Let's Talk About Light and Health – Out of the Womb: Lighting up the NICU

Robert White, MD, Randy Reid, MBA, Allison Thayer, MS

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Randy Reid: Hi, I'm Randy Reid, Executive Director of the National Lighting Bureau and I am joined today by Dr. Robert White, Director of the Regional Newborn Program at Beacon Children's Hospital in South Bend, Indiana. This is the second in our series: *Let's Talk About Light and Health*, and today's discussion is entitled: *Out of the womb, Lighting up the NICU*. Dr. White, welcome.

Randy Reid: Give us a little on your background and how you came to be the Director of the Regional Newborn Program back in 1981.

Dr. White: I grew up in this area and went to school at Notre Dame, then went out to Johns Hopkins for all of my medical training. When I was done with that and ready to get a job as a neonatologist, it was early on in the course of neonatology, so a lot of places were just getting started. One of those was the hospital here in South Bend, so very close to my hometown, and they were looking for a neonatologist to start their program, so it was a great opportunity. I made one request of them; I was really interested in the environment of care in the NICU. I thought it was pretty awful in the NICUs I had trained in and been in and so one of the things I asked for as a term of coming was that they'd be willing to build a world-class NICU. And they agreed. So I was happy to come, and within five years, we had built a NICU that was much different than the ones typical for that time, and we did have people come from all over the world to take a look at it. That built an interest in that topic of neonatology for me and for the rest of my career. The construction was completed in 1986, and it lasted us until 2017. We are now in a new unit which is the second world-class unit we have built, but we were in that one for 31 years.

Randy Reid: Can you tell us a little bit about how NICUs have changed from the work that you've done?

Dr. White: When I first started out in neonatology, NICUs were big open wards that had many babies (10 or 15 babies) in each room. They were brightly lit, usually didn't have windows, they were very noisy, very crowded. Family participation was very restricted. When I first started, families could come in for 15 minutes a day, and they could touch their baby, maybe, and that was it. They couldn't hold them or have any other interaction with them. So it was if you can imagine what the worst possible environment would be for the care of a newborn baby who's going through this really important stage of development, this is the worst possible environment that we could have put them in. From that, we have come a long way and we'll talk a little bit more, I think, about how we got here. Now we're much more interested in making sure families have as much time with their babies as possible, and the design of our NICUs has been driven a lot by that consideration.

Randy Reid: Speaking of which, I have five-year-old grand twins, and they were born a month early, three and a half pounds each, and they lived their first month in the NICU. Even as a grandparent, I got to go in and see them, so I do think they have come a long way. But I will tell you; there was a lot of light there that I noticed. For me seeing the wires, the tubes, the noise, it just broke my heart and I just said, 'these kids will never be normal.' And they're happy, healthy five-year-old girls and all worked well so we have a huge amount of respect for the NICU and for the people for the work that you guys do.

Randy Reid: We learned a little bit last month in our series about circadian rhythms. Can you tell us specifically about circadian rhythms for babies?

" It's fascinating in part because the baby's cycle is offset from the mother's cycle a little bit, and many pregnant women will tell you this, in the third trimester, that just when they're ready to shut down for the day and rest the baby becomes very active. I think the reason for this, which is just my hypothesis, that the mother's metabolic capability is trying to manage things for two organisms at that point, one of which is growing rapidly."

Dr. White: It's really fascinating because babies develop a circadian rhythm in utero. They get the signaling for that from their mother so both through substances that cross the placenta as well as the mother's own activity. It's fascinating in part because the baby's cycle is offset from the mother's cycle a little bit, and many pregnant women will tell you this, in the third trimester, that just when they're ready to shut down for the day and rest the baby becomes very active. I think the reason for this, which is just my

hypothesis, that the mother's metabolic capability is trying to manage things for two organisms at that point, one of which is growing rapidly. So, although the baby is small, they still have major metabolic requirements. If the mother is active during the day but the baby becomes more active when the mother is quiet, that doesn't put quite as much demand on the mother's circulation and oxygen delivery and metabolic requirements that would otherwise have the mother and baby in conflict. In any case, that rhythm is well established by the time the baby is born and even by the beginning of the third trimester, where some of the kids end up coming into our NICUs.

Randy Reid: Tell me a little bit about the importance of time-stamped breast milk.

" After a baby is born, then they have to get their circadian cues somewhere else. Typically, that's going to be from the environment, and light/daylight is a component of that. It was discovered, probably 30 years ago now, that another cue that a baby has for circadian rhythms is through the mother's breast milk."

Dr. White: After a baby is born, then they have to get their circadian cues somewhere else. Typically, that's going to be from the environment, and light/daylight is a component of that. It was discovered, probably 30 years ago now, that another cue that a baby has for circadian rhythms is through the mother's breast milk. This was discovered in maternal milk in babies born at term, and it showed a very clear distinction in the presence of certain hormones as well as minerals, calcium, and phosphorus, for example, in the breast milk. We repeated that study in premature newborns, which Mariana [Figueiro], your guest last month, was one of the people who really helped us do that research and showed that that same phenomenon is true even when moms deliver prematurely. If that's intended to be a circadian signal for babies, it's just as important in premature babies as in full terms, we hypothesized. So we give milk to babies according to the time of day in which the mom pumped it. Our moms pump their milk put little stickers on it to indicate whether it was pumped during the day or the night. We then give it to babies at that same time of day or night, within a 12-hour range, so that we can give them those circadian signals. The circadian system is really fascinating because it's not just the pineal gland that is taking care of melatonin for us. It's been shown in babies and even more so in older folks that many other organs have an independent circadian rhythm that is probably meant to be tuned with the brain and the primary circadian rhythm. But all these other organs have this independent cycling as well. There's much more we need to learn about circadian rhythms, but it's not really just as simple as your melatonin going up and down.

Randy Reid: That's fascinating, and I will tell you, I don't think what you have just described is very well known. My daughter had a baby a year and a half ago, and she pumped quite a bit, and to my knowledge, she had never heard of this.

Dr. White: I think we are one of the few units in the world that do this because it does take a little more effort, and our publication is the only one in the literature so far. So as much as people are inundated with research studies, it's probably pretty easy to miss, but I feel confident that as we understand more and more, it will become something that is typical for people to do because it's not that hard it is a little bit of an effort, but we can do that.

Randy Reid: Right, just give people the information and let them make their decision.

Randy Reid: Let's get to the lighting of the NICU because how difficult is it to light a room that's got to have 24/7 applications for the staff, yet you're trying to get babies to tune their circadian rhythm. How does that work?

Dr. White: So we have multiple considerations; the babies themselves are maturing so we have some kids who are 24 weeks gestation and other kids who are full term. Their needs may be different. Certainly, the stresses that bright lighting could put on them will be different at those stages. We also have staff who are in those rooms and have their own circadian needs, and that's different for the day shift nurses who might need some bright lighting to help them stay alert and to continue to trigger their circadian cycle properly, compared to night nurses who we don't want to give those bright lights to and suppress their circadian cycles so they can't sleep the next day when they get home and they get all out of sync. And then we have the families who are in there who have their own needs as well. Trying to get the lighting right for all of those populations is a challenge, and obviously, one big component of that is to make it flexible.

"To start with the baby's space, we don't want any bright light directly in the baby's eyes, so it's all indirect lighting, and that is accomplished using multiple luminaires that give us some flexibility to turn on and off as we need."

To start with the baby's space, we don't want any bright light directly in the baby's eyes, so it's all indirect lighting, and that is accomplished using multiple luminaires that give us some flexibility to turn on and off as we need. We have a procedure light, for example, so if we're starting an IV or putting in a catheter, we can use that procedure light just on the limb that we're working with, without getting it in the baby's eyes. We have this ambient lighting at the bedside, and then we have lighting in other parts of the room. Some of it is just for fun. For example, we have LED lighting that parents can change the color of so that when it's Notre Dame football game day, they can make the lighting over the sink (which is where this LED is) they can make that green.

Randy Reid: Who has control over that, by the way? Who can control the color temperature or the color?

Dr. White: Either the family or the nurses can do it. For valentine's day, we had a lot of red, and that's sort of whimsical more than anything, but it does give you that sense that we want there to be some individual control and make this as much like home as we can, not too clinical.

Dr. White: There's even UV lighting (I know we're going to talk about that in a little bit) over the sinks, UV-A lighting that will help keep our surfaces as clean as possible

Randy Reid: You're one of the first to participate in research using UV-A to disinfect the NICU spaces. How is that working?

Dr. White: We did the trial with Mark Rea and Mariana [Figueiro] and our colleagues at GE and showed that even though we are the cleanest place in the hospital (our hospital does surveillance and monitors surface contamination of many units throughout the hospital) and we always come out best so we do a really good job of that, but we still have contamination. Nosocomial infection is a really serious problem for pre-term babies, so we wanted additional ways of keeping our environment as clean as possible. When Mark approached us about this trial using UV-A, we were very happy to participate. We showed using controlled situations. We installed the lights in multiple rooms and then had days when they were on and periods of time when they were off. We did many cultures and other infection control measurements to demonstrate that during the days that the UV-A light was in use, the bacterial contamination of these surfaces was significantly lower. Since completing that study, we have purchased several lights in several of our rooms plus our breast milk preparation area, which is an area we want to keep really clean, and our IV preparation area also have these UV-A lights installed. The beauty of UV-A is that it is in continuous use. When our cleaning folks come around and clean the counters and the sink two or three times a day, they're clean at that moment, but the moment someone comes to wash their hands, that sink is contaminated. Or if something is laid down on the counter, it becomes contaminated immediately after and doesn't get cleaned with chemicals again until 8 or 12 hours later. The UV-A, however, is always there, so it keeps the bacterial colonization down continuously in a way that we could never accomplish with either chemical cleaners or with UV-C.

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Dr. White: This is the original layout of our NICU. You're looking at it from the outside, obviously, and we want it to be a little whimsical, use a lot of colors, make sure that people from the moment they approached us knew that this was going to be a little different than the typical hospital setting they were used to.

Dr. White: This is the floor plan of our NICU. You'll see the central area is an atrium (and I think you'll see pictures of that later). This was a really unique aspect of this NICU. I think we are the only one in the world that has this feature. Our previous NICU had skylights, so it raised the ceiling and brought daylight into the NICU all day long. It was really unique in that respect as well, and this atrium is just expanding on this concept. I can tell you that just for me having been here day in and day out, walking out from our workspace into that atrium on a sunny day just brightens my spirits and makes everything about the day a little bit better. I think that's true for families as well who walk out of their baby's room in a situation that might be very difficult to see some sunlight to see a little bit of the outside world is a piece of what we hope we can offer families instead of completely enclosing them in this hyperintense environment.

Dr. White: This is our entry area, and you can see through the front door into that atrium, so that's what greets people as they walk in. Not a bunch of lights and alarms, not a bunch of signs. We want a place for the kids to be distracted, so they're not at the bedside distracting their parents from the care of their baby. It is intended to be a place for the entire family.

Dr. White: This balcony area is much nicer now. This is when we first moved in. The nurses have really done a wonderful job of embracing this concept and have done a lot of planting. It's still covered at the moment, but in the Spring, there'll be all sorts of flowering bulbs and lilac trees, and dogwoods blooming on our balcony. So again, for families who maybe don't want to leave the hospital to go outside, they can just come here for a few minutes, a few steps away from their baby's room, and have lunch and decompress.

Dr. White: These are two views of the atrium, but this atrium, of course, goes all around the center of the NICU, so there's plenty of spaces for folks to meet and have casual conversations. You'll notice the floor is carpeted. That's unusual in a hospital setting, but it keeps the noise down dramatically, and it does set a very different tone again for the kind of place this is. It's not meant to look very sterile and clinical, but rather look a little bit closer to home for most people.

Here's the patient room, and you will see the infant space to the right that does have a lot of monitors. I can tell you, though, that those do not have audio alarms for the most part. There's a couple that we weren't able to get on to our electronic system that still do alarm, like the ventilator just to the right of the mom's head. We don't have a way of integrating those alarms into our system, but all the other alarms come through the nurse's cell phones as a vibration that alerts them to the fact that the baby might be in alarm condition. But none of those alarms sound at the bedside. You'll see some space for families towards the back; there's a desk and then these sliding glass doors that go into the parent space, which has a sofa bed, it has a bathroom, it has a refrigerator, and outlets so they can plug in and work if they need to. So it really is a space where families can make it their home away from home. At Christmas, they're often decorated. You see on that green wall on the left-hand side some mementos that are on a string that this mom has placed for her baby, but the families can really personalize the space, especially if they're going to be there for many weeks.

Dr. White: A less cluttered view of the patient space so you get a better idea of the lighting. From behind those sliding glass doors, that's daylight coming in through the window. You see the procedure light directly over the incubator, but there are no other direct lights that the baby would be exposed to. When we use that [procedure light], we can focus it away from the baby's eyes as well. Then the headwalls on either side you see some lighting that goes up onto the wall above and below it. There's some canned lighting in the ceiling that's away from the bedside that provides lighting over other spaces where people would be wanting more direct lighting. We do have vinyl flooring in the rooms, not carpet, but these rooms are still very quiet. The major source of noise that we really had to address was the heating and ventilation system. Our engineers did a great job with that so that these rooms are much,

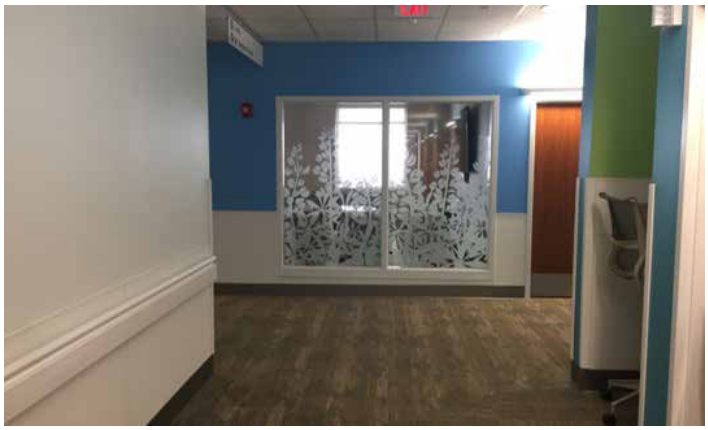
much quieter than the typical NICU and even quieter than lots of people's living rooms at home.

Dr. White: This is what we call our "couple care" rooms. In this case, the mother is still a patient. This is right after she has delivered so she can be a patient right there in the room with the baby. That is a very unusual feature. It is one that I think will become the standard in the future so that we're not separating mothers and babies at a time when the baby is critically ill and the mother is scared to death. She can be right there. A few moms choose not to, and that's okay, but most moms want to be there. It's very helpful for us too that instead of seeing a baby and then going across the hospital to the maternity ward to give a report to the mother, she's right there, she knows what's going on, we can have a conversation and tell her what our game plan is. This setting is one that we were the first intensive care nursery in the country to provide, but there are a number of other units that have now opened or are in the process of being designed that will incorporate this concept.

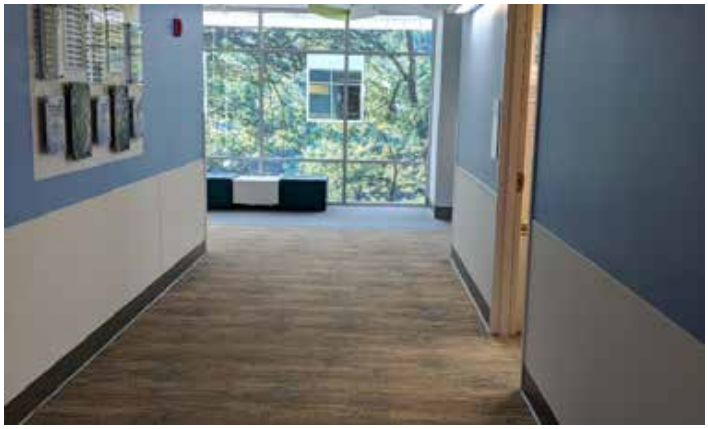
Dr. White: This is just outside the patient rooms. One of the things we learned from families (as we included them in our planning for this NICU) was that they wanted bright colors. Our nurses, when they went through the first pass of the design with the architects, chose pastels and muted colors, but the family said "no, we'd rather a place that was bright." That not only tells you what's important about the colors, but what's important about the lighting. We don't need to keep the lighting dim and low-key, some might say. Lighting that's fairly bright is good for people for their alertness, for their circadian rhythms, and for their general overall psychological well-being.

Randy Reid: At night, say three in the morning, is it the same light level?

Dr. White: No, so in the patient room the light is much lower, in the nurses' station the light is much lower, and in the hallways, these overhead lights (the ones that are just above the doors of the patient rooms), and the one that's over the nurses work area those lights are all off at night.



Dr. White: Here's another photo that demonstrates our attempt. At the end of the hallway, we still have a conference room, but if you're walking down this hallway, you can still see through (this is actually where I'm sitting right now, so the window behind me is the same window at the front of this photo). That hallway isn't blocked off, even though there's a conference room where you can still get daylight.



Dr. White: One more photo again demonstrating a hallway. In this case, it's into the atrium. The trees and leaves that you see there are the graphics on the atrium wall, and then the window at the far end is actually a patient room with mirror glass. So the families can look out those windows into the atrium, but we can't see into their room, so they get daylight and privacy at the same time.

Randy Reid: Can you tell our audience a little bit about the changes that you have seen in the NICU, not just locally but nationally, and how you have achieved these?

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Dr. White: After we built this new unit back in 1986 and had a lot of people coming to look at it, one of the things that was clear was that the codes that were written for hospital construction at the time were actually getting in the way of better design of NICUs. Our idea was that we would put together a consensus committee that would help design/write new codes for NICU design. We came to be this committee back in the early 90s. It incorporated nurses, therapists, doctors, architects, and experts from industry, including Mark Rea for lighting, for example, into a consensus committee that looked at all the requirements for NICU design and decided what the minimum standard should be based on evidence that was available. We had these strong criteria (it had to be evidence-based) if we were going to change what the recommendations were, and it had to be a consensus. We defined consensus as everybody in the group minus one. We didn't want something that was just a majority vote if there was a fair amount of uncertainty if this was really the right way to go. We wanted everyone to be convinced that the evidence pointed in favor of this change, but we didn't want to leave it in a situation where one person who wasn't quite sure, really didn't think that was the right thing, could stymie the whole progress that the committee thought we should move forward with. That "consensus minus one" was the way we worked the committee, and it's worked extremely well. We have had nine iterations now of this. The facilities guideline institute, which writes the standards for hospital construction and is the default for most state code organizations, has adapted these into their guidelines as well. For example, when we first started, you weren't allowed to put windows in newborn ICUs. The thought was that if you put a baby next to a window, there would be excessive heat loss to the outside, and that would be dangerous to the baby. Well, we realized and showed in our unit, for example, with skylights, that there were ways to do this without having the baby next to the window. You could still have a window and not put the baby next to it.

Randy Reid: The guideline institute, they've adopted that now, is that correct?

"Even though the baby may not need the window, the family and the staff benefit from it. We did this on many other levels; how the head wall was designed, how much space there was, what the support for families would be within these rooms."

Dr. White: That's right. In fact, we're moving towards the point where we're *requiring* windows because we want families in the room with the baby, and they need the windows. Even though the baby may not need the window, the family and the staff benefit from it. We did this on many other levels; how the head wall was designed, how much space there was, what the support for families would be within these rooms. That whole process has gone over the last 30 years to help facilitate a really dramatic change. More dramatic in the NICU than anywhere else in the hospital, from where we used to be to where we are now. We used to be kind of the most unpleasant place to be, to now, I think this is the most uplifting, bright place to be. We need that because, in an adult ICU or a pediatric ICU, a kid might be there for a couple to three days, and then they're better and go out to the ward or go home. In the newborn ICU, babies are here for weeks or months through a very crucial stage of their development, and the families are going through a very crucial stage as well. This may be their first baby, this may be a new relationship for them, and this is all happening under very stressful conditions. So it's more important maybe than any other place in the hospital to get it right and make sure that people have the proper medical support. The recommended standards do go into all of that for sure, but we want them to have the other supports the hospitals should be providing that may not be which medication or which IV the baby's getting but are still very important to their success, survival, and long-term development.

Randy Reid: From everything you said, it sure tells me that you're doing it right. I am glad to see that the research and what you've learned isn't staying in South Bend, that it is being adopted by the facilities guidelines and going nationwide and I assume even worldwide, correct?

Dr. White: Yes, and the amount of research that's coming out to help drive these changes is really dramatic, and again I think more in the NICU than any other place in the hospital we have lots of research on how the environment affects our patients. That's continuing, and Mark [Rea] and Mariana [Figueiro] have been a big part of that. I mentioned a couple of studies that we participated in with them. Mariana helped us with a study on breast milk, Mark helped us with the study on UV lighting, and we've done several other studies in conjunction with that team. That kind of research is happening more in the NICU than any other place in the hospital, and so we can make these changes based on evidence not just based on somebody's opinion.

Randy Reid: Dr. White, thank you for this, and we will now open the floor for questions. We want to thank our sponsor GE Current, a Daintree Company, for making today's session possible we could not produce these segments if it weren't for the generosity of our sponsors.

Attendee 1: Thank you for a great presentation and for the amazing work that you're doing all of you both at the NICU and the lighting folks. I wonder if you could talk a little bit about what difference these measures or changes in the environment, and particularly focusing on lighting, what difference have they made in the in the outcomes in whatever you consider those to be? Obviously, the one important set would be on the development and thriving of the infants, but anything that you've looked at would be of interest.

"Sure, the first study that was done on this question, to the best of my knowledge, was in the 1980s in England. Back then, everyone had really brightly lit NICUs 24 hours a day."

Dr. White: Sure, the first study that was done on this question, to the best of my knowledge, was in the 1980s in England. Back then, everyone had really brightly lit NICUs 24 hours a day. They decided to try just in their step-down areas (these are the kids that are no longer critically ill but are still too small to go home so they're pretty stable babies), and they decided to divide those up into two groups; one where the lights stayed on 24/7 and the other where they turned them off at night. They asked mothers to keep a journal once the kids went home, and (to maybe oversimplify the results) the journal showed that the mothers liked the babies who had been cared for in the room that was dark at night a lot better at six months of age than those mothers who were caring for babies that had stayed in the room that was continuously lit. I'm going to guess that that was because those babies slept better and were

easier to get to bed at night, that their circadian rhythm was better established. What we know for sure, objectively, was that those babies weighed about a pound more than their counterparts who were in the control group. We did the next study in South Bend, looking at infants in the early, critical care stage of their illness, and showed better neurological function at the discharge of those who were in the room with cycled lighting compared to those who were in the room that was continuous lit. Once we realized that continuous bright lighting was a bad idea, we went the other direction, and the theory was, well, in utero, babies have continuous dim lighting. So that's how we'll keep the NICU, and those randomized trials were done as well and still showed the babies that were in a circadian lighted environment did better than either continuous bright or continuous dim lighting. They looked at various outcome measures. Weight gain was one of them, and length of stay in the hospital was another. The important thing to note about the continuous dim lighting is that while that is what the babies get in utero, in utero, they still have those other circadian stimuli from the mother that I mentioned. Whereas once they're delivered, they lose the circadian stimuli from the mother, and then we're not giving them any from the environment as well. So those are the studies that have been done, and the outcomes (weight gain and length of stay) have been the primary ones more recently.

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Allison Thayer: The next question "When the babies are born prematurely, is it best to start the environmental entrainment learning from the time they are born or is it preferred to wait until the time they are normally born?"

Dr. White: Much of the research has been done from the time of birth or within a few days after. Those kids, if they had stayed in utero, would be getting circadian signals from the mother throughout that third trimester of pregnancy. So biologically, it does not make sense to me that we would wait and not give them our alternative signals that the mother can no longer transmit to them, that we would wait to give them our signals until they're full term. That's the way the studies have been done. So that "environmental entrainment learning," as you put it, is best done from the time they entered the newborn ICU. The first two or three days for kids who are really critically ill, we may keep the room pretty dark for those kids, and there are still places who aren't quite convinced about this, so they keep the room dark a lot longer, but I think the evidence is good that it can be started shortly after birth.

Allison Thayer: Next question we have: "Have the new design choices shortened the length of stay, and similarly has there been a noticeable positive impact on the staff?"

Dr. White: Some studies for babies did show a shortened length of stay. There have been fewer studies on the positive impact on staff in the newborn ICU, but elsewhere in the hospital, those studies have been done and have shown that there is a positive impact on staff. Mark [Rea] and Mariana [Figueiro] are in a better position to comment on that because they've done so much of that research, but the answer is 'yes' for both of those.

Allison Thayer: The next one that I have is: "What is the biggest challenge you face while trying to define lighting configurations and specifications for the NICU units?"

Dr. White: Inertia. People don't like to change. People who make up reasons why they're continuing to do the things they did even though there was no good reason to do it in the first place, they've decided that, well, this is how we've always done it, so you have to give us really good evidence before we're going to change. Actually, there were some reasons. For example, we had NICUs bright all the time very early on because that's the only way we could tell if a kid was pink or blue. Now, we have saturation monitors, so we don't need that anymore. Then as I said, a number of places think we should keep it dark because that's the way it is in utero even though there are other biological differences more important than that. But I think this inertia about 'you've got to present us a whole lot more data to change' than we have to support our current practice. So that's human nature.

Allison Thayer: Can you think of ways to make people less averse to these changes? Is it, like you said, the research but also the education of it as well and getting people more on board to ask for these changes?

Dr. White: Yeah, I think just as Mark and Mariana's team are really not only strongly committed to research but strongly committed to education and getting the word out. We do a lot of good research that a lot of people don't know about because they don't read all those journals. So finding other ways to get the message out is really important, and just like this series, I think that's how we can have a lot more impact than just publishing an article.

Attendee 2: Well, I just want to compliment you, Allison, as you had this idea, and I do think it's a very powerful way to get to know people like Dr. White. The question I have (and I should know the answer): the eye development (and this is the route to the biological clock) and so when the question was asked "should you wait till full term" and we agreed that that's not the right answer, but there must be a point at which it doesn't matter what the environment has because the eyes haven't developed well enough yet to send signals to the biological clock. Can you give us a sense of when that happens to the best of your knowledge because I'm not sure I know, and there must be a gap, or maybe there isn't a gap but maybe you could comment on that?

" The auditory cortex, for example, develops much earlier than the visual cortex. This sensitivity to light and dark is developed sooner than the visual capability that we associate with seeing faces and making out images. That's a later developing skill for babies."

Dr. White: This research was done by the primary author is Scott Rivkees, and Scott worked with premature baboons and showed that the retinal hypothalamic tract was intact by early in the third-trimester equivalent for those baboons. That's what you have to have. The eyes have to be able to receive the light signal and then transmit it to the pineal gland, and that happens through the retinal hypothalamic tract. That's how we know that almost all of the kids that (we have a few kids before the third trimester, but nearly all of them are in the third trimester at the beginning or into the middle of the third trimester) and their retinal hypothalamic tracts are intact. You also asked about 'is it the same for the visual system?' The retina is not very well developed at the beginning of the third trimester, and the visual cortex in the brain is not very well developed either. The auditory cortex, for example, develops much earlier than the visual cortex. This sensitivity to light and dark is developed sooner than the visual capability that we associate with seeing faces and making out images. That's a later developing skill for babies.

Allison Thayer: The next question we have: "What is the science behind light being used to enhance and treat the bilirubin measures." And can you also mention what is that for our audience members who may not know all these different terms?

> ***" The discovery that light could cause photoisomerization of the bilirubin molecule was made many years ago, at least 50 years ago, by a nun in a catholic hospital who noticed that the babies who were next to a window had less jaundice than the babies who are more inboard in the room. "***

Dr. White: The discovery that light could cause photoisomerization of the bilirubin molecule was made many years ago, at least 50 years ago, by a nun in a catholic hospital who noticed that the babies who were next to a window had less jaundice than the babies who are more inboard in the room. From that observation, a lot of research was done that showed that the normal isomeric form of the bilirubin molecule has to be conjugated in the liver. It has to have another chemical added to it in the liver before it can be removed from the body. Exposure to light causes this other isomeric form which can then be excreted without going through that process in the liver, so when the baby's liver is immature or diseased, phototherapy can help the baby get rid of bilirubin that they could not otherwise do. That's a standard practice in treating jaundice in newborns. It turns out there's a very specific area in the spectrum in the blue/green part of the spectrum that is most effective in doing this.

Allison Thayer: And that is for light on the skin, is that correct? Versus light through the eye?

Dr. White: Correct, we actually put a blindfold on the baby when we do that so that we're not exposing them to a bright light to the eye.

Allison Thayer: Along those lines, "How much light do babies receive in the womb?

Dr. White: That's fascinating too. It's more than you might imagine. We don't have a really good way of measuring that, and it probably is insignificant in terms of these things that we're talking about because, for example, we don't know if the baby's eyes our eyelids are open or closed. We presume they're closed a good part of the time, so even measuring what's present with a probe in the amniotic fluid doesn't tell you how much is actually getting through to the baby's retina. It's probably not enough to be clinically significant.

Allison Thayer: Similarly, we have another question about light through the eyes: "Are there any concerns about exposing light to the eyes of the infants that would either advance or delay the development of the eyes of infants? Is the *lack of light* unwanted at some point during the development, and is the *presence of light* unwanted at some point in the infant's eye?"

Dr. White: There was concern about that when we started turning the lights off, we thought maybe by doing so we would protect babies from one of the problems that premature babies get, which is retinopathy of prematurity. That's caused by excessive oxygen exposure, and so the retina gets more oxygen than it is supposed to get in utero; that causes constriction of the arteries in the retina, and then the retina doesn't develop as well as it should, it develops scar tissue, and that can actually cause blindness. Stevie Wonder, the singer, for example, was born prematurely and was blind because of being exposed to excessive oxygen long before we knew that it could do that. We knew about oxygen, and then people wondered maybe light can do this too, maybe excessive light can cause damage to the retina and some of these kids who are getting blind from retinopathy premature it's not just the oxygen but it's the bright lights in the NICU. As it turned out, turning the lights down and protecting babies from bright lights in any case, even if you have some lighting in the room like we do, none of it's a direct light to the baby's eyes. That did not change in the randomized control trials. It did not change the incidence of retinopathy prematurity. Within limits (nobody's tried shining bright lights in the kids' eyes all the time, and maybe that would be damaging, but), at the levels that we're talking about to give a circadian stimulus, it does not cause any damage or advance the development of the retina.

Allison Thayer: That's very interesting, and with the next question kind of fitting in: "Could the babies then receive/be sensing light through their skin?"

Dr. White: That is a fascinating question. Not only babies but maybe all of us. There is some evidence (and I haven't reviewed this literature recently, so probably even more now) that yes, the light exposure of our skin, and there's even suggestions that certain parts of the anatomy where that's most notable that can affect the peripheral circadian rhythms that are present in our body.

Allison Thayer: I do have a question for you, Dr. White. What do you see about the future of lighting in the NICU?

> ***" The discovery that light could cause photoisomerization of the bilirubin molecule was made many years ago, at least 50 years ago, by a nun in a catholic hospital who noticed that the babies who were next to a window had less jaundice than the babies who are more inboard in the room. "***

Dr. White: You know, Randy asked me that question during the interview, and I didn't have a good answer for him. As I've thought

about it since I think where we are is we just need more research. I think there is a lot more (this last question, for example, about light on the skin). Maybe if we understood that better, we would change what our recommendations are. We'll learn more about light exposure to other parts of the body, we'll learn more about which parts of the spectrum of lighting are most important (I mentioned there was one part of the spectrum that was most important for phototherapy for jaundice), and we know there are certain parts of the spectrum that are most important for the nurses for the alerting response that they get, that we want them to have while they're at work. We'll learn more about that. We'll learn more about ultraviolet light and how it can be used in the hospital to keep our surfaces clean with UV-A and to keep our air clean with UV-C. There are a lot of exciting areas for further exploration, and hopefully, we can keep up our practice current with all of that new research. At the moment, I'm not sure which direction that we'll go.

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Randy Reid: Well, Dr. White, I want to personally thank you, Allison, our producer, I would like to thank you, and we'd like to thank the audience. We had a very good turnout today, and about 90 stuck through to all of the questions, so Dr. White, that's a great reflection on you. Allison, you wrap up and tell us one more time about the next event.

Allison Thayer: Thank you for the great questions. We will be posting the recording of this video on our LinkedIn accounts, so if you follow us either the National Lighting Bureau or the Light and Health Research Center, we'll have it posted there and feel free to keep the conversation going if you think of any more questions put a put a comment in there, we'll keep the conversation going about lighting in the NICU.

Allison Thayer: Up next, like I mentioned for everybody who's still here that Dr. Sophia Axelrod from the Young Laboratory of Genetics at the Rockefeller University will be up next in March, and she'll be talking about more specifically lighting for babies and a light-dark pattern that we should be giving them for better sleep and for better health.

Disclosure: *Mr. Reid* ***is*** *Executive Director of the National Lighting Bureau, the editor of the EdisonReport and the editor of designing lighting (dl) magazine.*

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