SCOTTISH HOSPITALS INQUIRY

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Hearings Commencing
19 August 2024

Day 48
Tuesday, 5 November 2024
Mr Sid Mookerjee

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10:02

THE CHAIR: Good morning, everyone, and good morning, Mr Mackintosh.

MR MACKINTOSH: Good morning.

THE CHAIR: We have Mr Mookerjee this morning?

MR MACKINTOSH: We have Mr Mookerjee. My Lord, there are two documents that were placed in Objective Connect spaces for core participants and will make it into bundles in due course, one of which is a combined chart and table that was issued this morning, and the other, which was issued on Friday to core participants, is a set of admissions data. I wanted just to draw that attention to core participants and to indicate to anyone watching on YouTube that these two pieces of information will make it into bundles in due course.

THE CHAIR: Right, so the chart and graph is the document----

MR MACKINTOSH: That came this morning.

THE CHAIR: -- that came this morning. The document that came on Friday, again?

MR MACKINTOSH: Is a set of admissions data from Greater Glasgow and Clyde Health Board, which was produced some months ago but puts into context a particular aspect of Mr Mookerjee's evidence, and so I provided it to CPs on Friday. It will go into a bundle-- if it hasn't gone in this week, it will go in next week.

THE CHAIR: Thank you. I take it nothing arises from that. I take that as a no. Good morning, Mr Mookerjee.

THE WITNESS: Morning.

THE CHAIR: As you're aware, you're about to be asked questions by Mr Mackintosh, but before you do that, I understand you're prepared to take the oath?

THE WITNESS: Yes, sure.

Mr SID MOOKERJEE

Sworn

THE CHAIR: Thank you very much, Mr Mookerjee. Can I encourage you, when giving your evidence, perhaps to speak a little louder than you would in normal conversation? You have the microphones there and that should help.

THE WITNESS: Sure.

THE CHAIR: But we have a space to fill. I want everyone to be able to hear you, and I want to be able to hear you and I'm a little hard of hearing, so just maybe a little louder than you would normally speak.

THE WITNESS: Sure.

THE CHAIR: Yes. We'll take a break probably at about half past eleven

for coffee, but if you want to take a break at any other time during the day – and I anticipate we will take the day for your evidence – just give me an indication.

THE WITNESS: Sure, thank you.

THE CHAIR: Now, Mr Mackintosh.

Questioned by Mr MACKINTOSH

MR MACKINTOSH: Thank you, my Lord. (To the witness) May I take your full name, please?

A Yes, so it's Sid Mookerjee.

Q What's your current occupation?

A So, epidemiologist at University of the Hospital Sussex.

Q University Hospital Sussex. What I want to do before we get to your reports is just to have a little bit more detail and understand your professional experience and expertise.

A Sure.

Q So, your current role in Sussex, when did you start that?

A So I joined Sussex in November of last year, so November '23. So, prior to that, I was the hospital epidemiologist at Imperial College Health Care NHS Trust, and that was----

Q That's in London?

A Yes, and I was part of that large acute Trust since I joined all the way back in February of 2011. I took, well, ownership in terms of leading the epidemiology unit in 2015 for the Trust, and that was a role that I kept until I left in June of 2023.

Q So this epidemiology unit, in which part of the hospital's organisation does it sit?

A So both for-- so both at Imperial College London and at Sussex, well, hospitals, the role of the hospital epidemiologist has always sat within the infection control department, so the IPC department. And the IPC department, as you know-- so, for example, at Imperial College was across a set of four hospitals, which-- and it is similar for Sussex. So the epidemiologist is, essentially, well, as the name suggests, the epidemiologist for the hospital and so working for the hospital but based within the IPC unit.

Q How many members of staff form the epidemiology team in Sussex?

A Well, currently-- so I was offered the opportunity to build the epidemiology unit, well, at Sussex. So, currently, it is myself.

Q Right, and in London, at the UCL, what was the team?

A So, well, at Imperial College, the NHS Trust, at its height, as the operations lead for the epidemiology unit, there would have been around five or six people.

Q Within the infection control team at UCL-- Imperial College rather----

A Yes.

Q -- to whom did you report?

A So, as a hospital epidemiologist, you would report directly to what we call in London as the operational head for IPC.

Q Right.

A Which is normally the director of IPC, so my immediate-- so the person who would be managing me would be the DIPC, or the director for IPC, and it is----

Q In Sussex, is it similar? Do you report to the DIPC?

A Yes, so I have a few more lines in terms of who I report to at Sussex. So I report to the infection control-- yes, the lead of infection control, who will be the ICD or the doctor.

Q Yes.

A I also report to the DIPC.

Q Right.

A So I-- yes.

Q So in England, the DIPC sits above the lead ICD?

A Yes.

Q Right. Now, in your----

THE CHAIR: Perhaps I should know this: the DIPC is an acronym for?

MR MACKINTOSH: (To the witness) DIPC is?

A The director of Infection Prevention and Control.

THE CHAIR: Right, okay. Thank you.

A Yes, I'm used to saying the acronym because----

MR MACKINTOSH: So in an English hospital, the director of Infection Prevention and Control is the director of the infection control team, and they will have reporting to them the lead infection control doctor, the lead infection control nurse and, in your case, the epidemiologist and others, no doubt?

A Yes, absolutely.

Q So what sort of epidemiology exercises do you carry out in your current role in Sussex?

A Well, so I think the first thing I should say is that my role is unique in the sense that an epidemiologist who works within Infection Prevention and Control is a post that is found in, you know, at ICL, so now, well, at Sussex, and I think the only other example is at UCL.

Q Right.

A And so, based within the infection control department, essentially, what you are doing is something where the epidemiologist would be the elbow between the information that you get for the patients and the clinician, so what you're doing is you're making sense of the data.

Q Is that a continuous process or

reactive to requests from doctors and nurses?

A Oh, it's continuous. So you do both things. So the epidemiologist is, well, essentially, so making sense of the infections: where they occur, why they occur. You're looking at, well, outbreaks, you're looking at clusters, you're also at the behest of clinicians who have picked up things, and so you have to, you know, you have to respond in terms of how can you help in terms of what could be the cause of an infection or a few infections. And when you have some time, you look at what may have caused these, what might be reasons why these infections have, you know, have occurred.

Q So you might look at data for similar infections in the past and where they occurred and what their connection is to other events?

A Yes, absolutely.

Q Now, in either of these two jobs you've held, have you had any connection with-- have there been paediatric haemato-oncology units in those hospitals?

A Yes. So I don't think I can comment in too much detail in terms of the services offered within the paediatric haematology unit because I'm not an expert in that particular field, but in my role as the epidemiologist, yes, the-- my role would be across all the units of the hospital. And, to my best recollection, yes, the paediatric neonatology unit at Imperial College London was there and, of course, we have one at Sussex.

Q So have you carried out, just in very broad terms, these epidemiological investigations that relate to those two units in recent times?

A I have, yes.

Q Very broadly, what sort of issues have been challenges or across the agenda that you've been trying to ---

A So, similar to-- and similar in the sense that you'd be dealing with infection incidents. So you come in on a weekday, and you have to deal with a few infections which have happened in the paediatric-- And you can have an infection, so you then have to look into a patient, or you might have to look at a cluster, and you have to make sense of what these infections are, what the bugs are, where are the patients, are these patients linked in terms of have they given it to each other.

You then will always ask, in terms of the source, is the source the fact that-- So, for example, have these patients all been in the same room, for example? Therefore, they have caught this from each other, so transmission, or is it the fact that there are other causes, such as the environment, water or any sort of line that you may have inserted into the

patient, so----

Q Right. You were asked to produce a report for us, and you ended up producing four documents----

A Yes.

Q -- which have now been joined by a fifth, which we'll come to. What I want to do formally, in a sense, is just to identify what they are before we look at what happened, so I wonder if we could first put your quantitative infection link report from 9 May '24, which is bundle 21, volume 1, document 1, page 3. Now, this report, did you produce this report in May?

A Yes.

Q Will we eventually have to deal with how you reacted to comments provided by core participants?

A (No audible response).

Q If you nod, the poor person doing the transcript's not going to be able to write that down.

A Yes.

Q The second report is the supplementary report of 12 August '24, which is the same volume but now it's page 71, and you produced that on 12 August.

A Yes.

Q You provided with it, which precedes it immediately in the bundle, a note from me, which set out various things that I asked you to do.

A Yes.

Q Right. Then you produced an addendum to that report on 16 October '24, which is the same volume, page 767.

A Absolutely, yes.

Q That followed a consultation?

A Yes.

Q Right. However, it turns out there was a small error in this report, and the version in the final bundle is a corrected version. I wonder if we can go to page 772. So we're going to get to what this means in general, but very roughly, just so that the correction makes sense, what does this chart, this figure, show?

A So figure 2, well, essentially shows a trend graph for the period, so 2015 to 2022, for each of the aggregated years, and it looks at the individual rate of infection per 1,000 admissions for the physical space of 2A and 6A. We look at it both in terms of a first-- so 2A in green and then 6A in yellow, and then it's aggregated ----

Q That 2A and 6A, those are overnight-only admissions?

A This-- yes.

Q Yes, and then the dotted purple line, is that an aggregate of the two lines?

A Yes, it is.

Q Now after you'd issued this report, did Dr Mumford notice that there

was a numerical error on the labels in the chart? What was that that was changed?

A So, Dr Mumford had noted that two of the values pertaining to the dotted line in purple – so Ward 2A and 6A, aggregated rate of infection – at 2018 and 2022 were incorrect.

Q These numbers on the dotted line, should they be the same as the equivalent figure on page 91, if we go to page 91? Because it's effectively the same----

A Yes, it is the same graph.

Q Same graph, so the one on page 772 was initially mislabelled----

A Yes.

Q -- and you corrected it, and the final version on the website is the correct version?

A Yes.

Q Right. Now, you were also asked to produce a response to a questionnaire sent as a result of Direction 5 questions to your first report.

A Yes, yes.

Q That's bundle 21, volume 6, document 3, page 104. Now, that's the letter from Mr Nolan, but if you go over to the next page, this is, effectively, a further report in answering the questions.

A Yes.

Q Yes, right, and if we go to the end of that document, if we step on through it, we discover – one more page – that it was written on 11 August.

A Yes.

Q In addition, have you produced – and we'll come back to why you did this later – a revised version of the figure 2 table, which my colleague helpfully put on the screen just now, which, I was explaining to my Lord and the Chair, was produced last night at my request?

A Yes.

Q Now, we'll come back to why you did this and what the extra purple line means at the appropriate point.

A Sure.

Q What I want to do is just check that are you willing to adopt, subject to the fact that later reports may correct earlier reports, all five documents as part of your evidence?

A Absolutely.

Q Right. If we could take that off the screen, what I want to do is to go back to-- Well, the first question is to ask you did you have any connection to the Queen Elizabeth Royal Hospital for Children or NHS Greater Glasgow prior to being instructed by the Inquiry as one of our experts?

A No.

Q No. Could we go back to bundle 21, volume 1, page 5, please, where you've set out your declaration of understanding? Obviously, we can read what you've written in section 2.4 at the

bottom of the page. I wonder if you can explain in your own words what you consider your duty to the Inquiry as an expert witness is.

A Well, I guess it is, so, fundamentally to provide a unbiased analysis using the information which has been provided to me and use it as a lens, so taking into account the expertise I have to explain what the trend in infections are, what is the variation in the trend of infections, and how does the trend of infections then compare to the trend in water positivity.

Q If, in your investigations, you're faced with a realization that you have misunderstood something or that there is an error in your calculation, what are you required to do?

A To correct it.

Q And to bring it to our attention?

A Yes, absolutely.

Q Okay. Now, what I want to do is just to check on, before we look at the-- Take it off the screen, please. Did you take part in a visit to the hospital?

A I don't think I did.

Q No? In that case, you're the only expert who hasn't, then. Right.

A Yes.

Q So your knowledge about the shape and structure of the nature of the Schiehallion unit, the cohort of Schiehallion patients, the locations of wards, where does that come from?

A So, interestingly-- I mean, because I think it is often the case that, regardless of the work, that the lens that is used by an epidemiologist like me is the information that he or she is given. So I guess it's my understanding of the unit, the, you know, infections, is from the information which has been provided to me, and I can extrapolate based on my experience, which is now for about 14 years, working within large hospitals and how these units look.

Q How do you deal with a circumstance where the image in your mind of how a particular unit is organised turns out to be inconsistent with the data that you receive? What do you have to do then?

A So I'll say this: I think it's one of the reasons why the work that is done by an epidemiologist is unique-- is because, as I noted, the only thing I have to go on is the information which has been presented to me.

Q So I want to use an example, just to discuss how you dealt with this. There are calculation consequences of this, which we'll pick up later, but I want to just put this on the screen. So, my Lord, this additional document was uploaded on Friday. This is the haematology-oncology admissions data provided-- the supplement following the first report, and

do you recollect receiving this, Mr Mookerjee?

A Yes.

Q Now, we see across the screen columns for each of the years from 2015, the first year being a partial year to the end of 2022, and we see rows for different wards. Now, a good example might be if you look halfway down the left-hand side, you see "Yorkhill Schiehallion Day Care Unit, Haematology," and a total admissions from June into that unit of 52.

Now, do you know, for example, given that Schiehallion Yorkhill was the old unit before June, whether these patients in that row were actually admitted into Yorkhill or had been actually admitted into the new unit but mislabelled by medical staff? Can you tell?

A No, no. The simple answer is no. I can only go on what is on the sheet, so if things have been mislabelled, I wouldn't be able to know or comment on it. I can only go on what is here.

Q So, for example, would it be fair to say that the Inquiry suggested probably to you that-- The Inquiry team suggested that the evidence we'd heard in the first two hearings was that the Schiehallion cohort occupied two wards, originally 2A and 2B, and that's where they were to be found, and that's the broad approach you understood followed that approach?

A Absolutely.

Q Yes, and yet, if we look into 2016, for example, we see third row down nearly 400 patients who are haemato-oncology paediatric patients recorded as being in the RHC area 1B day surgery. Now, given that's not 2A or 2B, did you take account of those patients?

A No, and the reason for that is because when you're presented with what we see here, which is a lot of data, you need to go back to the ask, and the ask was that I look at the rate of infection in the Schiehallion unit. My understanding of the Schiehallion unit is that these were units that, prior to the decant in 2018, were 2A and 2B, and post decant, to some extent, 4B and 6A.

Q Right, we'll come back to this in more detail at the right point of the narrative, but I wanted just to touch on it before we went into detail. Let's take that off the screen. Conscious of having dipped our toe into the data a little early, what I want to do now is to-- You've already explained what you thought you were trying to achieve, but before we go into how you did it, I wonder if we can look at your first report, so that's bundle 21, volume 1, page 12, and the issue of how on earth do you consider-- work out causation from data.

So, actually, it starts from the previous page – page 11, 5.5 – and you have a quote at the bottom of the page from Kundi, and I wonder if you can explain. You don't need to read this through. We can read the next page or so, but just give us an idea of how you, as an epidemiologist, in this sort of context, try and understand causation by reference to data.

A So I think to start us off and to start me off, there are many things that you can understand from the term "causality," and when it comes to the realm of infections within a hospital and the sources of those infections, you are not-- or you are taking the definition of "causality" that I have noted in paragraph 5.5.3, which is that you're looking at the association.

In this case, you're looking at the association between the exposure variable, which, in this case, is the microbiology from the water, and you're looking at the outcome variable, which, in this case, are infections. And you're looking at how are those two variables associated. So, essentially, in layman's terms, what is the relationship between these two things?

Q So if one goes up, what happens to the other one?

A What happens to the other, and broadly, if one goes up-- if the exposure goes up, because you have to start somewhere----

Q Yes.

A -- if the exposure goes up, what happens to the outcome? If the exposure goes away, what happens to the outcome? If you look at a trend of the exposure – and by that I mean if you look at a measure of the exposure, where, in this case, is water positivity, for example – how does the trend of water positivity make itself available over a period of time?

And how does-- and if you will overlay that with the trend of infections, what does that say about the peaks within the water positivity, and how do they relate to the peaks within the infection? And you can do this both in terms of observation – you can look at it – but you can also utilise epidemiological tools to understand that relationship.

Q What sort of tools do you think are appropriate, in this context, to understand that literature?

A So, if you're-- so, within this context, I think there are tools that will allow you to understand association, and one of those tools is something like the correlation of a coefficient. So you're looking at how do these two time series, and----

Q These two pieces-- sets of data?

A Yes, and how do these two sets of data, of which you have multiple points over years-- how do these two series, well, first of all, present themselves, and how are they associated with each other. And what you are essentially asking of epidemiologists is what-- how does the trend, so the bar charts going up or down, how do those peaks and troughs over time within water positivity, how do those peaks and troughs look in the background if you put the infection in your foreground?

Q So when you're measuring correlation, how does that mathematical process give you comfort, if that's the right word, that there is some form of correlation? What's the mathematical-- keeping it at a level, bearing in mind that I don't think any of us are mathematicians here apart from yourself----

A Sure.

Q -- how does correlation work in the way that it gives you some assurance that there's something going on?

A So you-- so what the tool allows you to do – and it's a tool which has been used for many, many years – is that it allows you to look at the slant of the trend over time, and it gives you what is called a coefficient of correlation, which is essentially a number, and the closer that number is to 1----

Q From below, as it were? From 0 to 1?

A From-- yes, from 0 to 1. So the higher the number is to 1, the more associated these two values are. As that number gets closer to 0, it-- you can take from it that these two values are less associated with each other. So, essentially, they're doing-- they are not associated and they are presenting themselves as one is not linked to the other.

Q What, they're more independent, in essence?

A They're more-- yes.

Q Okay.

A Yes, exactly.

Q So when an epidemiologist talks about there being an association or correlation, how does that relate to the concept of causation, a causal link? Because obviously "causal link" means lots of different things to lots of people and, as lawyers, we have our own particular understandings of that, but what do you understand by trying to find out whether there's a causal link?

A Well, I think, in reality and on the ground, what you're looking for is, on the balance of probabilities, that the exposure variable is linked to the outcome variable.

Q So that level of correlation we talked about?

A Yes.

Q So can you ever do any better than that as an epidemiologist?

A No.

Q So a scientist might be able to run a prospective study in a randomised-- if it was ethically appropriate. You can't do that? The correlation's the bee's knees, from your point of view?

A Yes, because what you would have to really do, if we wanted to go down the academic route of saying that an exposure variable, like the microbes in water, can cause infections in patients, is to essentially do something that is-- you would have to do something like a randomised control trial where you subject patients to water contamination. Because what you have to do, if you really want to go down the academic route of causality, is you have to understand and you have to adjust for the confounders.

Q So what are the confounders?

A The confounders within a hospital are many. It-- the confounders are the level of risk that the patient cohort carries.

Q In this context, might that be that they're more susceptible to infections?

A Yes, absolutely. The confounders can be, how far away were the patients from the water outlet?

Q Okay.

A And does the distance between the patient's bed and the water outlet, if the distance is closer, is the link-- is there more of a risk that the microbiology from the water can impact on the patients?

Q Would confounders also be related to the age or the demographic background, all these things?

A Yes, absolutely. Yes, so the confounders can be age, it can be what antibiotics they are on, it can be the level of morbidity, so how sick they are, and so, to adjust for these things is not possible.

And to give some context, even if you think of how the word "causality" came about, it came about in the 1950s because we were looking at how things like smoking are related to lung cancer, and you often hear people sort of say that there is a causal link between those who smoke and your risk of lung cancer, that if you smoke, you get lung cancer.

But that is not absolutely the case because what smoking does is it will increase your risk of lung cancer, but no one can say that if you smoke, you will get lung cancer, and that is what causality is trying to ask of us, is it is concerned with, in my mind, an academic-- well, pursuit of linking to things where the exposure will 100 per cent of the time lead to the outcome, and

that the outcome cannot happen without the exposure.

Q So it's trying to understand whether-- the nature of the risk that an exposure causes and whether it's significant?

A Well, more than that because, actually, if you ask that question, what you're doing is you are asking something that is much more practical. So, for example, if we can use the same example, what you said right now is asking the question that if you smoke for 60 years, what is your risk of lung cancer?

Q Right.

A And so you are asking that if you smoke from the age of 15 to 60, what is the risk as compared to someone who smokes two cigarettes in their entire lifetime? What causality is trying to do is trying to ask a very specific question, which does not-- which has, in my mind-- I can't think of an example in reality where that definition is met.

Q So what's the specific question it's asking?

A So bear with me. So yes, so the question it's trying to ask is, does smoking, the exposure, always lead to lung cancer? The answer to that, in practical terms, is no, because we know people who have smoked who don't get lung cancer.

It's then trying to flip it over its head and go, "If you have someone who has got lung cancer, is it 100 per cent caused by smoking?" The answer to that is also a no, because you can get lung cancer off many other-- for many other reasons. Smoking is just one of them. So, in practical terms, you can never prove causality, and I can't think of an example where you can.

Q But what can you show in that context?

A You can show the relatedness. So I'll use a few synonyms. You can show relatedness, you can show association and you can show the degree of association.

Q Is that what you're trying to do in papers for us?

A Mm-hmm, absolutely.

Q Right. Now, one of the things that we've discussed in your reports, and we've had other evidence about, is an academic by the name of Bradford Hill.

A Yes.

Q We've had various evidence from witnesses both encouraging reference to the work of Bradford Hill and discouraging an overly formulaic approach to it. Various people accusing each other of doing precisely those two things. So who was Bradford Hill and what's the point that they're making that you take as relevant to the work we're

doing?

A Yes, so a few points here. The work which was being done in the '40s, the '50s and the '60s around the link between smoking and lung cancer-- Hill was someone who was associated with that work, and so what came out of that is what you'd call-- I mean, you will hear a few things about it. They're called the nine-- well, the word for this are "guidelines."

Q Do we find them on page 14 of your----

A And you can find them on page 14, yes. They are also referred to as "postulates."

Q Right.

A But what is key, and Bradford Hill himself said, and I quote from paragraph 5.9----

Q That's page 13.

A Yes, from page 13, is that what the nine-- the postulates do is that they outline the core things that one needs to think about in terms of frequency, the association and the impact to aid people like myself when they are interrogating the evidence. And he himself noted that and he advised against, and here I've noted this in 5.10:

> "None of my nine viewpoints can bring indisputable evidence for or against the cause-and-effect hypothesis."

And how I read that is that they-- that what these nine postulates do is they provide a framework from which to work and from which one can-- or you can use to make sense of the evidence.

Q Okay. Before we leave this section, I want to just go to 5.7 on page 13. So I just want to check – if we can zoom in on the top half of the page, please – am I right in thinking that 5.7 is effectively your hypothesis that you're wanting to investigate?

A Yes.

Q Right. Now, before we move onto how you did that, I want to just take you to a particular document. This is the Public Health commentary on the draft Case Notes Review prepared by Dr Crighton in February 2021, which we took her to and we took Professor Stevens and Professor Wilcox to. So, that's bundle 27, volume 6, document 29, page 310.

Now, there's a lot in this, but the point I wanted to put to you was the third and fourth paragraphs. The third paragraph goes:

> “Given the known and well-published risks of infections among this group of patients, it would be useful to overcome the limitations of descriptive epidemiology – time, the place, the person – showing crude

numbers of patients by pathogens along a timeline through additional epidemiological analysis."

Then:

"Useful additional analysis would be calculating incidence of infections of interest in the population at risk; establishing the trend of infections, incident, time; comparison incident rates and other comparative units in Scotland, the UK and published data; standardisation of infection rates to account for known confounders like age, sex, ethnicity, deprivation; calculated rates of infections within the cohort based on published data."

Then there's a reference to an HPS paper, which we'll come to later, then discussion of Bradford Hill, and then it turns, as it were, into a critique of the Case Notes Review. Now, ignoring Professor Wilcox's comments, which I think are the second and third comments, and Professor Stevens' comments at the top, is there any similarity between what you have attempted to do and what one reads Dr Crighton suggesting in these two paragraphs?

A So what is being suggested is two things. If we could just go over that first because I think it is important to understand that, and for me to understand that as well-- is that you undertake a piece of epidemiological analysis that looks at the time, place and the person, and you understand the trend of the infections. You understand, in this case – and we'll go back to this – the infections are the outcome variable and the water is the exposure variable.

So you look at the trend of the outcome variable, you look at the trend of the exposure variable, and it just says that you look at it along the timeline. Now, the thing I would warn against here is showing crude numbers of patients because, of course, what you really need to do, and what I've done in my reports, is to look past just the numbers of the infections and weight it for the activity.

Q So you're measuring the rate of infections?

A So you're measuring the rate of infections per thousand-something.

Q Okay.

A It then goes on to say that you can compare these incidence rates, and then the third thing it then goes on to say is that it-- that you could standardise the infection rates to account for known confounders. So, on the first two things, we-- or I had done that. To come back to the second point, the rates of infection at the Schiehallion for the time period 2015 to 2022 have been compared to

comparator units.

And on the third, the way in which I have adjusted or done something about what we know are the confounders – like age and sex and ethnicity and deprivation – is to compare the rate of infection at the Schiehallion to as many as many like-- you can say-- so the word will be "comparator units," and make sure that, in the comparison, when it comes to the comparator units, that you accumulate as much information on the admissions, the patients and the infections so that what ends up happening is that, the more information you have, that the data itself, through it being a large set of data, adjusts for these confounders, like age, sex----

Q So the bigger the dataset, the less chance that an odd balance of age or sex or treatment or outcome will distort matters?

A Yes, absolutely, and, to reverse that, what you are trying not to do is to compare to small amounts of infection because you run the risk of bias. You run the risk that the comparison has been made to patients who are not similar to the cohort that you're trying to compare them to, and so what you are-- essentially, what you're trying to do is to compare it to as big a set of data that you can.

Q Is this, I suppose, the equivalent of when we hear about opinion polling? One can produce a sample of people you poll who are proportionately the right age, sex and everything, ethnicity, as the electorate?

A Yes.

Q Or you can just compare it with a very, very, very large number of people and then you don't need to balance it out because the size of it will do that for you. Is, effectively, that the distinction you're drawing?

A So before I say yes, there is a caveat, which is you have to balance two things in-- So here is you're looking at a very-- we're not looking at the-- or we're not looking at the electorate here. What we're looking at here is a very specific cohort of patients who are paediatric, haematology, oncology patients, and so it would not suffice to sort of-- to compare a cohort of patients which is that specific to the population. So you can't compare the risk of infection within this cohort to, for example, A&E.

Q You couldn't, for example, compare them to an entire children's hospital?

A No. You cannot, and you----

Q Or even two combined together?

A Yes, and you should not because that is not a comparison of like things, so you're not comparing, well,

apples to apples.

Q One of the things that Professor Stevens said last week in his evidence was that he-- I think he said two things about the work you were trying to do, one of which was that there was clearly a difference between the different types of a haemato-oncology units around England and Wales. He described some as being large, some as being small and some as having their outpatient services happening off-site for geography reasons.

We end up with four comparators here, but do you need to know anything about the distinction between these four comparators in order for this methodology of having a large sample to still work to exclude confounders, or suppress confounders?

A So, from my point of view, what I'm looking for is a dataset which is large – that's my first priority – but which is specific to the population that we are concerned with because that would allow me to take from it that, regardless of how care is provided to these patients, that, because it takes into account two large units and two small units, that actually we have a good spread.

Q So you need to know that?

A Yes, I need to know that, but I'm more concerned about the spread of the data, and, by spread, I mean, "Is the data we've got from the comparator units a sufficient representation of the risk of infection within the paediatric haematology-oncology group of patients.

Q Right. So do you think you have that information?

A Well, I think yes, and I pause there because it's the best that I could do. We sent the Freedom of Information request to remind me, I think, 15----

Q Well, we see on page 21 of bundle 21, volume 1-- we see at 7.2.4 the questions you asked for the year of construction, the number of admissions, number of individual patients, the total number of blood cultures, total number of positive blood cultures and:

> "A list of the numbers of all organisms, by species, isolated from blood cultures from patients on the paediatric haemato-oncology unit (whether deemed significant or not), by site, (peripheral venepuncture, peripheral line or central line) by year from 2015-2022, total and de-duplicated numbers for same infection episode."

Over the page, we see the list of the hospitals that were asked. Now, you only got answers from four, 7.2.6.

A Yes, well, we received answers from a few more than four, but the other, and I think there were three

other-- the data that they provided was not what we asked for.

Q In what sense?

A In the sense that-- so, broadly, they were not able to-- they were not able to extract the admissions specific to the paediatric haematology-oncology unit.

Q So they could give admissions for their whole hospital?

A For the whole hospital.

Q Yes.

A Which I could not use because you would then not be comparing, well, apples to apples.

Q Right.

A Or they could not give you-- or me an exact number of infections as per what we asked for, for those years. They had them----

Q So if we go back to the previous page, is it the final bullet point they couldn't give you the----

A Absolutely. So what they could give me is a number of all organisms, but they could not split them into those organisms which were gram-positive and do the separation between what were then the gram-negative infections that we wanted to look at. So what I ended up with was admissions for the entire hospital----

Q Yes.

A -- and all the infections in the paediatric haematology-oncology unit, but not in a way that I could then look at which organisms were causing it. So they were giving me, so, numbers of infections rather than----

Q Individual infections?

A Yes, exactly.

Q Because the last bullet point generates, effectively, a spreadsheet where each row is an infection.

A Yes.

Q Right. If we go over the page, it's probably just worth, at this point, picking up a question: would there have been any value in making this comparison with other types of hospital unit? Now, I'm going to put three to you. Would there be any value in making this comparison with the entirety of a large teaching hospital with accident & emergency on site?

A No.

Q Why?

A Because, again, I mean, if we go back to fruit, it wouldn't be comparing, well, apples to apples because you would be-- you would then be comparing the rate of infection within a-- within the specific population of the Schiehallion cohort to the rate of infection of all patients-- for the hospital.

Q Would there be value in comparing this data set for the Schiehallion unit with, for example, a regional cancer centre for adult patients?

A No, again, for the same reason-- is because what we have in hand is the rate of infection within the paediatric haem-onc unit, and you are then comparing it to the adult haem-onc unit. And the risk of infection in these two units, you would consider to not be the same.

Q Is there any value in comparing with, for example, a large district general hospital that has no oncology services?

A Absolutely not.

Q Right. Before we get into the methodology in more detail, I want to just understand what role Dr Mumford and Ms Dempster had in the design of the methodology that we're about to talk through. What role did they have in your design of your methodology?

A Well, essentially, in their capacity as clinicians who have worked within the NHS and have the clinical and the microbiological expertise and have the experience of looking at infections and have experience of looking at the exposure variables – in this case, so water – that they were able to act as a sounding board, such that we went through the steps of the methodology as a unit.

Q So that's the three of you working together?

A Yes, absolutely, and because what a-- as we noted, what a-- what the epidemiologist has – me, in this case – is the data as the only source of the truth. And the challenge for me was-- is to make sense of that data. And so what you need, and I do this in, you know, in-- is that you need to speak to clinicians to understand that are the decisions and are the presumptions that you're making, are they true?

And you essentially need-- you essentially need to triangulate so that you're not doing this in a vacuum. That you're doing it with someone who is working with patients, who understands patients, who has intimate knowledge of these infections, the microbiology and what causes them.

And so, from the very beginning, when I worked to understand what the data is telling me, how do you, well, analyse it? Because of course, as you saw from the admissions list, for example, that I was given from NHSGGC, that it takes a lot of interpretation and it's a lot of work to understand what that set of data is trying to tell you.

Q So what that means is, as we go through, I'm going to need, occasionally, to ask you if Dr Mumford and Ms Dempster helped you with context, because that's probably important for us. You've been talking about the need to compare, to work out

an infection rate.

A Yes.

Q The number of infections in a unit in a period of time divided by an activity. So what I wanted to do is to discuss that in broad terms. So I'm assuming that the number of infections in that period will be the numerator?

A Yes.

Q The number on top of the fraction?

A Yes.

Q And the measure of activity will become the denominator on the bottom of the fraction?

A Yes.

Q Right. Now, we've talked about, or you have referred to, comparing apples with apples. How do the numerator and the denominator have to relate to each other for this to be a success, this exercise in calculating an infection rate?

A So the way in which a rate is put together is, in this case, for example – and we will stick to the example – is what is the question? The question is that, in a specific-- the cohort of patients, what is the rate of infections weighted for the activity?

And what that is trying to ask is that we understand-- so if we understand that on day one, so for example, we saw one infection, on day two we saw five, on day three we saw four. We can add that up, but what that will not give you is how does those infections relate to the activity? I.e. were there more patients on the Tuesday?

Q So you have to have a measure of activity?

A So you have to have the measure of activity, and the activity has to be the risk cohort in which the infections happened.

Q So if the activity covers a risk cohort of 100 patients, the infections must be drawn from within that 100 patients?

A Yes.

Q If the infections were drawn from a larger group or a smaller group, the activity must shrink or expand to match-- to map onto the infections?

A Yes, and because what you are trying to do here when you calculate a rate of infection is you are looking at the risk cohort. So, for example, the number of admissions that have been had to the unit in a year, for example, and within that risk cohort, how many infections did those patients have?

Q Is there not an issue that arises that if we, for example, go back to page 21, the questions you ask of the comparator unit all turn on how the person compiling the answer interprets the word "the paediatric haemato-oncology unit." So they've got to decide

what you mean by that. To use an example, if their paediatric haemato-oncology unit comprises a single ward, that's going to be easy.

A Yes.

Q But if it comprises multiple wards but doesn't include within it an ICU, then do the patients who are in the ICU get counted in this answer? That's the question the person compiling the answer has to think of the answer to.

A Yes. So, normally, you would go about it in two ways. So, in answer to-- yes, so I would agree. There is a level of interpretation, but – and I would stress that-- is you are making this request of trust within the NHS, and so I would argue that the wording around what the FOI here says in terms of the paediatric haematology unit makes sense and will make sense to anyone who is in receipt of this FOI.

Because you can go about it and, as someone who has worked in the NHS for coming up to 15 years, the FOIs, you know, they have to be in plain English. They are received by the Trust and when the FOI officer reads it, he or she or they will send it to the paediatric haematology unit because it says----

Q So there is a measure of trust, in a sense?

A Oh, absolutely.

Q Yes.

A It's also a measure of expertise. When you send a FOI to the NHS Trust, to a Trust, you are trusting them to be expert and you build-- or you use their framework of expertise as the backdrop for sending them the FOI. Because these FOIs aren't being sent to the layperson; they're being sent to experts who work within a hospital. In this case, we have sent it to about a few dozen.

Q Is this, in a sense, related to the issue of confounding data, in that how the FOI is answered might – it might – be answered in a slightly different way in all four units who've answered? You don't know that, but having a large enough data set, you hope to----

A To adjust for it.

Q To adjust for it. It's the same principle?

A Yes, absolutely.

Q Right. How would you respond to the suggestion that's been made that you can't deal with confounding without knowing the data about it? So it's been put to me that I might ask you this question: you've suggested that the cohort will be the same in all the comparator hospitals. However, you don't know that, so are you just not-- Doesn't it undermine your work that you're, in a sense, taking something on trust here that this is a genuine

comparator unit?

A So I think what you've noted is what you have to do in reality. In the real world, you are doing a few things. You are being asked a question, which is you have the rates of infection at the Schiehallion, and you have to compare it to other trusts. You send the FOIs and, yes, there's a huge measure of trust and expertise that you depend on, and you acknowledge the fact that there will be variability. You acknowledge it.

Q So it will eventually become clear when we get on a little bit further on that the initial response to the equivalent request to Greater Glasgow for admission data produced only the overnight admissions, not all admissions. How would you know whether one of the other trusts had made the same mistake?

A Well, I would hope they did not, but you trust them to understand what is here, so 7.2.4, point 2, the request, which is:

> "The number of admissions to the paediatric haematology-oncology unit by year for the period."

Because to any NHS trust that is trying to respond to that request, the ask is really clear, which is that you want the number of admissions. We are not asking you to split the admissions by overnight or, you know, all the day cases.

Q Because what is an admission, from your understanding, in a hospital?

A Well, so I'll answer that with the epidemiology hat on because I can only do that. For me, an admission is when you have a admission date on the system.

Q So an outpatient appointment to see a consultant, that wouldn't be an admission unless you were admitted for a particular process?

A Absolutely, so I think the second point of that is important because, yes, let's start with an inpatient gets a admission because they are going to be using a bed. So, in layman's terms, they are admitted to the hospital and therefore they are assigned an admission date.

Q In old language, they're clerked in?

A Yes, exactly, but there are more ways in which to care for patients other than moving them from A&E to a bed, especially when it comes to the paediatric haematology-oncology patient cohort, where-- and I think this was a point which was repeated by Professor Stevens, that this cohort, or in this cohort, day cases are used extensively to provide care.

Q So those day cases will be admitted, under your understanding?

A Yes, absolutely, and in fact, because of the kind of care being provided to those patients – which will

involve instilling lines so that you can pass antibiotics or other drugs – there might be other minor procedures-- that these sorts of interventions require that there is a admission date on the system.

There's a very simple reason why. It's because when it comes to the end of the month and the NHS, the hospital, then want to be reimbursed by the government for the drugs that have been provided to the patient cohort, that it is linked to the admission of those patients.

Q So this is the England situation?

A Yes, absolutely, and actually, in a lot of trusts, in order for certain antibiotics or other IV drugs to be administered, the pharmacy department has to have a admission date for that patient.

Q So that's why you feel confident that the admission date in the comparative hospitals is calculated as you'd expect?

A Mm-hmm, absolutely, yes.

Q However, I think this is a good time before the coffee break to talk about the choice of admission date as the denominator. I think we can finish that in 10 minutes. So you have used admission data – dates or number of admissions – as your denominator, and that's what you requested in the FOI. Other witnesses have taken the view that occupied bed days is the best denominator. Just to bring us up to speed and so you can recollect the evidence, we've had evidence, I noted, particularly from Dr Kennedy and also from the authors of the various HPS reviews----

A Yes.

Q I think others did, too, but just to pick on those two as public health doctors and the National Infection Prevention Control Agency, they both took the view, quite clearly, that occupied bed days is the best measure of activity.

The reason they gave, I think, can be fairly summarised as this: if you're a patient who's in the hospital for three weeks, six weeks, you have more connection to the environment than a patient who's in the hospital for three days, and occupied bed days will measure that length and quantity of your exposure to the risk. From our recollection, that was the height of their point. Why do you say that admissions is a suitable activity measure, and why didn't you use occupied bed days?

A So, a few things to say here, so bear with me. When you look at the paediatric haematology-oncology cohort of patients, you need to first understand-- and this is where a lot of the back-and-forth between the other experts and myself was ongoing-- is to understand how these patients are presented to the

hospital.

The understanding is that the day admissions that these patients go to are maximised such that they don't have to spend time in the hospital in a bed and so that they can receive all the care that they need to on that day. The caveat to that is, or a facet of that is, that the paediatric haematology-oncology population receives a lot of care in day case episodes.

Q Mm-hmm.

A So they are in and out a lot, and so that is one point. The outcome of that is that you have what is called accumulation of risk, in that you have accumulated risk by way of exposure to the hospital. You have accumulation of risk in terms of their contact with other patients. They have accumulation of risk in terms of their contact with staff members who are giving them care. They have exposure to the water, to the surroundings, to the ventilation. They have exposure to the antibiotics. They have exposure to the other drugs. They have exposure to the other sort of interventions that they are given.

So you can see-- so the context is that if the care is provided in a way to minimise them staying on as inpatients-- because, I mean, we have to understand that these are kids.

Q Mm-hmm.

A You know, so you want them to be able to come into a hospital, be provided the care that they need, and then they can go home.

Q Are you effectively saying that admissions captures that aspect and bed days doesn't?

A Absolutely.

Q But surely admissions won't capture the children who stay in for weeks or even months?

A Well, a few things to say there, and I think it was noted by Professor Stevens last week as well, is the question that I had to deal with is how do you differentiate between the risk of, say, for example, spending, so 10 days in hospital, and is that risk more or less than if the same patient had made these visits to the hospital, so if they had 10 visits to the hospital?

Do I think, and is there evidence for me to think, that the risk that a patient is in as an inpatient is different to the risk that they are at if-- when they have these repeated interactions with the hospital. So that is one thing. So the conclusion that I came to was no, that I don't have evidence that one risk is more than the other.

Q Right.

A The second thing to say is that the infections that we are dealing with here are not just the inpatient

infections. We are dealing with infections that these-- that have been recorded in these patients through the cultures which have been taken as blood cultures at any part of their stay at the hospital. So it could've-- So we included the blood cultures which were taken at their day cases. We have included the cultures which have been taken as inpatients.

Because-- and then you look at both the UK HSA and the HBS guidance-- that both of these infections will be termed as “healthcare associated” because, as part of the definitions, if you have repeated interactions with the hospital, the resulting infection is termed as a "healthcare-associated infection."

Q I get the impression the way you've explained this is that – tell me if I'm putting words in your mouth – admissions is good for one thing----

A Yes.

Q -- and a thing that you think is important. Bed days is good for another thing. You have no evidence to suggest that one is more important than the other, but you've picked admissions. Is that broadly it?

A Yes. There is one more thing to add to that.

Q Yes.

A It’s that the fundamental work that I had to do was not just to look at the trend in the rate of infections at the Schiehallion but to contextualise it, and to be able to contextualise it, you have to compare it to the rate of infections at other hospitals. And so you have to go through this process of being able to get the same information from other hospitals, i.e. the infections and the activity.

Q So why did you not ask for occupied bed days in the FOI?

A Because, in my experience as someone who has worked within the NHS, it is a simpler task and a much more-- to be able to get the admission information from the record because it is a simple task of tallying up the number of admissions that you have within a month and aggregating it for a year because, of course, you are depending on the date of admission within your hospital system.

Q So it's easier for them to do it?

A So it’s easier for them to do it and there are-- there is less of a human element to it, so you don't have to calculate anything much.

Q What's the human element if you're calculating occupied bed days?

A That you have to physically go on to the ward to-- and, in this case, to all the wards which make up your paediatric haematology unit, and you have to go calculate the occupancy. So you would have to calculate, well, how many beds on a given day are full, and you would

then have to come back the next day----

Q At the same time?

A -- at the same time and then go, "How many of the beds are full on day 2?" And you would have to repeat that for every single day of that month.

Q So if that was data being collected regularly, they would be able to do it?

A Well, most hospitals don't because, as you can see, you-- it is superbly-- it is hard to be able to, you know, do that because it is resource intensive.

Q Right. Before we have the coffee break, I think it's worth noting we're going to come to an attempt you made to draw some information from occupied bed days. My Lord, this is probably a good time to break, unless you've got any more questions about this particular conundrum of admissions versus bed days?

THE CHAIR: No. Let's take this moment for a coffee break. Mr Mookerjee, can I ask you to be back for ten to twelve?

A Sure.

THE CHAIR: You'll be taken to the witness room and I hope you'll be given a cup of coffee, or at least the offer of a cup of coffee.

A Yes, sure. Thank you.

(Short break)

THE CHAIR: Mr Mackintosh.

MR MACKINTOSH: Thank you, my Lord. A couple of small things, Mr Mookerjee. We talked about the data return from Greater Glasgow and the need to replace that. Did Greater Glasgow not also provide you with occupied bed day data as well?

A Yes.

Q Yes, and we'll come to the use of that later.

A Sure.

Q I also noticed that the Cardiff and the Vale unit only provided bed days for under-14s.

A Yes.

Q Does that restriction also apply to their admission data?

A No.

Q How can one tell?

A Because, of course, the manner in which the FOI has been replied to is that they sent a spreadsheet back where you have a value for each of the years, and, of course, the question being asked is that we want it for the paediatric haematology unit.

Now, as I say that, I recognise the fact that it goes back to what we spoke about, is that there might be some amount of variability in the ways in which the FOIs have been answered in that

some units may have patients that, you know-- that they are admitted to that are not-- that are less than a certain age group. But, largely, as we understand what we mean by paediatric patients, they should be patients that are less than the age of 18.

Q But if there are any differentiations, you would hope to deal with them by the size of the sample?

A Yes, absolutely.

Q Right. What I want to do now is turn to the actual calculations you carried out and start with the numerator for the Schiehallion unit, the rate of infections. The top line of the calculation for the rate of infection for the Schiehallion unit.

A Sure.

Q I wonder if we could go to bundle 21, volume 1, page 25. So you already explained that the comparator hospitals had given you a dataset where each row was an infection.

A Yes.

Q Did you have a similar dataset for Greater Glasgow and Clyde in the Queen Elizabeth?

A Yes.

Q Right. Now, on this table, you've recorded the number of organisms under each category.

A Yes.

Q Both gram-negative, what I think are described as environmental infections, and fungi. What I want to understand is why does a particular species get into this table and therefore into the calculation? What's the thing that causes it to be there?

A Sure. So I think the one thing that I should clarify is that this list is the list of organisms, of both bacteria and fungi, that I ended up with, and by that I mean that, if you go back to the criteria that I used, is we were looking at all environmental bugs, so bacteria and fungi, with key exclusions which I have made clear.

Q And these exclusions are listed on page 23, paragraph 8.17?

A Yes, so that was the inclusion criteria.

Q The definition of an "environmental bug," as you put it, gram-negative environmental bacteria, where does that come from? Is that from you or from Dr Mumford or Ms Dempster or----?

A So collectively and through a thorough investigation of what we know from what has been published. There is variability in what the literature sort of states is an environmental bug, but, largely, there is agreement that these are bacteria or fungi that spend a large proportion of their lives in the environment, like water.

Q So if we look at the list on

page 25, how does that-- not the numbers but the actual species involved, how does that compare, for example, with the bacteria considered by the case note review?

A So, very well. There is actually significant overlap between the list that you see here on my report on page 25 and the case note review.

Q Have you been able to look at the connection between this list and, say, the list used in the HPS 2019 reports?

A Yes, I have.

Q Is there a similar or different ---

A No, there is considerable lack of overlap between my report and the HPS report.

Q Right. Which one has more bacteria in it, is the way I'm putting it.

A So mine does.

Q Right. Now, one of the things that I think intrigues the Inquiry, or certainly intrigues me, is-- and I want to resolve is there are some species that seem important in the evidence that we've heard. So, for example, I noticed that there's no Aspergillus, no Mycobacterium chelonae, no Cryptococcus, no Fusarium – not sure I've had evidence about that – and no Mucor----

A Yes.

Q -- in this list, which goes on to the next page. Why is that?

A Well, it's a facet of the way in which the infections were analysed. So, to remind everyone, I was looking at the bloodstream infections, which were linked to the physical spaces which were 2A, 2B, 4B and 6A.

Q So if, for example, a Mycobacterium chelonae infection was found in a different ward in the children's hospital, it wouldn't be in the dataset?

A No.

Q And if a Mycobacterium chelonae infection was described other than as Mycobacterium chelonae for a reason we've heard evidence about, it wouldn't be in the dataset?

A No.

Q No. If we then go on to the next page, page 25, there are-- 26, sorry, there are six yeast species identified.

A Yes.

Q There are two questions that arise from that. The first question is, how did they get into the list? What's the reason they're there? It's not something we've heard a lot of evidence about.

A So, sure. So in the discussions with Dr Mumford and with Linda Dempster, it was clear that these species of yeast were found in the environment. And if I recall, but do correct me, it was-- they were found in the showers and in the samples that were taken from the drains. So we thought it

prudent that, since the question is asking is the link between environmental organisms and infections, that we include these as well.

To note that they make up a very small-- they make up a very small proportion of the total list. So in total, the list we have here on 25, which extends to 26, is essentially a list of the bacteria and the yeast for which there was a positive infection identified on 2A, 2B, 6A and 4B.

Q In a bloodstream infection, in a patient, in a haemato-oncology patient?

A In a bloodstream infection in a patient, exactly.

Q So an adult patient in 4B wouldn't count?

A No.

Q A paediatric patient in 1B day surgery wouldn't count?

A No.

Q Something that's mis-described because it hadn't yet been sent off to the reference lab for final description wouldn't be?

A No.

Q Right, and if, for example, there was a view expressed by an infection control doctor that the particular species was a risk, if there hadn't been an infection in that group, it wouldn't be in here? This is not a list of what you were looking for, this is a list of what you found?

A Yes, exactly, and I should stress that it was-- The way in which I went about this was to essentially start with the question, which is I'm looking at infection episodes in the Schiehallion unit, and my understanding of the Schiehallion unit is that it is the physical spaces, which is 2A, 2B, 4B and 6A, and so I utilised the spreadsheet of infections which was provided by NHSGGC, and I should stress that that spreadsheet had 215,000 rows.

Q So you had to de-duplicate and find the locations?

A Yes, for the period 2015 to December of 2022.

Q But within that, you found 187 rows that met your requirement?

A Yes, absolutely.

Q Now, before we move on to where these were, I want just to deal with an issue that a couple of core participants have raised, but I think I'll put it in a sort of broad way. We've heard evidence that, for example, the yeasts can be commensal infections that come from the patient's own skin. We've heard evidence that some of the microorganisms – and I'm not going to go into the detail – are often gut-translocated infections. So we've heard all that evidence of possibility.

How does the methodology we're now discussing attempt to take account

of, deal with, neutralise, whatever the right word is, the risk that there might be an alternative causal connection between the infection and the bacteria, it might come from the patient themselves as opposed to from the water or the environment? How do you deal with it in your methodology?

A Well, by asking the question that is there another plausible explanation, and is-- and, to my knowledge, no other explanation has been provided. So you have to go with what you have in front of you, and the expertise and the knowledge that these bacteria and these yeasts are predominantly those that are environmental based and that, in a significant number of cases or proportion of cases, in reality, the movement of these bacteria and these yeasts is from the environment to the patient.

Q To what extent is, if you found it-- and we'll discuss whether it's found, if you found an association, is that the answer to the problem, or am I making it too simple? If you find an association in the epidemiology and the data, is that your answer to the suggestion, well, maybe it's a gut translocation incident?

A So I think what you're trying to ask, and correct me if I'm wrong, is how do you-- what constitutes an association, but I'll go back a step. You are always asking, what is the source of an infection? We know that work had already been done in terms of those infections which were line associated. That hasn't accounted for these infections, i.e. we are still dealing with the reality that is that we've had these infections over the period of eight years.

So the question being asked – and, I mean, here is where the hypothesis is – is there's no other explanation and, therefore, you have to start somewhere, and the hypothesis is that 'somewhere.' Is you ask the question, without any other reason, I think that I will start with that the outcome variable here, which are the infections, are linked somehow or are associated to some degree to the exposure variable, which is water.

Q So, effectively, what you're doing, if I understand it correctly, is you are testing this hypothesis?

A Yes.

Q You're not testing any other hypotheses. If you've got a very strong association signal, that would be interesting and relevant to a discussion about which hypothesis is right, but it doesn't answer anything other than the hypothesis that you've been asked, which is, is there a link?

A Absolutely, because in testing of the-- by setting your hypothesis and the methodology and the outcome, what

you want to get to is a point where you say one of two things: that the outcomes that have come out of my analysis agree with the hypothesis or, in fact, they don't. So I could have come up with a outcome where the results of the analysis that I carried out said, in clear terms, that there is no association and, therefore, I would then have to reject the hypothesis.

Q Right. This is a possibly cruel question, but I'll try and set it up. We heard evidence from a completely different methodology from the case note review, and they reached a view, for better or worse, that around about 30 per cent of the cases that they looked at were more likely than not to have a link to the environment.

So let's imagine a scenario where some omnipotent agency tells us that, amongst your 187 infections here, 30 per cent are linked to the environment and 30 per cent are enteric gut translocation cases. If that was going on, what would the output from this exercise tell you? What would you see, compared with a scenario where 70 per cent were linked to the environment? How would the output look different?

A I mean, in basic terms, when you look at the time series of the water positivity and you look at the time series of the infections, they wouldn't match.

Q Because the enteric wouldn't be affected by the water positivity?

A Exactly, and I should say that one that one of Bradford Hill's rules-- the guidance would not be satisfied, which is that if there was a cause of the infection that was unrelated to the water, then when the water positivity dropped, the infection-- no, the infection would be unaffected.

Q Right. Okay. I want to move on to the question of time. So you've talked throughout your evidence and throughout your reports about whole years. You've asked yourself repeatedly questions, "What is the number of infections in a whole year? How many admissions in a whole year? What is the infection rate in a whole year?" Why not do this by months and get a more granular signal?

A I mean, the simple answer to that would be, and as you've seen from other graphs which have been presented, you know, over the course of the Inquiry, that what that would do is to provide the data in a manner which would be hard to comprehend, hard to make sense of.

Q So could we see an example in the HPS report, bundle 7, page 229?

A Yes.

Q So what is it about these two-- Well, let's look at the gram-negative one at the top of the screen, but what is it about this method of presentation that

you say is hard to comprehend?

A Well, in simple terms, it is too busy, and by that I mean that the human brain, and even a trained brain like mine, is unable to make sense of the undulations which makes up here the rate of infection per, you know-- because, so, month on month there is a lot of-- or you can see clearly that there is a lot of variability, and you would expect that. You would expect that the rate of infection will vary one month to the next, so what you're really trying to do in terms of the analysis is to adjust for the variability, is to adjust for the busyness.

Q Right.

A One of the ways in which you can do that is you can aggregate the monthly rate of infections into a yearly figure because that then allows you – both in terms of observation and in terms of the tools that you can apply to the data – to work out a trend.

Because, I mean, for me, I can't work out from this graph what the trend is doing. I can sort of see that from 2016 to late 2018, there is a upward trend, but that becomes a lot clearer if I take the monthly rates, all of these points of data, and I will aggregate them into a yearly figure because then you can very clearly sort of see what the rate of infection is doing over that period of time.

Q Right. One of the issues that's arisen is to do with your approach to deduplication and also dealing with the situation that might arise where a patient has an infection.

A Yes.

Q Then a few days after or within a couple of weeks, they might have another blood test with the same infection emerging, and how do you make sure you're not counting the infection twice? If we go to page 79 of bundle 21, volume one – this is in your second report – paragraph 2.31, you've sort of summarised your position here. What I want to ask you about is, you said in the middle of it:

> "In line with national reporting in England and Scotland, a unique infection episode is identified by a positive blood culture with a named organism (pathogen of interest – gram-negative and fungus), and where a repeat blood culture within 14 days of the initial culture is regarded as representing the same infection episode being suffered by the patient, and therefore excluded by the de-duplication process."

Now, if we were to go actually back to bundle 7 and we were to go to page 220, so this is the October 20-- Do you see that, in the middle of the page there, from the words "From this population":

> "A positive blood culture of a single organism that has not been previously isolated from the patient's blood within the same 14-day period (i.e. 14 days from date last positive sample obtained)."

Now, have you taken a different approach from HPS?

A No.

Q Well, they talk about 14 days from the last positive sample, and you take the words "14 days from the initial positive sample." I suppose I have to posit a scenario to you. Let's imagine that on day one, this patient gets an infection.

A Yes.

Q There's a positive bloodstream infection result. On day 12, they have another test result, and it's also positive. On day 18, they have a third one; it's also positive. If I understand what's being said on this page in bundle 7, page 220, you count 14 days on from the first one.

A Yes.

Q So the first one would count, the second one wouldn't and, from your understanding, the third one wouldn't either. Is that my right reading of what they're saying here? The third one wouldn't count either?

A No, and the reason for that is you go back to the understanding that what blood cultures are trying to do is they are trying to give you a cross-sectional report on whether the patient has an infection from a bug.

So if we take your example, the patient had a culture on day one, and so you know that on day one they have X organism. So in line with what we understand from-- is that that organism is then indicative of a infection that the patient is suffering from, and that the patient can suffer from that infection for a period of 14 days. Because what is being done within that period is that the clinicians are treating that patient for that infection.

At or after day 14, if you continue to get a positive from that patient for the same organism, that is then, both by the definitions put forth by UK HSA in England and by ARHAI in Scotland-- is regarded as a new episode of infection.

Q So you don't think there's a distinction between your approach and their approach?

A No, absolutely not. I think the distinction is in semantics. I have used the word "initial," and here on page 6 they use the word "last positive."

Q There's not a risk that you will have effectively counted more infections because of your approach?

A No, absolutely not, because the definitions in the way that I read it and the definition that I've used are definitions

which have been used by the UK and in Europe for now, I think, since 2008.

Q But in any event, you're using the same definition in the calculator of the numerator within the Schiehallion unit as you use in the calculator, the numerator, the comparator unit.

A Absolutely, so you're comparing apples to apples.

Q Okay. What I want to do is, having dealt with, from my point of view, how you calculate a Schiehallion activity data set, I want to look at it, which is in bundle 21, volume 1, and we find it on that page-- I think it's 24. Now, this table, I'm going ask you what it explains in the moment, but I want to just be clear: is this the only calculation you have done of the number of infections in these wards?

A Yes.

Q You've not revisited this at any point?

A No.

Q No? Right. Can you explain to us what this table tells us?

A This table gives you the number of unique infection episodes where the infection was linked to 2A, 2B, 4B, 6A for the year and every year from 2015 to 2020.

Q And 2015 is a half year.

A And 2015 is a half year. Oh, actually, it goes down to the second page----

Q It goes over the page, unhelpfully.

A Yes, yes, so it goes, yes, for the eight-year period from 2015 to 2022.

Q Okay, and so if we go back to page 24, we can see that, for example, in the first full year in Ward 2A, there were 18 of your qualifying infections.

A Yes.

Q There were 46 in '17 and 29 in '18, which is also a partial year because decant happened in September.

A Yes.

Q Right, and we can see that in the day case unit in 2B in '16, there were nine; there were 20 in '17; and there are nine in '18, which is also a partial year.

A Yes.

Q Then in 6A, which is both day and overnight patients, we have six in the last three months of 2018, 17 in '19; eight in 2020. Then over the page, we have two, eight and two. If we just go back, do we also see possibly some data errors here? I mean, we know that in 2020 Ward 2B was closed, so there is a case being flagged in 2020 in Ward 2B. We don't know how that got there, but you just have to trust the numbers?

A Absolutely. I mean, I was provided this information from NHSGGC in terms of the spreadsheet, and what was on that spreadsheet were infections, so bloodstream results, and the only thing

I had in terms of being able to link those results to the Schiehallion cohort was where the results were taken. So they had a specific-- they had what you call the location ward, which is the ward where the sample was taken.

Q According to the data set?

A Yes, according to the data set, so----

Q So you didn't have the information that Dr Kennedy described having of consultant name, access to the medical records, awareness of what tests were done?

A No.

Q No. Any particular reason why you didn't ask for consultant name, rather than doing it by ward location?

A Well, I think the-- Because, in my experience, the ward location where the sample has been taken is the version of the truth that can be most-- that is most helpful and trustworthy.

Q Might there also be a factor that if you're looking, in terms of your denominator, for admissions to only 2A, for example, and you take the consultant name, you will pick up patients for those consultants who happen to be in intensive care or Ward 1A?

A Absolutely, yes, exactly, so the task at hand was to work out the infections and the activity for the Schiehallion cohort. So what I did was take the infections which were tagged to these four wards, and I then took the admissions, which were provided by NHSGGC, for these four wards and for these four wards only.

Q Right. What I want to do is look at the comparator infection data, so if we can go to page 29 of the same bundle, so you have a big table here that goes over the page, and I want to understand what's going on in the various columns. So obviously we have "Years" down the left-hand side. We have "Organisations" down the right-hand side. I'm assuming "Admissions" is the data they gave each unit gauges?

A Yes.

Q What is "Positives"?

A So "Positives" is a number-- Say we look at the first line there for GOSH, Great Ormond Street, it is made up of any culture which has come back positive for that year, so GOSH in 2015 had 182 positives.

Q So if we go back to page 21, is that the penultimate bullet point in 7.2.4?

A Absolutely, yes. We asked for a number of all organisms.

Q So that's a raw number they've given you? They've given you that number? Okay.

A Yeah, absolutely.

Q If we go back to page 29, the gram-negative and fungal positives

column.

A Yes.

Q Who worked out that number?

A So, I did.

Q Is that taken from the spreadsheet they gave you?

A Yes, exactly. So my requirement was that I should be able to verbatim apply the methodology that I applied to the dataset that was provided by NHSGGC.

Q So the same system?

A And I verbatim apply that to the comparator organisations. So, I needed from them exactly what you said, which is a line which allows me to split the organisms that we considered for NHSGGC, and you can see, for example, that for GOSH, that number was 62. So we excluded the others for that year.

Q So that GOSH number, and, indeed, all its colleagues down that column, is the number of individual infections de-duplicated in the same way, during the year for the micro-organisms on the list that appears five pages before this in the report?

A Absolutely, but just to say one thing, that it is-- that it would have included, as I did for the data from NHSGGC, all the environmental organisms with those few exceptions.

Q The ones we excluded?

A So, for example, E. coli.

Q Yes.

A Because the table that I put into my first report in terms of the organism names and then a number against it----

Q That's page 25.

A Yes, is what I ended up with. So that is not to say, in answer to your earlier question, that, for example, a bug that we know is an environmental pathogen and should have been in here was excluded. It was because that organism was not linked to 2A, 2B, 4B or 6A.

Q There might be organisms that are gram-negative environmental bugs----

A Yes.

Q -- that you could have included in your list, but they aren't included in either Schiehallion or the comparators, because they didn't happen in Schiehallion.

A Yes.

Q Right, and then you create something called the "rate of BSI per 1,000 admissions." What's the formula for that? What two numbers are you interacting to get to 11.39?

A Sure. You are using in the numerator-- you are-- So if we go with the first line and you have it replicated for all other lines, 11.39 is calculated by dividing 62 by the number of admissions for that year, which is 5443, and then you

multiply it by 1,000 so that you get a rate of bloodstream infection per 1,000 admissions.

Q Now, a cursory look at this column will see that there's a relatively large disparity, difference between the rate of BSI infections between, say, Great Ormond Street and, just to pick an example, Cardiff and the Vale.

A Sure.

Q If we go over the page, we see sort of a middle position for Leeds and perhaps a low-end position for Oxford. Do you have any understanding of why that might be, and does it matter?

A Well, I think one of the reasons why that might be is because the number of admissions per year is a measure of your activity. And as we have heard from Professor Stevens, two of these units were larger than paediatric haematology units and two were smaller.

Q What might you draw from that conclusion about their nature of their work?

A That the two larger units were seeing more admissions on a year-to-year basis as compared to the two smaller units.

Q But that's being accounted for by dividing by the number of admissions, so why would the numbers be different?

A Exactly, so the-- so what matters here is – and what you are trying

to do in terms of why do we calculate a rate of infection per 1,000 admissions – is so that you can compare smaller units to big units. It's so regardless of how many admissions you have in a year, that if I am at Oxford, say, in 2015, that I can take my-- that you can take your number of infections, that is 25, and I can get a rate of 9.09, which is a rate per 1,000 admissions, and you can compare it to comparator units for that year.

Q So you might, if we go back to the previous page, take that 9.01 from Oxford and look it and compare it to the 11.39 in Great Ormond Street and feel mildly pleased with yourself, to some degree?

A Absolutely. Yes. Absolutely, because, I mean, and I should say that that is one of the fundamental ways in epidemiology and in healthcare that you contextualise your rate of infection, because otherwise you're just comparing yourself to yourself.

Q But just to take an extreme example from this and try and understand what it might mean, if you look at the 2019 rate for Great Ormond Street, it's 16.01. You look at the 2019 rate for Cardiff and the Vale, it's 5.

A Yes.

Q Is there a risk that what we have here is a basket of different sorts of apples, in the sense that this is not a

homogeneous-- an aggregate sample of comparators? If that is the case, how do you deal with that?

A So I think, in answer to your first question, yes. I mean, we understand that there are differences within these organisations, that the number of admissions is a proxy marker for the differences that we know to exist, but what is important here is that we have sufficient-- (1) that we have a spread. We have a spread in terms of the number of institutions for which we have data. We have a spread in terms of the amount of time over which we have the data. Here, we have it for eight years for most of these organisations.

And so what that allows you to do is to take solace that, yes, that we are conscious of the fact that these institutions are different, but, in selecting at random – because we sent the FOI to about----

Q Twenty-four.

A -- 15 institutions and we got good data from four – that the spread in terms of the admissions that we are dealing with, the spread in terms of the years over which we have asked for that data, that that adjusts for the bias and that then provides us with an acceptable and rigorous rate of BSI per 1,000 admissions.

Q As a comparator?

A To compare to.

Q Right. Now, obviously, in the last few minutes, we have gone through a half hour. We've worked out with you what the infection rate in the Schiehallion unit's wards are, what the infection rate in the comparative hospital's wards is, what their denominator is and what-- well, the number of-- sorry, the number of infections in the Schiehallion unit, number of infections in the comparators, their denominator and their infection rate. We haven't, of course, discussed the infection rate in the Schiehallion unit. What I want to do is move on to that now----

A Sure.

Q -- with a conscious awareness that, for a reason that we'll discuss, that number came out a bit strange and needed to be recalculated with new data.

A Sure.

Q Staying with your first report, if we go on to page 35, you calculated a bloodstream infection rate for 1,000 admissions for each of the four wards by taking the number of infections and dividing it by the admission data you had been given.

A Yes.

Q But this admission data turned out to be overnight cases only.

A Yes.

Q Now, just for an example so we can follow the mathematics, but I

imagine you're not relying on this-- these answers. You're not relying on the work at this stage to be accurate.

A Sure.

Q Let's look at 2015-- sorry, back to 2016. We have a rate, according to this calculation, of 37.6 infections per 1,000 overnight admissions.

A Yes.

Q Right, and then you compared it with the comparator units in the next table down. Sorry, I missed a stage out. You then created an aggregate rate for 2016 by aggregating 37.6 in the Schiehallion unit 2A with 15.4 in 2B. But, of course, that was with overnight admissions in a day unit. There hangs the problem. Have I got that roughly right?

A Yes.

Q Yes, and so that number of 25.38 provides the second row of the next table at 9.2 for 2016, which you compare with the overall comparator rate of 6.6.

A Yes.

Q And you would use something called an incidence rate ratio?

A Yes.

Q Now, what's the incidence rate ratio? Because we'll come back to this when we use the right data.

A Sure, so what the incidence rate ratio is able to provide is a statistic of the difference in magnitude between two rates, and it is essentially what that says on the tin, is here. If you were taken to example of 2016, you have the rate of the Schiehallion that we understand to have been, you know, 25.38. We have the overall comparator rate of 6.66 and the incidence rate ratio is a division of 25.38 by 6.66. And what that gives you is 3.81, and how you read that is that there is approximately a four times larger rate at the Schiehallion----

Q In this calculation? Is that rounding up and rounding down? So a number of-- if you see a few rows down, there's a 6.12, that rounds down to 6?

A Yes, exactly.

Q Right, so----

A So anything above a .5, as per mathematical rules, would be rounded up to the next whole number and anything that is at a .4 or below would be rounded up to the last whole number.

Q Okay. Now, nervously, because obviously, you end up recalculating. Let's go to page 38. So this was produced in your first report.

A Yes.

Q That blue line is the then calculated Schiehallion rate per 1,000 overnight admissions?

A Yes.

Q And the dotted green line is the comparator rate? Sorry, the straight

green line is the comparator rate per 1,000 admissions in total. So, effectively, you've compared pears with nectarines. That's not quite the right comparison in this report.

A Yes, exactly. I mean, the-- so, at this point when the report was produced, I had the data that was provided by NHSGGC in terms of the admissions, which were then later on-- But at this point what we have done with the information that we were provided was that the blue line it gives you, the BSI rate per 1,000 admissions for the Schiehallion unit as a whole----

Q Yes.

A -- and the green line, which undulates a bit. So it's a whole line. It gives you the aggregated rate for the comparator. So it would-- So, for example, for 2016, would be an aggregated value for Oxford, Leeds, for GOSH and Cardiff and Vale, and what the dotted blue line and the dotted green line then give you is what you call "the line of best fit."

Q Which is something like a trend.

A Yes, exactly, so it gives you-- It takes into account all of those points of data from 2015 to 2022 and it lets you know the direction of travel, in this case, of the rates of infection.

Q Okay. Before we go to your attempts to recalculate what is the blue line on this chart – the Schiehallion infection rate per 1,000 admissions, including day cases – I want to look at the comparators because you were challenged by NHS Greater Glasgow about the aggregation of the comparators. If we can go to page 86.

So what have you done here in this version of the same figure? Again, I perhaps invite you to ignore the top purple line of the Schiehallion rate because it hasn't been recalculated, but look at the bottom. What is going on the bottom of this graph?

A So what is going on here is that I have responded to the note that-- or the question that, "What is the level of variability within the comparator units?" So how different is the rate for GOSH as compared to Leeds as compared to Cardiff and Vale as compared to Oxford for each of those years?

And so what I've done here is I have drawn up the rate for each of those units. So you see the individual rate for GOSH in dark green, which starts at 12.39-ish and it goes up to about-- Yes----

Q If you want the numbers, we can go back to----

A Yes, you can go back to the numbers. But, I mean, the point is that the purple line, it does exactly the same thing for Leeds----

Q Because there wasn't data from 2015 for Leeds?

A Absolutely, yes. So the set of data for Leeds started in 2016, same thing for Cardiff and Vale in blue and the exact same thing for Oxford. And the last thing I have done is I have kept the aggregated rate, and what the aggregated rate, in the dotted red, gives you is the mean value.

And what that says, in layman's terms, is you can observe it-- is that all the rates, regardless of which institution they are from, seem-- they are close by to each other for each of the years, so there is not much variability.

Q In fact, if we go back to the numbers, which is in the earlier report on page 29, we see that the maximum numbers that are ever reached are 16.01 in 2019 for Great Ormond Street and, over the page, that remains the maximum number.

A Yes.

Q Right. If we go back to page 86, please. Now, what we want to do is think about how you recalculated the exercise, and I get the impression from your report and-- that there were challenges in doing this. I want to see the different approaches you took. So we looked, at the very beginning of your evidence, at the return that Greater Glasgow gave of a single document that

was provided to CPs last Friday. If we have that on the screen, please, that would be really helpful.

Now, you had told us two things about this data when we talked about it before. One is you made an observation halfway down the left-hand side, the Yorkhill Schiehallion daycare unit row that ends in the total of 52, you hadn't considered that because----

A No.

Q -- you weren't looking at Yorkhill, and you also-- we'd observed that the RHC, row 3, area 1B day surgery entry, you'd ignored that because it wasn't 2A, 2B, 4B, 6A?

A Absolutely, yes. Mm-hmm.

Q Right. What did you do with the sort of, I suppose one could describe it as the smaller numbers in the bottom half of the table, which are all, of course, individual patients who have infections and have their own particular story, but they are, relative to the scale of the number of infections-- sorry, admissions, they're quite a small number of admissions? They are entries for around Ward 2C, Ward 3B, 3C, 3A, and you see them there. What did you do with the bottom half of this table?

A So I had to exclude anything that did not identify the ward as 2A, 2B, 4B or 6A.

Q If we go back to bundle 21, do

we end up, on page 88, with the numbers you extracted from that table?

A Absolutely, and----

Q I want to just make the connection because I think it's-- the other table's messy and I want people to be clear what you've done. So let's look at a row and find its friends, as it were. So row 2016, that cumulative total of 2,066 admissions, including day cases, I'm assuming, is made up of adding 1,772 for 2B to 494?

A Yes.

Q Right, let's go back to the previous table and find those two numbers. So, 2016, we see, "RHC Ward 2B, total 1,772," "RHC Ward 2A, total 494." So you've not taken account of any of the other numbers in that column?

A No, I haven't. The other thing to say here is that, even though we stuck to 2A, 2B, 4B and 6A, that there are multiple-- that the ward name 2B occurs under a few different names. I think I might use the example of 2B. So, on the first line----

Q So this is row 4 you've spotted here?

A Yes, exactly. So 2B is also-- You have admissions under "RHC Schiehallion Day Unit 2B." So, for example, if you take into account the admissions, I would count everything in that row----

Q That, of course, only appears in 2022.

A Yes, absolutely, and I would add it to the numbers under line 1, which is under "RHC Ward 2B."

Q Yes.

A And I would then have to meticulously make sure that 2B does not occur anywhere else in the spreadsheet because I was well aware that the spreadsheets being given to me had some quality issues in terms----

Q This is around the infection spreadsheets?

A Yes, exactly. That there were multiple names under which Ward 2B was known. (Knocks over glass of water) Oops. The hand movements were, like-- (Handed paper towels) Ah, cheers. Thank you very much. So there were multiple names, so Ward 2B had, if I remember right, three or four names under which Ward 2B could occur. Similarly with Ward 2A. Similarly with 4B, and the same with 6A.

So it was a difficult task, first of all, to make sure that each and every time, so, for example, 2A was mentioned, that I include it, but it was made even more difficult because everything that I had to exclude also had four different names assigned to it.

Q Because one thing that occurs to me is, if we look at each year, the third

row appears as a repeated theme, and you've not taken account of that. That's RHC 1B day surgery.

A Mm-hmm.

Q "Clinical Decision Unit" appears, and is actually quite a lot of entries after 2018-- after 2017, and you've not taken account of it either.

A No, I haven't.

Q And that's because----?

A And that's because it doesn't contain the wording "2A," "2B," "4B" or "6A."

Q Now, we've heard evidence that the Clinical Decision Unit is a ward-like space within the children's hospital.

A Yes.

Q But the water testing results – that you eventually will talk about after lunch – you did a comparison with, and the bloodstream infection results, you've not looked at either of those that are tagged "clinical decision units"?

A No, I have not.

Q Right. So, therefore, you haven't included them in the admissions number?

A Yes. No, I haven't.

Q The same would apply, for example, for, about-- just above the Yorkhill Schiehallion row, there's an "RHC Paediatric Haemato-oncology" row, which only appears in 2019. You've not taken account of that either?

A No.

Q Because, I mean, I might, having been involved in the Inquiry for some time, suspect that's an attempt by somebody to record data at a point around the decant when there was lots going on.

A Sure.

Q But you haven't reacted in that way.

A No, because, I think, I wanted to take an objective look at this and to remove any sort of interpretation or subjectivity or bias out of it because I would not have known, and I do not know now, whether the "RHS Paediatric Haematology-Oncology," are these Schiehallion patients?

Q And are they in 6A? You don't know?

A No, I don't know.

Q Right, so let's go back to bundle 21, volume 1, page 88. Now that we've connected the table to the maths, what is effectively being described in here? If I wanted you to point to me all the wards that only contain overnight patients, what would you tell me?

A That would be difficult, but I could garner a guess, and your question was overnight?

Q Overnight.

A For inpatients?

Q So no day units, yes.

A So inpatients?

Q Inpatients, yes.

A I would hope that I would go for RHC-- Well, let's start from one side to the other. That, for example, QEUH, 6A, CH says the word "inpatients" in it.

Q Yes.

A So that's clear.

Q Okay.

A So I can include that.

Q And you know something about 2A.

A And I know something about 2A, so RHC Ward 2A, but you then have this issue where you have more than one name for RHC Ward 2A. So what I've done is, rather than go around in circles asking about, "What is the difference between 'RHC Ward 2A' and RHC Ward 2A Schiehallion' where there are only 130 patients in 2022?"

Now, I can guess that maybe the ward name just changed. So once they came back to 2A, that they decided to change the name of the ward as well and they added the word ‘Schiehallion’ at the end of it, but I would have-- I took an aggregate, so I added them up. So "RHC Ward 2A," I added that to "RHC Ward 2A Schiehallion" and I took into account "RHC Ward 2A Clinical Decisions Unit."

Q Because it had 2A in its name?

A Because it had 2A in it and it has 6. So I operated on the basis that I would be inclusive and include numbers, but as long as I can stand by why I did it.

Q Right. What I want to do before the lunch break is to go to the document that was handed out to CPs this morning, and I just want to discuss what the entries are, what the lines are, and then we'll discuss what they mean after the lunch break.

A Yes.

Q So let's find-- as it were, find a friend we've seen before. The dotted orange line, is that the same line that we saw back on page 86?

A So I might not see the same colour as you, so remind me. So the-- because you said the dotted orange line.

Q Where the orangey/ magenta-ry thing is.

A The one line?

Q The one that's generally at the bottom but not always.

A Oh, yes, okay. So, yes. Yes. So that is your overall comparator institution rate, which is the aggregated rate for each year for Oxford, Leeds, for Cardiff and Vale, and for GOSH.

Q And that's been the same all the way through your reports?

A Yes, absolutely.

Q Right, okay. The green line.

A Yes.

Q Now, it may be that we need to jump back to page 88 on-- So just

remembering, keeping that in mind, the green line, what's the numerator for the green line?

A The numerator for the green line will be infections in Ward 2A.

Q Right, and the denominator from the green line, where is that-- where are those numbers on this table?

A So the denominator for Ward 2A, I've actually aggregated into table 4, but it is a aggregation of the column in table 3 that that goes from top to bottom for RAC Ward 2A, and you can see 254 for 2015, 494 for 2016, 276 for 2017, 181 for 2018, and then----

Q So if we go back to the document that we were just-- went up this morning, that green line starts in 2015, rises and falls again.

A Yes, but to note that the green line is the rate of infection line.

Q Yes.

A Yes, absolutely.

Q It is the numerator divided by the denominator?

A Yes, absolutely.

Q Right. Again, let's look at the purple line, which you've called the, "Overall Schiehallion rate per 1,000 admissions," which is presented graphically for the first time today.

A Yes.

Q That sits at the bottom of the chart----

A Yes.

Q -- and rises to a peak of 25.7 in 2017. Now, you've done the calculations below, but what I want to is to go back to page 88 first and find its denominator. Where's its denominator on page 88 in table 3?

A So the denominator would be all admissions that were linked to 2A, 2B, 4B and 6A after the decant.

Q So that's the cumulative column on page 88, figure 3?

A Yes.

Q Let's go and find the numerator. Is the numerator on page 24 of volume----

A Yes. You have to go back a bit, yes.

Q Yes, and is it the cumulative in the right-hand side there?

A Absolutely, so you go from 7 to 9. I mean, sorry----

Q Over the page. We mustn't forget the page.

A Yes, exactly. From 7 to 7, and in terms of the----

Q If we go back to the chart produced this morning.

A The admissions go from 1,303 in 2015 to 1,950 in 2022.

Q So that gives us the purple line on this chart?

A Yes.

Q The yellow line, which you

described as “Ward A infection rate,” where do we find its denominator? Would that be page 88?

A So Ward 6A, you mean?

Q 6A, yes.

A Yes, so we-- yes, we go back to page 88, and the numerator will be-- sorry, the admissions will be on page 88----

Q So the denominator, sorry?

A -- exactly, will be all admissions made to 6A, which I have aggregated in table 4. So----

Q That's on the next page.

A -- it starts with the number 72 in 2018 after the decant. It goes up to 301, 130, 115 and then you have 27 admissions for 2022.

Q Yes, and then the numerator for that orange line, is that what we find back on page 24?

A Yes, exactly. So you have-- the numerator will be 6 for 2018, 17 for 2019, 8 for 2020----

Q Over the page.

A -- 8 for 2021 and 2 for 2022.

Q So if we go back to the chart produced this morning, what is the dotted purple line?

A Yes, so that the dotted purple or pink line, from my lens, is the line that follows the rate of infection from 2A and continues to 6A. So it essentially follows and is the rate of infection for patients who were inpatients on 2A who then, after the decant, became inpatients on 6A.

Q So the dotted purple line is the infection rate across these two wards for inpatients?

A Yes.

Q And the solid purple line is the infection rate for all patients?

A Yes.

Q Right. Now, the final thing I want to do before the lunch break is just to ask you to explain what the blue bars are. We'll do the whole bit about what it means and the methodology, but in simple terms, what are the blue bars?

A The blue bars are the rate of water-- are the rate with which the water was positive, so the water positivity rate for each of the years from 2015 to 2020.

Q Now, just to be clear, on this chart, which line is not in your addendum report on its final page?

A Say that again, please.

Q One of these lines is not on the final page of your addendum report, and I want you to just be clear which one it is, because you calculated it last night.

A Yes.

Q Which one's that?

A So, is-- so we-- the one that we have calculated last night was the overall Schiehallion rate per 1,000 admissions.

Q Right. Before we break, just a question about comparison. I'll ask you more questions about this after lunch, but have I got this right, that there is a comparison you can make between the purple line of the overall Schiehallion rate and the dotted magenta line overall comparator rate because it's the same denominator in both cases, total admissions?

A Yes.

Q Yes.

A Absolutely, yes.

Q You can't draw a direct comparison between the other infection rate lines because they're only for inpatients?

A Yes.

Q Or is there anything you can draw from that?

A So the dotted pink line gives you the aggregated rate of infection in Wards 2A and 6A, and it takes into account the admissions only for 2A and then for 6A. So I would still say that, yes, there are some caveats to it, but in our initial attempt using the admissions-- using the second set of corrected admissions from NHSGGC, what we calculated here was the rate of infection for the two inpatient units, where there-- where we could be firm that only inpatients were there, in 2A and then 6A.

Q Well, we can't be firm for 6A because it has an outpatient unit.

A Yes, absolutely. But we can say, and we can see from here, that there is a magnitude of difference which is substantial when comparing the Ward 2A/6A aggregated rate of infection to the comparator rate for each of those years.

Q I think what we need to do is explore that more after lunch.

A Sure.

Q So, my Lord, if that's-- That's an appropriate time to probably break. A bit late, I apologise.

THE CHAIR: Well, we'll take our lunch break and if we can be back for five past two, Mr Mookerjee?

A Sure.

(<u>Adjourned for a short time</u>)

THE CHAIR: Good afternoon, Mr Mookerjee.

A Afternoon.

THE CHAIR: Now, Mr Mackintosh.

MR MACKINTOSH: Yes. Thank you, my Lord. Mr Mookerjee, I've had a few questions from colleagues, which I think is probably a good time to ask them now, so if we could put the new document back on the screen that came up this morning, just something to refer to. Now, the new line on that table, which is the purple line you've called

"Overall Schiehallion rate per 1,000 admissions"----

A Yes.

Q Obviously, the numerator of that comes from your table on page 24 of bundle 21, volume 6.

A Yes.

Q Previous page, please. Now, can we just check, as far as a yes/no question, do these numbers of infections include infections that were found in day case-only patients?

A No.

Q No?

A They include all infections.

Q All infections. No, but what I mean is, within there, will you find the day case-only infections and the overnight cases?

A Yes.

Q Yes, both types?

A Yes, both types.

Q So just to use some examples for clarity, if a patient is visiting the hospital two or three times a week for a number of weeks, or as a day case, and they have a bloodstream infection of one of those organisms, they're in those numbers?

A Yes.

Q If a patient is in the hospital for six weeks as an inpatient and they have a bloodstream infection, it will be in the numbers?

A Yes.

Q Right. If we go back to the documents from this morning, would you agree with the idea that in order to rely on the new overall Schiehallion rate calculation, one would have to be sure that the comparator institutions were supplying admission numbers that included day cases?

A (After a pause) Well, I guess the presumption is that the understanding of the word "admissions" is the same and that the word "admissions" has been understood in the same way and has been responded to in the same manner.

Q Because I suppose we can do a check. If we look at the bottom of this table first, we see cumulative admission numbers provided by Greater Glasgow, which range, in complete years, from the high teens-- to 1,900 up to 2,500, if we treat the pandemic here as an outlier.

A Yes.

Q If we go to page 29 of bundle 21, volume 1, we see that, putting aside Great Ormond Street for a moment, the numbers are less than Cardiff and Vale, less than Leeds, and a little bit less than Oxford, and so whatever they're doing, they're providing more admissions than Greater Glasgow are providing.

A Yes, I think the basis on which the numbers are accepted is that the patient had an admission date assigned

on the electronic system.

Q So that would include day cases?

A Yes.

Q Right. The next question, if we go back to-- We'll stay in this bundle and we go to page 88. You make an observation in paragraph 2.62 that:

> "On comparing the first and second admission data set for NHSGGC, I noted that admissions to Ward 2A and 4B have remained fairly constant, apart from 2018 … but not so for 2B and 6A, where admission figures have doubled, tripled, [or] in some cases, increased 11 times from the figure provided for NHSGGC for [the previous] year."

A Yes.

Q Now, I recollect you discussing that when we had a consultation. That's when you put this in. What concerns do you have about this change in the numbers, and what did you do about it?

A Well, I'll answer the second part first because it's a simple answer of there's nothing much that I could do, in the sense that I took at face value the admissions which were presented to me, you know, in terms of the first spreadsheet, and I took at face value the admissions spreadsheet where these numbers changed. Now, the reason why I noted that is because I could have accounted for in my thinking for a slight increase in the admission numbers, but it is----

Q Over time?

A Yes, over time, but it is interesting that-- And here, of course, I'm comparing the second to the first admissions set-- that I was surprised at how different those aggregated figures for admissions were for 2B and 6A, and as I've noted-- So I convince myself of things having doubled when you account for, you know, more than just the overnight-- the admissions, but it increased by quite a bit----

Q I just wondered if you compared this-- So if we just look for a moment at the third column on table 3 on page 88, "RHC Ward 2B," which, for whole years, has numbers 1,700, 2,200, 1,700. Then if we go back to page 28, the previous data set, which we're told only included overnight patients, was in the high hundreds.

A Yes.

Q Could that not simply be explained by the fact that the normal patient in 2B is not an overnight patient and, therefore, these hundreds of patients recorded here on page 28, the ones who are admitted, are being admitted-- I don't know whether electively

or as a surprise, but they're out of the ordinary for the general population of the ward?

A Yes, and that is the understanding with which I continued, which is that I am surprised at the extent to which admissions to these wards were down to day cases and to outpatient stays where you had the admission date there. But yes, my final thoughts on that were similar to what you said, which is that I will have to accept that the change in numbers is accounted for by the fact that a large proportion of those patients are day cases and that they make up the large proportion of the admissions.

Q Right, and if we go back to the document produced this morning, is that anxiety that you had, described in the paragraph we've just looked at, part of the reason why you calculated the 2A and 6A infection rates, the green and the orange/yellow lines on this figure?

A Absolutely, because what I wanted to do, in layman's terms, is to cut the data in a lot of ways and to see whether the results I'm getting speak the same truth, or they have outcomes which are similar, in that I adjust for by doing these different analyses.

Here, I've done it specifically for infections that are in inpatients, and we know that 2A, 6A-- And I've looked at the trend, and I've compared the trend to-- For example, how would the trend look if I took into account infections from-- for all of Schiehallion? And what I'm trying to get from that is a feel for, are there inconsistencies within the data that are skewing the results?

Q Right.

A I don't see that, in the sense that, largely, the ratios are changing, but what is remaining the same is the fact that we started with a low figure in 2015, and then it then goes higher. So, essentially, what it's saying to me is that the data is representing what we know was happening at hospital level, no matter the way in which you cut it.

If you look at 2A, 6A, if you look at the entire Schiehallion unit, you take the old admissions, you take the new admissions, whatever you do and however you cut it, the general-- the trend and the takeaway messaging remains similar, which is that you see this increase in the rate of infection at the Schiehallion and then a gradual decrease, so generally.

Q So why did you not calculate what is now the purple line, the overall Schiehallion rate, in your supplementary report?

A Because-- and we go back to what we discussed in the morning, which is I'm taking into account infections for four physical spaces, and I should be

taking into account the admissions for those four physical spaces and those four physical spaces only. So I did that in the supplementary report with the new admission data.

If I may say here that I've gone above and beyond that. I've sort of given myself some leeway, going, "How does the trend look like?" If I put my head onto one side and I go just, you know, "So, wait for a second, Sid. Let's just take the infections for those four units, but take into account all the admissions," in response to the criticism that the comparator units are doing the same.

Q What do you derive from that re this new exercise that you've done with the purple line?

A That the proportions have changed, but the takeaway message from the trend remains similar, in that there is an escalation in terms of the rate of infection with, then, a drop-off. The changes, of course, are the magnitude of that escalation----

Q Yes.

A -- and the period of time over which that escalation is sustained and, essentially, in layman's terms, how steep is the slope afterwards?

Q It's a smaller peak over a shorter period of time.

A Yes.

Q How relevant is it that when we went back and looked at the four separate comparator units, we noted that the, as it were, peak year in Great Ormond Street of 2019 was a rate of infections of 16.01 per 1,000 emissions? Although that's not the same year as we see the peak for the Schiehallion rate, it's not that different from 25.7, and so to what extent do you consider this overall Schiehallion rate calculation to be significant?

A Well, there is a difference in those two proportions in that we were specific in our FOI and, in my understanding of what was received from the comparator units, that what we want here are infections linked to the paediatric haematology unit and we want admissions for that cohort of patients and for that cohort of patients only, and those FOI-- and those comparator units that could not do that said so.

Q Right.

A So we're comparing quite a specific proportion where the activity matches the infections exactly in terms of space.

Q Yes.

A And we're comparing it to a proportion which is the purple/pink line here, which is overall Schiehallion rate, where we've kept the infection-- where we have retained the infections. We've been very specific about the infections.

Q Yes.

A But we have inflated the activity to include the activity for the entire RHC.

Q No, we haven't.

A I mean, sorry, by that I mean the-- for all four units.

Q Is there anything that arises from the fact that, to go back to page 29 of the bundle – thank you – each of these rows connects infections in one year with admissions in that year? You seem to have said before this morning that the comparison is between the aggregate in the year----

A Yes.

Q -- not the aggregate-- not the-- an overall-- You haven't produced a single number. You produced a rate that varies each year.

A Yes, absolutely.

Q So what I'm just wanting to check is that, obviously, I don't think it would be surprising if some people, seeing your evidence, looked at – to go back to the document from this morning – the overall comparator rate per 1,000 admissions or the cumulative incident rate on the right-hand side and go, "Well, the difference is only 2 and a bit times, 3 times if you round it, and the differences between the four comparators is 1 or 2 times."

So is this higher section in 2017 and

2018, without doing the water positive stuff – we'll come to water positive stuff at the moment – is it sufficiently high enough compared to the comparators either collectively or together or separately to be significant?

A The answer is yes because, as I said, what has changed in calculating the overall Schiehallion rate is the magnitude of the difference at each of those years when comparing the overall Schiehallion rate to the comparator rate. What is essential here is to-- is not to compare the overall Schiehallion rate to each of the rates of the hospitals that we are comparing to one by one.

Q Why not?

A Because you're then comparing the overall Schiehallion rate to a proportion made up of smaller numbers. So what makes up the rate of infection from Leeds in terms of the numbers is not enough in terms of making a rigorous rate of infection to compare to.

Q So if the dominant----

A So the sample size is not big enough.

Q So if you've made the bigger sample to deal with your confounding factors, you're not allowed to go and pick, cherry pick?

A Yes, you----

Q You pick another fruit?

A Exactly. Yes, yes. You cannot-- and the reason you should not cherry pick is because-- remember what we are trying to do here is we're not trying to do a selective comparison. The whole point of this is that we're not trying to be selective in who we compare to because that would open us up to being able to compare what was happening at the Schiehallion to a rate of infection from a unit which was performing really badly and then we-- and then, of course, the Schiehallion rate would look really good.

The other way of doing it is that if you were comparing the Schiehallion rate to a unit which was doing really well in one year or two years, and the Schiehallion rate for that, for those rates, would look really bad.

Q So, for example, if you can go back to page 29, if you compare the Schiehallion rate to the 2022 rate for Cardiff and the Vale, it looks very bad.

A Yes.

Q But if you compare it to the 2019 rate for Great Ormond Street, it doesn't look too bad.

A Sure.

Q You're saying that's just the wrong approach to this?

A That's the wrong approach because let's-- because of the data that makes up that rate is-- you're sort of climbing up the iceberg here and you're--

you then want to compare your iceberg in its entirety to the peak of, you know, to the peak of the other iceberg.

You lose the confidence in what you are comparing to and so you-- what is essential is to let the numbers do the talking, and by that I mean, when you are comparing to something, that something needs to, in this case a rate of infection-- needs to be made up of sufficient numbers both in terms of infections and the admissions.

Q Thank you. What I want to do, I think, now is to look at what you did in your addendum report because your addendum report, which we find from page 767 of this bundle 21, volume 6, was produced in response to a suggestion by me that you should do some work around occupied bed days.

A Yes.

Q Now, what I want to do first is just to check with you from page 768 what information you ended up with from the comparator hospitals on occupied bed days. I think it's from paragraph 2.1, section 3. So what did you have from Great Ormond Street?

A Well, unfortunately, even they had noted that they were not able to provide exact numbers for bed days.

Q Right.

A And rather, even an institution like them, GOSH, could only provide a

percentage or a proportion figure. So, essentially, what they've done is they've done a rounding-up, going, "These are the number of admissions in terms of all our paediatric admissions, and we think 40-odd per cent for a given year were made up of admissions that were specific to the paediatric haematology-oncology."

Q So they're not actually counting them?

A They're not counting them.

Q Right.

A And it goes back to the point that I was trying to make about how difficult it is to get an accurate bed days figure and what it entails, but you have to do the legwork. There isn't, in my knowledge, and I could be-- I'm happy to be proven wrong on this. There are not many electronic patient record systems that can accurately and automatically, so without human interference, will give you the activity data for a specific cohort of patients.

Q Let's look at Cardiff and the Vale. So, effectively, their occupied bed days only went up to 14-year-olds.

A Yes, so they were able to. Well, perhaps because they're smaller, and so perhaps, somehow, they were able to get their bed days for the paediatric haematology-oncology, but one of the caveats was that the age range was not the same as the age range we used.

Q Right. Onto the next page, 769, Leeds couldn't do it.

A Leeds couldn't do it, and they said so.

Q And Oxford, what did they manage to do?

A So Oxford were able to send the data for bed days for paediatric haematology-oncology. The problem is – and we go back to this issue of comparing something big to something small in terms of the numbers – is it's not appropriate to take-- to do a comparison to one unit because you only have that unit to compare to and you-- and the biases then get exaggerated and they're not adjusted for in the same way if you had four units or five units or six units.

Q So you didn't do-- and you couldn't calculate, do you think, a comparator unit for Oxford?

A No, because all of my, you know-- all that I had learnt told me that you shouldn't be doing that.

Q Right.

A Yes.

Q However, you did calculate an infection rate for Ward 2A only using occupied bed days, and the results are on page 770, and what I wanted to ask you before we look at them is why did you do it for Ward 2A only?

A Because I wanted to be-- well,

I could be sure of only one thing, that Ward 2A was only made up of inpatients.

Q Unlike 6A?

A Unlike 6A or the others.

Q Right.

A And so the numerator-- going back to rule one, the numerator, then, in terms of the infections from 2A, would match the activity that I'm using, which is bed days.

Q For inpatients?

A For 2-- Yeah, for-- Which is a measure of inpatient risk, and it is important to say that, that what bed days does is it's a cumulative inpatient risk. You have to be in the hospital to accumulate that risk.

Q It's impossible, it's no use to work out the risk from-- for outpatients, but it's a useful way of working out the risk to inpatients?

A Yes, but you have to be sure then that the numerator is then made up of infections that are also linked to only inpatients.

Q Because you made the assumption that no outpatient would have their bloodstream infection test tagged "2A."

A That is the assumption.

Q I mean, we've not had any evidence to the contrary, but that's the assumption. Okay.

A That is the assumption.

Q So we've got this table here and so, effectively, you've only really been able to do the work for the four years before the decant. Of course, as we've already discussed, the first year is a half year and the second and-- 2015, and the final year, '18, is a two-third year before decant. So you report that, giving yourself rates of infection per 1,000 occupied bed days for inpatients, 1.75, 2.79, 6.26 and 6.86, and that then is presented graphically on the next page.

A Yes.

Q Now, firstly, does it matter, for the validity of the first and last columns, that they're only for part of a year?

A No, because we take that into account by only taking the infections for the same period.

Q Yes, because the numerator and denominator are both limited in time the same way.

A They're both-- Yes, they are both-- So, for example, for 2015, the rate of 1.75 was only based on the infections from June to December, and it will be the same for the bed days.

Q Okay, so if we go onto the next page, what I wanted to explore with you – I'm not sure I've asked you this before, even in a consultation, and therefore I hope it's a good question – is, if you look at these numbers here, particularly 2016, we have a rate per 1,000 occupied bed

days of 2.79.

A Yes.

Q Now, if we go back to the graph that was provided this morning, we have a rate, the green line, for 2A only, of a rate of 36.44 for admissions, and, if we go back to 2015 at 23.62 compared to 1.75 and, for '17, 166.67 compared to 6.26, and '18, 6.86. Now, I suspect you don't know the answer, but what sort of factors are driving the mathematical relationship between those four numbers and their equivalent four numbers of occupied bed date?

A So I think the blunt answer to that would be that it's the magnitude of the difference from the rate at 2015 to '16 and then from '16 to '17, and then from '17 to '18, and so, you know, you would have to-- you would have-- So, for example, if I'm looking at this, I would go, "Okay, so the rate for 2A, using the 1,000 admissions, was 23.62. It jumped to 36.44. How does that look like if I look at 2A's rate per 1,000, you know, using"----

Q Bed days.

A -- "our bed days figure."

Q That's on page 771 of the other bundle.

A It goes from 1.75 to 2.79, so that tells me that, regardless of the way that I've cut the data, that both analyses are saying the same thing, and what they're saying is the rate was 1.75, it then

increased to 2.79----

Q Can we go back to page 771 of bundle 21, please?

A Now, I'm not going to do the maths in my head because I'm good at using a spreadsheet but my mental math has suffered with age, but it's then gone from 2.79 and it has jumped quite a bit. Now, I was going to say it has more than doubled – well, slightly – from 2.79 to 6.26 in 2017, and then I would say it has remained fairly consistent, from 6.26 in 2017 to 6.86 in 2018.

And so what is that telling me? That the trend of 2A of-- so looking at the 2A rate of infection per 1,000 bed days seems to mimic the trend of two-way rate of infection per 1,000 admissions. By "mimic," I mean, essentially, if you follow my hand.

Q It rises----

A It rises.

Q -- slowly and then steeply.

A And then it's maintained. Because I think one of the things that everyone gets very excited about is peaks and troughs, but I think one of the-- what is very significant here, too, is the fact that you have a rate of infection of 6.26 per 1,000 admissions for bed days-- per 1,000 bed days and, in 2018, that rate has remained fairly consistent at 6.86 per 1,000 bed days. So even though one would say, "Okay, that rate

looks fairly similar"-- but that is a lot of kids having, you know-- that 6.26 is made up of a lot of infections.

Q This may not be the right way of approaching it, and I want you to slap me down firmly if this is the wrong way to approach this.

A Sure.

Q Is it possible, using either of these methodologies, to work out the percentage chance of a young person having a bloodstream infection by admission or days spent in the unit?

A Yes, absolutely.

Q Is that a valid thing to do before you do it?

A But that is exactly what that rate means. It means-- and you can do it per 1,000 admissions, you can do it per 1,000 bed days. It is easier to do it per 1,000 admissions, and I'll tell you why: because the human mind can make sense of the fact that, if you take into account 1,000 admissions, you can sort of go, "Okay, this is made up of 1,000 admissions over a set period of time."

What you get out of that is, say a child over that year had a set number of admissions to the unit and say-- for the case here, say, for example, they had-- for that year, they were admitted to the unit 1,000 times, that their chance of having an infection which was linked to an environmental bug was----

Q Shall we go back to the previous table?

A -- and now we have to go back to-- Yes.

Q Is it the purple line?

A Yes.

Q Would that mean that, conscious that this is a study produced from data that you've analysed with all the assumptions you've discussed, that, for admissions in total, there are 25.7? A child admitted 1,000 times will get 25 infections?

A Yes, so I mean, what it basically-- So the way to read that is, if you use another example, that, if you were crossing the road 1,000 times, you would get hit by a car 25.7 times. That's sort of the-- that is one way of looking at it.

Q Obviously, someone watching this might immediately think I should ask this question, which is, on the green line for 2A, how valid is it to say that, in 2017, a child admitted toward 2A was looking at, am I right in thinking, a 16 per cent chance of catching a bloodstream infection?

A Yes, because you take 166.67 of 1,000.

Q If we go back to page 771, conscious that occupied bed days is a harder thing to comprehend because each day is followed by the next day----

A Yes, and you're taking into account-- It's not as clear an activity marker as an admission.

Q I suppose it's a bit like that statistic that one used to read about of pilots in a war. They have to go and fly their plane 100 times and if it's a 1 per cent chance of being killed 100 times, it rapidly becomes a certainty they're not going complete the 100 missions.

A Yes.

Q So if you look at this table, is the number-- what is the number that draws out of the prospect percentage chance of a child occupying a bed in Ward 2A in 2017 of having a bloodstream infection-- catching a bloodstream infection that day? Or is that too precise a question to ask?

A That is too precise.

Q Is there a better way of phrasing it?

A The way to phrase it-- and, you know, there is not an equivalence to admissions where you can almost go, "Each time, I am exposed to the hospital, and if I count all of those exposures, what is my risk?"

Q Yes.

A Here, roughly – very roughly – you're sort of saying that, if a child spent 1,000 or the equivalent of 1,000 bed days, that their chance of infection would be 2.79. I am hesitant to sort of go down

that route because----

Q No, I appreciate that.

A -- I don't think that there is a-- that, unlike admissions, that the way in which-- or what bed days gives you is a cumulative risk of just staying in a bed and all the interventions which are, you know-- that you are accumulating.

Q Because I'm conscious that there may be somebody watching this who's thinking of this piece of mathematics.

A Sure.

Q That they can identify how long either an average patient or a particular patient spent as an inpatient in Ward 2A in, say, 2017. They have a number of days. They count them up. They multiply that number of days-- Well, they might do that, I suppose, but they factor it against 6.26 as the rate per 1,000. They come up with a rate for those 27 days, and that is a number. I'm not going to do the number now, but you can see how it might be done. Do you have any comment on the validity of that?

A I think the-- what I'll say is that that is one of the reasons why the communication of risk is a difficult matter and a confusing matter, and that there are ways in which to understand the world – in this case, the risk of infection – that allow you to segue from a rate to a risk easier as compared to when you start

looking at things like bed days.

What I will say, though, looking at figure 1, is I'm conscious that we haven't compared this and we haven't been able to compare it to comparators for reasons that the comparator institutions have been clear about. They've been unable to give us the bed days.

That if I was looking at that chart, and I'm looking at it now, what I understand from it is that the risk of infection, if you want to use that word, "risk," it increases from 1.75 in 2015 to 6.86 in 2018.

Both as a trained epidemiologist and as someone who might have a kid who is going into a hospital, and if that was presented to me-- and you can see a lot of these things on charts and-- that would concern me because it just stares to me that, okay, in 2015 the rate was 1.75. It increases, but okay, it might be within a ballpark figure in 2016, but what is happening in 2017 and 2018? Now, of course, the sure-fire way to understand how unusual the rate in 2017 and 2018 per 1,000 bed days is for 2A is to have been able to compare it to other units.

Q There is one comparison that you can make on the previous page, which is-- or can you? Sorry, page 70-- 770, that's it. In 2022, there are 4,299 occupied bed days in the new unit.

A Yes.

Q And there are no infections?

A There are no infections.

Q Yes. What I want to do is go back to the table that was produced this morning and, before we deal with water positivity, what do you think that the new line, the purple line, tells you about what is going on, from an epidemiological perspective?

A I mean, what stands out so bluntly is that something was happening in 2017 because that rate is an aberration as compared to the other rates on either side of that, both 2017 and 2018, but the eye is drawn to 2017. So-- and I have looked at these sorts of graphs for 14 years. That, to me, would say that something was happening there and I want to know why we had that peak.

And, I mean, the other thing that I would say is something was happening there, and it seems, to me, that something was corrected for or something happened or some changes were made, something happened better. But after that increase – let's call it the norm – in 2017 and 2018, the rates go back to 8.06, 5.87, 4.18.

Q Which are less than the comparator mean?

A Which are less than the comparator, so if this was completely new to me, my hunch would be that there's been some sort of quality improvement

program, that some-- I mean, if everything else has remained the same, that people have responded to that escalation and things have got back.

I mean, the thing I'll end with is-- and I always say this regardless of where I am, but just because a rate of 8.06 in 2019 looks less than a rate of 17.48 in 2018 and that looks less than the rate of 25.70 in 2017, does not mean that the rate of 8.06 in 2019 should be ignored because it is still a lot of infections in a very-- in a population of patients that are already----

Q I wonder if we can just ask one more question before we move on to water positivity. We've discussed what might be-- what inferences can be drawn about risk for the inpatients and what probably can't be drawn about risk, and what issues you have with those approaches.

I wonder if you look again at the new line, the purple line.-- If one is trying to test the hypothesis – which I recognise wasn't entirely your hypothesis, but it's a part of it – that having an inpatient stay gives rise to an increased rate of infection, how helpful is the purple line in working out the answer the question about inpatient risk? Does that contribute at all?

A Yes, because, I mean, if you-- you're-- with specific sort of-- With

specific reference to inpatient risk, I would go that I know 2A infections were inpatient infections. I looked at a rate of 2A infection rate per 1,000 admissions and I can see-- and I can see that the trend in infection rate increased from 2015 to 2017. I compare it to a broader rate of infection in the new purple line, and I see a similar escalation of risk, rate of infection, from 2015 to 2016 to 2017.

What that tells me is that we know that, in terms of the infections that we included, we included all infections. That, no matter how we cut it, we can say that there is a risk and there was a risk to the patient, whether you take a strict Ward 2A infection rate made up of infections only linked to patients who are inpatients or you take a broader cut of data.

Q Okay. What I want to do is to move on to the water sampling issue. Now, I'm conscious that you did this twice. The first time you looked at water sampling and the correlation between the water sampling and the infection rates, it was the original chart.

A Yes.

Q The ones that was-- when GGC produced the original data, which only include overnight cases.

A Yes.

Q Of course, the infections include day cases and so there would have been an increase, the infection rate

would have been artificially higher. You're nodding.

A Yes.

Q You then recalculated that once you'd produce the green and yellow lines on the chart that's on the screen at the moment.

A Yes.

Q We find that on page 92 of your-- of the bundle in your supplementary report. Before we go into what it says at this third bullet point on page 92, I wanted just to talk a little bit more about correlations because----

A Yes.

Q -- what does correlation have the potential to tell us about the correlation or association between, in this case, the water positivity and the infection rates in inpatient wards?

A What correlation is giving you is the degree of association or the closeness of the relationship between these two time series. The first-- First, the exposure time series, which is the water positivity, the blue bars, and in the foreground, the time series that is made up of the rate of infection. And what the correlation tool is able to do is, it's able to take the data points, which-- I should note that each of those points in data of which we have----

Q If we go back to the document from this morning.

A -- we have four infections, we have eight of them.

Q In which year?

A One for each year from 2015 to 2022.

Q Yes.

A And for water positivity, we have it for 2015, '16, '17, '18, '19 and '20. Now, each of those data points-- and I'll get to the caveat regarding why I didn't include 2020 in my correlation analysis. Each of those data points, my point is, is in itself an aggregation. In the case of water, those six data points are made up of 4,759 water samples.

Q Over the five/six years?

A Yes, and 500 of those 4,759 water samples which were positive. For infections, the eight points of data, 2015 to 2022 inclusive, is made up of 4,430 admissions, of which 100 and-- and 187 infections. So the point I'll make here is that there is a-- the tendency, and I will accept it, that, at the face of it, you would look at data points and go, "You have five data points. You have eight data points." They don't seem like enough----

Q To do a correlation?

A -- to do a correlation. You know, you can-- I wouldn't blame someone for asking the question, "Shouldn't I have 100 data points?"

Q Well, indeed, that was going to be my next question, so carry on.

A Sure, and what I should remind myself and others is each of those points is, in itself, an aggregated-- is the product of, in the case of infections, a lot of infections and a lot of admissions. And in the case of water, a lot of water samples for those years, and for most of those years a lot of water samples which were positive.

So it's an artefact of aggregating a lot of data into yearly points that lends one to believe that you are really just dealing with eight or five, but in fact what you're dealing with is, as I've said-- and what the correlation co-efficient is based on is it's looking at 500 water sample positives or 4,759 water samples. How does that over that period compare to 187 infections or 4,430 admissions? That's the numbers we are talking about here.

Q Right, so you reject the suggestion that because there are six years involved, it's just not possible to do a correlation analysis. However, you need to explain, I think, why you didn't look at 2021 and 2022. Why----

THE CHAIR: Sorry, I failed to hear that question, Mr Mackintosh.

MR MACKINTOSH: (To the witness) I think you need to explain why it is that you stop the water positivity result analysis at the end of 2020. You don't continue this analysis on into '21 and '22. Why is that?

A I will remind myself of this, but I think it would be useful for, as reminding myself, to, I think, go back to page 31 of my report, where I'm talking about section 8.4, QEUH and RHC water sampling data. In fact, so lucky for me, the point is the first point, which is 8.4.1 on page 30, which is that NHSGGC, by way of what I received, which was called the Dr Chaput spreadsheets----

Q Yes.

A -- there were 18 of those spreadsheets, 18, 1-8, "...detailing water sampling data for the period 2015 to January"----

Q So can we go to page 31 on the document, please? Sorry.

A -- "-- to January of 2021." Yes, the first point there. So that is all the data I had, and so what I could do was rather than include one month of 2021, which would not be sufficient as a figure for that year, I calculated the water positivity for each of the years 2015, '16, '17, '18, '19 and 2020, and I stopped there.

Q Because you've got a partial year in '21?

A Yes, exactly. I mean, for '21, I only had one month. I should further add that the task of putting together the water positivity data was in itself a job and a half, in that I-- and I note this in section 8-- is that I was dealing with 18

spreadsheets.

It was clear to me from the very beginning – and, of course, I knew – that this has been compiled by different stakeholders because the formats were different. The manner in which the data had been input was different. The rigour with which the data, in terms of what kind of water sampling had taken place, where it had taken place and what, in fact, were the results at the end of it were, for some years, to me, incomprehensible.

It got better for 2017, '18 and '19, but it was-- So, for example, I mean, one of the fundamental issues I had with this was the variable names at the top of the spreadsheet for each of the spreadsheets or for most of the spreadsheets, they were not matching.

Q So the names of the wards?

A The names of the words, the ways in which the testing results had been input, the manner in which or the language used to specify whether a water result was positive – what was it positive for? – the manner in which a water positive test was indicated. So sometimes you had the organism name and nothing more.

Sometimes, and a lot more often after, I think, 2017, you had the TVCs. A lot of the columns that I would have liked to have seen with information were blank, which meant that it wasn't immediately

accessible to me whether a water result was negative or positive.

Q Right, so you had all this problem of assembling----

A Yes, you had these huge issues with it.

Q But did you actually use the figures, such as they were, for 2015, '16, '17, '18, '19 and '20?

A No, I used them for 2015, '16, '17, '18 and '19----

Q Why not use '20?

A -- and I did not use the figure for 2020, and I did not use it for two reasons. One very significant reason is that there was a considerable decrease in the number of water samples which were sent to the lab in 2020, as compared to 2017, '18 and '19. There was a huge drop, and I think we can all figure out what that drop was. The drop----

Q A drop of about 20 per cent.

A Yes. One of the reasons is because we all know that we got hit by COVID and, in my head, I was wondering whether that played a role in terms of being able-- for the contractors or whoever do the water sampling because you have to physically be able to collect the water sample. Did they have any issues with gaining access to the ward areas during the height of COVID?

Q I appreciate that, but I just wondered if you could explain, if that's an

approach that you think is appropriate for 2020, surely one should've ignored the figures for 2016? Because there's effectively no testing at all in 2016, or very little, so whatever's going on there, there's a reason. We've heard some evidence of what it might be. It's not COVID, but it's nothing to do with-- It's complicated, so if you're going to ignore 2020, why did you not ignore '16?

A Yes, I agree, and I'll tell you why. So let's go back to the first point. So in 2020, the world changed, in the sense that the context within which I am accepting that water sampling was taking place in 2015, '16, '17, '18 and '19, in terms of how a NHS trust can operate, is different to the world that we saw ourselves in in 2020. So the 2020 set is from a context within a hospital that is now operating within a very different set of rules and contexts to the previous years, if you see my point.

Q I see.

A Because the pandemic had some fundamental ways in which to change the context, and so I draw a line between, you know, the pandemic period and the pre-pandemic period because I cannot-- or I need to be conscious of the fact that the pandemic period may have introduced a factor such as access to areas, which was not the case for any of the previous years, if you see what I mean.

Q Yes. Okay, so you didn't do include '20, but you did include '16.

A Yes, and '15.

Q And '15.

A But in full recognition of the fact that water sampling in 2015 and '16 were at levels for far less than what they came to be in 2017, '18 and '19.

Q Does that not undermine the benefit of the correlation? Because you told us at the beginning of your evidence that there are, what, 4,000 positive samples over the whole period, and there are tens of positive samples in those two years. Does that not run the risk that that end of the correlation calculation is somehow undermined by lack of sufficient data points?

A So I think you have to go with what has been presented to you, and you have to do the best with what is provided. There are things that I can adjust for, which is evidence that the context within which water sampling can be taken has changed because of the pandemic and the restrictions which were put on people who were not clinicians and not immediately involved in patient care accessing these areas.

But I do not see that in 2015, '16, '17, '18 and '19, so I went with the assumption that all areas were open to be tested, and I recognised the fact that

the testing was less in certain years and then it was escalated in other years. But what I'm not taking into account is just the water sample for positive numbers, in the same way that I have not just relied on the infection incidents. I am providing a rate of positivity.

Q So this is the same idea? You take the number of positives divided by the number tests?

A Yes, exactly, so you weight it. You weight the numerator for the activity----

Q By dividing it by----

A Yes, and the activity, when it comes to water, is the water samples which have been sent.

Q Which is much lower in '15, '16.

A Which is much lower, but then again, so is the numerator. But as long as I make sure that I present a rate-- so it is 5 per cent, 4 per cent, 3 per cent, it's per 100, sort of the way in which we do the infection rate, which is, you know, per 1,000, because a rate can adjust for the differences in the number of samples you have sent.

Q Okay, so you've made these assumptions and these steps, and you've then done your comparison. I think you put the result on page 92 in your supplementary report. I wonder if you can just take us through--

Because obviously, you've said that you're not going to rely on the previous rate curve from the first report, which produced a Pearson's correlation coefficient in the fourth line of this paragraph of .07, indicating a moderate, very strong positive correlation, but then you recalculate the statistic and you came up with a different number. What did you come up with?

A Yes, so I then looked at the correlation by comparing the aggregated 2A and 6A rate of infection to the water positivity figure for the period of 2015 to 2019 inclusive, and the resulting figure for the correlation coefficient was very similar. It was 0.6.

Q What does that tell you about the nature of the association?

A As I say in the text, that it indicated a moderate to strong association between infection rates and water positivity.

Q Did you rerun the comparison with interventions that you ran in the first exercise, or did you not do that for the supplementary report?

A I don't think I did that for the supplementary report. What I will say, if you allow me----

Q Of course.

A Two things: that the-- that I am conscious that there was a change in the correlation coefficient. It went from 0.7,

which indicated a moderate to very strong association, and you will remember that the closer that number gets to 1 the stronger the association.

Q Yes.

A It drops slightly to 0.6 and the consensus from the literature is that that should be interpreted as a moderate to strong association. What I did not include here is the confidence intervals----

Q Yes, I was going to come to that.

A -- around those two confidence intervals, but I do have them at hand. The reason why I did not include them within that is for one reason, which is that is normally a statistic that is used when comparing what is happening within a smaller sample to say something about a larger group. So, for example, if you take into account the voting analogy----

Q Yes, an opinion poll.

A Yes, opinion poll. If you have 10 people and you know that they have voted in a certain way, that you need some confidence intervals around that because that gives you a sense of where the true value lies.

Q That's the margin of error we hear about?

A Yes, in the population.

Q Right.

A Because normally what you're trying to do is you're trying to run some statistics-- and that's what the word "statistics" means. It is that you are running the calculations on a smaller sample to be able to then say something about a larger sample.

Q Right.

A Right. This is not what we are trying to do here. Here, we're just dealing with the data on the ground, which we are using to say something about what was happening in that context and in that context only, if you see what I mean.

Q Yes.

A I have not used it, and neither can we use it, to say something about other hospitals or the population as a whole.

Q That wasn't the purpose of the exercise.

A Yes, exactly.

Q Right.

A But, for the purpose of completeness, I do have the confidence interval.

Q So what is the confidence interval on that .6 result?

A It is tight, which is 0.59 to 0.61, which means----

Q So that means the range is from what to what? Because we'll need to have this clear.

A So it's 0.59----

Q Yes.

A to 0.61----

Q I see.

A -- with the correlation coefficient at 0.6. Now, what does that say? The rule is that if you have wide confidence intervals, it means that you do not have enough certainty of the statistic, because that statistic could be anywhere on that scale, so you have a wide margin of error. If you have narrow confidence intervals-- and here we have very narrow confidence intervals. It's a .01 on either side of the statistic, so the confidence intervals go from 0.59 to 0.61.

Q Right.

A And what that says is that you can be pretty sure that the value of 0.6 is firm, and the underlying framework of that is the fact that 0.6 is based on a lot of data.

Q Okay. What I want to do now is to pick up what conclusions you feel you can make.

A Yes.

Q Then we'll look, if you don't mind, briefly at the use we might make of the other reports that you've looked at. I don't want to go into them in huge detail, but in respect to other reports, I'm simply going to ask you what's interesting that we might want to draw out for our own purposes.

So just in respect to the conclusions you make, if we go back to your hypothesis, which was on page 13 at 5.7. So your hypothesis was that:

> "There existed a positive association correlation between the occurrence of patient infections with environmental organisms and the presence of environmental biological contamination at the hospital between '15 and '22."

Now, what, in broad terms, is your conclusion in respect of that hypothesis?

A That I accept the hypothesis that there is a strong association between the exposure variable, which is the water contamination, and the occurrence of infections from environmental bugs in the Schiehallion cohort.

Q Within the exercise, are there any particular aspects of the different comparisons you carried out – both between Schiehallion and the comparator hospitals and looking at rates of change within the Schiehallion data you had – that particularly support that conclusion that you should draw to our attention?

A So, a couple. That there is-- that we look-- So in line with Direction 4, we have three outputs. One, that when you look at the trend in the rate of infection of the Schiehallion unit, that there is clear, from the data-- that you had unusual peaks that were not in line with either what the Schiehallion rate experienced before or after and was not

in line with what comparator units were experiencing at that time.

Q Okay. Any other particular observations?

A Now, I've combined, you know, the first two into sort of, like, one statistic. So the second one would be that when I ran the correlation coefficient – both using the admission data which was presented to me to begin with and then the corrected one – that the correlation coefficient itself based on a large number of data points, which were-- says something that is quite-- is that you have a moderate to strong association at a correlation coefficient of 0.6 between the time series that is the water positivity time series and the time series in terms of the rates of infection, which makes me move to accepting the hypothesis that the rate of infection is not independent of the exposure.

Q I've just got a few remaining criticisms to put to you. Well, two. You might have already said you've said this, but I want to put it to you in terms: apart from in the water positivity rate calculations, you've not actually used any other obvious statistical tools here. Am I right, and does it matter?

A Well, I would argue that everything that I have done from beginning to end has made use of everything that I have that you can possibly use in terms of tools to understand the relationship between two variables and----

Q But say-- Sorry, carry on.

A -- and that one tool is to understand what is the incidence rate, which is the rate of infection. The other tool is the comparison of that infection rate in the cohort of concern to comparator units. The third tool is to employ-- and we did that in terms of what is the magnitude of the difference. The fourth tool is to then look at the specific tool around the coefficient of correlation. And these are the tools which, you know, which make themselves available to this kind of analysis.

Q Thank you. Now, what I want to do now is to move on to look at some of the other reports. That'll take about 20 minutes, and then we'll have a break to enable core participants to see if there are any questions they would like me to ask.

A Sure.

Q Now, you've had to look at a number of different reports that we've shown you over the last few years, and you've referred to some of them in your reports already. I'm not going to go over old ground. Also, we've had evidence from Dr Kennedy, Ms Imrie, Ms Rankin, amongst others, and Dr Peters and Ms Harvey-Wood about their pieces of work.

So we have that on board then to take into account, but I want to just walk through the various groups of them and I'll group them by authors, I think, for clarity.

A Sure.

Q So the first one is the two pieces of work done by Kathleen Harvey-Wood and Dr Christine Peters in 2018. I'm going to use the PowerPoint presentation to look at them, and as I understand there's also a report.

The PowerPoint presentation is bundle 27, volume 6, document 9, page 107. Just for completeness, the report, if anyone needs it, is bundle 19, document 19 at page 143. So that's definitely the wrong place. Bundle 27, volume 6? Yes, I've got that wrong, so give me a moment to get the right one. (After a pause) Thank you. Which bundle was that?

UNKNOWN SPEAKER: (Inaudible).

MR MACKINTOSH: Oh, right, sorry. (To the witness) So this report, I think you've had an opportunity to read this.

A Yes.

Q Maybe if we just step through two pages, three pages to look at this, which shows the, I understand, percentage of positive blood cultures through the report. Now, you've read these presentations.

A Yes.

Q I've obviously noticed that they use, as a denominator, positivity of blood cultures. Is there anything useful that you would see within here that we should be looking at as a piece of epidemiology evidence that sort of stands out, either positive or negative, in respect of the hypothesis that you've just discussed?

A The thing I would take from this, from this analytic, is what you can see here, although it hasn't been labelled, which is the red line which is slanting upwards.

Q Yes.

A Which is the trend line, which gives you the overall feel in terms of what the positive blood cultures looked like over the period from June '14 to July '18. And what that tells me is that the rate of positivity was increasing over that period, that the line of best fit is slanted upwards, which is indicative of the fact that the percentage positive rate was lower from June 2014 to about March '16, and there are a few exceptions to that in a few months there, so particularly October '15, Jan '16.

But then the trend line picks up this escalation, and I would use the word here "overall escalation," from July '16 onwards, bar some months where the rate of positivity drops, with what you can observe are these unusual peaks in Feb

'17 and April '17 and then, of course, in December '17 and March '18.

The assumption here is that – and I think it's been adjusted for – it's a rate of positivity, so of the blood cultures being sent, that's the rate of positive. It also-- I mean, if I was just looking at this, you always take the rate of positivity as blood cultures as a proxy marker for the risk that is affecting the patients.

So it says to me that the larger the proportion of blood cultures which are coming back positive is a marker for that the patients are suffering from more infections. But the caveat is that you could be sending in more blood cultures because you are more worried about these patients, but you still need the patient to be positive for the blood culture to come back as positive.

Q While we're on this slide, I wanted to ask you a general question which applies to lots of these reports, is that many of them use a dataset that runs back in time before the opening of the hospital. Indeed, Dr Kennedy made the criticism of this trend line that you shouldn't have had a trend line that runs before the change, and you're sort of nodding.

A Yes, I agree.

Q But I'd like to understand, if you've got any thoughts, about how we should treat this left-hand third or quarter

of these graphs. Not here, it's in Dr Kennedy, it's in HPS, there is a segment of data from Yorkhill, the old Yorkhill. It's just a year and a bit sometimes, sometimes a bit longer. Do you have any advice about how we should look at that?

I mean, a good example might be if we jumped to Dr Kennedy's second report, bundle 6, page 107, which he gave some specific evidence about. So Dr Kennedy gave, if I recollect his evidence correctly-- We discussed this with him, this graph of selected gram-negatives. It's a much shorter list than your list.

A Yes.

Q I asked him what we should draw from this graph, what stood out, and I seem to recollect he noted the existence of some sort of event happening in early '18, in early '17 and in '13, and when we were looking at the SBC graph for the HPS report earlier on this morning, there was things going on on the left-hand side.

A Yes.

Q How should we approach that evidence, that information? Should we think about it in a particular way? Should we take account of it? Should we ignore it? What should we do with it?

A So my immediate reaction to it would be going back to what is the question at hand, and the hypothesis we are trying to test here, which is, "Is there

a relationship between the environment that came to be in the new build and the rate of infection?" If you stick to that, then the consequence of answering that question is to ignore everything that came before it because the setting is not the same. The patients were moved into the new build in June 2015.

We are-- The question at hand here is, "What do the"-- "How related"-- or, "What is the association between the environment, with the water positivity being the variable of choice, and the infections?" And so it would not be advised, in fact, it would be wrong, to-- In answering that question, you would have to start from the point at which the patients went into the RHC, the new build.

Q But what about the idea that it's the same patients, broadly speaking? Putting aside for a moment the evidence we've heard about the different nature of the bacteria involved, which is evidence about that, you're not a microbiologist, so I'm not going to ask you about it.

Putting that aside, is there not some information that we can derive from the various charts? I mean, this is one-- a good example here, where the left-hand fifth of this chart, less than that perhaps, is before the move and, therefore, some reassurance can be derived that, for a significant period of time – in this case, up until January '17 on this chart – there's no real change in what happens. Is there anything wrong with that as an approach?

A So I wouldn't agree because I think, and I'll go back to what we are trying to ask here-- is we are asking, "Is the rate of infection in the patients who moved into the new build"-- "What is the association between the rate of infection and what is in, you know, what is eventually a specific environment, a physical thing which was not the same at Yorkhill?"

So the only thing that you can do here is that, if were-- you know, you were pushed to do something with the rate per 1,000 bed days of the Schiehallion, of the of the paediatric haematology cohort at Yorkhill between July '13 and prior to the move to the new build, would be a mean rate of infection, but a mean rate of infection for that population in a setting that is different to the setting that they went into.

Q But isn't that just what you did with the comparator units? You created a mean-- I mean, we don't know, we've had no evidence about the nature of the buildings in Oxford or Cardiff or whatever. Isn't that just the same thing?

A Well, I----

Q It might be a difference of scale, I accept that, but it's----

A Sure. I think the difference of

scale matters, and it matters quite a bit. Going back to why I did not compare the rate of 2A per 1,000 bed days to just one other comparator, in the same way it would not be sufficient to just compare the rate per 1,000 bed days in the Schiehallion in the new build to itself, if you want to extend that point, to what it was in the old build.

Because it only lends itself to so much, and what it lends you-- and that sort of comes back to why I am not a believer in just using SPC charts, is ultimately you are comparing yourself to yourself. And the true nature of your rate of infection is to contextualise it within what is happening in the world around you, i.e. to other comparator units. That is the only real way in which you go that, you know--

These are four or five units. They are all taking care of paediatric haematology-oncology patients. Over the same period of time, with certain assumptions, of course, how do our rates compare? I think that comparison externally is superbly-- you know, is key to being able to understand where you are. I mean, it's sort of the analogy that I only know how tall I am when I compare myself to someone shorter or taller. I mean, otherwise, I'll just think, "Well, I am, you know, I'm fine."

Q You're the same height you were last week.

A Yes, so, yes, exactly, but the point is that I-- you know, I can then go on to say that I am shorter than Fred but I am taller than Mansi.

Q Right.

A But it is as core as that.

Q So you mentioned SPC charts, and I suppose that means I'm now going to talk to you about SPC charts.

A Sure.

Q So if we can go onto the HPS report on bundle 7, page-- if we go to page 227. Now, I know, and we all can read, what you think about SPC charts. You've said it in your report. Can we go to the bottom half of the page? Over this page, if we go onto page 229, we see, indeed, a chart.

A Yes.

Q Figure 4. Now, if we can take as read your critique of SPC charts – we've read it, we've put it to various people, we've heard evidence – I just want to work out what we can do with them, given your concerns, and I suppose I want to use an example.

If we just look at this one, which is an SPC chart for the gram-negative case definition for HPS data July '13 to September '19. You'll notice there's a circle and it's drawn around the incident rate per 1,000 occupied bed days in late '17, early '18.

If we go back to page 227, bottom of the page, do you see it starts discussing gram-positive organisms at the bottom of the last page? We go over the page, it says:

> "When using the gram-negative case definition, an upward shift or the run of 10 data points above the mean was observed from March to December '17 within the upper warning limit breached in... "

Various dates given, figure 4. Now, I absolutely get that, (A), you don't like SPC charts because they have a baseline that is themselves and you have other criticisms of them.

A Sure.

Q But we have a lot of this material----

A Sure.

Q -- collected at the time and people have given their opinions about it, and I'm pretty sure they've made their decisions based on these. How should we use this information, not only the graphs themselves, but this narrative form here? I'm taking it you don't think it's entirely useless, so what shall we use it for?

A And I'm taking your question as-- you're asking me what is the usefulness of SPC charts within the broader context, not just for the Inquiry.

Q Yes. Well, no, I'm thinking about the Inquiry. It's about what we use it for.

A For the Inquiry. I think-- so I've written down two points and I will just sort of-- Let's start with that as a starter for 10-- is that just because the data points do not fall outside the upper limit and at which point they will then be termed an abnormal variation, doesn't mean that they are not of interest and therefore don't warrant being looked into.

Q Okay.

A So that's one, and the learning from that is that SPC charts tend to give the reader, in my opinion, a sense-- a sense of comfort, or they can lead to that-- that, "Let's wait for rates of infection to peak above the parapet," which I have to stress is, "Let it peak above the worst possible scenario."

Q Right.

A Which is what the upper limit is. The upper limit isn't there to say, "That's when you should see me. That's the worst possible scenario when you should be seeing me." But use that as a marker to go back and go, "What caused me to peak out then?" if you see what I mean.

Q So you look at the point of change?

A Yes, it's just a proxy marker that, "Things have got so bad that now

my rate of infection is above the upper limit line." So that's one. So the learning from that is don't wait for the upper limit line. That what is important is you can view the variation, and if you see a lot of peaks, look into it. Don't wait for it to creep up in the parapet.

And my second point that I made already, which is in a vulnerable population such as the paediatric haematology unit cohort, do not-- what I feel-- sense is that the SPC charts and, therefore, what it lends the reader to do is to wait for the data points to fall into the realm of the abnormal or the unusual to suggest something is wrong.

So, in answer to your question, what can you take from it? Unfortunately, I wouldn't take much from those charts, but a tweak to those charts, you could-- would make more sense, which is back to my point about-- so isn't it quite hard to read a graph that looks at month-on-month rates of infection because of the variability and the busyness of that graph?

It would have been a lot better if these SPC charts would have looked at a rate of infection by quarter because then at least it gives you that-- a sense of what three months are telling you. And I say this when you're looking at it retrospectively.

When you're looking at things in a

live manner – so if you're using SPC charts and you're going, "Okay, it's the month of July, you know, the SPC chart is running live. What is it telling me?" – don't wait for the peak to peak above, you know, the upper limit.

Q Okay. I want to look at one more report, which is a presentation that you hadn't seen when you wrote your reports, but I think you saw it this week, which is done by Dr Kennedy and Ms Rogers to the-- I think to the IMT on 20 September 2019. That's bundle 27, volume 13, document 13, page 77.

Now, I think it's important, before discussing it, to put it in its context. So its context is September '19, so that is a year after the decant. I suppose it's also relevant to spot there'd been a change to the IMT chair. There had been, earlier in that month, the suggestion from the then lead ICD and other microbiologists that the ward was microbiologically safe. There had been some suggestion from HPS that they weren't willing to accept that at the time, and then this is produced.

Dr Armstrong gave evidence that she felt it was quite an important piece of work and I'm conscious that it refers to success with CLABSI data, but I wonder if there's anything that we should take from it as an Inquiry in trying to understand what's going on in the second

half of 2019.

A Sure. Would you like to sort of show me a specific analytic?

Q Yes.

A And then I can sort of---.

Q Yes. I felt that there's only about four graphs in here. The first one seems to be CLABSI rates, but it has gram-negative within it.

A Yes.

Q Is there anything that can be taken from the gram-negative CLABSI data on page 78?

A Well, I think what you can take from it is that, if you look at the blue line, which I take here as the rate per 1,000 line days of CLABSI----

Q That would include gram-positive, gram-negative, everything?

A Yes. That if you look at Jan '15 to about May '17, the general-- the trend over that approximate two-year period is one of escalation. More or less, the-- if you sort of-- I'm trying to, in my mind aggregate the months into a year or a quarter. It settles, i.e. it remains high. Something was-- the mitigation steps were brought in and the reduction plan----

Q The CLABSI?

A The CLABSI reduction plan has then led to a decrease if you look at the trend from May-- from about May '17 to July '19----

Q This is the blue line? This is the blue line?

A Yes, exactly. The blue line, the general trend has been downward. So the CLABSI rates went up and then they went down. But interestingly, over the period when the CLABSI rates were going down, look at what is happening to the rate of gram-negatives. Something there suggests that the CLABSI or the steps to mitigate line infections was working with regards to bugs that were other than gram-negatives.

Q In essence, the gram-negative is the only bit that's left by the end?

A Yes, and that there are other causes for the gram-negatives that were not just the fact that some of them were linked to line-associated BSIs.

Q I just wondered whether page 85 and its associated table, which is page 86-- If we go back to 85. I suppose we looked at enough of these charts over the last 10 weeks. Is there anything you see in there that we should be taking account of to understand what's going on, bearing in mind the bacteria that are included in that list?

A And I presume that the rate here is not based on as comprehensive an infection list as I have in my reports.

Q I think if you look on page 86, it doesn't seem to have as many cases.

A Sure, yes. And if we go back to 85? So, again, it would be much

easier to look at this on a year-by-year basis because, I mean, these----

Q Because you would be able to do an almost direct comparison----

A Yes, exactly.

Q -- between your work on bed days.

A -- I was-- yes, exactly. So, I mean, almost by-- if you could, by-- you know, if you could superimpose mine on this and we can have a look at it, but it-- you know, observationally, graphs should work-- I mean, they are made to be able to impart what the data is telling you in a sort of visual manner. Well, I'm struggling at that, but----

Q I mean, I'm just wondering whether----

A What it is telling me is that the rates of gram-negative, the blood cultures, is on the way up. If you take into account where the data points are in September '15, November '15, Jan '16, and you compare it to where they end up in September '17, November '17, Jan '18, March '18, May '18, you know, and-- So if you take into account those two as the start of the pipeline and the end of the pipeline, and you sort of drew the line of best fit, it would be slanting upwards.

Q Because it occurred to me that there's an interesting question which I regret to say I haven't put to Dr Kennedy, because I don't think I got this until after he gave evidence.

A Yes.

Q Is that if we look at the definition at the top, it's the crude rate of all the gram-negative blood cultures. Now, when I read this, I assumed, and I don't know whether I'm right here, that that will include – since it goes 2A, B and Ward 6A – the day cases, so infections from day cases, but the rate is per occupied bed days.

A And one point, if I can, because as soon as you said----

Q Well, I've interrupted you enough, so keep going, please.

A No, no, because as soon as you said gram-negative, I was looking for that next word, which is are these environmental?

Q Can I let you look at the next page when I finish the sentence----

A Sure, yes.

Q -- because could it be, if we just take this on trust, that the numerator in this table is all the gram-negative – I'll come back to what that means – infections for both day cases and overnight admissions in 2A, 2B and Ward 6A between November '14 and July '19, divided by the number of occupied bed days, accepting that, remembering Professor Stevens, that you only get to be an occupied bed if you're admitted----

A Yes.

Q -- might that not suggest that-- Well, these peaks are quite high, compared to, if we go back to bundle 21, volume 1, page 771, which is your calculation with a larger data set. Because you've got peaks of six and a bit per 1,000. If go back to the previous slide----

A They have peaks of----

Q Twelve. Now, I'll allow you----

A It's 11----

Q -- to answer your question.

A -- and 13 and----

Q Going on to the next page, you're not a microbiologist, but this is a memory test, in a sense. That list of species, how much connection does that have to the sort of species that you were considering in your work?

A Well, I mean, I think the blunt answer to that would be that there are less here than were in my list.

Q But are there things in here that weren't in your list?

A (After a pause) I will have to be reminded, I think. At the end----

Q So if we go back to your list, which is on previous bundle, page 25.

A Yes. Yes.

Q So if we can put on the screen bundle 27, volume 13, and then you've got the hard copy, I think, of your report.

A Yes.

Q Because the impression that I formed was that this is not as many infections as your list, and I may be wrong.

A Yes, the numbers are-- So I had 187 in total, and someone would have to do a bit of mental maths to do----

Q Well, we can do it at least for one of them in the time we have, which is if we go down to-- On page 25 of bundle 21, volume 1, you had 16 cases of Enterobacter cloacae.

A Mm.

Q This one has-- I picked the wrong one. It doesn't have any. Let's pick one with one----

A No, I think it has the second from the top.

Q Yes, it does, so it has a not dissimilar number of cases.

A Yes, it has----

Q All I wanted to do from this, because I'm not making you do epidemiology on the hoof, is we've got Dr Mumford and Ms Dempster coming along next week.

A Yes.

Q There's a question I thought I might ask them, and I think I want to make sure that I'm not getting the epidemiology daft in order to do this. So if we go back to the previous page.

Is this a reasonable question to ask them to look at this chart and the one on the following page, to look at your list and

your report, and possibly even, actually, Dr Kennedy's work as well, and to start comparing in very broad terms not necessarily the rate per 1,000 occupied bed days but the changes in those rates? Is that a reasonable exercise for them to do in a week's time?

A I think I would lean towards the latter, which is you can compare these outputs in terms of the changes because we're not using the same cases, so we have to keep that in mind, but what we can do is in broad terms ask the questions, such as, are the trends and the magnitude of the differences between the sections of each of these graphs-- Do they say similar things?

Q About timing an event?

A Yes, exactly.

Q Well, I will come back to that with Dr Mumford and Ms Dempster. My Lord, those are all the questions that I have for Mr Mookerjee. Traditionally, we take a 10-minute break to see if any core participants have a question or two.

THE CHAIR: We'll do that. Mr Mookerjee, I need to find out if there's further questions in the room, so I'll ask you to return to the witness room, and we should be back in about 10 minutes.

A Sure, thank you.

(Short break)

THE CHAIR: Mr Mackintosh.

MR MACKINTOSH: I have three questions, my Lord.

(The witness re-entered the room)

THE CHAIR: I understand we have three further questions, Mr Mookerjee.

A Okay.

MR MACKINTOSH: So the first question relates, I think, to the issue of use of epidemiology in managing outbreaks.

A Yes.

Q So the question is, is the level of comparative epidemiology you've described typically required during the management of hospital outbreaks? And there's a follow-up, depending on your answer.

A Okay. I mean, so it's a broad question. My response to that would be that every attempt should be made to compare so that you, as someone who is dealing with these rates of infections-- that you have clearly sort of marked out as being unusual or part of an outbreak or a cluster-- that you should be making every attempt to compare and to contrast, and to use, you know, your organisational

links to understand more about your context.

Q Could it be argued that sometimes the best comparator is the unit itself, in the sense that you plot the interventions and measure the impact of the interventions? Sometimes that actually might be an easier way of proceeding: you look at the intervention and see whether it made a difference.

A So I'll still stick to the fact that the first point is very important, but I agree that the second point is also important, that I'll expand on that, in that it's only as good as the surveillance that you have going, and so what you need is ongoing surveillance.

You need to be able to understand quite soon after something has happened that it has happened, and you should be moving on from incidence to rates, although, you know, in a live, on-the-ground manner, on the coal face, the incidence is what you will see to begin with in terms of clusters.

And yes, if you see a cluster of cases and you do something about it, that is essentially what we do in the clinical circle. If you see that a ward has five or six cases, you tag them as a cluster because they've happened in the same, you know, in a space, so roughly at the same time. I mean, there-- You have definitions for that: two cases within a

period of seven days, three cases within 14 days.

So you presume they're linked unless you get evidence that they are not linked, that they are a marker of something is going on. Either there has been transmission or there has been transmission from the environment to the patient, but you can then institute some steps and the go-to is to then look at what does-- what do the mitigation steps do to the outcome?

If the cases go down, you have some sense that what you've done in terms of mitigating has worked. If they don't go down and they continue, whatever you have done is not working because you either incorrectly identified the source of that infection, or maybe the reason for that infection, the few cases, requires more than a single sort of step. It requires a multitude. It requires a multimodal way of doing things.

So I agree, but it requires you to have your finger on the pulse, and the key, the pillar here, is the data. The data has to be really good. You need to have people who understand the data and who are able to turn the data into something that is meaningful for clinicians, and the clinicians have to have access to that data in a live manner to be able to not just pick up things that are going wrong but then to do something about it and

then for them to get some reassurance that what they've done has worked.

Q Right. Now, related question to the first question I asked you. I realised I should show you bundle 7, page 231, which is the-- Sorry, not 231, page 267. In fact, 231 will do. We'll stay with 231; it's the same paragraph.

So this is the HPS report from November 2019. It's the comparison with other health boards. I'm not going to go into the detail of what is observed here, other than to note that what appears to have happened here is a comparison between the overall hospital rate of positive blood cultures between the RHC and the combined Aberdeen Children's Hospital and the Edinburgh Children's Hospital.

This seems to be of significance to some decision-makers and is widely repeated, and I wondered if there are any risks that one has to take account of when relying on such a comparison exercise between the whole children's hospital and other whole children's hospitals in this context?

A Well, in this context, the-- one of the central themes of the context is we're looking at, what are we asking? We are asking, is there anything unusual going on in terms of the infection rate in the specific cohort which is the paediatric haematology-oncology cohort?

To that end, I wouldn't take the overall hospital rate at the RHC and compare it to what I think is the overall hospital rate at two other centres, because that does exactly what it says on the tin, and it doesn't answer your question.

And the question is, what is-- are the rates of infection we are seeing within the paediatric haematology-oncology unit, are they unusual? Should I be doing something about it? Because the overall hospital rate will, at the RHC, at the children's hospitals, will not be specific for that cohort and will give you an answer that is diluted.

Q Okay. What I want to do is move on to the next question, which is, if we go to your report, that's bundle 21, volume 1, page 21. You listed the information you sought and obtained from four hospitals. Would it be fair to say that you have no knowledge of the nuance or detail or the differences between the patients in these four comparator hospitals and each other and the Schiehallion? You can't comment on----

A No, I can't.

Q -- on anything to do with the distinction or the difference?

A No, I cannot.

Q Now, you've already explained why you don't think that matters, but do you think you have made that clear in

your report, that this is not a-- you can't make a view about whether there is truly a comparison to be made between Cardiff and the Vale or Oxford and-- other than the fact that they are just, in general terms, paediatric oncology units?

A Well, I think in asking that we want-- that here is what we are trying to do and what we want from the comparator institutions is infection data and the activity data that is specific to the paediatric haematology-oncology unit, we have remained faithful in what we want from the comparator sites.

The way that we went about it is we sent this to every single centre that we knew had a paediatric haematology-oncology, you know-- had a centre that-- and what we-- and so what we received was a-- was something which was not biased by us. We received information from X numbers and we then had to take what we perceived to be a complete set of data.

In doing so, in epidemiological terms, it was good that we ended up with a admission number, a total aggregated admission number, from all of those four hospitals for those eight years, for more or less, which was a pretty high number. I haven't added up all the 4,000s and the 2,000s, and so, similarly, we got a high number of infections.

So I'll go back to the fact that we

aren't comparing one hospital to another. We are comparing our interest, which is, "How do we contextualise what is happening within the Schiehallion?" and we're comparing it to an aggregated rate over a long period time: '15, '16, '17, '18, '19, '20, '21, '22 to-- So, ultimately, four other hospitals, lots of admissions, lots of patients, and so that adjusts for the biases and the confounders, which comparing one to one will not.

Q So what I wanted to do is one final question. It's back to this 14-day thing again.

A Yes.

Q So it's been suggested that you're calculating, you're de-duplicating on the 14-day basis on a different basis from NSS or, indeed, the UK standard. In essence, the problem is this, that's been put to me: that, if we go back to our example of a case on day 1, day 12 and day 18, if I understood your evidence correctly, you would count the case on day 1 and the case on day 18.

A Yes.

Q Yes. The position that's been put to me is that the correct way to proceed is that you ignore anything that happens within the 14-day period that follows any positive sample and, therefore, that the 18-day example would also be excluded because it's within 14 days of the 12-day example.

Now, I realise that you've done the same thing for both comparator and Schiehallion, but how do you to respond to the suggestion that you're doing this wrong, you're not following national standards?

A So if you look at, and I shared this with yourself-- there is a protocol on the NSS.NHS.Scotland, the website.

Q Yes.

A And it comes under the heading of "Protocol for national enhanced surveillance of bacteraemia."

Q Yes.

A It's from 2020.

Q Yes.

A It says, and I use Pseudomonas aeruginosa as an example:

> "A case of bacteraemia is a patient from whom Pseudomonas aeruginosa has been isolated from the patient's blood and who has not previously had the same organism isolated from blood within the same 14-day period, i.e. 14 days from the date last positive sample obtained."

When you put that guidance into practice, and Pseudomonas is one of the reportable infections, both in England and in Scotland, so you report it nationally, so it's part of mandatory surveillance-- If the patient came in on 1 November and had a blood culture, that blood culture, which, say you have positive for Pseudomonas aeruginosa, that blood culture would be reported to UK HSA or to HPS.

If that patient, for whatever reason, had blood cultures taken every single day from day 1 to day 14, it would be considered that those blood cultures are indicative of the same episode of infection that we were told about from the first blood culture that we reported.

Q But you wouldn't report the blood culture on day 15, according to this criteria, is that-- Have I understood that correctly?

A So, in practice, how the reporting works is that you take the difference in the date of collection of the second sample and you subtract it from the date of collection of the first sample, or the first reported sample. And if the numerical-- the value is more than or equal to 14, you report the blood culture-- the second blood culture.

If the numerical value between those two blood cultures is 13 or less, you don't report it because that blood culture is still indicative of the episode of infection that we told UK HSA or RI about using the first culture. But-- and, for surveillance, you have to draw these lines in the sand, and it can well be argued that an episode of infection can travel longer than a 14-day cycle, but, in the real world, you have to make some decisions.

In the real world, if the numerical-- the difference between the collection dates is 14 or more, you report that sample with that collection date because it is now indicative of a new episode of infection.

Q I understand that, Mr Mookerjee, but at the risk of confusing us all at quarter to five on a Tuesday night, if there are three infections and the first infection is on day 1 and the second infection is on day 12, you don't report the second one because the difference is less than 14. I understand that.

You have a third infection on day 18. Now the difference between the first one on the 1st and the third one on the 18th is more than 14, but the difference between the second one on the 12th and the one on the 18th is only six. So it's being suggested me that you wouldn't report the 18th one because it's too close to the 12th one.

A No, so it's not true because, in reporting, and I have led on the national reporting for the past 14 years-- that UK HSA will ask you very clearly-- Because remember, this is the only lens that they see----

Q I think that's why I'm being asked the question, so----

A Yes, exactly, so is-- "We saw that you uploaded something that is a proxy measure for a patient that has

suffered-- or is suffering from a bacteraemia on 1 November. Any other culture from that patient where either the genus [so, in this case, which is Pseudomonas] or the species [which is aeruginosa], if that remains the same, we do not want to see any samples from you."

So up until the day where the sample is collected more than or equal to 14 days after the first. "The only time that we want to see a sample from you between those two dates is if something about that bug changes."

A No, I understand that. I----

Q I think that's an important thing because, from a surveillance point of view, what we are all trying to work out here is, "How many episodes of infection do patients have nationally?"

Q But that's not what you're doing in your study.

A Well, here, I'm applying the definitions that we use nationally to work out how many unique patient episodes of infection did we have for the period 2015 to 2022?

Q So I think I understand that, and what I think I want to wrap up with is, if there a difference between the way you've approached this and the way in which people in Scotland have approached this, I want to check that the way you approached it for the

Schiehallion infection rate and the way you approach it for the comparator infection rates is the same.

A Yes.

Q My Lord, I have no more questions for this witness. Thank you.

THE CHAIR: Mr Mookerjee, that is the end of your evidence and you're therefore free to go but, before you go, thank you for your attendance today and thank you for the considerable work that will have gone into these reports, supplementary report, the addendum to the report and the consideration of the additional questions. So can I repeat my thanks, but can I also repeat that you're free to go?

A Okay. Thank you very much.

(The witness withdrew)

THE CHAIR: Now, as I understand it, Mr Mackintosh, we plan to resume tomorrow at ten with Dr Walker.

MR MACKINTOSH: Who, I'm pleased to say, is in the jurisdiction.

THE CHAIR: Right. Well, we shall, all being well, see each other tomorrow, and I would wish everyone a pleasant 5 November.

(Session ends)

16:47