their loose fitting --

3 A. Yeah, they're loose-fitting masks around the face. They
4 protect the wearer -- well, the first and foremost thing
5 is to actually protect other people by stopping big
6 droplets being exhaled out, so they hit the mask inside
7 and they don't get transmitted to other people. But the
8 aerosols can escape, as you can see in figure 14 --

9 Q. We're going on come on to that.

10 A. Oh, we're going to --

11 Q. Yeah.

12 A. They escape, but they protect the wearer in so much that
13 large droplets heading for the nose or the mouth, but
14 not the eyes, don't hit that. But aerosols can get
15 round the gaps basically.

16 Q. And if we look at our figure 14, the first column, (a)
17 and (d) represents the thermal exhalation plumes
18 produced by someone when no mask is worn and they are
19 sitting quietly -- sorry, (a) is no mask is worn and (d)
20 is when the mask is worn. So that's what it looks like
21 if someone is sitting quietly, the plume that is
22 produced.

23 A. So you can see the thermal plume rising up over them in
24 every case and you can see -- I presume here this
25 person's breathing through their nose and you can see

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1 fit to occur.

2 Q. If a wearer fails a fit test for whatever reason,
3 I think you also say in your report at paragraph 197 --
4 but you don't need to call it up -- there are respirator
5 hoods that can be used in those circumstances if the
6 fit test fails for whatever reason?

7 A. Yes, yeah.

8 Q. All right, now I would like to ask about the
9 effectiveness of different mask types. And if it helps
10 you, we go to I think around 210, or page 79, in your
11 report.

12 (Pause)

13 I think you say -- can we take down paragraph 210
14 for a moment. Thank you.

15 But in short, is it difficult to evaluate the
16 effectiveness of mask types?

17 A. No. It depends how you want to evaluate them.

18 Q. Let me deal with some of the detail --

19 A. Lab or field trial.

20 Q. All right, let me deal with some of the detail then.
21 I think you said at your paragraph 210:
22 "... demonstrating that masks are actually effective
23 at inhibiting the transmission of [Covid] has proven to
24 be ... somewhat challenging ..."

25 A. Yep, right, I think I just need to clarify this, because

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1 the plume coming down, the exhalation plume from the
2 nose going down towards the ground, not even going
3 forward.

4 The next one, (b), is where they're actually saying
5 "also", and the last one is a laugh actually. And then
6 the same thing repeated with the surgical mask on it.

7 Q. My Lady, that may be neat way of encapsulating the role
8 a surgical mask can play in helping either prevent the
9 spread of infection or, in the large droplet case, the
10 inhalation of it.

11 Did you want to say something?

12 A. Yes, can you see how, when the mask is worn, there is
13 aerosols escaping out through -- around the nose bridge,
14 and you can see how they join into the thermal plume
15 there and then travel wherever, in that sense.

16 Q. Respirator masks, as we know, are tight fitting and are
17 therefore designed to protect the wearer from inhaling
18 aerosols?

19 A. They also protect them from pushing them out into the
20 environment as well, but they are designed primarily to
21 protect against all particles, aerosols and droplets.

22 Q. My Lady has already heard that in the UK we use FFP3
23 generally and you have to be fit tested.

24 A. They've got head straps that go round the back of the
25 head. That's important because that enables the tight

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1 your question --

2 Q. Clarify away.

3 A. Right. So you can get a mask, put it on a mannequin or
4 in a lab in a controlled situation and you can test the
5 effectiveness. So it's not difficult to do that. So
6 that was my answer to your question. Right?

7 If you want to see how they behave in the real
8 world, do they actually stop a pandemic or stop
9 something, you have to do a trial of some nature. And
10 that is tricky because what happens is things change,
11 you get lack of compliance, you get different rates of
12 infection occurring. If you want to do a randomised
13 controlled trial -- you can't do a randomised controlled
14 trial because every -- you can't blind it, for a start,
15 because people know who is wearing the mask. There is
16 a lot of factors. People get vaccinated in the middle
17 of the thing. It get very difficult to do that type of
18 thing.

19 So it's challenging. That is challenging, the real
20 world thing. The stuff about actually seeing how they
21 behave in the lab, the actual physics of it, is
22 relatively straightforward actually.

23 Q. It was my fault, it was a bad question, sorry, for
24 thank you for making that clear.

25 There is, however, as you set out in your report at

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1 paragraphs 213 and 214 onwards, findings of
 2 a Royal Society review which conducted, I think,
 3 a review of, was it, 34 different studies?
 4 **A.** Yes, it was, up to Omicron, I think.
 5 **Q.** Yes. I just want to summarise those because they're
 6 important.
 7 **A.** Yeah.
 8 **Q.** I think that the Royal Society found that the vast
 9 majority of studies they looked at found that masks
 10 reduced infection; is that right?
 11 **A.** Yes, they were effective in mitigating and reducing the
 12 transmission of infection.
 13 **Q.** That wearing a mask reduced Covid transmission in the
 14 community?
 15 **A.** Yes.
 16 **Q.** And that seven of the studies found that respirators
 17 were more effective than fluid-resistant surgical masks?
 18 **A.** Yes.
 19 **Q.** And that drawing all of the different studies together,
 20 the Royal Society found -- and perhaps we could
 21 highlight paragraph 215, please -- there in bold, the
 22 Royal Society expert group concluded that:
 23 "... the weight of evidence from all of the studies
 24 suggests that wearing masks, wearing higher quality
 25 masks (respirators), and mask mandates generally reduced
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1 protecting healthcare workers against Covid?
 2 **A.** Yes, yes.
 3 **Q.** In the similar vein, going on, please, in your report to
 4 paragraph 221, a number of other studies that you cite
 5 in that paragraph, but you say there in bold -- are we
 6 talking here about a distinction between FFP2 and FFP3
 7 masks? I think we are, so let me deal with FFP2.
 8 **A.** Let me just have a quick look at this statement and see
 9 what it said.
 10 (Pause)
 11 Yeah. Yeah.
 12 **Q.** Right. FFP3 is what is recommended in the UK, although
 13 my Lady will hear in due course that, in the absence of
 14 FFP3, because supplies ran out, FFP2 was considered to
 15 be an acceptable mask in the absence of FFP3.
 16 **A.** Yeah.
 17 **Q.** Right, and so that provides some context. Help us,
 18 please, with your paragraph 221, though.
 19 **A.** Yes. Right, so what I'm saying there is that -- right,
 20 that first part of that paragraph really should be read
 21 in conjunction with paragraph 219. Could I show that,
 22 please?
 23 **Q.** Yes, or just summarise it for us.
 24 **A.** Right, so simply you can't distinguish between -- you
 25 can't disentangle masks, face masks, from ventilation.
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1 the transmission of SARS-CoV-2 [Covid] infection."
 2 **A.** Yeah, I mean, in blunt terms they found, looking at the
 3 overall, the whole thing -- and remember, stuff that --
 4 this was done late on, after the pandemic. It's much
 5 higher quality evidence than early in the pandemic.
 6 They found the weight of evidence was that wearing masks
 7 was better than not wearing masks, and respirators were
 8 better than surgical masks.
 9 It's as simple as that, really.
 10 **Q.** They went on to consider the specific issue of
 11 respirators and surgical masks.
 12 And can I call up paragraph 218, please, on page 83.
 13 We can see there the Royal Society review stated:
 14 "There is also evidence, mainly from studies in
 15 healthcare settings, that higher-quality 'respirator'
 16 masks ... were more effective than surgical-type masks."
 17 **A.** Yeah, absolutely. There the N95 is an American
 18 classification, but it's equivalent to a FFP2 actually.
 19 **Q.** Which is not generally used in the UK --
 20 **A.** Not generally used, but good, a very good mask, a very
 21 good mask/respirator, as we'll ... yeah.
 22 **Q.** So, translating that to healthcare settings, I think you
 23 said a little lower down in your paragraph 218 that
 24 there was good grounds for believing that respirators
 25 generally performed better than surgical masks at
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1 The two are related and in the hierarchy of controls,
 2 right, and 219 is building the case, so here it is here.
 3 So, basically, if you, basically surgical masks
 4 perform better when there's lower levels of pathogens in
 5 the air, lower levels of virus in the air. So let me
 6 just give you two examples, right. If we had a room
 7 with no virus in the air and we had people wearing
 8 surgical masks and people wearing respirators, two
 9 groups, you would find no difference between them
 10 because there's no threat. Right.
 11 You go to the opposite end, where you've got loads
 12 of virus in the air, you would find that there was
 13 a huge difference, the respirators would be really
 14 effective because -- if they're fitting well and -- but
 15 the surgical masks would be ineffective because there is
 16 a big supervirus out there and they're allowing aerosols
 17 to get through. So the effectiveness of surgical masks
 18 depends on the viral load, whereas the respirators are
 19 kind of immune to that. Right?
 20 So you've got to look at the load in conjunction
 21 with that. So when we come on to 221 now, right, when
 22 you're asking me about that, if I could just have it
 23 larger, please.
 24 **Q.** Yes, thank you.
 25 **A.** That statement where it says:
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1 "This led Cheng ... to conclude that ... surgical
 2 masks might provide sufficient protection when exposure
 3 levels are low, in virus-rich environments, such as on
 4 Covid wards, they may not be adequate."
 5 Right? So, in other words, if you've got
 6 a situation where you've got a whole load of Covid
 7 patients or suspected Covid patients, who are maybe even
 8 presymptomatic or at early stages and highly infectious,
 9 gathered together, you're likely to have a high viral
 10 load in the air. Your surgical masks may not be
 11 effective against that, whereas, if you're dealing with
 12 a Covid patient who's maybe just one patient or a low
 13 number, and they're towards the end of their infection
 14 and they're not producing as much, the virus in the
 15 environment might be less, therefore the surgical mask
 16 may be more effective in that situation.
 17 **Q.** So pausing there --
 18 **A.** That's what that --
 19 **Q.** I know, so pausing there, in a situation where there is
 20 someone dealing with a ward full of either suspected or
 21 actually confirmed Covid patients, is that an argument
 22 for saying that, where there's likely to be such a high
 23 viral load, there is a stronger argument for the use of
 24 respirators?
 25 **A.** Yes, or better quality masks of some nature but
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1 a group -- you don't think about this -- one might be
 2 working on a place where there's a real high Covid risk
 3 and the others aren't. It doesn't make a difference,
 4 you know, do you see what I mean, this is why it's --
 5 **Q.** So let me draw some of --
 6 **A.** Sorry, I'm --
 7 **Q.** No, not at all. Let me see if I can draw some of these
 8 threads together though because I think you make the
 9 point, and others will doubtless make it, my Lady, later
 10 in the hearing, that the realities of wearing FFP3 can't
 11 be ignored here, they are uncomfortable, they can lead
 12 to skin irritation, they are hot?
 13 **A.** Yeah.
 14 **Q.** After, I suspect, this afternoon's break, I'm going to
 15 ask you a little bit about FFP2 but let's just pause
 16 there because you mentioned in that answer that we can't
 17 ignore the role of ventilation, and I'd like to just
 18 come on to look a little bit of that.
 19 Clearly though when one is talking about masks, it
 20 requires compliance by the wearer, and I think you said
 21 that you're aware that in hospitals infected patients
 22 were significant drivers of infection amongst healthcare
 23 workers and other patients, and that mask wearing
 24 amongst patients, and I'm at your paragraph 206 --
 25 **A.** Sorry, was that --
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1 certainly respirators would be a strong argument.
 2 **Q.** Right.
 3 **A.** In fact, that's what the bold bit at the bottom is
 4 there --
 5 **Q.** Yes.
 6 **A.** -- which was Ferris' study found that healthcare workers
 7 who were wearing a surgical mask had a 31-fold increased
 8 risk of acquiring a ward-based infection -- SARS-CoV-2
 9 infection -- when working on a Covid ward, compared to
 10 when working on a non-Covid ward. I think I've got that
 11 paraphrased right.
 12 **LADY HALLETT:** Professor Beggs, as a layperson, the
 13 conclusion seems to be like common sense.
 14 **A.** It is common sense, sorry, even to a professor of
 15 engineering, it is common sense as well.
 16 **MS CAREY:** If you've got loads of it in the room, you need
 17 better protection than when you have less of it.
 18 **LADY HALLETT:** Yes, yes.
 19 **MS CAREY:** Is that --
 20 **A.** Yeah, yeah, yeah. But the problem -- but it's even the
 21 hierarchy of controls. You'd be amazed that people
 22 don't realise that they -- that's one of the challenges
 23 when you're doing a trial, you know, how do you know the
 24 threat's there in the first place, you're comparing two
 25 groups who are wearing masks. One might be in
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1 **Q.** 206, which is on page, if it helps you, 78.
 2 **A.** Yep.
 3 **Q.** "... mask wearing amongst [patients] was essential to
 4 reduce patient-to-patient and patient-to-[healthcare
 5 worker] transmission ..."
 6 But, of course, it's difficult to enforce,
 7 particularly, for example, if the patient is so unwell
 8 they can't tolerate wearing a mask.
 9 **A.** Can I just explain that a bit more in its full entirety,
 10 as briefly as possible?
 11 So what was found in the -- various studies have
 12 found is that the most -- most of the infection to other
 13 patients was from patients who became infected with
 14 Covid in hospital, nosocomially infected patients in
 15 hospital and they infected other patients and they also
 16 infected healthcare workers, right, they drove it, and
 17 the reason they did that is because they caught the
 18 infection in hospital and they were there during that
 19 incubation period and early infectious periods. That's
 20 when they were most infectious, so anyone who came into
 21 contact with them was going to be at risk. So they're
 22 the kind of key players in terms of driving infection in
 23 many situations.
 24 So one of the things that my colleague
 25 Chris Illingworth and his study at Addenbrooke's was --
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1 found from his study was to encourage patients to --
 2 in-patients to wear masks. Now, this is a big problem
 3 because these patients are ill, they're uncomfortable
 4 and they're certainly not talking about -- we're talking
 5 about surgical masks not respirators or anything -- and
 6 they're trying to get in-patients to I think --
 7 according to my clinical colleagues at Addenbrooke's,
 8 they were trying to do that but they kind of ended up
 9 all over the place and it was difficult, you know;
 10 people have to eat, you know.
 11 **Q.** Yes. So if there is a high viral load in the room --
 12 **A.** Yeah.
 13 **Q.** -- one way of preventing you from contracting the
 14 infection is mask wearing?
 15 **A.** That also helps to keep the viral load down.
 16 **Q.** I know, I know, but the other way of helping reduce the
 17 viral load is therefore ventilation?
 18 **A.** Absolutely.
 19 **Q.** Right. Can we just deal with some terminology in
 20 relation to ventilation?
 21 **A.** Yep.
 22 **Q.** Ventilation is the introduction of fresh air to flush
 23 away bacteria?
 24 **A.** And viruses.
 25 **Q.** I'm taking your words.

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1 **Q.** Air cleaning is the process by which the air is cleaned,
 2 as the name suggests, with a filtering unit?
 3 **A.** Yes, absolutely, so that does move -- we've got one over
 4 there.
 5 **Q.** We're going to come onto that later.
 6 **A.** It's got a fan and air goes through it. So it promotes
 7 air movement but it cleans the air.
 8 **Q.** All right. Now, can I ask you please to look at
 9 paragraph 238 on page 90 of the report. Dealing now
 10 with ventilation.
 11 **A.** Yep.
 12 **Q.** Paragraph 238, you say at the top of the paragraph that
 13 room ventilation is ineffective against large droplets,
 14 ie those greater than 100 microns, because they behave
 15 ballistically and drop to the floor.
 16 **A.** Right.
 17 **Q.** Is that correct?
 18 **A.** Yes. Sorry, general room ventilation that we normally
 19 have, that you can have specialist systems that do do
 20 that but that's a different animal. But, yes, it is
 21 correct.
 22 **Q.** You go on there to, in that paragraph, make the point
 23 that ventilation can only flush away and remove aerosol
 24 particles that are suspended in air as these travel with
 25 the air currents?

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1 **A.** My words, all right.
 2 **Q.** And viruses.
 3 **A.** I obviously was talking about bacteria there.
 4 **Q.** All right.
 5 **A.** But ventilation is -- yes, it is.
 6 **Q.** Thank you.
 7 **A.** No, ventilation is the action of introducing fresh air,
 8 outside air that's clean to -- what we do is we dilute
 9 the concentration and we flush away the particles in the
 10 air. So it flushes away anything that's in the air, as
 11 aerosols, so that could be dust, that can be, you know,
 12 inanimate stuff, it can be bacteria, fungal spores and
 13 viruses, right? So it's indiscriminate. It flushes
 14 that away.
 15 **Q.** I follow that. Let's just concentrate on the virus for
 16 these purposes. Air conditioning is the movement of air
 17 around or between rooms; it's not the same thing as
 18 ventilation, is it?
 19 **A.** Air movement is the movement of air around between
 20 spaces so, in this room, for example, we could have
 21 a ceiling fan -- we haven't got one, you'll have to
 22 imagine it -- it would be moving, you would feel the air
 23 currents generated by that, but that's not ventilating
 24 the space, it's promoting movement, and many people get
 25 confused between the two.

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1 **A.** Absolutely, if it's headed for the floor and it's
 2 heavier, it's not going to be flushed away.
 3 **Q.** "With respect to this, room ventilation is generally
 4 only effective at mitigating the far-field infection
 5 risk, because it cannot remove aerosol particles in the
 6 near field ..."
 7 **A.** Yes, yes definitely. Again, there are very specialist
 8 ventilation systems that could do the near field but,
 9 generally speaking, it only affects the far field, it
 10 flushes out the particles and reduces the concentration.
 11 **Q.** "So, in IPC terms, room ventilation is a measure
 12 designed to mitigate the transmission of disease by the
 13 airborne route."
 14 Pause, please:
 15 "Therefore, there is an inherent inconsistency in
 16 saying that room ventilation is important, which
 17 simultaneously arguing that airborne transmission does
 18 not occur."
 19 **A.** Yeah.
 20 **Q.** "This is something that many may fail to appreciate."
 21 Put that into layman's terms, please.
 22 **A.** Yeah, I'm not going to mention anybody, I'm talking in
 23 general about things, as what happens is that there's
 24 an inherent disconnect between -- frankly, you see it
 25 all over the place in much of the IPC literature that's

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1 been -- certainly in the historically is -- people
2 generally think ventilation is a good thing, but then
3 they argue that airborne transmission doesn't occur, in
4 which case you'd say, "Well, if it's all droplet, why on
5 Earth we need the air -- why do we need the
6 ventilation?" And, you know, it's a -- they're contrary
7 positions and they say, "Oh, well, it's good to have
8 it", and then, well, if it's good to have ventilation,
9 you're arguing that there's things in the air and they
10 could be breathed in.

11 So people don't fully connect these -- join the
12 dots, if you know what I mean.

13 **Q.** I mean, you're never saying you should only have masks
14 or you should only have ventilation, that's not what
15 you're saying, if I'm following?

16 **A.** Certainly I'm not saying that, no. I am saying -- I'm
17 just saying that there's a disconnect in -- you need
18 a holistic approach, you need to look at all the routes
19 and you need to have something that's workable.

20 **Q.** Now, at your paragraph 240, you set out the ways in
21 which engineers quantify the amount of ventilation
22 required to minimise the risk of airborne transmission,
23 air changes per hour, and you say there it's the number
24 of complete air changes, so the replacements of air that
25 will occur in one hour. Just help us with the example

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1 like a door handle or something where it might be
2 sitting there for days.

3 **Q.** All right. Fresh air rate per person, you set out
4 there. It's generally specified in terms of litres of
5 fresh air per person per second and so, for example, in
6 a classroom containing 30 people, the fresh air rate of
7 10 litres per second was specified, you'd need
8 a ventilation rate of 300 litres per second?

9 **A.** Yes.

10 **Q.** Right. Now, we won't descend to the arithmetic in a
11 number of circumstances but that's generally the way --

12 **A.** That's just generally -- it's very useful in situations
13 especially like this room here, where we have quite
14 a high occupancy level. If you have a lot of people in
15 one space, one's relating to the room, the other's
16 relating to the people.

17 **Q.** I think you make the point in your report that a room
18 can have a region of high and low virus concentration,
19 it's not one or the other?

20 **A.** Absolutely, you showed a picture earlier on which was
21 from a CFD analysis of a ward and you saw that all the
22 aerosols were down one side of the ward and not the
23 other, so that's because there was a diffuser like this
24 actually dividing the air and concentrating it in that
25 area, and it was kind of circulating round. So we were

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1 that you set out there.

2 **A.** Yeah, right, so we've got a room here. Let's say we had
3 two air changes -- doesn't matter what size the room is,
4 let's say we had two air changes per hour, that's the
5 usual -- ACH is what that means -- two air changes per
6 hour, that would mean that the complete volume of the
7 air in the space was replaced twice in an hour. So if
8 we had a particle of air, I know it's a mixture of
9 air -- of gases, but if we had a particle of air, that
10 would mean -- or an aerosol suspended in that air, one
11 aerosol, right, one viral particle -- on average it
12 would remain in the room for half an hour at maximum,
13 and it would be flushed away.

14 **Q.** So six air changes an hour would mean that it remained
15 for ten minutes?

16 **A.** Ten minutes, yes.

17 **Q.** Right.

18 **A.** So that's the kind of longest. Now, that's assuming
19 complete mixing. You can have pockets of air which are
20 stagnant and that's why we need to look at how that's
21 moving around in the space but that means that, if
22 you've got six air changes per hour, generally the
23 particles are not hanging around for a long period in
24 that space and, therefore, if there's a virus in them,
25 that virus is not having a long time to decay. It's not

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1 getting air movement and so it meant that certain people
2 were more at risk than others.

3 **Q.** Take another example, there might be a lower
4 concentration by a window that's open --

5 **A.** Yeah.

6 **Q.** -- than there is at the far end of the room further away
7 from the window?

8 **A.** Excellent example because it relates to naturally
9 ventilate spaces. Naturally ventilated spaces are
10 really deep -- people don't realise this but it's
11 a complex fluid mechanics problem, this space is a very,
12 very deep space and we've got some windows. If we were
13 just relying on the windows to produce that, we would
14 have ventilation there but we could have very still
15 stagnant regions over here and it would be difficult.
16 So you can have that but, obviously, also where the
17 infector is, you will have -- likely to have a high
18 concentration and if you, again, also have a strong air
19 current, they might be picked up and deposited
20 somewhere.

21 So understanding how the air moved around wards is
22 quite important, not just specifying the air change
23 rate, in my opinion.

24 **Q.** Fine, well, that brings me on to the hospital
25 ventilation guidelines, which start in your report at

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1 paragraph 245, and there are what are known as health
2 technical memoranda which are published, and what do
3 they do, in a nutshell, please, Professor?
4 **A.** Yeah, these are basically guidelines for all NHS estates
5 and hospital engineers and people involved in buildings.
6 They deal with the ventilation, so ventilating hospital
7 buildings basically, but they're actually healthcare
8 facilities, so it could be clinics as well, and they're
9 called specialist ventilation. Most of the concentrated
10 effort is on things like operating theatres, isolation
11 rooms, negative pressure isolation rooms, bronchoscopy
12 suites, things like that.

13 But they also cover general wards and non-clinical
14 areas, toilets and things like that. Although -- so
15 they're de facto the guidelines that people go to, and
16 there's two of them: one is for the design of them and
17 the other one -- so they specify the air change rates
18 that should be --

19 **Q.** Right. Understood.

20 **A.** And the other one is for the maintenance and operation,
21 so validating how they run, ensuring that they're still
22 doing what they're supposed to be doing.

23 **Q.** Now, the HTMs, there are HTMs in England, similar ones
24 in Scotland and I think similar ones in Northern Ireland
25 and Wales; is that right?

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1 decision tree: is the infection likely to be airborne or
2 is it likely to be not airborne -- droplet is
3 non-airborne by the way, right, or contact born; and if
4 it's droplet then it's just an ordinary ward you don't
5 have specialist insulation, you don't have negatively
6 pressurised isolation rooms; if it's airborne then you
7 need negatively pressurised isolation rooms and various
8 other things. And the only two diseases that are
9 basically classified as being airborne are TB and
10 measles.

11 **Q.** TB and what?

12 **A.** TB and measles.

13 **Q.** Oh, measles. Thank you, I misheard you.

14 **A.** Yes, TB and measles are classified. So this
15 classification of whether it's airborne or droplet is
16 huge in ramifications all the way through the whole
17 thing.

18 **Q.** Now, you say at paragraph 249 in your report the HTMs,
19 the 2021 ones, classified spaces within hospitals as
20 either being areas where the risk of airborne infection
21 is high and therefore specialist ventilation is required
22 or areas where the airborne infection risk is low and
23 therefore general building ventilation will suffice.
24 Can you just help us what do you mean by "specialist
25 ventilation"?

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1 **A.** This is where I'm getting a bit iffy. There are --
2 certainly in Scotland and England there are ones.
3 There's something governing that in Northern Ireland and
4 Wales, what they're called, but they're going to be
5 based on the same kind of standards. Again, engineering
6 physics is much the same and that's it, yeah.

7 **Q.** Now, the HTMs that were in play during much of the
8 pandemic, is that a document from 2007? I'm looking, if
9 it helps you, at your paragraph 247 on page 92.

10 **A.** Yes.

11 **Q.** The current --

12 **A.** Yes, no, I can see that. Right, so, brief history,
13 right? So at the beginning of the pandemic it was the
14 2007 documents --

15 **Q.** Thank you.

16 **A.** -- that were valid and they went through until
17 I think -- is it June 2021 when the new guidelines took
18 over? However, the new guidelines were written before
19 the pandemic.

20 **Q.** Right. Whether it's the 2007 or the 2021 guidance, they
21 broadly used the same distinction between "airborne" and
22 "non-airborne"?

23 **A.** Absolutely, they used exactly the same. They're just
24 slightly modified in various ways but they -- from what
25 I can see, but the key thing is they use a rigid

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1 **A.** Right, yeah, so let's get this the risk is high and low,
2 get that out of the way first of all. If it's deemed
3 airborne, then it goes down a certain pathway, right?
4 So if it's airborne, the risk is high, right, by that.
5 If it's deemed droplet, the risk is deemed low and it
6 goes down a different pathway. So all the specialist
7 stuff kicks in. So there's really a couple of areas
8 where they consider it really important. I'm talking in
9 broad terms here.

10 **Q.** I understand.

11 **A.** Yeah, so the classic one is operating theatres because
12 there's risk of bacterial infections and surgical site
13 infections. So huge amounts of the documents are given
14 over to operating theatres and that's not really
15 relevant for what we're talking about here in
16 a pandemic.

17 The next area is: is it airborne? Well, if it's
18 an airborne disease like tuberculosis, then the patient
19 should be put in a negatively pressurised isolation
20 facility with a specialist ventilation system that makes
21 sure that there's an air -- a foyer, an airlock that
22 prevents the microbacterium tuberculosis from escaping
23 into the rest of the hospital, so it protects other
24 people.

25 **Q.** Understood.

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1 A. Then aerosol-generating procedures, the classic --
 2 forgive me, I'm at a loss here but the classic one is
 3 a bronchoscopy suite where we actually look -- do
 4 a procedure with an endoscope to actually take biopsies
 5 in the lungs. A lot of coughing, classically done with
 6 TB and classically produces lots of aerosols with
 7 potentially TB that are infectious. That needs good
 8 ventilation, that's specialist. So you see how the
 9 pathway goes down that.

10 If it's droplet, you end up on a normal ward, you
 11 know.

12 Q. Yes. So, on a normal ward, not to denigrate it but --

13 A. So I think six air changes is the specified thing for
 14 that --

15 Q. I'm going to come onto that but I think you make the
 16 point at paragraph 250 in your report that, in general,
 17 where you are not dealing with those high-risk areas,
 18 such as the operating theatres and the like, in general,
 19 areas and wards within healthcare systems, odour control
 20 is the main reason for ventilation, not infection
 21 prevention?

22 A. So this is the whole point, they basically say -- so if
 23 you think about the -- in the light of the IPC hierarchy
 24 of controls, it just doesn't even figure. This is just
 25 saying that the ventilation there is to stop -- you

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1 purposely and deliberately.

2 Q. Just a few other matters please on this. I think you
 3 have mentioned already that the HTM guidance says six
 4 air changes an hour for a general and acute ward but, in
 5 your report, you suggest that the evidence shows that
 6 the actual ward ventilation rates are lower than that?

7 A. Yes.

8 Q. Is that, can you help, is that dealing across the UK or
 9 is that based on English studies; are you able to help
 10 with that?

11 A. Yeah, I can, yeah. Right, first of all, we've got some
 12 a lot of very old hospitals, right? Hospitals are built
 13 at different times and they -- so, you know, we have
 14 Victorian hospitals, Nightingale wards that are just
 15 opening the windows, and they're very prone to whichever
 16 way the wind blows, basically, in those situations
 17 whether they achieve -- you get great variation there in
 18 the amount of air changes, as I think I say in my
 19 article here. But, for example, the ward that I --
 20 I worked closely with Addenbrooke's Hospital, I'm
 21 involved in a study there, but where we measured the
 22 rates there, they were considerably lower, I think less
 23 than one air change for a mechanical ventilation
 24 system -- sorry, I need to find the -- it's in here.

25 Q. You say at paragraph 257, if it helps you:

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1 know, get rid of smells, basically, no other real
 2 purpose, not for infectious purpose, according to this.
 3 Obviously it should be for infection control purposes.

4 Q. So if there were, for example, an asymptomatic patient
 5 on a general and acute ward, the ventilation would be
 6 doing nothing to try and help dilute the amount of viral
 7 load in that ward?

8 A. Absolutely, not, it would be, no, the ventilation would
 9 be there, if it's six air changes that would be helpful,
 10 it's good but many wards, older wards, don't even
 11 achieve that. But the point is you're not even
 12 recognising it and these are the guidelines. So these
 13 guidelines are, in my opinion, out of date.

14 Q. Fine. Can you help me with that: does the guideline
 15 even talk about --

16 A. It doesn't, there is no higher risk on normal wards and
 17 the only purpose in normal, non-clinical spaces and
 18 general wards is about controlling odour, making the
 19 place comfortable, and shouldn't be trying to use too
 20 much energy, and patients and healthcare workers are at
 21 no higher greater risk. It's written in my report, I've
 22 only quoted what they've said and, in the light of the
 23 Covid pandemic, I'm afraid I don't believe that's fit
 24 for purpose and I've said that -- purposely and
 25 deliberately saying that, and I'm saying it now

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1 "Evidence would suggest that" --

2 A. Could you put this up?

3 Q. Yeah:

4 "... actual ward ventilation rates are often well
 5 below those specified in the HTM ..."

6 For example at Addenbrooke's, as you have just been
 7 telling us, Butler found delivered mechanical
 8 ventilation rates to be between 0.96 and 0.73 air
 9 changes on two medicine for the elderly wards, well
 10 below what was deemed acceptable in the 1970s and far
 11 below the six air changes that we've got now in the 2021
 12 HTMs.

13 A. So this encapsulates what I'm saying here, right? So
 14 now, in the current HTMs, it's six air changes, that's
 15 the standard. When the building was built in the 1970s
 16 at Addenbrooke's in that one, it was 2.5. So that was
 17 the standard, it was designed to that, which is
 18 considerably lower than what we have now, whether that's
 19 a right standard or acceptable standard is another
 20 matter but, even then the -- when we actually measured
 21 the air change rates from the mechanical ventilation
 22 system -- and what we do is we actually put a hood
 23 anemometer over the grilles to see how much air is being
 24 brought out.

25 We found it was less than one air change so it was

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1 not performing to its standard then and way below the
2 other standard. The bottom one there, the Nightingale
3 ward, basically that's a ward with cross ventilation and
4 lots of windows and no mechanical ventilation and
5 there's huge variation there because of basically how
6 the wind blows, basically, and whether the windows are
7 open. There are some other -- I mean, when I was
8 writing this report, I didn't --

9 **Q.** Can I pause you there --

10 **A.** Sorry.

11 **Q.** -- because I think we've got the point there that there
12 is great variation depending on the age of the hospital,
13 type of ventilation they've got and the ability to reach
14 now the guideline of the six air changes an hour. But
15 help me about this: what do the HTMs say, if anything,
16 about non-clinical areas and the ventilation that's
17 required, for example, in a staff room or where the
18 cleaners go to get equipment?

19 **A.** Right.

20 **Q.** Do they say anything about it?

21 **A.** No and yes, right? So largely no, right? But if I can
22 just sum it up, right?

23 **Q.** Of course.

24 **A.** So the -- I've given the flavour of what it says.
25 Basically it's saying these are ancillary places,

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1 **A.** And from what we know and what we know about
2 transmission of Covid, they don't adequately reflect
3 this. They do put a kind of preamble on them, say we
4 wrote these before the Covid --

5 **Q.** I follow that, yes.

6 **A.** Which they do stress and, yeah, that's reasonable, yeah.

7 **Q.** Just before we break, if I may, my Lady can I just look
8 briefly please at the interventions that can be used to
9 supplement ventilation and, Professor, it's dealt with
10 in your report starting on page 97. Obviously opening
11 a window but that is subject to wind direction, strength
12 of the wind, comfort of the patient if it's winter,
13 that's probably not going to be hugely practical.

14 **A.** Well, can I -- I'll just list them, they're very useful.
15 Obviously you could open windows. It's a good way to
16 boost ventilation. But there's lots of downsides.
17 You've mentioned winter. You freeze the patients in
18 winter, that's not a good situation, especially if these
19 are patients who are very ill and need to be comfortable
20 and maintain their body temperature. You also get
21 pollutants in from outside, you get particulates from
22 traffic, that's not good for respiratory health at all,
23 fungal particles are not helpful either. Noise, you get
24 noise traffic. You know, there's a whole load of things
25 and, also, once you've opened them, when you've got

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1 they're not that important, right, in terms of the
2 ventilation is for odour control and that. You then
3 have a great long list, so there's very little on ward
4 ventilation actually written in the text.

5 What you have is a big table with various spaces
6 listed so, in that table, which covers about four pages,
7 you will have things like ancillary spaces, some will be
8 a sluice thing, a ward toilet, I can't remember whether
9 there's an office building, a waiting area, how they
10 gradate it but they'll have usually something, an air
11 change rate, and, generally, I don't know I wouldn't
12 like to comment at this bit but that's how they treat
13 it; it's kind of an also-ran space.

14 **Q.** Understood. So there is a concentration, if that would
15 be the right phrase on the high risk clinical areas?

16 **A.** No, the high risk from according to the criteria of --
17 to me it's not concentrated on the high-risk areas
18 from --

19 **Q.** Do you think --

20 **A.** -- a Covid point of view.

21 **Q.** Sorry, I didn't mean to cut across you. Do you think
22 that the HTMs in general reflect the risks of
23 transmission from airborne infectious viruses?

24 **A.** I don't think they do at all.

25 **Q.** Right.

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1 a deep plan space, you can't necessarily get good
2 ventilation. It's good in that area but not further in.
3 So there's limitations. That's what I would say.

4 **Q.** Assuming that we are dealing with not a new hospital but
5 one of the older hospitals in the estate, clearly you
6 can't rip down the ceiling and redo the ventilation, or
7 not easily and certainly not cheaply in a pandemic.

8 **A.** It's a hugely expensive to change and upgrade
9 ventilation systems, and disruptive as well.

10 **Q.** So the kind of portable or easily built into options
11 include portable air cleaners; is that right?

12 **A.** Yeah, portable -- usually they're portable but call them
13 supplementary air cleaners, supplementary devices that
14 help to remove pathogens or nullify pathogens in the
15 air. Pathogens, by the way, could be bacteria or
16 viruses.

17 **Q.** Fine, and helpfully there's a figure there giving us
18 an example of what one may look like but it's easily to
19 put into the ward or the room or whatever you want to
20 ...

21 **A.** You have several in this room but there's one there.

22 **Q.** Thank you very much. All right. There are what are
23 known as upper room UV lamps. What are they, please?

24 **A.** Right, upper room UV, it is a technology where you're
25 using ultraviolet light, so we can use ultraviolet light

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1 at 254 nanometres, that's UVC light. It actually --
 2 when the photons of light hit the virus they actually
 3 destroy the genetic material and prevent it from being
 4 able to replicate again and cause infection. So upper
 5 room UV -- you can put UV in air cleaners like that in
 6 a box, so they're doing the same thing as the filter,
 7 the HEPA filter, air efficiency filter -- other
 8 technology is different -- or you can actually put them
 9 on fittings up onto the ceiling, at high level above
 10 people's heads, you can't see the actual field, and
 11 create a UV field.

12 Now this is a very old technology that was used in
 13 the 1930s and 40s, right up to the '60s in the States on
 14 TB wards, and what you're doing is allowing the natural
 15 air convection currents to take the pathogens and the --
 16 in the case of TB, through the field and it's getting
 17 zapped. It's above the heads of people, so it's safe
 18 and it -- you can get a huge air -- equivalent air
 19 change rate.

20 **Q.** So pausing there --

21 **A.** So --

22 **Q.** -- there are a number of ways of trying to improve the
 23 ventilation in a ward, in a staff room, if we wanted to,
 24 in any number of settings and I think you say that these
 25 portable interventions have a role to play in a pandemic

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1 cleaners and, in theory, achieve the same effect
 2 relatively cheaply. They're very flexible and these are
 3 things that should be looked at, in my opinion.

4 **Q.** Right.

5 **A.** That's what I'm trying to say.

6 **Q.** I think you made reference there to SAGE and they
 7 published a report in November 2020 where, effectively,
 8 they endorsed the use of portable air cleaners to
 9 provide supplementary ventilation in spaces that were
 10 poorly ventilated?

11 **A.** Absolutely.

12 **Q.** Can I just ask you this --

13 **A.** It's a very useful document as well. There was nothing
 14 out there before that.

15 **Q.** Is this the position: that there were no guidelines to
 16 help hospitals as to what type of portable ventilation
 17 they should or might think about installing?

18 **A.** Yeah. Well, I was looking at this back in 1999 when
 19 I first started looking at this. There was no
 20 guidelines, that was upper room UV. There has been no
 21 guidelines at all until the pandemic. So we knew these
 22 technologies could potentially be effective but nobody
 23 knew how many facilities should we put in a space, where
 24 we should put them to best effect. We still don't know.
 25 It's a complex fluids mechanics problem.

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1 because there's a balance that needs to be struck
 2 between ventilation in non-pandemic times and the
 3 ventilation that may be required during a pandemic?

4 **A.** Yeah, I think this is -- well, first of all, I'm not the
 5 only one saying this, SAGE EMG said this as well, right?

6 But, to be honest, I actually was -- throughout the
 7 pandemic, I had a central role in trying to promote
 8 this. I could see that no one was doing this so
 9 I actually got these trials off the ground at
 10 Addenbrooke's to do that, so I was very much
 11 an instigator in trying to promote the use of this and
 12 get the trials to get the evidence because I could see
 13 that we hadn't got the evidence.

14 Going back to what you said, they've got huge
 15 potential. You've got an estate, money's short, in
 16 everything we should be looking at utility. Can we --
 17 what can we do, the biggest bang for our buck. So we've
 18 got wards that we can't necessarily upgrade the
 19 ventilation system and, actually, do we need the -- you
 20 know, in a pandemic situation, if you've got a ward
 21 that's used for cohorting patients, you might need
 22 a very high ventilation rate but, when it's not being
 23 used for that, you don't need as much. You're not going
 24 to change the whole ventilation system for that, it
 25 costs a fortune. But you can bring in portable air

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1 **Q.** So is there effectively an ad hoc way that the hospital
 2 might decide to do it and it might be done in one
 3 hospital and another way in another.

4 **A.** Yeah, this is what happened. I can only speak for my
 5 experience of what I observed in various places. But
 6 people put -- they were put in wards but they were
 7 sometimes put -- not by us in our trial -- but sometimes
 8 put in corridors, probably having a minimal impact. If
 9 you put too small a unit in, it's not going to have the
 10 effect.

11 **Q.** Now, pause there because it's right to note that since
 12 the emergency stage of the pandemic finished in May
 13 2023, NHS England produced two technical bulletins which
 14 effectively provided some practical guidance regarding
 15 the use of filters and UV air cleaning devices; is that
 16 correct?

17 **A.** They were built on the SAGE initial document, they were
 18 very welcome in my opinion because they again brought
 19 more, brought it to the forefront and the potential for
 20 it but the trouble is that the -- right, I'm just going
 21 to use a term here -- the applied research is not there.

22 The fundamental research is there, we know that
 23 these things kill the virus and clean the air, how to
 24 use them and where we should use them to best effect is
 25 not -- and so the guidelines can only reflect the

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1 research. This research should have been done for the
2 last 20/30 years, you know and, because it's not there,
3 we can't -- we need to do it.

4 **Q.** Final question from me on this topic, please, I just
5 want to go back to UV lamps. You mentioned that they
6 obviously may pose a degree of risk to health?

7 **A.** I would say that the risk of the upper room UV is, at
8 254, fairly well known, it's fairly minimal. The
9 biggest danger there is, if someone does something
10 stupid like climbs on a desk and looks up into the UV,
11 they're blinded. So they have got baffles to stop
12 people looking inside, so that you're shielded, you
13 can't see them. That's an obvious thing. Also, if
14 there's a reflective surface that they reflect on to
15 someone, they can irritate the eyes, basically.

16 The other one, 222 nanometres --

17 **Q.** We don't need to descend to that but, given that there
18 is a degree of risk --

19 **A.** Yeah.

20 **Q.** -- from a UV lamp, do you think there are more
21 advantages to HEPA filters, the portable units, than
22 there are over the UV lamps, if we are looking at
23 proposing one type of portable ventilation over the
24 other?

25 **A.** I think that the HEPA filtered portable filter units are
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1 **Q.** So we've got droplet and airborne and, you would say to
2 a lesser extent, contact and fomite transmission?

3 **A.** Yes.

4 **Q.** And if you were to be asked whether you think there is
5 more aerosol transmission than droplet transmission,
6 would you be able to opine on that?

7 **A.** I would most definitely say that I believe there is more
8 aerosol transmission, airborne transmission, than
9 droplet. Precise figures I couldn't tell you at this
10 moment.

11 **Q.** I understand, right.

12 You consider that the majority of the exhaled viral
13 load is in aerosols, either smaller particles --

14 **A.** Yes, I do.

15 **Q.** And it's the aerosols that penetrate deep into the lung?

16 **A.** They penetrate up the nose to the receptors and the
17 upper respiratory tract. And the smaller aerosols
18 penetrate deep into the lung, but they penetrate into
19 the respiratory system.

20 **Q.** From your perspective, the 5-micron distinction that we
21 looked at earlier does not accord with the physics?

22 **A.** Yes, definitely.

23 **Q.** And the 100-micron diameter should be the dividing line
24 between droplet and aerosols?

25 **A.** In my opinion, that should be the case. Obviously it's
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1 an existing, old, mature technology that's well
2 understood and therefore is ready to go quickly and we
3 should see if we can get as much utilisation out of
4 that. But I also think the potential bang for your buck
5 of, say, upper room UV is well worth looking at. We
6 need some trials to look at that because that might be
7 useful as well.

8 **MS CAREY:** I'm going to move onto a different and final
9 topic with the professor.

10 **LADY HALLETT:** Certainly, I shall return at -- let's say
11 15 minutes. People can work out what time that is.

12 (3.13 pm)

(A short break)

14 (3.32 pm)

15 **LADY HALLETT:** Ms Carey.

16 **MS CAREY:** Thank you, my Lady.

17 Professor, in your report at part 5, which starts on
18 page 104, you set out key findings which are effectively
19 a summary of all of the detail that you've included in
20 the preceding pages, but can I see if I can summarise it
21 further, if I may, and please correct me if I'm wrong
22 but I think your key findings can be summarised as
23 follows: that Covid is transmitted also via the airborne
24 route?

25 **A.** Yes.

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1 a little bit of a movable feast, depending on things,
2 but basically that's the -- it's the ballistic to the
3 aerosol --

4 **Q.** That's what I was going to say. And the reason for that
5 dividing line in your evidence is because particles less
6 than 100 microns can travel longer distances, float in
7 the air, whereas over 100 microns they behave
8 ballistically?

9 **A.** Yeah. And to add to that, the ones that float in the
10 air can be inhaled.

11 **Q.** Yes, quite, thank you.

12 **A.** Whereas the others, unless you -- it's very difficult to
13 be inhaled, right.

14 **Q.** You consider that to concentrate on aerosol-generating
15 procedures is to lose sight of the fact that not only do
16 some AGPs produce fewer aerosols than coughing but we
17 lose sight of the fact that breathing, talking,
18 shouting, singing are ways of producing infectious
19 aerosol particles?

20 **A.** Yes. However, I would like to just add that in saying
21 that I believe that there's too much emphasis in those
22 guidelines on the aerosol-generating procedures, as
23 opposed to the natural aerosol generated by exhalation,
24 I'm not saying that the aerosol-generating procedures
25 are not important.

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1 Q. I follow that.
 2 A. Yeah.
 3 Q. It wasn't to diminish them, but it's to lose sight of
 4 all the other ways in which one can become infected?
 5 A. Yes, to just concentrate on their own is incorrect in my
 6 opinion.
 7 Q. I think you said to us earlier that good hand hygiene
 8 was important but the evidence that it substantially
 9 mitigates transmission of respiratory viruses is
 10 relatively weak?
 11 A. Yes, it is relatively weaker, looking at the Cochrane
 12 reviews and other reviews. Nevertheless, good hand
 13 hygiene is good because those other pathogens, bacterial
 14 pathogens, MRSA, things like that, so -- I'm not against
 15 good hand hygiene, it's very important. And it's easy,
 16 that's the point, it's easy utility, you can do it.
 17 Q. Yes, quite.
 18 In relation to asymptomatic transmission, which for
 19 these purposes include the presymptomatic stage, you
 20 consider that by September 2020 it was clear that there
 21 was widespread asymptomatic transmission?
 22 A. Yes. I would say there was a strong body of evidence to
 23 strongly suspect that that was -- well, no, yeah, it
 24 was. And as a precautionary thing we should have been
 25 concerned about it. Yeah. To my understanding.

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1 future pandemic preparedness by the government,
 2 including but not limited to hospital IPC. It should
 3 include scientific advice from experts, similar to the
 4 SAGE Environmental Modelling Group, but also working on
 5 pandemic preparedness as well as the emergency response.

6 In a nutshell, why do you say that there needs to be
 7 a multidisciplinary approach, and who should be part of
 8 it?

9 A. Well, having looked at an awful lot of evidence and read
 10 an awful lot of papers and looked at an awful lot of
 11 reports, what becomes absolutely clear to me is that
 12 some of the fundamental errors, in my opinion, or
 13 assumptions, could have been maybe avoided or could have
 14 been -- things could have been flagged up if people had
 15 had the expertise from the -- certainly from the
 16 engineering/physics background, and understood more
 17 about how aerosols behaved. Often people are coming
 18 from a -- reading what other epidemiological studies
 19 have done, their training is in medicine or in
 20 microbiology or nursing, and they maybe missed things
 21 that I would spot.

22 So -- I'm not saying it's me, you know, but we need
 23 someone -- there's very few people with -- I straddle
 24 both biology and that, that's not a common environment,
 25 but we need to have people -- and there's a whole raft

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1 Q. Yes. To final summary by me, whilst the fluid-resistant
 2 surgical masks are helpful at reducing exhalation of
 3 droplets, they offer limited protection against the
 4 inhalation of aerosols?

5 A. Yes.

6 Q. Full protection is provided by FFP3 masks but there are
 7 practical considerations such as the need to fit test,
 8 how comfortable they are, that may limit the utility of
 9 the FFP3?

10 A. Absolutely. They -- when fitted properly, they prevent
 11 aerosol inhalation and infection by that route, but
 12 they're uncomfortable, they can irritate the skin,
 13 there's a whole load of baggage that comes with them, so
 14 utility is not so good.

15 Q. And finally, as we just discussed before the break,
 16 Covid-19 highlighted the need for good ventilation in
 17 healthcare settings, and indeed in other settings?

18 A. Absolutely, absolutely.

19 Q. Right. Can we turn, then, please, to your
 20 recommendations, and, Professor, they are at 112 in your
 21 report. Perhaps if we put those up on screen as well it
 22 would help those following.

23 Now, some of these we may have touched upon already
 24 in your evidence, but your first recommendation is there
 25 needs to be a more multidisciplinary approach taken to

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1 of people coming through from the pandemic who've
 2 learned -- from the engineering who have gone into this
 3 area to look at because of the pandemic, so they're out
 4 there, who have that kind of physical, biological,
 5 science side that could give extra expertise. And
 6 I think that that would be very useful.

7 I've also added that it should be in preparedness
 8 rather than in response.

9 Q. Yes.

10 A. So one of the good things that's come out of the
 11 pandemic is a whole load of engineering schools have
 12 suddenly woken up to the fact that there is -- all the
 13 stuff I've talked about is actually engineering, and
 14 there's a whole load of PhD students and other people
 15 looking at this area, so the expertise in this area has
 16 grown.

17 LADY HALLETT: So you're drawing a distinction between
 18 preparedness and response, because Catherine Noakes was
 19 part of SAGE, wasn't she? She chaired the --

20 A. She was the --

21 LADY HALLETT: -- modelling subgroup.

22 A. Right, this is where I'm at a slight disadvantage, not
 23 being an insider in that. I know Cath very well, but
 24 she was -- I understood that the Environmental Modelling
 25 Group was something set up for the pandemic, didn't

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1 have -- wasn't standing. Is it now standing --

2 **LADY HALLETT:** No, no, it was set up -- well, I think it was

3 set up for the pandemic. Certainly it was SAGE's for

4 emergencies.

5 **MS CAREY:** Yes, but EMG was a subgroup of SAGE.

6 **A.** Yes, I think it was -- well, SAGE goes on, doesn't it,

7 in various ways, it's not just for the emergencies, is

8 it? Or have I got that wrong?

9 **LADY HALLETT:** We're going down a --

10 **A.** Sorry, I'm showing my lack of --

11 **LADY HALLETT:** It's all right, it's just that you're saying

12 make sure that the likes of you or Catherine Noakes or

13 people with similar specialities are involved in

14 planning not just response.

15 **A.** Yes, make sure --

16 **LADY HALLETT:** I have it.

17 **A.** Yes, when you're preparing for the next pandemic, get

18 people from all disciplines to get a good idea what's

19 going on. Cath Noakes joined SAGE but not at the

20 beginning, after -- I think later on actually as well.

21 **LADY HALLETT:** We can check her evidence, I've already heard

22 from her so we can check it.

23 Right, Ms Carey.

24 **MS CAREY:** Can I ask you, please, you've obviously alluded

25 to the fact that at present it's not able to say "the

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1 terminology?

2 **A.** Well, I think they've got it in step with the rest of

3 the world. I don't think you can do that. But I think

4 this education thing -- you know, once people start to

5 understand how these things behave then they think --

6 they realise the need to change that terminology.

7 That would help people to come to agreement, I would

8 have thought. It's when people are just looking at

9 their guidelines from their discipline and don't

10 understand maybe the fundamental physics going on

11 underneath.

12 **Q.** You have referred in your evidence already to the fact

13 that you consider there is a need to revise and upgrade

14 the HTM guidelines on hospital ventilation, so I don't

15 need to ask you about that.

16 **A.** I do believe that, yes.

17 **Q.** That's a firm recommendation you make.

18 **A.** Yes.

19 **Q.** In relation to portable ventilation, as we were just

20 discussing in the break, do you consider there is need

21 for more evidence and indeed guidelines on the

22 deployment of portable supplementary air --

23 **A.** Yeah, we --

24 **Q.** -- devices --

25 **A.** These are -- you know, certainly portable air filters,

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1 amount of transmission is airborne, the amount

2 transmission of transmission is droplets", I don't want

3 to go over that again, but recommendation iii:

4 "Much confusion currently exists in the terminology

5 used in the healthcare system guidance from ...

6 the UK ..."

7 That's before you even add the WHO guidance into

8 that. What do you say and how do you say we can resolve

9 differences in terminology?

10 **A.** Right, well, first of all, to say the WHO is actually

11 looking into this whole area and is making slow progress

12 from what I can understand on this whole issue, and

13 I think one of the things that we could do is actually

14 education, so that people who are from a clinical

15 background would actually have explaining what

16 an aerosol is and how things work. Then they would have

17 a better understanding and then that would start to

18 bring people together. The problem is that people are

19 often talking about the same thing but using totally

20 different terminology and being totally confused. And

21 with a bit of education ...

22 The problem is that some people are -- well,

23 a little reluctant to change their opinions, I think

24 that's fair to say, you know, but ...

25 **Q.** How do you think the UK should go about changing the

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1 HEPA filters, are low-hanging fruit. They're cheap,

2 easy, we know they clean the air, we know they do

3 a similar job to ventilation. If ventilation is good

4 then portable air cleaners are good. What we don't know

5 is how many do we put in, where should we put them to

6 best effect. So it's applied research, which in the big

7 picture of things is fairly cheap. And, you know, it's

8 quick to do. But we need to know where we should be

9 putting them to get best effect, you know. And that

10 should be reflected in the HTM guidelines as well,

11 because they should be -- just as a standard procedure

12 I would say.

13 **Q.** You consider there needs to be, at your

14 recommendation vi:

15 "... a need for further multidisciplinary research

16 to better understand how air and indeed [infectious]

17 aerosols move around hospital wards ..."

18 **A.** That goes back to the slides that you showed, which

19 showed the aerosols, the particles all on one side of

20 the ward. In other words, we assume -- when we talk

21 about air changes and we specify air changes, we assume

22 that it's all completely mixed and it does the job. But

23 when we do CFD, we suddenly realise: oh, there's

24 pressure gradients, things are -- that diffuser is

25 actually putting the risk up for these people on this

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1 side of the room, the aerosols are going out into the
 2 corridor. We need to understand how to do that better.
 3 Again, it's applied research.
 4 **Q.** Fine. Now, that recommendation there you concentrate on
 5 hospital wards, but just thinking about all those
 6 non-clinical areas.
 7 **A.** Oh, non-clinical as well.
 8 **Q.** Would you include those in there, that generally we need
 9 to understand how the air moves around the hospital?
 10 **A.** Yes.
 11 **Q.** Yes.
 12 **A.** Yeah, in fact, non-clinical -- hospital waiting rooms
 13 are really important --
 14 **Q.** Yes.
 15 **A.** Waiting areas are really important areas.
 16 **Q.** The final one I would like to concentrate on before
 17 I conclude is masks. Right?
 18 Now, we have, through you, examined the efficacy or
 19 otherwise of FRSM versus FFP3, and you've mentioned
 20 a number of times that there are potential practical
 21 problems with widespread use of FFP3: it needs to be fit
 22 checked, it's uncomfortable. It leaves, does it not,
 23 staff, patients, whoever wants to wear them, with
 24 a slightly binary choice?
 25 **A.** You're absolutely right. This was the one thing that,
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1 we could achieve.
 2 **Q.** Let's look then, please, at what you say on your
 3 page 113 at recommendation v, which is a good
 4 introduction to this recommendation. There you've made
 5 the point already:
 6 "... FFP3 provides better protection for [healthcare
 7 workers] caring for patients with [Covid] than surgical
 8 masks. This raises the questions [as to] whether [the]
 9 ... (FRSMs) provide adequate protection to [healthcare
 10 workers] when caring for Covid-19 patients."
 11 Or indeed for those who are asymptomatic?
 12 **A.** Yeah.
 13 **Q.** "Therefore, barriers in the way of wider respirator use,
 14 whether due to guidance, regulation, fit testing, supply
 15 or comfort should be addressed urgently by the UK
 16 Government to ensure that more effective respiratory PPE
 17 is widely available before and during the next
 18 pandemic ..."
 19 **A.** Yeah.
 20 **Q.** "... and that [healthcare workers] are better
 21 protected ... In particular, consideration should be
 22 given to alternative face mask solutions, such as FFP2
 23 masks with ear loops, which offer superior protection
 24 against the inhalation of infectious aerosols compared
 25 with surgical masks, while being more comfortable than
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1 as I -- my brief was to look at the science of these
 2 things, and as I looked at it -- obviously I knew about
 3 the science of both masks, but when I looked into how
 4 they were being used, under the guidelines, I realised
 5 that all we had was essentially, in the NHS, a binary
 6 choice: you go down one route that's respirators, if
 7 that's kind of specified, in which case then it falls
 8 under the COSHH regulations and HSE; otherwise it's
 9 surgical masks. And from a point of view of preventing
 10 airborne infection, from the science point of view, one
 11 is -- it's all or nothing. These -- if they're fitted
 12 properly, the FFP3 masks prevent airborne transmission.
 13 The surgical masks, there may be a little bit of
 14 inhibition, but they're not that effective, so they
 15 allow the aerosols to get through.
 16 And as a scientist that made me think: well, there's
 17 an awful lot in between there, surely we can --
 18 **Q.** Pausing there --
 19 **A.** -- improve and get something with -- can I -- I want to
 20 say utility, if you don't mind. These have got good --
 21 the surgical masks, good utility but not effective
 22 against airborne. FFP3, very effective but not good
 23 utility, they're difficult, they come with baggage, if
 24 that ...
 25 In the ground there may be an optimum solution that
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1 FFP3 ... with head straps ..."
 2 And of course you don't need a fit test.
 3 **A.** Shall I --
 4 **Q.** Now, yes, let's break that down. I have an FFP2 --
 5 **A.** Yep.
 6 **Q.** -- to show an example of a type of FFP2 which is
 7 potentially a middle ground between the FRSM --
 8 **A.** Yeah.
 9 **Q.** -- and the respirator.
 10 Why do you think there should be more consideration
 11 given to that middle ground?
 12 **A.** Right, so this really comes from public health and also
 13 from the point of view of reducing nosocomial
 14 infections.
 15 First of all, I don't want to be prescriptive. It's
 16 just that when I looked into this, there was the
 17 FFP2 masks with ear loops which was already there, so it
 18 was a kind of low-hanging fruit that might be applicable
 19 if used in the right way.
 20 So what we have at the moment is we have a binary
 21 situation, and when you go to the FFP respirators with
 22 behind the head straps, they're uncomfortable, they need
 23 fit tests, you get hot, there's a whole load of baggage
 24 that comes with it which makes them difficult when
 25 you're in a working environment. And they fall under
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1 the COSHH regulations, so they need to be fit tested,
 2 and there's a whole load of stuff there.
 3 These don't stop the aerosols, but in the ground in
 4 between, from the point of view -- I'm interested in the
 5 greatest benefit for the greatest number, right, so the
 6 greatest benefit for the greatest -- that's very much
 7 like a public health point of view: you're trying to use
 8 interventions that mitigate the transmission. They
 9 don't do it perfectly, but they reduce it.
 10 And when I was looking into this, I was finding
 11 studies where people had looked at FFP2 masks with ear
 12 loops, especially in Germany, and they were finding that
 13 there was a performance that was 50% better than the
 14 surgical masks, they were performing much better than
 15 the surgical -- and these were straight out of the box,
 16 without adjustment of the nose loop, and when you
 17 adjusted the nose loop you got much better performance.
 18 They're not fit tested.
 19 **Q.** No.
 20 **A.** So these would fail as respirators -- and we're not
 21 trying to pretend that they're behaving as respirators,
 22 they're behaving as masks -- but potentially that might
 23 be a middle ground that's got better utility, causes
 24 less discomfort to healthcare workers, provides better
 25 protection against aerosols, and is reasonably cheap and

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1 be better education about airborne transmission for
 2 healthcare workers and those completing risk
 3 assessments?
 4 **A.** Definitely.
 5 **MS CAREY:** My Lady, that does conclude my --
 6 **Questions from THE CHAIR**
 7 **LADY HALLETT:** Just before I turn to questions from
 8 core participants, I think the vulnerable families
 9 wanted to ask you questions, I turned them down, but
 10 I'll ask it in summary because I think they probably go
 11 without saying.
 12 If you improve ventilation in hospitals to -- and
 13 obviously protect, in so doing, clinical and
 14 non-clinical staff -- it goes without saying, does it
 15 not, that you'd also help protect patients?
 16 **A.** It does, yes.
 17 **LADY HALLETT:** It also goes without saying that the most
 18 vulnerable patients would be better protected?
 19 **A.** Yes.
 20 **LADY HALLETT:** Thank you.
 21 This is a question that I was concerned -- thinking
 22 about too.
 23 In relation to portable air cleaners, in normal
 24 times, ie non-pandemic --
 25 **A.** Yeah.

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1 is easier to use.
 2 And I'm not wanting to be prescriptive --
 3 **Q.** No.
 4 **A.** -- but what I'm saying is this is an area which we
 5 should be investigating or the health service should be
 6 investigating.
 7 **Q.** So is your recommendation, in short, that the government
 8 needs to investigate that middle ground and whether
 9 there is a form of protection, whether it's FFP2 or
 10 not --
 11 **A.** Yeah.
 12 **Q.** -- that can provide that balance between the higher
 13 levels of protection with the added uncomfot and all
 14 the baggage, as you say, that goes with FFP3 and the
 15 lower levels of protection --
 16 **A.** Absolutely, I'm looking -- there will be an optimum
 17 sweet spot. And that might not be the same for every
 18 environment, and remember it's got to be taken into
 19 account with the viral load in the air. By no --
 20 **LADY HALLETT:** I have the point, Ms Carey, thank you.
 21 **MS CAREY:** Thank you.
 22 It's finally this, because there are some questions
 23 from the core participants.
 24 **A.** Right, sorry.
 25 **Q.** Would you support a recommendation that there needs to

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1 **LADY HALLETT:** -- do hospitals have these portable air -- or
 2 are they only brought out in an emergency?
 3 **A.** As far as I know they weren't being used but they
 4 appeared during the pandemic. But they have been known
 5 about for years.
 6 **LADY HALLETT:** But the question is, I mean, do all hospitals
 7 have a supply of them? Should we be using them all the
 8 time?
 9 **A.** Sorry, I take that back. I used to be a professor of
 10 medical engineering at Bradford University and
 11 I certainly was aware that there was units being sold.
 12 They were probably being used in operating theatres to
 13 provide extra ventilation, so they were being used in
 14 certain specialist places. It's an old and well known
 15 technology. And they're easily obtainable, you know.
 16 Does that answer the question, sorry?
 17 **LADY HALLETT:** I think the answer is that the more of them
 18 about even in normal times, the better ventilation you
 19 have, the better the chances of patient and healthcare
 20 worker safety?
 21 **A.** Yes.
 22 **LADY HALLETT:** Thank you.
 23 Right. Now --
 24 **MS CAREY:** My Lady, could I just correct one thing?
 25 Professor Beggs was kind enough to indicate there are

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1 some revisions to paragraph 18.

2 **LADY HALLETT:** I've got them.

3 **MS CAREY:** Your Ladyship will have them, but they've not
4 been read into the record and I'm asked to do so. It's
5 two minor revisions, but essentially the sentence should
6 read:
7 "... but now in August 2024 he acknowledges that the
8 inhalation of infectious airborne particles,
9 ie aerosols, is likely an important route by which
10 SARS-CoV-2 and other respiratory virus infections can be
11 transmitted."
12 And in the final sentence, where it currently reads
13 "droplet/aerosol" it should read "droplet/airborne."
14 **LADY HALLETT:** Thank you.

15 **MS CAREY:** Thank you, my Lady.

16 **A.** Excuse me, there's one thing you missed there, sorry,
17 looking at it, it should be appendix 11A.

18 **MS CAREY:** That's fine, we'll deal with that. Thank you
19 very much, my Lady.

20 **LADY HALLETT:** Thank you.
21 I'm now going to allow some of the core participants
22 to ask you some questions, Professor. They have limited
23 time, so -- I often have to say this to witnesses --
24 please remember when giving your answers that the longer
25 your answers, the more you eat into the time that

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1 They need to be aware of these things underlying things,
2 then that will influence their opinion on the
3 epidemiological evidence. Does that make sense?
4 **Q.** Yes, it does, thank you.

5 **A.** Yeah, so I think they definitely need to be aware of the
6 science. So if, for example, I'm not trying to give any
7 real situation, but if you have someone who's from
8 a public health background and they're talking about
9 airborne transmission, they will talk about what they've
10 learnt and what they know from the textbooks and the
11 epidemiological trials but they won't necessarily talk
12 about thermal plumes or any of the stuff that I've been
13 talking about here, and so it's very helpful to have
14 that knowledge as well, so that you can interpret the
15 epidemiological data.

16 **Q.** That feeds into your recommendation about having
17 a multidisciplinary approach?

18 **A.** Yes, that's why, hence why I've said it.

19 **Q.** Thank you.
20 Onto another question. If I could ask you to look
21 at page 65 of your report at paragraph 165 -- it's right
22 at the bottom of the page --
23 **A.** Yeah.

24 **Q.** -- if we can pull that up or if you just have it in
25 front of you.

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1 I've not so generously allowed them.

2 **THE WITNESS:** All right.

3 **LADY HALLETT:** Right, Ms Foubister, where are you? There
4 you are.

Questions from MS FOUBISTER

5 **MS FOUBISTER:** Thank you, my Lady.
6 Professor Beggs, good afternoon, I represent John's
7 Campaign, Care Rights UK and Patients Association.
8 A lot of our questions have actually been covered, so
9 I anticipate I will be a little bit shorter, you will be
10 pleased to know.
11 Starting with this one: you explain in your report
12 and you've mentioned today certain differences in
13 opinions among scientists, whether between clinicians
14 and physicists or otherwise. When scientists are
15 offering information to government or advising
16 government, do you think that those making decisions
17 should be given an overview of differing opinions?
18 **A.** Yes. I think the one thing that's -- it's not cut and
19 dried, you know, there are quite a few clinicians who
20 also share my viewpoint, they're not from an engineering
21 or physics background. I think that people need to be
22 aware of the physics underneath it. So you used the
23 word "opinion". They need to be -- a lot of this is
24 known, it's fact, it's well understood about behaviour.

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1 **A.** Where is it, 65?

2 **Q.** It's now on the screen, I think.

3 **A.** What is it, 165?

4 **Q.** Paragraph 165, so the paragraph starts, and here you say
5 that there were studies that showed that most of the
6 virus was in smaller --
7 **A.** Yeah, yeah.

8 **Q.** -- respiratory particles. The second sentence from the
9 bottom, so you did touch on this briefly already but
10 this is just to pick out a particular point, you say
11 that:
12 "The authors of the PIP report were aware of
13 Lindsley et al's findings and commented on them in their
14 report. However, their conclusions downplayed [those]
15 findings in favour of the assumption that most of the
16 viral load is in the larger droplets."
17 So I have two questions.

18 **A.** Yep.

19 **Q.** The first is that, based on the knowledge available at
20 the time, should the authors of the PIP report have
21 given more credit to the Lindsley report, or taken it on
22 board more rather than downplayed it?
23 **A.** They looked at -- they were reporting the consensus at
24 the time was that the virus was in the larger droplets,
25 rather than the small aerosols. Lindsley had just come

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1 out, and I think they should have taken more notice of
 2 that because this was actually hard evidence, this was
 3 actually experimental evidence which undermined
 4 an assumption -- an assumption, the assumption --
 5 I don't think there's any evidence out there for the
 6 virus being evenly distributed throughout all the
 7 respiratory particles in the large droplets. I'm not
 8 aware of it, it's always been an assumption that's been
 9 repeated from way back, and here was some hard evidence
 10 coming out saying, no, it's in the small aerosols.
 11 Well, you've got an experimental evidence against
 12 an assumption, therefore, in my opinion, yeah,
 13 I probably should have given more weight to that but
 14 I'm not going to be too harsh on that, it had just come
 15 out, you know, there was a lot of other evidence and
 16 that, that they were --

17 **Q.** Understood.

18 **A.** -- dealing with and, you know, perhaps they were being
 19 cautious. That's what I would say.

20 **Q.** If that report hadn't been downplayed so much, do you
 21 think that might have made a difference to the thinking
 22 about the transmission of Covid-19?

23 **A.** Undoubtedly, undoubtedly, because that would have
 24 immediately undermined the assumption of the droplets,
 25 as far as I'm concerned and, you know, all -- there's

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1 and only question that remains, and it's this: in your
 2 report, at paragraph 229, you reference the SAGE report,
 3 *Masks for Healthcare Workers to Mitigate Airborne*
 4 *Transmissions of the SARS-CoV-2 Virus*, published in
 5 April 2021, which places good ventilation above the use
 6 of surgical masks in the hierarchy of controls.

7 Question: considering this, do you believe that
 8 reducing viral load in the room air in healthcare
 9 settings should be and should have been prioritised
 10 above the use of surgical masks?

11 **A.** Yes, and that's what they are implying there but, as you
 12 saw from the guidelines, which were written before the
 13 pandemic, it wasn't on the radar in, other than a few
 14 places.

15 So from the point of view of people that you're
 16 representing, this is hugely important because, wherever
 17 they're working in the hospital, whether in a clinical
 18 capacity, frontline facing --

19 **Q.** Yes.

20 **A.** -- patients or in a more ancillary capacity, they were
 21 exposed to potentially aerosols that are produced, and
 22 therefore at least -- I'm not saying that the guidelines
 23 were wrong in terms of the ventilation rates, if they've
 24 been applied or applied, what I'm saying is it should be
 25 recognised in the guidelines.

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1 numerous studies now, they're all in the public domain,
 2 and you can see that the viral material, the RNA and
 3 live viruses, the bulk of it, over 80% is in the small
 4 aerosols in some of these studies, implying that they're
 5 coming from different places in the lungs. That would
 6 have had a profound difference to that -- that
 7 preparedness.

8 **MS FOUBISTER:** Thank you. Those are all my questions.

9 Thank you, my Lady.

10 **LADY HALLETT:** Thank you very much, Ms Foubister, I'm very
 11 grateful.

12 Mr Thomas?

13 **Questions from PROFESSOR THOMAS KC**

14 **PROFESSOR THOMAS:** Professor Beggs, you will be pleased to
 15 know that one of the questions that I had you've already
 16 answered, and forgive me for the positioning.

17 I'm representing and asking questions on behalf of
 18 FEMHO, the Federation of Ethnic Minority Healthcare
 19 Organisations and just, to give you a little bit of
 20 context, FEMHO's deeply concerned about the challenges
 21 surrounding infection prevention and control,
 22 particularly the disproportionate impact it had on
 23 black, Asian and minority ethnic healthcare workers and
 24 patients.

25 So with that context in mind, let me ask you the one

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1 However, they were written before the pandemic and
 2 that's why they need to be updated completely. But it's
 3 very important that it's not just the clinical spaces,
 4 it's the whole of the hospital, if that makes sense.

5 **PROFESSOR THOMAS:** It does, thank you.

6 My Lady, Counsel to the Inquiry has already answered
 7 the second question, so I don't need to ask that one.

8 Thank you.

9 **LADY HALLETT:** Thank you very much, Mr Thomas, very
 10 grateful.

11 Mr Marquis?

12 **Questions from MR MARQUIS**

13 **MR MARQUIS:** Professor, I ask very few questions on one
 14 specific topic. I ask them on behalf of the Frontline
 15 Migrant Health Workers Group.

16 To help orientate you, it's page 32 of your report,
 17 paragraph 78, and it's the section of your report that
 18 deals with the risk of inhaling an infectious dose.

19 **A.** Yep.

20 **Q.** So if I can just recap the evidence you gave this
 21 morning, really to contextualise my question but also to
 22 save some time, because I have limited time. The risk
 23 of becoming infected increases with the amount of
 24 particles in the air, ie the concentration?

25 **A.** The risk of becoming infected increases with the

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1 increased number of particles that you inhale. So if
 2 you're in -- in somewhere with a high concentration in
 3 the air, so the risk goes up when there's more in the
 4 air, yes.

5 **Q.** Exactly. The second risk is it goes up also with the
 6 volume of air that one inhales?

7 **A.** Yeah, so if you're in a gym and you're working out on
 8 a treadmill, you're going to -- you know, a huge amount
 9 more air is being inhaled and so therefore if there's
 10 a high concentration, you'll be taking a load more
 11 viruses in. But this does apply in a healthcare setting
 12 to people who are actually doing more manual work,
 13 pushing loads, I assume someone like a porter would be
 14 affected by this. They would be working harder in that
 15 situation, so their lung capacity would go up in that,
 16 yep.

17 **Q.** Exactly the point, it's on the physical exertion point
 18 that you make reference to in that paragraph.
 19 When you exert yourself physically, it has
 20 a significant difference in respect of the volume.

21 **A.** Yeah --

22 **Q.** Can I give you the example that you use in your report,
 23 perhaps to save a little time?

24 **A.** Yeah.

25 **Q.** A resting healthy adult --
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1 may be in the space for longer.

2 **Q.** Well, quite. If we take, as an example, a cleaner,
 3 would you agree that a cleaner who's working longer
 4 hours, moving between wards, Covid and non-Covid, and
 5 the non-clinical spaces that we've referred to in your
 6 evidence today would be at a high risk precisely because
 7 their duration is increased and their exertion is
 8 increased?

9 **A.** You'd have to do the calculations, but in theory, that
 10 could happen, yes. What I do is I do calculations and
 11 I do the sums and then see how that works out, how many
 12 likely viral particles that go in an inhale. But those
 13 are all factors.
 14 In simple terms, the more you inhale, the higher the
 15 concentration; the longer you spend in there, the
 16 greater the risk. That's --

17 **Q.** All things being equal, the longer the shift and the
 18 harder the work --

19 **A.** Absolutely, if you're --

20 **Q.** -- the higher the risk?

21 **A.** -- in there -- yeah. Yeah.

22 **MR MARQUIS:** Thank you very much, Professor.

23 **LADY HALLETT:** Thank you very much, Mr Marquis, very
 24 grateful.
 25 Right, I think that completes your evidence,
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1 **A.** That's --

2 **Q.** -- inhales 69 litres of air a minute.

3 **A.** Yeah.

4 **Q.** The same adult, walking at a moderate pace, inhales
 5 between 20 and 40 litres in --

6 **A.** Yeah, and someone doing hard exercise, I think it goes
 7 up tenfold, yeah, it greatly increases. So, therefore,
 8 if you've got particles in the air, you're sampling them
 9 at a faster rate.

10 **Q.** Three minutes to go, Professor.
 11 You say that physical exertion is the infection risk
 12 that is often overlooked. Now, do you mean overlooked
 13 from an IPC perspective or just generally?

14 **A.** I think both actually.

15 **Q.** Okay, thank you, I'll park that there if I can.
 16 So, as a risk factor, exertion, you've mentioned
 17 porters, porters who are lifting and moving patients and
 18 cleaners who are doing the physical labour of cleaning,
 19 that would have an implication in terms of infection,
 20 both near field and far field?

21 **A.** Both near field and far field, the only mitigating thing
 22 against that is they may not be in that place for that
 23 long, especially porters. They may be in to collect the
 24 patient and then out, so their duration would be less.
 25 However -- maybe also for cleaners, but then some people
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1 Professor Beggs.
 2 It's been a long day for you. I hope --

3 **THE WITNESS:** Thank you.

4 **LADY HALLETT:** -- it's not been too tiring. It's been
 5 extremely helpful --

6 **THE WITNESS:** Thank you.

7 **LADY HALLETT:** -- and some very interesting points that
 8 you've made. And I'm very grateful for all your care in
 9 preparing your report and of course in giving your
 10 evidence today.

11 **THE WITNESS:** Thank you.

12 **LADY HALLETT:** Thank you for your help.
 13 **(The witness withdrew)**

14 **LADY HALLETT:** Right, 10 o'clock tomorrow.

15 **MS CAREY:** Yes, thank you, my Lady.
 16 **(4.10 pm)**
 17 **(The hearing adjourned until 10 am**
 18 **on Thursday, 12 September 2024)**
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