SCOTTISH HOSPITALS INQUIRY

Hearings Commencing
9 May 2022

Day 4
Thursday 12 May
Professor Hilary Humphreys

C O N T E N T S

14:30

THE CHAIR: Good afternoon, Professor Humphreys. Can you see us, see at least me?

PROFESSOR HUMPHREYS: Yes, I can and I can hear you.

THE CHAIR: Right. You certainly sound very clear to me. As you appreciate, you are about to be asked some questions by Mr MacGregor QC. Before that, will you take the oath?

PROFESSOR HUMPHREYS: Yes, I will.

Professor Hilary Humphreys

(Sworn)

THE CHAIR: Thank you very much, Professor. I should just say that, if for any reason, you want to take a break during your evidence, just please indicate that and we can do that. Now, Mr MacGregor.

Questioned by Mr John MacGregor

Q Thank you, my Lord. You are Professor James Francis Hilary Humphreys. Is that correct?

A That's correct.

Q You have provided a report to the Inquiry dated the 1 April 2022?

A That's correct.

Q Just for the benefit of Lord Brodie and the core participants, that is in bundle 6 at pages 3 to 28 and Professor Humphreys' CV is available in bundle 8 at pages 51 to 62. Professor Humphreys, the content of your report will form part of your evidence to the Inquiry. You are also going to be asked some questions today and if you do want to refer to your report at any point, please do just let me know.

I want to begin by asking you questions about your qualifications and experience. Am I correct that you are currently Emeritus Professor of Clinical Microbiology at the Royal College of Surgeons in Ireland, University of Medicine and Health Sciences?

A That's correct.

Q What does that role involve?

A Well, I retired from clinical practice in 2021, so I remain actively involved in research and education and various other professional activities.

Q Within your report and your CV, you have set out a number of your degrees and diplomas. Do those include a Doctor of Medicine----

A Correct.

Q -- a Bachelor of Surgery----

A Correct.

Q -- and you also have a diploma in hospital infection control?

A That's correct.

Q What is the diploma in hospital infection control?

A That was a diploma awarded by the London School of Hygiene and Tropical Medicine. Based upon reflections over many years, it was part of a training course that was instituted in the UK for people with a particular interest in healthcare infection prevention and control.

Q Okay. If I could begin by looking at your report, which is firstly at page 6 in the bundle, which covers your career history and professional background. If we could begin back in the 1980s, did you qualify as a doctor in the early 1980s?

A Correct. I qualified in 1981 from University College Dublin.

Q You then held registrar positions in Dublin and Bristol from 1985 until 1991?

A That's correct.

Q You completed postgraduate training in internal medicine and then specialist training in microbiology?

A That's correct. After I qualified, I did a few years in general medicine in areas such as cardiology,

nephrology and general medicine including on call and then decided to go into a career in clinical microbiology.

Q In 1991, you were appointed senior lecturer and consultant microbiologist at University Hospital at the University of Nottingham. Is that correct?

A That's correct.

Q What did that role involve?

A It involved a combination of contributing to the service in University Hospital Queen's Medical Centre in Nottingham in terms of diagnosis, prevention, control and advice on treatment, as well as teaching medical students and others and engaging in the research activities of the department, which especially functioned on interest in staphylococcus aureus, a common bacteria causing healthcare associated infection.

Q So, just so I am understanding, you were involved in infection prevention and control, is that correct?

A That's correct. I was.

Q Then in research into clinical microbiology?

A That's correct, yes.

Q Did you stay in that role

until 1998, whenever you were appointed professor of microbiology at the Royal College of Surgeons in Ireland?

A That's correct, yes. I did spend a year in another hospital in Dublin, but it was really a very temporary appointment. The essence of what I've been doing has been since 1998 in the RCSI and Beaumont Hospital.

Q Again, as you say, you were also consultant microbiologist at Beaumont Hospital in Dublin.

A Correct.

Q What did that role involve?

A Well, again, a bit analogous to the role in University Hospital in Nottingham: providing a clinical service in terms of diagnosis, treatment, prevention of infection; a combination of laboratory work; clinical work on wards, such as the critical care areas; then general education in terms of improved use of antibiotics and infection prevention measures.

Q You mentioned that you stepped down as consultant microbiologist in August 2021.

A That's correct, yes.

Q Have you remained active in research and teaching since retiring?

A Yes. I'm still involved in a couple of research projects and there's still work outstanding from the time that I was head of department in the RCSI.

Q Do you have specific areas of interest in terms of your research?

A Well, I suppose generally as a microbiologist you can be engaged in research in different kinds of molecular research or virulence. I suppose my particular areas have been in the epidemiology patterns of infection in hospitals; preventative measures, including, for example, enhanced decontamination or cleaning; and then looking at trends over time. Those would be the general areas, although I have conducted and been involved in research in other areas such as basic pneumococcal disease – pneumococcus causes bloodstream infection and meningitis.

Q Would the general public understand your research to be in areas including hospital-acquired infections?

A I think they would, yes.

Q In relation to that area, hospital-acquired infections, and more generally in infection prevention and control, have you written in peer-reviewed journals?

A Yes. Over, I suppose, nearly 30 years or more, yes.

Q In terms of that area, infection prevention and control, approximately how many peer-reviewed journal articles have you written?

A In total, over 300. I suppose if you were to look and categorise them as infection prevention and control, probably two thirds or more would be in that particular area.

Q So, would it be fair to say, in terms of the summary of your career history and professional background that you have set out, that for approximately 30 years, you have been involved, both working in and researching into healthcare-associated infection and more generally infection prevention and control?

A Yes, I think that's a fair summary.

Q Now, you mention within your report at page 6 that you chaired a hospital infection prevention and control committee both in Nottingham and in Dublin, a post that you held. Can you explain to the Inquiry, what do you mean by “an infection prevention and control committee”?

A Okay. So apologies if you see me looking to the left. I have

the document up on my left, so I'll be referring to it as you make reference to it, so I hope you don't think I'm not paying attention to you. So, that would have been a multi-disciplinary committee which would have met frequently, such as maybe monthly. It would look at data, would make recommendations about measures that should be taken to improve prevention and control and then would liaise with senior management. It had become more formalised, I think, in the UK in terms of more formal recognition of, for example, a doctor who would head up on infection and prevention control, but it certainly was, and continues to be in some countries, a format in which, if you like, a microbiologist has input into hospital strategy and measures to minimise hospital infections.

Q So, effectively a committee – you said multi-disciplinary – that would meet to discuss and try and mitigate hospital-acquired infection and infection prevention and control issues more generally?

A Correct, yes.

Q You mentioned being president of the Health Care Infection Society.

What is the Health Care Infection Society?

A So that's a society that was established about 40 years ago, initially driven by microbiologists like myself to heighten awareness, research and education in hospital infection, and subsequently more widely healthcare-associated infection, which includes things like residential institutions, nursing homes. It includes microbiologists, both medically trained and scientifically trained, infection prevention and control nurses, epidemiologists, scientists and others. It publishes a journal, the Journal of Hospital Infection, which would be regarded as one of the international leaders in the field and it awards research grants, organises educational meetings and engages in advocacy. Although primarily it's based in the UK and would have largely a UK membership, it has membership from outside the UK in Europe, North America and beyond.

Q Thank you. Now you mention at the bottom of page 6 of your report, or the bundle with your report in it, you describe your research as being "applied/translational". What do you mean by that term?

A Well, microbiology is both a clinical specialty, but it's also a science. So, at the scientific level, the kind of research that might be undertaken would be at a very detailed level about virulence factors and genetic components in the laboratory, but it might not necessarily relate to medicine or to healthcare generally. So my research has largely been looking at, "What can we learn in microbiology that we can apply to the care of patients in hospitals or elsewhere that will mitigate some of the consequences of being admitted in hospital?"

Q You are familiar with a document called the Health Technical Memorandum 03-01 from 2021?

A Correct.

Q What is that document?

A It basically, I think, lays out a lot of very useful and interesting information on ventilation and the requirements required for this and they are documents that are used, not just in the UK but beyond, because of the expertise that's collated together within them.

Q Did you provide input in relation to the latest version, the Health Technical Memorandum 03-01 of 2021?

A I did, but I would say it was nowhere near as great as the input of many others. My input was largely one as a clinical microbiologist to give a sense of whether or not the

measures and recommendations were both comprehensible and relevant to clinical care.

Q Who asked you to become involved?

A I think it was the chair, or the lead, of that particular group that was devising that guideline, or that document, rather.

Q In terms of the guidance which the Inquiry has already looked at, that would be an individual called Malcolm Thomas. Is that correct?

A Correct, yes. Yes, I know Malcolm.

Q Now, you mentioned that you reviewed the document and I think you said that you had a relatively limited input, but you are recognised as a contributor, is that correct?

A That's correct, yes, I'm listed in the contributors. I was a bit surprised to be listed as a contributor because although I suppose I technically did contribute, I didn't feel my contribution was as much as many others who were involved in it on a more continuous basis.

Q Again, whenever you reviewed that document, could you just explain to the Inquiry the type of input that you had?

A Well, I'm a medically trained clinical microbiologist. I'm not an engineer, an architect or a technical services person so I suppose I was looking at the document to see, number one, did it make general sense in terms of what it was recommending, in terms of aspects of infection prevention and control? Number two, was it sort of understandable and comprehensible? Now, any document like that has a lot of technical information and that technical information is very valuable and I need some guidance through certain sections of it, but the sense that it would be relevant, would be important and would be largely comprehensible in terms of its general principles and advice to people like me working in hospitals and beyond.

Q Okay. So, in terms of the review that you undertook of that document, did you have any significant concerns in relation to its content from an infection prevention and control perspective?

A No, I don't recall that I did.

Q So, we will come on to look at this in slightly more detail, but you will be familiar that there is a table within that guidance which sets out a whole range of parameters within a hospital, table A2. For example, pressure regimes and air changes per

hour?

A Yeah, correct. Yes.

Q So would you have reviewed that in terms of reviewing the draft Health Technical Memorandum?

A I would have looked through it. I wouldn't necessarily have provided detailed feedback as to whether the precise mathematical specifics of the air changes or whatever were correct. It was more whether the overall tenor of it, the general recommendations, were what I felt was reasonable or not.

Q What was your view on the overall tenor of the document?

A I felt that it was fairly logical and was plausible in terms of what we're trying to do in these circumstances.

Q Just to be clear, what do you mean by that, "What we were trying to do in these circumstances"?

A Well, that the recommendations were based upon either evidence or what was known to be appropriate and that they were reasonable in terms of what could be implemented. So, for example, obviously the more air changes you have in a facility, in theory, the greater the dilution of any contamination in the air, but you may not require huge air changes where the risk is relatively

low. So, that sort of balance between making sure we have preventative measures in place, but that they are, I suppose, balanced by other aspects such as expense, space and so on.

Q So the values that we see within that document, should they be understood as being a compromise following discussions between multi-disciplinary parties, engineers, infection prevention and control clinicians and the like?

A In the general area of research in this area, there are certain principles that have been shown to be the case, which is that the more air changes you have, the more dilution of contamination you have, the better the quality of filters you have, the less likely you are to get contamination coming through, but, for example, if you're asking me "Is there a strong evidence that, for example, six air changes per hour is better than five or not as good as seven?" I don't think you can be as precise as that. In fact, internationally, there are some variations into what people would recommend in terms of air changes per hour, in some of the parameters that are laid out in this document.

Q Thank you, Professor. If I could ask you to move on within your report in the top right-hand corner of

page 8, we are at section 2, the Executive Summary. Now, you begin by dealing with the whole concept of "healthcare-associated infections." Can we just be clear, what do you mean by that term?

A Okay. So, if you go back about 20 years or more, people talked almost exclusively about hospital-acquired infections. In other words, it was just about infections acquired in hospital. So the term "healthcare-associated infections" is a broader term. It takes into consideration infections not only acquired in the hospital that – be it the outpatients, the emergency department, or the ward – but it also includes infections acquired in GP surgeries, in nursing homes, in residential units. So it's a broader term than simply "hospital-acquired infections".

Q You state a range of factors that would be relevant to a patient acquiring a healthcare-associated infection. So those include "virulence and transmissibility of microbes." What do you mean by that?

A So, virulence would be how dangerous a bug is or a microbe is. If you take, for example, something like rabies, which has an almost 100 per cent mortality, as opposed to a

virus that might cause a common cold like rhinovirus. Again, anthrax would be regarded as a very virulent bacterium, whereas a staphylococcus found on the skin of all of us would be regarded as of low virulence. Then transmissibility refers to the capacity of that microbe, whether it be virus or bacteria, to spread from one person to another. So, for example, the current Omicron variant of SARS-CoV-2, the cause of COVID 19, is more transmissible, it's easier spread than, for example, earlier variants.

Q You also mention a relevant factor would be the vulnerability of the patient. Again, can you just explain what you mean by "the vulnerability of a patient"?

A How prone they are to get infections. So if we take, for example, the very young – by that I would mean, say, premature neonates – or the very elderly people who are maybe in their eighth or ninth or beyond decade, perhaps more specifically, patients who, by virtue of an underlying disease, such as a cancer or leukaemia are patients who are on treatment that reduce the body's defenses in terms of coping with infection, such as high dose steroids. So that's what I mean by the vulnerability. So, a healthy 40-year-old

male coming in for a hernia repair is not as vulnerable as maybe a 70-year-old patient with leukaemia and underlying diabetes mellitus and I would say, just to finish on this particular point, I would say the cohort of patients who are vulnerable to infection has probably increased over the last number of decades, largely because we have been better at treating many of their underlying diseases, such as cancer.

Q Thank you. Now, just in terms of a couple of terms that have cropped up in the Inquiry so far, there has been references to "immunocompromised patients." What would you understand that term to mean?

A I suppose immunocompromised, and I would admit that there's a certain amount of maybe looseness in the use of terminology here – I suppose immunocompromised patients would be maybe a subcategory of vulnerable patients where specifically their immune system is compromised. Now, that can be compromised because they were born with a defect – although that's relatively rare – but more likely it might be because they've got an underlying disease such as cancer or they're on treatments, such

as chemotherapy for cancer, which affects the immune system in its efforts to, if you like, kill the cancer cells. So "immunosuppressed" would be patients with cancer on chemotherapy, patients with leukaemia, patients who have had organ transplantation, patients with HIV disease would be examples of this kind of patient.

Q Thank you. Another term that has cropped up in the work of the Inquiry is the term "neutropaenic patients". What does that mean?

A So neutrophils are cells found in the peripheral blood – that's blood that you might, for example, take from an arm giving blood for a test – and it's a white blood cell and it's important in the immune system. One of the things it's particularly good at is partially digesting or altering the surfaces of bacteria or viruses so that other parts of the immune system can kick in. So a patient who is neutropaenic means that they have virtually no neutrophils, sometimes no detectable neutrophils, and so those patients would be particularly regarded as highly vulnerable to infection, and particularly to opportunist infection. The term opportunist means, if you like, microbes that would not normally affect a normal individual with a normal immune system, but would do so

somebody who is immunosuppressed, particularly severely immunosuppressed. So an example of that would be aspergillus fumigatus or aspergillosis, which is a fungus which is all around us, doesn't normally affect individuals who are well and healthy, but if you were severely neutropaenic, and particularly for a prolonged period of time, would be at high risk of invasive aspergillosis affecting the lungs and possibly the brain and spleen as well.

Q Within your report, still dealing with risks of healthcare-associated infections, you also mention “compliance with optimal professional practice” being relevant. What do you mean by that?

A So that refers to healthcare staff, be they doctors, nurses, allied healthcare professionals, and their approach to the management of patients or clients. So I suppose, if you think about it in general terms, how fastidious are they, how conscientious are they, how careful are they that, for example, they ensure that they washed or decontaminated their hands before approaching the patient or in the care of an IV, intravascular, line or drip? That's what I mean by “professional practice”. Do they wear personal protective

equipment when they should do so? Do they take it off appropriately? So all of those kind of activities, human behaviors are very important in preventing and controlling infection.

Q Then the final factor that you list is specifications of the physical environment. Again, in layman's terms, what do you mean by that?

A I suppose the facility or the building in which the patient or the client is being cared for, in terms of is it clean, is it bright, is it spacious, is it airy? Does it have additional measures when the particular patient is at very high risk of infection, such as controlled ventilation? I think it's probably fair to say that as the cohort of patients in hospital have become more complex and older with more vulnerable and immunosuppressed patients, I think those aspects perhaps have become more important in terms of our understanding of the risks that those patients face.

Q Okay. So, if I understand your position, having run through all those issues, there is really a range of factors that are in play in relation to risks associated with healthcare-associated infections, is that correct?

A Correct.

Q In terms of the physical environment specifications and the

physical environment, is that one factor among many or is it more important than others?

A I think it's one factor amongst many, but it is more important in certain categories of patients than it would be in others. So, again, go back to my example of the male in their forties coming in for a hernia repair, it's not so critical in that sort of patient. But, clearly, in the patient with leukaemia who's neutropaenic, it is much more important.

Q So could there be scenarios within a hospital where there is adequate ventilation and a patient nonetheless still contracts a healthcare-acquired infection?

A Yes, yes. So some infections are spread by contact. So if, for example, a healthcare member of staff hadn't adequately washed his or her hands and were carrying a bug on their hands, they might pass that on directly to the patient and the physical infrastructure might not be that relevant in that particular situation where there was a breach in infection prevention and control measures.

Q Now, am I correct, in terms of the ultimate analysis in your report, that your ultimate conclusion is that inadequate ventilation would create a risk to patient safety and care

in a hospital environment?

A Yes, it would. I think it would vary depending on the part of the hospital and in the categories of patients being managed there. But, yes, that's correct, and I think that's probably increasingly recognised as a result of what we've learned during the pandemic.

Q So are there specific patients that are at higher risk if there is inadequate ventilation in a hospital?

A I think those-- Well, there's, first of all, the patients who are at risk because the patient has a transmissible infection. So, for example, if you have a child or an adult with measles, that's quite transmissible, and so if that individual patient is not managed appropriately in an appropriately ventilated facility, then that patient can transmit the measles to other patients in the hospital. Then there's the patient who's very vulnerable to infection, severely immunocompromised. Again, if we use the example of the neutropaenic patient, if he or she is exposed to air that is not filtered adequately, then they may be exposed to those opportunist microbes that I told you about, including aspergillus.

Q Within page 8 of the bundle, so still within the executive

summary of your report, you refer to a body of evidence in relation to risks associated with immunocompromised patients. Can you just explain what you mean by that body of evidence?

A I suppose it's partially good research studies that have been done over the years and partially experiential, which is, you know, our experiences and how we report on them and how we share our information. I think increasingly – as you and others, I'm sure, will know – over the last 20 or 30 years, we emphasise evidence-based medicine. So where we have good scientific evidence, we apply that in the care of patients. Now, there isn't necessarily strong evidence for some of the things we do in healthcare, including in infection prevention and control, but there is common sense and intuition and what I call biological plausibility. In other words, that-- if you, for example-- By that I mean-- If you think about this from a logical point of view, that the more bugs you have in a particular area, the more likely you are to get infection. So if you reduce the number of bugs, then you're less likely to get infection, even if you haven't shown that in some sort of scientific or experimental setup.

Q So just to make sure that I am understanding: there might not be actual scientific experiments that you can point to, but in terms of your experience, you are talking about a plausibility drawing upon experience in the field of microbiology?

A Yeah, yes. I mean, I think it's fair to say, and most people would recognise, that unlike, for example, in the treatment of cancer or, for example, the use of vaccines, the rigour of the evidence for some of the things we do in the prevention of healthcare-associated infection would not be of the same standard. One of the reasons for that is that often what we do is multipronged. We do a number of things at the same time. So to separate each individual component of that and to say, “Well, this particular part, reduce it by 20 per cent, and this part, reduce it by 30 per cent,” is not possible, I'm afraid.

Q Is that why, in fairness, in your report, you talk about risk as a general concept, but very fairly say, for example, in the executive summary, “it is challenging to quantify that risk, and to make an estimate as to the risk when there are deviations from recommendations”? Do you see that?

A Yes, I-- Yes, that's something that I think is-- It would be, obviously, ideal if we were able to say

that if a certain factor is not in place, it increases the risk by twice or three times. But we're not in a position to be as precise as that in terms of many of the interventions we take in the prevention and control of healthcare-associated infections.

Q So, at this stage, really talking at a level of generality, we are talking about risk associated with inadequate ventilation in a hospital as opposed to you as an expert being able to talk to an absolute causation to a specific outcome for an individual patient. Is that correct?

A Yes, I think that's a fair summary of the position as I would see it.

Q Can you explain, please, Professor Humphreys, what role do clinical microbiologists have in infection prevention and control, specifically in the identification, management and mitigation of risk?

A So the clinical microbiologist or infection specialist, as the role may be undertaken by an infectious disease physician in parts of the UK and elsewhere, would essentially be involved in surveillance, in other words, the overseeing of the collection of data to see trends over time and to see, for example, whether or not there has been an increase in

number of infections on a particular ward. He or she would liaise with the laboratory in terms of the laboratory results that might confirm those infections. He or she would be involved in both ongoing strategies in terms of infection prevention, such as increased cleaning or decontamination, or in response to outbreaks, and would review information over time to see what needs to be done in the future to improve things or what needs to be done in terms of how to react to something new, whether it be a new multidrug-resistant superbug or, as we've seen over the last two years, COVID-19.

Q How would a microbiologist or an infection prevention and control committee link into a hospital management board?

A Increasingly now, the leadership, if you like, and the direction of infection prevention and control in hospitals and other healthcare institutions is more at senior management level than it would be, say, 20 years ago. It's now, in the UK and in Ireland certainly, very clearly within the remit of the chief executive officer or his or her delegate as would be seen fit, and it certainly would be something that would be looked at by

trustees or by boards in terms of the safety of the hospital as part of patient safety.

Q Would some form of risk register be maintained?

A That's been my experience over recent years, yes.

Q Can you explain what you mean by a risk register?

A I think a list of issues either that need to be addressed or, in some instances, may not be addressed, and then a judgment as to whether or not the risk is low, medium or high. When I've seen risk registers, it's usually a red-- something that's in red indicates something that needs to be addressed urgently, something that's in amber is maybe something that is a priority but wouldn't be as high a priority, and then either yellow or green is something that needs to be done at some stage or other but is-- represents a relatively low risk.

Q Thinking again about microbiologists and infection prevention and control officers, are there key performance indicators in this space?

A I think most people would accept that there are and indeed there should be, otherwise how do you know how well you're doing or how poorly you're doing? So I think in the UK and

Ireland, key performance indicators would be the number or the rate of acquisition of clostridium difficile or C. diff infections in hospital or the number of hospital-acquired bloodstream infections due to MRSA or, for example, the number of new cases of, say, multidrug-resistant bacteria like CPE, which stands for carbapenem-resistant Enterobacterales. So that's a more recent, if you like, multidrug resistant bacterium.

Q So would they effectively be looking at standard issues or standard pathogens that might be encountered?

A Correct, and you'd also be looking at, if you like, either a target that you should be below or looking at a range in which you should fall depending on the category of hospital you are and the risk. So, for example, if you're a tertiary referral centre, it might be expected to have more complex patients and therefore your rates might be higher than if you were a fairly uncomplicated district general hospital.

Q What about the converse? What about rare pathogens? Would there be any key performance indicators in relation to those?

A Yeah, so, I mean, a good

example of that would be, for example, legionella. So legionella is usually acquired in in the community or perhaps travel associated. But if you had, say, a legionella being diagnosed in a patient who's been in hospital for two or three weeks, you would know that because the incubation period is up to two weeks at most that that was almost certainly acquired in hospital. That would ring alarm bells in terms of looking to see what the source was and whether measures were in place that should be in place to prevent hospital-acquired legionella.

Q How should those responsible for the management of a hospital respond to the identification of rare pathogens?

A Well, first of all, I think very quickly, and certainly would need to convene a group to address the issues, to, first of all, decide what nature of investigation would be required, what measures need to be taken, if you like, to prevent any further cases and then look at why it might have happened and to learn from it in the future, as well as obviously dealing with ongoing cases if they occur in terms of making sure those patients are adequately managed.

Q So, within a hospital setting, if concerns were raised by

microbiologists, how would you consider those should be dealt with by hospital managers?

A Well, if you're talking about a case of hospital-acquired legionella, then I would think it should be-- it should ring alarm bells and should be dealt with immediately and should be overseen by the CEO or his or her delegate, and normally they would regard that as a very serious occurrence, and rightly so.

Q Thank you. Moving on, within paragraph 3.2 of your report, so that's on page 9, you use the terms----

THE CHAIR: Sorry. Sorry, Mr MacGregor, I wonder if you quite got an answer to your question. The question, as I have noted, “If concerns were raised by microbiologists,” and the answer is, “If legionella, alarm bells.” Now, the two things may connect, but I just wonder if the-- Sorry, Professor Humphreys, but I am just trying to make sure I have absolutely got your evidence.

MR MACGREGOR: Professor Humphreys, I asked you the question in terms of if concerns were raised by microbiologists, how those should be dealt with. Certainly my understanding was you would go to say that, certainly for particular issues, that it should be really raised at the highest levels

within management. But again, if you could just explain what your evidence is, please.

A Yeah, sorry, I went perhaps on a side issue with legionella. But I suppose in other areas, on an ongoing basis, I think there's an increasingly recognised relationship between senior management and infection prevention control team, as it were, including the clinical microbiologist if he or she is the lead of that, and he or she would be liaising regularly with senior management on ongoing measures and in terms of strategy, but also in terms of any unexpected occurrence that might take place, including outbreaks from time to time. So, yes, there needs to be very clear governance on the relationship between those who are the infection prevention control team and senior management. I'm not sure if that's answered the question more comprehensively.

Q Thank you.

THE CHAIR: Thank you.

MR MACGREGOR: I was moving on to look at paragraph 3.2 of your report, which is on page 9 of the bundle. At that section in your report, you use the terms “pathogens” and “microbes”. Can you explain what you mean by those?

A Yes, so a microbe is a microbe such as a bacterium, a virus or a fungus, but it mightn’t necessarily cause disease. So there are lots of bacteria, for example, in the environment that we never come across in terms of human health. A pathogen implies that, in some or all circumstances, it will cause disease, whether that is symptomatic or asymptomatic. So, for example, if we take a bacterium called staph aureus, the resistant version of which is MRSA, you may see that in the environment, you may carry it in your nose, but it can cause significant illness, including bloodstream infections.

Q You mention at paragraph 3.2.2 of your report:

> “The factors influencing whether or not a hospital patient acquires a pathogen can be described or categorised into three areas: host, actual pathogen and environment.”

If we take each in turn, what do you mean by host?

A So the host, I mean the patient and his or her vulnerability. So, going back to what I said earlier on, if the patient is very elderly, a lot of

underlying diseases, malignancy, on drugs that affect the immune system, then they are especially vulnerable. The pathogen will depend upon, I suppose, its virulence and its propensity to cause disease in different circumstances. So perhaps if I can give you an example of that: if you take a bacterium called staphylococcus epidermidis, this is a bacterium we all have on our skin, as the name epidermidis may suggest. On the skin, it causes no problems. However, if it gets into the bloodstream and you have an artificial heart, then you may get a condition called endocarditis, which is an infection of the heart, whereas, if you look at a pathogen like staph aureus, we would generally say that that's more virulent, more pathogenic, and you may get an infection even in the absence of something unusual, like having a heart valve. Then the environment is really some of the things we've touched upon, the infrastructure, the space, the cleanliness, the decontamination of instruments; but also, I include in that the human environment, and going back to, again, what we said was, if you like, the personal professional practice in human behaviour.

Q Again, can you just explain what your position would be in

terms of the interplay between those three factors, in terms of the risk of a healthcare acquired infection?

A I think that, obviously, in a situation where you have a very vulnerable or immunosuppressed host or immunocompromised host, where you've got a very severe pathogen, and where you've either inadequate environment or poor professional practice, then you've a cumulative effect in terms of the risk to the patient. As I said, you might have a very vulnerable patient and you might have, you know, a pathogen that could cause infection in that patient, but because they're in maybe a-- good circumstances and there's good professional practice and a variety of other factors, they might not get infection. I'm not sure if that explains what you had in mind.

Q Yes. Thank you, Professor Humphreys. If we look within-- at page 10 of the bundle, paragraph 3.24, I think fairly you state there:

> "The interplay between the virulence of the microbial pathogen… and the patient, particularly the patient's immune response, governs whether or not the individual gets an infection, and if so, how severe."

Then you go on to say that:

"While many microbial virulence factors have been described in the laboratory, linking one or more of these to a particular infection and its severity in an individual patient is often not easy."

Is that correct?

A That's correct, yeah.

Q Within page 10 of the bundle, you talk about intrinsic factors and extrinsic factors. Again, what do you mean by those terms?

A So, by intrinsic factors, I mean those, if you like, internal to the patient, so for example, their age, whether they've got underlying disease like diabetes mellitus, maybe whether they smoke, maybe whether they're obese or overweight, and so on. Some of those are modifiable, but some of them are not. Then extrinsic risk factors in terms of what happens to the patient in hospital or in healthcare, what drugs we give them, what kind of procedures, what measures we might do that, while important – such as an operation – might render them more vulnerable to an infection.

Q Again, am I correct in saying, as you summarise in paragraph-- at page 10, that really there is a limit sometimes to what you

can do in terms of intrinsic factors in relation to a patient?

A Correct, so particularly if the patient is admitted as an emergency. So, if a patient is admitted electively or it's a planned procedure, you can ask them perhaps to try and lose weight, to reduce smoking, you can try and optimise the control of their diabetes mellitus and so on; but if they come in as an emergency with a perforated appendix or a perforated colon and they need urgent emergency surgery, well, in that situation, you don't really have time.

Q For those patients, can extrinsic factors such as the environment be particularly important?

A Well, in those circumstances, what would be particularly important would be that the-- obviously, if we take that example of the emergency surgery, that the surgery is done quickly, that it's done in an appropriate operating theatre, that the surgical team take all due precautions necessary so that, even though this patient has not been prepared for surgery optimally, then the risk is mitigated to some extent.

Q Are you familiar with the terms natural ventilation and mechanical ventilation?

A Yes.

Q Can you have natural ventilation within a hospital setting?

A Yes, many parts of the hospital are naturally ventilated or traditionally have been naturally ventilated.

Q Are there certain sections of a hospital that should only have mechanical ventilation?

A Well, the operating theatre-- for most surgical procedures, it should be carried out in a controlled, ventilated facility. In other words, an operating theatre or an operating room. There are other areas of the hospital, pharmacy, laboratories, central sterile units where, for procedure reasons, they need ventilation. Then also you need controlled or artificial ventilation where you have either patients who are vulnerable to infections, such as the patient neutropaenia, or where you have patients who pose a risk to other patients, such as the patient with measles, patients with infectious tuberculosis. There are other areas as well, but those are some examples.

Q Now, within your report, you mention at times prophylactic antibiotics. What are they?

A So most individuals think about antibiotics as drugs that are given to treat infections; so you have a urinary tract infection or cystitis, and you go to your general practitioner and he or she gives you an antibiotic to take for that. In prophylaxis, we're either talking-- we're usually talking about prevention, either primary or secondary prevention. So primary prevention would be the patient goes, for example, for an elective procedure – let's say for an artificial knee joint replacement – and the surgical team, or maybe the anaesthetist gives one or two doses of antibiotics starting just before the procedure. Why does that happen? Because as the surgeon goes through the skin, into the joint, he or she – despite best procedures – may introduce bacteria into that area, whereas by giving a dose of antibiotic before the procedure, you're getting blood and tissue levels of an antibiotic that can kill immediately that bacterium before it may lodge on the new joint. So that's an example of, if you like, primary prophylaxis or surgical prophylaxis.

Secondary prophylaxis would refer to maybe more so in the community where, for example, if you've a case of meningococcal meningitis, you would give prophylaxis to their close contacts, such as people living in the same household.

Q Would you need patient

consent to administer such antibiotics?

A Yes, you would. That would almost always be-- For example, in the case of the surgical patient, it would be included in the surgical consent.

Q Within your report, at page 13 of the bundle, you introduce the concepts of source isolation and protective isolation. If we could take each and in turn, what do you mean by "source isolation"?

A Source is basically where you have a source of infection, so you have a patient with a transmissible infection and you're trying to prevent that infection spreading to other patients in the immediate area. So, you know, it might be-- we talked about measles earlier on, which is highly transmissible; you want to prevent the measles in the patient who is admitted to hospital spreading to other parts of the hospital. Another category of infection would be influenza and indeed COVID-19.

Whereas protective isolation, you're basically using the isolation to protect a patient or a group of patients. So, again, go back to the examples we've used already, the patient with neutropaenia. We agree, I think, that patient is highly susceptible to infection. We want to protect him or her, so we put that patient in isolation to protect him or her getting microbes from other patients in the ward or indeed members of staff.

Q So again, if we could go back, for source isolation, what pressure regime would be required?

A Well, in that situation, you want to make sure that the air in that patient-- because the patient is the source of the infection, you want to make sure that the air surrounding that patient doesn't go out to the rest of the room. So you want it, basically, to be negative. You want the air to be coming into that patient rather than going out from that patient because, if the air goes from the patient to the rest of the area, it will bring whatever pathogen they have, such as measles.

Q Then the converse of that, if you wanted to achieve protective isolation, what pressure regime would you require?

A You want the air, in other words, to be positive. You want the air to be going from that patient. So that patient is-- doesn't have an infection, but he or she is at risk of infection. So you want to protect that patient from the air outside the isolation room, so you want positive pressure, so the air going from the patient's area, the patient who is vulnerable or

immunosuppressed, to the rest of the ward rather than the other way around.

Q If we just think for a moment, Professor, about the consequences of potentially getting the pressure regimes wrong. So take, for example, neutropaenic patients, what would be the potential impact on a neutropaenic patient if you got the pressure regime wrong?

A Well, they would then become vulnerable to any microbes, including pathogens, that would be outside their isolation room in the ward, whether it be multidrug resistant bacteria such as MRSA or, if there wasn't adequate filtration, fungi – including aspergillosis.

Q Potentially, how serious could that be for a neutropaenic patient?

A Well, aspergillosis, for example, is a very serious infection, and even with appropriate treatment, antifungal treatment, it can be difficult to treat, particularly if the neutropaenic state is prolonged. So, yes, it could be very consequential.

Q If a neutropaenic patient was in the wrong pressure environment, would you expect that risk to be identified?

A I would hope it would be. It should be if measures are in place to

make sure that that patient is in the right air-controlled facility. Now, you know, some isolation rooms have the facility for them to be switched to protective or source isolation, and it's absolutely really important that the correct category is provided for the right category of patient.

Q Just at a practical level, how would it be ensured that such a patient was in the correct pressure regime?

A By checking that the ventilation was switched to the right category and documenting it.

Q Now, in relation to ventilation systems themselves, I think you very fairly say at page 14 of the bundle that you're not an expert in the detailed technical specifications for a ventilation system. Is that correct?

A That's correct, yes.

Q But you offer some observations in terms of how one might go about setting regimes within hospitals. Is this really a balance amongst a whole range of factors?

A Do you mean between different ventilation facilities or between the ventilated facilities and the rest of the hospital?

Q I think amongst a whole host of factors, are we talking about balancing logistics, common sense,

plausibility; are all of those issues in the mix?

A Yes. So we've identified some areas in the hospital where I think it's-- and it's in the various official documents, both English and Scottish documents, where we recognise that we need ventilation. The question really is, for example, how many operating theatres you need will depend upon what your throughput is and what your planned throughput is likely to be over the next ten years or more. The number of air-controlled rooms, whether they be for patients – excuse me – who are highly vulnerable to infection or whether they be for patients with infection, again, will depend upon your case mix. I suppose the more of these, obviously, you have, the better, but you've got to balance that against, you know, the cost of both building those facilities, the cost of maintaining them – increasingly we're aware of the energy issues – and then obviously, you know, there may be space.

So, for example, I recall a particular situation in my own experience where we were modifying an existing facility, and we had a guideline which said "You need X amount of square metres for a particular unit for each room" but on

the other hand, if we went to that, we would have significantly less room so we would have less, if you like, access to the service that we were providing. So there was a compromise made that we would slightly reduce the size of the room in that facility to make sure we had enough rooms to provide the service that we were that we were trying to provide.

So that's an example where sometimes, particularly in existing facilities, it can be difficult, if you like, to get all the parameters right because there are some constrictions in place; and of course there's often also a budget in place which may or may not allow what you might ideally like as opposed to-- And indeed you're often trying to not only decide what you need for now, but also decide for what you think you will need over the next 30 years, but it can be more difficult to justify what you think you're going to need over 30 years as opposed to what people will say, "Well, we clearly need X number now. Do we really need X number plus Y in 30 years' time because we're spending money now, the benefit of which we may not see for some time."

Q So a range of factors to be considered, including cost.

A Correct.

Q Would you consider that overprovision or overengineering would equally be undesirable in relation to healthcare ventilation?

A Well, as a kind of microbiologist in infection prevention and control person, I probably would be arguing on the overengineering aspect of it. I would say they need, perhaps-- you know, I've been looking into the future and saying we need to-- as I said to you earlier on, I think the cohort of hospitalised patients is becoming more complex, so I would be anticipating what our needs would be. I think particularly that's been, I think, well seen with COVID-19, but on the other hand, there are there are mechanical and physical restrictions on what you can provide. So there has to be, I suppose, sometimes a certain amount of compromise in terms of what's likely – even allowing for what you hope you would be able to provide now and into the future.

Q Just moving on. In page 15 of the bundle, you return to look at the two tables that we have touched upon before. So, firstly, appendix 1 from the Scottish Health Technical Memorandum, and then secondly appendix 2 from the Health Technical Memorandum in England. Am I right in thinking that you say, at page 15,

that there is no particular science that you are aware of that justifies really any particular of those air change regimes?

A Well, what I would say perhaps maybe more correctly with more precise science: I think that, if you look at what's recommended, it's-- it makes a lot of sense, it's plausible because you're basically, for example, increasing the air changes according to where you think there is risk, and you're applying what we know biological-- So, I mean, there is, I suppose, intrinsic biological plausibility – call that evidence, if you like. What I suppose what I'm trying to get across and perhaps I haven't explained it adequately, is that there isn't a sort of a randomised control trial which says that, for example, 10 air changes per hour is as good as 12 or 13 air changes per hour but, in that ballpark, you're in the right place to, if you like, optimise the facilities that you provide.

Q So, for example, if we took critical care areas that have 10 air changes an hour, in your professional opinion, would you be able to say whether 11 was better than 10, or 9 was equally as good as 10, or is that simply impossible?

A I'm not sure I could. I mean, I think if you look at the

mathematics of this and, again, this is technical areas that-- you get dilution-- you get more rapid dilution the more air changes you have, but you still get fairly good dilution of contaminated air in a relatively short space of time even with 10 air changes per hour.

Q In your opinion, is there though a risk associated with reducing air changes?

A There is a risk, but I wouldn't be able to give you a judgment as to how significant that risk would be. I mean, if you go from, for example, looking at that page you're referring to. If, for example, you've got-- you talk about 25 air changes for a general operating theatre and you go down to 15/16, then I think you're into territory where there may be a significant risk. On the other hand, if you're going from 25 to 20, the risk may not be so great. In any event, over time, over-- with age, air changes within an operating theatre may decline due to, if you like, the longevity of the plant, as it were.

Q So if we look at page 15 of bundle 6, approximately six lines up from the bottom of the page, is that why you reach the ultimate conclusion by saying:

> "Hence, while it is difficult to be definitive, ACH of 7, 8, and 9 might still give significant protection, but those at 5 or less would probably not as they would be similar to what you would see in a non-mechanically ventilated area. Nonetheless, failing to implement guidelines is likely to increase the risk of adverse events occurring, such as infection, even if quantifying this increased risk would be challenging generally and especially in the case of an individual patient."

Yeah, I mean, that would be my view, and it's my opinion and it's my judgement but I'm not saying that there might not be others who might take a contrary view. But my understanding of the whole role and value of ventilation and the impact it has, with other measures to prevent and control infection, that would be summarised there.

Q In terms of the importance of flowrate within a hospital ward or room once comfort levels have been achieved, does that really depend upon the clinical context you are dealing with?

A Yes, I think so. So, again, if you look at the situation-- Well, let me just give you an example.

So let's say you have a general ward, and you have a-- the patients are stable, there's no infection. You might have, for example-- generally people say you have about six air changes per hour in a normally ventilated room. Now, if you have a situation where you're trying to reduce infection being transmitted by, for example, SARS-CoV-2, we try to increase those air changes by opening windows and opening doors, even though obviously there's a comfort issue there. So there's both the air changes per hour, there's the direction of the air and then there's the filters that you were using, as I understand it, are what's important there. So, the greater the air change is, the greater dilution you have, reducing the number of contaminants in the air and therefore the safer it is. That's generally the principle upon which we work.

Q If I could ask you, please, Professor Humphreys, to look within bundle 1 to page 837 and to paragraph 5.6, please.

A Still in my document, is it?

Q No, in the top right-hand corner it should say "page 837". It should be from SHTM 03-01 Part A.

A I've got 756, let me just see.

Q It would be page 837.

A Sorry, no.

Q Top of the page would have "5. Ventilation Strategies".

A Excuse me. What page is it again, Mr MacGregor?

Q So, in the top right-hand corner, it should have "page 837".

A I've got 756. I wonder if it is just further down the pages. Let me just see. 970. 837. Sorry, I have it now, apologies.

Q Thank you. Do you see at the bottom there, there is a paragraph 5.6?

A Yes.

Q That states:

"With natural ventilation, it is almost impossible to maintain consistent flow rates and ensure that minimum ventilation rates will be achieved all times. However, this variability is normally acceptable in non-clinical spaces such as office accommodation, staff areas, library/seminar rooms and dining rooms, and some clinical areas such as level 0 and 1 care spaces and waiting and consulting rooms where risk of airborne infections is likely to be low."

Do you see that?

A Correct, yes.

Q Would you agree with that statement?

A I would, yes.

Q So, is it fair to say that if a purpose of a particular room or ward is neither control of infection from an infectious patient or protection of a particularly vulnerable patient from infection, the flow rate is not clinically important?

A No, and if you look at, even in-- we talked earlier, I think, in terms of naturally ventilated areas in hospitals. Often, in general medical and surgical wards where we believe that we have low-risk patients for infection, often they would be naturally ventilated, even though patients would be there for a period of time.

I think the difficulty we're now facing is that within that category are a cohort of what we call “general medical or surgical patients.” We often have patients who are at some risk of infection because of advances in medical care, including the use of drugs that affect the immune system – biological agents, which are used to dampen down the inflammation in patients, like, for example, patients with rheumatoid arthritis or patients with multiple sclerosis. So, I think we're seeing changes in that and

obviously, if you've patients in hospital who are in those areas for whatever reason – so, for example, they have to move through the hospital to radiology or whatever – then if they're highly immunosuppressed, then it does represent a risk.

Q Thank you. So, is the principal purpose of flow rate in general wards, or non-isolation rooms, to ensure the comfort of patients?

A I think that's a fair comment, yes.

Q Would you agree that the need for a particular relative pressure environment depends upon the individual clinical context?

A Correct.

Q Is the principal situations in which it is required, to prevent the spread of infection from a room containing an infectious person, or to protect a particularly vulnerable patient from airborne infection?

A Yes. Those are two very clear categories in which you need dual ventilation in a single room.

Q Would it ultimately be a matter for clinicians to decide on the particular requirements of any ward or room?

A Yes and it also would be a situation where – and this often happens – you have to prioritise

maybe one patient over another because you may not have sufficient numbers of rooms in which to, ideally, cater for patients. So you might have to look at an individual patient and say, “Well, patient A is at greater risk than patient B”, even though you would also like patient B in a similar facility.

Q Are you familiar with the work of Dr Lidwell and what has been referred to as “The Lidwell Report”?

A Correct, yes.

Q Can you explain to the Inquiry, what is The Lidwell Report?

A The Lidwell Report – and a lot of the work that he and others did – was looking at, basically, the quality of air, in terms of the numbers of bacteria and air changes. It was done a number of years ago and I think has informed, especially in operating theatres, the design and specifications of operating theatres, not just in the UK and Ireland, but indeed beyond that. Of course, Lidwell was also involved in a seminal trial, a clinical trial, looking at the role of ultra-clean, ventilated theatres – or sometimes they are referred to as “orthopaedic theatres” – to reduce infection further in prosthetic joint, or artificial joint, surgery.

Q In terms of the work that Dr Lidwell did in terms of air changes

per hour, do you know what conclusions his research reached?

A I think, obviously, the more air changes per hour, the more rapidly you dilute the contamination in the air and, indeed, render very little, if any, of the residual air that's present. This comes up often in a context which I find where sometimes surgical colleagues want to have what we call a “septic patient” at the end of the list. So they're operating on a number of patients who are what we call “clean surgery” which is that they have no infections. They're going in to do a particular procedure. Then they have a patient who, for example, has an abdomen and pus needs to be drained from the abdomen. They want to put that patient at the end of the list believing that it's safer to do so, because he or she will not contaminate subsequent patients.

Now, if you actually look at the mathematics of it, once you get a very rapid dilution of existing microbes in the air in a very short period of time – for example, if you've got six air changes per hour in a room – after half an hour, with three air changes, you'll only have removed 95 per cent, so you're removing the residual contamination in that area very quickly over a relatively short period of time,

but obviously it depends on how long you can wait before you bring another patient into that operating theatre. Obviously, in other areas of the hospital, it will depend upon the air changes and how quickly you will get to that situation where more than 99 per cent of the residual contamination has been removed.

Q So, applying the principles developed by Dr Lidwell, after four air changes would approximately 98 per cent of contaminants in a space be removed?

A Correct, yes.

Q Does his research indicate that each successive change will remove a smaller and smaller number of contaminants?

A Yes, you're getting closer and closer, but never quite mathematically reaching 100 per cent removal of the existing contaminants. I don't know whether it's relevant, but interestingly enough, I came across a research paper a while back and again, this was not confirmed in clinical practice, but it was looking at the mathematics of all of this, looking at the risk in outpatient and emergency department, according to the number of air changes and the potential risk to healthcare professionals. I thought this was an interesting statistic, that

the risk of a healthcare professional acquiring TB from an infectious TB patient was 2 per cent or 1 in 50 if there were five to six air changes per hour and they stayed in that area for 15 minutes. So again, it's obviously related to how infectious the patient is, but it's also related to how long you stay in that area with that patient and how many air changes you are and the higher the number of air changes, obviously you can either stay in longer for the same risk or you reduce the risk.

Q Would you agree that whether there is any increase in risk or, if so, the extent of any increase depends upon the particular individual circumstances?

A Yes, I think it would, yes.

Q Just to return to the issue of natural ventilation, are you aware of whether higher summer temperatures impact on whether natural ventilation can still be relied upon?

A I know that over the course of my career I've often had queries from medical and nursing colleagues in the height of a summer when we've had a rare heatwave to say that "It's very hot in here and we believe that there's an increased risk of infection arising from the heat." Now, I think there's two factors there. I

think, first of all, there's the discomfort for patients and staff, and the fact that, if people are uncomfortable, they may not perform to the best of their ability. In terms of the risk of temperature *per se*, I've only seen one study, which was an epidemiological study in the United States, which showed a correlation or a relationship between increasing seasonal temperatures over the summer and post-operative surgical site or wound infection rates.

Now, they did try to control for other variables, things like the changeover of doctors, usually during the summer, a case makes different types of surgery and so on; but again, going back to that term I used earlier on, it's kind of biologically plausible because, if you have a humid environment and a warm environment, bacteria will replicate more commonly. Therefore, the skin on the bacteria, which will often be those skin that cause surgical site infection, may be higher in numbers when you've got a humid or hot condition.

Now, obviously, throughout Britain and Ireland, most of the year, we don't have such high temperatures, for example, into the 30s or beyond, but certainly it's potentially possible that, in those circumstances, you might get higher infection rates due to that

biological issue, but I think also because of the fact that staff will be uncomfortable and they may not be working at their optimal, if you like, capacity.

Q Would you regard four air changes per hour with mechanical ventilation supplemented by natural ventilation in a room to be a significant departure from a standard that required six air changes per hour?

A Yes, I'd find it difficult to make the judgement on that because it would depend upon what the nature of the natural ventilation was and whether it was continuous. So, for example, with natural ventilation, it's said that if you have the ventilation coming in on one side and going out at the other side, and if it comes in-- if it goes out at the top, it goes out quicker, so there are the various ways in which you can design natural ventilation to maximise the airflow through that area. So I think I would be cautious about making assumptions about that; that may be within the limitations of my technical expertise in these areas.

Q Thank you. I would just like to ask you a couple of questions about single rooms in hospitals. Is there a general trend towards near 100 per cent single rooms in modern hospitals?

A Yes. I think that's the view, that we should move towards that. Although, for the reasons-- some of the reasons we've discussed and for other reasons such as privacy and dignity, but I think there's also a recognition that there are challenges in doing so, and they're not just in terms of resources. There are downsides to single-- I mean, as a microbiologist, I would love to see 100 per cent single rooms because I think that would certainly contribute to preventing infection or could significantly contribute, but there are other issues to consider apart from expense. There's the issue of it's more difficult for nursing staff to observe patients if every patient is in a single room; there's a sense that some patients, when they're in a single room, feel stigmatised or isolated or cut off from other people; there's the issue of-- there's been some reports that, for example, falls are more common in single rooms because nobody sees that the elderly patient is about to fall and can reach out and help them falling. So there are sort of-- there's an argument going on, but I think in any new build, new hospital, I think serious consideration would be given to trying to provide 100 per cent single rooms.

Q Okay, but would you accept that there could well be a clinical justification for a departure from 100 per cent single bedrooms?

A Yes, and to go back to a sort of quasi-parallel situation was that if you-- if, for example, you had the option of 100 per cent single rooms or a mixture of single rooms and maybe double or three bedrooms, but you had more beds, then what that would mean is you would have-- you would be able to provide a greater range of services or you would be able to provide the same range of services in a shorter time with shorter waiting times. Particularly if you felt that some of the patients you would be admitting to that hospital were not very high risk and therefore they could go into a two or three bedroom, then that would be the trade off, if you see what I mean.

Q Within your report in relation to multibed wards, you indicate that you think there should be a maximum of three beds. Why do you reach that opinion?

A Well, I mean, that's a judgement and opinion. I think the hospital that I've worked in for the last 20/25 years or so has had six-bay rooms. Now, of course, it also does depend upon the size of those multibed rooms, but I do think six

complete strangers in a room together is far from optimum. So, if you have to make a compromise and you can't have 100 per cent single room, I would have thought two to three, at most four, with adequate space is a compromise that you might live with – but that's a matter of opinion, and it's just my opinion.

Q In fairness, is that an area where views amongst clinicians may differ?

A I think it is, yes. Indeed, some clinicians – particularly, for example, clinicians in the areas of oncology and haematology would-- even though some of their patients would not be high risk – they would be at risk, but they might not be at high risk – but they would be very keen on 100 per cent single rooms, and I can understand that. My impression also is that a lot of our critical care colleagues would also like to see 100 per cent single rooms in ICUs, for example.

Q Am I correct in thinking-- That's obviously your opinion, but is there any guidance that supports the view that it should simply be a maximum of three beds?

A In terms of general areas within the hospital or ICU?

Q Well, perhaps if we take

both, if we take general wards first.

A In general wards, that would be my view. As I said, some might say that that's too liberal and it should be only two; others might say it should be four or it could be six as long as they're low risk. In terms of critical care, I think-- somewhere I think I've referred to the number of rooms that should be single rooms, and it increases to 50 per cent if you're going to be admitting a lot of patients with neutropaenia.

My experience over the last five to ten years is that we're seeing increasing numbers of high-risk patients in critical care – such as, for example, ICU – as we have more aggressive treatment for these patients and as they live longer. So I think-- 50 per cent I think is-- it would probably be required, if not more, in most tertiary referral centres; again, that would be opinion.

Q Are you familiar with the term "high efficiency particulate filtration"?

A Correct, yes.

Q Is that something that is called HEPA filtration?

A HEPA filters, yes, that is correct.

Q What is a HEPA filter?

A Again, my understanding

as a non-technical expert is that it's a very sophisticated filter which filters out almost all the particles that you are likely to see spreading from one area to another. It's a much more sophisticated and effective filter than what you might have, for example, even in a general operating theatre or in a general clinical area. HEPA filtration is particularly important in areas where you're going to have neutropaenic patients because it will screen out the fungal spores that cause aspergillosis. HEPA filtration is also used in ultra clean ventilated theatres or orthopaedic theatres used for prosthetic joint implantation because you really need very pure air there to reduce the likelihood of bacteria from skin contaminating the artificial joint.

Q Are you familiar with the term "patient pathway"?

A In a very general sense, yes.

Q What does that mean?

A It conveys to me a patient is admitted to hospital and has a number of, if you like, either geographical areas in which they might be but also either procedures or checks in terms of investigations, documentation and so on.

Q For a patient that was deemed to require HEPA filtration, would you expect to see that across the patient pathway?

A Ideally, yes, but obviously the patient who requires HEPA filtration may need, for very good, legitimate reasons, go to other parts of the hospital which may not, in the course of that travel, have HEPA filtration. Normally, what we would do in that situation is we would ask the patient to wear a mask that would mitigate that risk or the patient might be on prophylaxis-- prophylactic antifungal agents, again, like we discussed earlier, to prevent aspergillus.

Q So you would expect some form of management to be taking place of that situation.

A Yes, I think so. I mean, again, sometimes in an emergency situation, the emergency might necessitate very urgent action taken before those measures could be instituted.

Q Would you expect that to be recorded anywhere?

A I certainly would like it to be recorded, but whether or not, particularly in an emergency situation, it would or would not, I can't honestly say that it would. The priority would be to provide urgent care to that patient in

wherever it was required. For example, if the patient who was severely immunosuppressed needed to go to the operating theatre or needed organ support in the critical care area that would be the priority, and the documentation of aspects of that might not be there.

Q Would you expect that to be communicated to the patient?

A I'm not sure that it would be. Again, it might be the sort of thing that might get overlooked in the emergency of the circumstances in which the priority was to provide urgent life-saving treatment for that patient.

Q With the absence of HEPA filtration across the patient pathway, would it potentially expose the patient to increased risk?

A It would, but that risk and the measure of that risk would be dependent on obviously the vulnerability of the patient, but it also would be where they were going on that patient journey and whether there were other mitigating factors such as, for example, on antifungal prophylaxis.

Q Professor Humphreys, are you familiar with the term "chilled beam technology"?

A Not really, except that I know it's a function or it's a technical

aspect of ventilation, but I would rather not comment on details of it.

Q Again, do you have any knowledge or expertise in the term "comfort modules"?

A Not really, no.

Q Are you familiar with the term "thermal wheels"?

A I have a vague understanding of the concept in terms of energy conservation, but I wouldn't-- it would be outside my area of expertise.

Q Are you aware of any risks associated with thermal wheels in relation to the treatment of immunocompromised patients?

A Well, I know that wherever you're in a situation where you have heat you may get condensation, and where you've got condensation, you've got to be very careful you don't have stagnant water because of the risk of Aspergillosis. But, other than that, I would defer to those with more expert engineering knowledge.

Q Okay. If I could just take you to page 25 of the bundle and to Appendix 2 and to the second paragraph, you state, in relation to the table:

"This table is a very helpful summary, especially for

those not expert in engineering and aerodynamics."

In relation to aerodynamics, can I just be clear, do you mean air movement?

A Yes. The movement of air to and fro, yes.

Q In relation to the guidance that we have looked at, both the Health Technical Manual and the Scottish Health Technical Manual, are you aware of whether they have tolerances built into them?

A I'm not aware that they are. They are recommendations, guidelines as to what should be the case, particularly, I think, in new builds. Obviously, where you have an existing facility, it may or may not be possible to refurbish to provide those guidelines-- provide those specifications.

Q If I could ask you to look back, please, to page 19 of the bundle and to paragraph 5.2 of your report, so this is a section of your report called "5. Perspectives on the role of ventilation and preventing HCAI". Do you see that on page 19?

A Yes. I see 5.2, yes.

Q At 5.2, you state:

"There is a need for a review of ventilation quality in healthcare facilities, particularly for vulnerable patients even if risks are complex and there are a number of factors, which affect the development of infection."

Can you just explain why you put that statement in your report?

A I suppose for two reasons: number one, I think – going back to something I think I've already alluded to – I think that over the last 10 or 15 years, the complexity of care has increased in hospitals and particularly in in critical care areas, and we're now seeing a much greater, I think, number of vulnerable patients who are immunocompromised and a more heterogeneous group of patients, some of which may not be recognised as vulnerable.

So, again, I go back to an example I gave earlier, there's lots of medical and surgical conditions that are now being treated with very powerful but very effective what are called "biological agents", which affect the immune system and dampen down inflammation, such as in the treatment of multiple sclerosis, such as in the treatment of inflammatory bowel disease, such as Crohn's disease. These patients often come under the radar. They're not necessarily flagged as immunosuppressed or vulnerable

because they're-- they have kind of common medical conditions. But what's changed is not the condition, but the treatment of condition. It improves the outcome, improves the quality of life, but it renders the patient more vulnerable to infection than would be the case if they were not on those.

The second reason I state that is I think, in the context of the COVID-19 pandemic, we have realised that we-- our hospitals were under huge pressure because of the transmissibility of COVID and because we had very, very defined and, in many instances, very limited facilities in which to care for these patients because most of our areas within hospital were naturally ventilated and we had no control over where the airflows were going. So we often had to come up with innovative ideas in terms of, for example, putting fans on windows to extract the air from a core area where there might be COVID patients to make sure the air from those COVID patients was not going back into the rest of the ward.

So, for those two reasons, I think we need to review and I think probably either increase the number of air control ventilated facilities or avail of alternative technologies such as

portable HEPA filtration systems, or there are various air purification systems that are marketed out there commercially that may be worth looking at.

Q If I could maybe just take you through that in a little more detail, could you just be clear of what you think this review should involve?

A Well, I think we need to look at the categories of patients we now have in hospital compared to 10 or 15 years ago because most of the facilities that many of us work in are not only 10 or 15 years old, but would be older, much older than that, and we need to look at the proportion of those patients that are low risk, medium risk, high risk, and maybe very high risk, such as our neutropaenic patients. We need to look at what current facilities we have for those patients and whether we believe that those are adequate or not. Then I think we need to incorporate into that some sort of future planning not only for increased numbers of some of those patients that I talked about, but perhaps a bit more flexibility such that if we have another pandemic, we can perhaps react better. So those would be, in very broad general terms, the kind of things I'm talking about.

Q In terms of that review,

what disciplines do you think should be involved?

A I think it would be-- it would need to be multidisciplinary; it would need to be-- involve, obviously, management and healthcare planners, it would need to involve infection prevention and control and infection specialists, it would need to involve clinicians looking after these patients, engineers, architects and probably health economists as well amongst others. I mean, that's not an exhaustive list.

Q Again, just so I am absolutely clear, what would you be seeking to achieve through such a review?

A I think more to marry, if you like, the facilities that we have and will have in the future with, if you like, the patient demographics in terms of the numbers of patients at various levels of risk so that we can try and match better the facilities we have according to the patients and the vulnerability that they have.

Q Professor Humphreys, the final question that I have for you is in section 7, your conclusion section, at pages 20 and 21 of the bundle, you try to tie your report together by giving the example of road safety and trying to use that as an analogy in relation to

risk in relation to healthcare ventilation. Can you just explain to the Inquiry through that road safety analogy how you have tried to draw things together?

A Well, I've always taken some inspiration and indeed knowledge from my understanding of the approach to road safety in Ireland, and I'm sure it's the same in the UK, in terms of the emphasis on basically the physical structure in which we drive, so making roads safer, removing bends, using motorways rather than single lane roads which are safer than single-lane roads, providing better lighting, using technology, for example, in the case of the car, the seatbelt and the airbag and various other measures in the car now which can tell us when we're too close to car in front. Then the most difficult one of all, I suppose, is the human behaviour, what we do as drivers in terms of, “Do we do what we should do when we're in the car?”, in terms of not go into a car with alcohol, put on our seatbelt and drive within the speed limit and so on and so forth. I think there's a kind of parallel there in healthcare-associated infections. So we have, if you like, the infrastructure, which we focused on in terms of space, ventilation, we have the technology, which we have in some instances in terms of more rapid

diagnostics, we have it in terms of, for example, various devices that are now maybe more safer than others, and then we have, if you like, trying to improve human behaviour, which in some ways is the most challenging of all, but that's through education, through motivation and obviously having people accountable for their behaviour.

Q Thank you, Professor Humphreys. I do not have any further questions, but Lord Brodie may have some questions for you and there may be applications from core participants but thank you.

THE CHAIR: Thank you, Mr MacGregor. Does anything arise from Professor Humphreys' evidence? Right, I have got an indication that something does. Mr Ellis, do you want to speak to Mr MacGregor? (After a pause) Mr MacGregor.

MR MACGREGOR: Thank you. Just a couple of questions, Professor Humphreys: in paragraph 6.1 of your report, you mention HEPA filtration systems. Are filtration systems an acceptable method of reducing contaminants in air where necessary, either in place of or together with air changes per hour?

A My understanding in my-- is that HEPA filtration are usually used

in conjunction with controlled air changes in hospitals. So what you want is-- For example, if you look at the example we gave earlier on, so you've got a neutropaenic patient in a single room, you want to make sure that the quality of the air coming into that room where the patient is is of the highest quality. But then you also need the air changes and the air pressures to make sure that there are no-- there's no contamination coming into that room where the patient is from other parts of the hospital, if you see what I mean.

Q Thank you.

A I don't know whether that answers the question.

Q Where necessary, could mobile filtration systems meet patients' requirements for clean air?

A They may do so. I think we need to look at that a bit more. I know in the past, before COVID, we looked at-- in its situation, we looked at mobile HEPA filtration units. But the problem was that if you don't have a seal system the HEPA filtration may actually draw in air excessively. So you need to look at the specification of the mobile HEPA filter and whether it can actually filter the air volume in that particular space, and you need to look at where the air is coming into that

room or that clinical area to make sure that you're not overburdening the HEPA filtration unit. So those would be the issues that I think we need to look at. Now, I wouldn't-- I would need to take advice from engineers and so on as to the details of that, but that would be my-- the issues I would raise about that.

Q Thank you, Professor Humphreys.

THE CHAIR: Mr Ellis, are you content?

MR ELLIS: (No audible reply)

THE CHAIR: Thank you very much, Professor Humphreys. That is the end of your evidence. Thank you very much for that. If you were here, I would say you are free to go, but you are free to do whatever you wish. Thank you very much for your evidence.

A Thank you very much.

THE CHAIR: Now, if I remember correctly, our timetabling for tomorrow is a 9.30 start.

MR MACGREGOR: 9.30, my Lord.

THE CHAIR: Well, we will see each other tomorrow at 9.30.

(End of Day 3)