# Raising the Bar Sydney 2018

# Ollie Jay – The heat is on

**Welcome to the podcast series of Raising the Bar Sydney. Raising the Bar in 2018 saw 20 University of Sydney academics take their research out of the lecture theatre, and into bars across Sydney, all on one night. In this podcast, you'll hear Ollie Jay's talk, The Heat is On. Enjoy the talk.**

[ Applause ]

>> Thank you Christian [assumed spelling]. Thanks for coming out everybody. So, yes, my name's Ollie Jay. I'm a thermoregulatory physiologist. This means I'm interested in the way in which the human body regulates its body temperature.

Most people are quite surprised to hear that's actually a thing. I want to take you back on a bit of a journey first. Like you all to think of the year 1910. Chances are that nobody here was actually born in 1910. That would make you 108 years old.

So, in-- 108 years ago, in 1910, this was two years before the Titanic was built, and then sank. Was probably built already, and then sank. It's four years before the first World War started. And, this is when Australia started keeping formal weather records.

So, 1910 is the reference point. So, let's fast forward to 2005. That's 95 years later. So, what happened in 2005? Maybe everybody can think about what they were doing then, and you can probably recall it quite easily. So, Roger Federer had already won six Grand Slam titles, three Wimbledons, two U.S. Opens, and one Australian Open.

Internet was rife, of course. John Howard--I always get his name wrong--John Howard was reaching the twilights of his time as PM of Australia. That's back when prime ministers lasted longer than three years, of course. Yes, three years.[inaudible] three years. So, in 2005-- well, since 2005, beg your pardon, Australia has experienced 7 of the 10 hottest years on record. So, the record start in 1910, we've experienced 7 of the 10 hottest years on record since 2005. Let's move forward to 2013. Facebook and Twitter have gone public.

Roger Federer is still winning Grand Slam titles. I moved to Australia. I recognise that's not a seminal moment for most people in this room. Since 2013, in Australia, we've experienced 4 of the 5 hottest years on record. So, let's just think about that for a second. The changes of that, or the probability of that occurring due to chance, without anything else going on in the background--you probably know what I'm getting at with this--the odds of that occurring are 1.1 million to 1.

You're only twice-- no, sorry, half as likely to be hit by lightning. And, if all this talk about heat gets you a little frisky tonight, and you go home, and you end up conceiving, you're two times more likely to give birth to quadruplets in 9 months' time.

So, that kind of gives you an idea that something's going on. I think any reasonable person will accept that our climate is changing. And, the heat is most certainly on. That's the title of the talk. [inaudible] So, why is it a problem? [inaudible] It's Australia, mate. That's my Australian accent. Quite brutal. I'm working on it. It's got on much better [inaudible]. Barracuda brand. Doesn't get more Australian than that.

You know, people think that heat is a way of life. And, that's fair enough. I grew up in the UK, and it's certainly a lot hotter here than it was in Wales growing up. But, the heat can be absolutely deadly. To give you an idea, there was a heat wave in 2003 that swept across Western Europe over the course of about two or three weeks. And, that killed 70,000 people. And, that's actually a conservative estimate. So, 70,000 people were killed by a heat wave. These are excess deaths.

So, if we compare that death toll to the amount of people that died due to the Ebola pandemic over the course of two years, it's six times as many people in one part of Europe, due to one extreme heat event. Which is quite striking. Another thing that we'll be familiar with through the news quite recently, there's been a lot of natural disasters in the news recently. Quite tragic events. We've had earthquakes. We've had tsunamis. We've had floods, landslides, lot of natural disasters.

And, these are tragic of course. It's not a competition, so, it'd be a really crap competition if it was. But, if you look at the amount of people that have died due to extreme heat, if you combine all the other deaths due to all other natural disasters combined, heat still is responsible for more deaths than everything else. And, you could probably throw terrorism on top of that as well. And, heat still kills more people around the world. Which is quite striking.

So, my talk today is going to describe a little bit more about the way in which extreme heat impacts human health. And, hopefully we can go away with a better understanding of it, and I'll be happy to take questions at the end as well. Looking forward to that. So, I'm going to try to hit four main points. The first one I'm going to talk about is the way in which the human body thermoregulates. So, we have physiological mechanisms that try to keep body temperature within a safe limit. And, I'll talk about that in a little bit more detail shortly. After that, we're going to give a demonstration about the way in which we measure core temperature. That could be quite confronting for some of you. We'll look forward to that.

[ Laughter ]

And then, after that, I'll show you briefly, using my little gadget in the corner here, the way in which we evaluate thermal environments. So, oftentimes we'll look at the weather reports, we'll look at the air temperature, and leave it at that. There's far more to a thermal environment than simply our air temperature. So, hopefully maybe you'll get some tips on how to interpret the weather forecast a little better this coming summer. Excuse me. [inaudible]

And then, finally, I'll finish up talking about the way in which we can keep cool during extreme heat events, without the use-- with minimal use of air conditioning units. This is very important because the use of air conditioning, paradoxically contributes to future extreme climate events. Through the fact that we generally use quite a lot of fossil fuels to use these units. So, I'll go through that as well. OK.

So, on to the first bit. The way in which we thermoregulate. So, if I-- oh, there's quite a lot of people here. Maybe 100 people? Rating myself, so it's 100 people. If I measured everybody's core temperature in this room right now, everybody would be within .2 or .3 degrees Celsius of each other. That's because we really tightly regulate body temperature around a fixed value. Now, the exceptions to this are, so some of the females in the audience, during the menstrual cycle, core temperature will rise by about .5 degrees Celsius during the second half of the menstrual cycle, which is called the luteal phase.

But, typically, everybody's core temperature is round about 37.0 degrees Celsius. We have a circadian rhythm, so our body temperature changes throughout the day. So, we're coolest just before we wake up in the morning at about 4 A.M. I've got jet lag right now, so I was up for 2 course before-- And then, we're warmest, so we'll increase by about a degree Celsius throughout the day. So, right about late afternoon, early evening, we'll be at our hottest. So, you might be changing from 36.5 to 37.5 degrees Celsius, maximum. But, everybody will be pretty much in sync. And, that's testament to the way in which we physiologically regulate body temperature.

So, how do we do this? We've got two primary mechanisms. The first one is called a cutaneous vasodilation. So, this is the blood vessels in the skin. When the skin gets warmer, our core temperature rises, we send signals to our blood vessels, and those blood vessels open up quite wide. So, they dilate. So, it's the idea of increasing the diameter of a vessel. And, we do this autonomically. We do this in the background without even thinking. And, what this helps us do is direct hot blood, that is, near the body core, and direct it near the skin's surface.

So, we're basically trying to get hot blood, or the heat, away from the internal-- the temperature sensing tissues in our body, trying to direct it towards the skin's surface. That's typically not enough, but it does play a big part in some of the related illnesses I'll describe shortly in a minute. The other thing that is very, very important is our ability to sweat. If there's one thing you can take away from today's talk, is it's not the production of sweat that cools you down, it's the evaporation of sweat. And, this is very, very important, because when we start considering things like air velocity, wind across the skin, if we're considering ambient humidity, which is very, very important, then this really impacts our ability to evaporate that sweat from the skin.

So, our body temperature-- let's say we're all starting off with 37 degrees Celsius. We're exposed to a hot environment, and/or we're exercising. Our body temperature will start rising. We'll then start vasodilating. If that's not enough, we'll start sweating. And, if that's not enough, we don't get enough heat dissipation from the skin's surface to the surrounding environment, our body temperature will continue to rise. So, if we're moving from 37 degrees Celsius, by the time we get to 38.5 degrees Celsius, we start finding it more difficult to concentrate.

We find it difficult to do complex cognitive tasks. If our body temperature keeps rising then, it's not enough, physiologically to keep that in check, we might get to 39.5 degrees Celsius, and at this temperature, we start having an increased risk of heat exhaustion. And, heat exhaustion is characterised by symptoms such as nausea, vomiting, light-headedness, fainting, et cetera, et cetera. So, these things can-- we're only 2.5 degrees Celsius away from what your body temperature is right now. And, it can get worse.

It will get to 40 degrees Celsius, and in our mind, in our brain, that tells us that if we're conducting exercise, we'll stop exercising no matter how motivated we are, when we reach 40 degrees Celsius. So, this is fail-safe mechanism that seems to be in the human body [inaudible] than whatever [inaudible] in the research right now. Because some individuals can actually drive their core temperature even higher. But, under very specific circumstances. So, next we'll get to a core temperature of 41 or 42 degrees Celsius. This is where things get really, really messy.

So, in our gut, we have junctions. Try to do this without handing the microphone-- junctions like this. And then, because we're directing all that blood from the body core towards the skin surface, we start having a reduction in the amount of oxygen that's delivered to our gut. And, those junctions start getting wider and wider, and looser and looser. And then, all the nasty stuff that's inside of our gut, all the endotoxins, or as a former PhD student of mine used to call it, poo bacteria, when he was trying to teach it, it starts leaking out of the gut into the surrounding tissues, in situ. And then, we might have something called septic shock.

We have multiple organ failure. And, we die. It's pretty grim, right? And, it's messy. Used to say, you can't uncook an egg. That was a thing that we used to say in testament to the irreversible damage that heat stroke can have on an individual. Unfortunately, somebody at Flinders University figured out how to uncook an egg the other year. Which is very, very inconvenient for me. Anyway.

There's an example of an elite athlete suffering heat stroke and dying, a guy called Korey Stringer. For those of you who like American football, he was an All-Pro offensive lineman for the Minnesota Vikings. This was in August, 2001. He was a millionaire. In very, very good shape. And, he was competing for his position on the team in a pre-season training camp. And, because he was a big guy, he was generating lots of heat. He's wearing all that equipment, which is preventing heat loss to the surrounding environment. It was very still, it was very hot, it was very humid. He ended up reaching a core temperature of 42 degrees Celsius, and he was dead on arrival at the hospital.

And, that actually gave rise to a lot of research in this area, particularly for exertional heat illness, and [inaudible] sports. The other thing that I really want to mention briefly is the way in which people die, typically during heat waves. So, there's heat stroke, which is typically coupled with physical activity. But, there's also a lot of people that die of heart attacks during heat waves. And, again, if we go back to the way in which the body thermoregulates, it kind of makes sense, the pathway in which these events happen.

So, we have that vasodilation I mentioned earlier on, where we're directing blood flow towards the skin surface, and we're opening up those blood vessels in the skin. But, to prevent yourself passing out, when you vasodilate, because your blood pressure goes down, your heart has to start contracting more, and more, and more. And, less blood is getting back to the heart, so it's got to pump even more, and more, and more. And, the extra cardiovascular work requires more blood flow to the tissues of the heart, and it needs more oxygen delivery to the tissues of the heart. And, if you've got some kind of underlying infirmity, this results in cardiovascular collapse.

This is responsible for more than 50% of deaths during heat waves. On one hand, I think that is really quite noticeable, is that we don't really hear too much about deaths associated with heat waves in the media. I think this is maybe due to the fact that heat waves are not visually dramatically events. It's not like this huge wave that's crashing in and wiping buildings out. Or, cracks opening up in the ground. It's this, what we call a silent killer. And, probably what the issue is as well, frankly, is as a society, the most vulnerable, and the victims of extreme heat, are actually the most vulnerable among society. It's the oldest, it's the poorest, and it's the sickest.

So, this is a very important thing to keep in mind. OK. So, that's how we thermoregulate. Check my notes here, and make sure I'm on the right-- OK. So, the next thing we're going to do is give a demonstration. So, a kind of a round of applause for Conner [assumed spelling] and Georgia [assumed spelling]. They're going to come up here. They're PhD students in my lab.

[ Applause ]

They're going to give you a quick demonstration. Actually, if you don't mind, we're going to have an extra round of applause, because Georgia received the comments from her PhD examiners yesterday, and she passed. So, congratulations.

[ Applause ]

That's a bigger cheer than I got. That's not fair.

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>> OK. So, the way in which we measure core temperature-- actually I probably should mention why we measure core temperature. So, we have a lab. And, in the lab, we have a chamber, a climate chamber. And, what we do in that chamber is that we simulate different extreme heat events from history .

So, we can simulate the extreme heat of [inaudible] Chicago 1995, the one from Adelaide, 2009. And, what we're trying to do is help public health authorities inform the guidelines, the things that they tell people to do during heat waves to keep cool, with evidence. So, we're very fortunate to receive an NHMRC project grant last year to help us fund-- or, help us conduct this research.

So, a key part of that is basically we're exposing people to these extreme heat events. We're measuring how hot they get. And, we're testing the different strategies that people can use that are alternatives to air conditioning. And, we're seeing which ones keep them cooler relative to other ones. So, this is a typical probe, core temperature probe. Has anybody got any ideas where I might put this? Anybody? Don't be shy?

>> Axilla?

>> The axilla? It's a bit long for the axilla, but yes, that's a place. That's the armpit, for those of you who don't know what axilla is. Anyone else? Yes sir?

>> In a cold beer.

>> In a cold beer, yes. Yes. That would make you hypothermic. In Australia, hyperthermia is the same as hyperthermia and hypothermia. Hot [inaudible]. It's a bit of an inside joke.

So, somebody's probably wanting to say, but they don't have the courage to say, it's up the bum. True. One of the main ways in which we measure core temperature is with a rectal temperature probe. It's nice and thin. Flexible. Smooth. And, we insert it 12 centimetres beyond the anal sphincter. And-- yes, tickles a bit when you first put it in. And then, you don't really feel anything. So-- any volunteers? [inaudible] Yes. Sorry, Conner, we're not going to do that. [inaudible] The old rectal temperature gag. It's a very niche joke. It's like my friend. He was a stats lecturer, and he used to wear a t-shirt that said the n's justify the means.

[inaudible] Because n is the number of data points that you have, and the means are more robust when you have more data points. Yes. Just described my joke. OK. Alright. Onto the demonstration. The other way that we measure core temperature is not just inserting this probe--a different probe of course--into the rectum, it's into the oesophagus. So, the oesophagus, of course, is the food pipe. And, the way in which we enter the food pipe is through the nose. So, what we do is that we insert this probe up the nose, down the back of the throat. There may be a little-- a few tears, but that's OK. It's quite normal. Do you gag?

>> [inaudible]

>> You get emotional. OK, yes. Me too. Alright. So then, we'll ask Conner to take a gulp of water. That opens up the food pipe. And then, Georgia's going to fire it down there. And then, all that's going to be left is a 40 centimetre probe. The only thing that's going to be left is this, hanging out of his nose like this. So, what I'm going to do, is put it in, provided it's comfortable for him. This is a very regular thing that we do in the lab. And, he'll keep it in, and we've got a handheld device that will measure his core temperature. So, if you're curious yo8 want to come and check it out afterwards. Come and have a chat with Conner, and you can see how hot he is.

Alright. So, Georgia?

>> Yes?

>> You ready?

>> I am.

>> Yes. OK. So, what we're doing now, is we're going to talk everybody thought it, if that's alright. She's dipping it in a bit of water, just to get a little bit extra lubrication. All right, Conner?

>> Yes.

>> Yes, OK. That's right. So, we get people to check which nose is-- which nostril is clearer.

So, we set the head back. Sorry, don't want to get in people's way, so they can all see this. We set the head back. And so, basically we're lining up the nostril with the throat, so it's basically straight down.

>> All good to go?

>> Alright, Doctor Chasen [assumed spelling], take it away. I can call her Doctor Chasen now. It's quite good. OK.

>> [inaudible]

>> [inaudible]

>> Yes, of course. [laughs]

>> [inaudible]

>> OK, this is up the nose, down the back of the nose.

>> [inaudible]

>> You OK there?

>> [inaudible]

>> OK. Usually it goes a little more smooth than this, but there you go.

>> [inaudible]

>> Alright. So, you didn't say hello to make sure it's in the right tube. Yes. There you go.

>> There was a little bit resistant.

>> Little bit of resistance? [inaudible] OK. So, we'll take this up, and we'll take him back, and then we'll tape him up, and then we'll have him hooked up later on. OK. Thank you, Conner.

>> [inaudible]

>> Yes. Very good. Very good. Yes, yes. Yes. Very good. So, the gentleman at the front asked if that was a fresh probe. Yes, of course. Yes. All probes come fully ready in their own little slip here. So, it's all very clean. OK.

The other way in which-- so, these are more old-school ways of measuring core temperature. So, rectal temperature, esophageal temperature. Another way, which is a bit more space age, if you will, is using something like this. This is a telemetric pill. And, inside of here is a thermometer. And, it emits a telemetric signal that we can pick up with a handheld device. So, what Im going to do is, I'm just going to, maybe, hand these around. Pass these around, and people can check out what they look like. So-- maybe just pass it around.

Well, you know what it looks like, but yes. Maybe if we can start here. Just pass it around. So, what we do with these pills-- if you're tempted to swallow it, it's probably not that tasty. If you do, don't bite. Because there's wires inside. So, we'll swallow that pill and then it'll enter the stomach, and eventually it'll exit the stomach, and it'll go into the gut. And then, it's exiting this telemetric signal. And then, we'll pick it up-- where are we--with this handheld device, which looks quite old-school actually, itself. And, this is a really nice, non-invasive way of measuring core temperature. It's also wireless, so we can measure people in the field. So, if we're looking at occupational heat stress situations, or we're looking at people in sporting environments, we can measure their core temperature continually using that method, which is quite nice.

OK. So, next on-- I realise I'm going on a little bit here, but. We measure the thermal environment. Now, most people will be familiar with the weather report, and looking at air temperature. There's far more to interpreting the potential thermal stress of an environment than just looking at air temperature. The reason is there's actually six parameters that determine how we respond to a given thermal environment, and air temperature is just one of them. Now, the first thing I want you to know, is that when you get that air temperature that's on the weather forecast, that temperature is actually in the shade. It's not in the sun.

I remember going to Watson's Bay at Christmastime. And, we were queuing for the ferry, and this lady in front of me says, it's 26 degrees Celsius. It's way hotter than that. Of course it's hotter than that, you're in the sun, right? So, it's realising that the temperatures that we get from our weather forecaster, actually in the shade, not in the sun. During the height of the summer in Sydney, you can add 15 to 17 degrees Celsius on top of the ambient air temperature in the shade, to give you something that we call black globe temperature. So, the way in which we'll measure black globe temperature--I'll take it off this thing here--the way we'll measure black globe temperature with this little black globe thermometer at the top here.

And, this little unit here allows us to measure the other three environmental parameters that are important. This black globe temperature, which takes into account solar radiation, so the amount of heat that you're getting directly from the sun, and reflected from surface areas. There's ambient air temperature in the shade, which is inside this little window here. There's wind velocity, which is very, very important, because that determines how quickly sweat can evaporate off the skin. And then, of course, there is ambient humidity as well. So, this unit measures all four of those environmental parameters. And, that's very, very important when you're interpreting weather forecasts in the future, I think. Not just looking at the air temperature.

There are two personal parameters as well to determine how hot an environment will be for a given individual, or how hot they'll get, rather. It's obviously what you're doing in that environment. So, what your physical activity levels are. And, also what you're wearing. So, how much insulation there is. So, there's insulation, there's also something called evaporative resistance clothing. So, the main way in which we cool down in the heat, through the evaporation of sweat, if you're wearing something that doesn't allow a lot of evaporation to get through it, so it has low vapour permeability, that will result in a low level of heat loss, and you'll end up getting very, very hot.

So, obviously it's all kind of madness, or it's nonsense to interpret a weather forecast just looking at the air temperature. Because that air temperature can result in a whole host of levels of heat stress, depending on what you're doing, what you're wearing, how humid it is, how windy it is, and how much sun there is. And, whether you're in the sun. So, my advice is, next time you look at the weather forecast, check out what the humidity is going to be. Check out whether it's going to be windy or not. And, also consider whether you're going to be in the shade, or whether you're going to be out in direct sunlight.

If you're out in direct sunlight, that's-- you should add about 15 degrees Celsius onto that value at the height of the summer, which is quite something. OK. So, that's measuring core temperature. So, I'm [inaudible] last bit here, which is measuring [inaudible]. Oh, one thing I should add, is this unit, so we've just been commissioned to do the new extreme heat policy for the Australian Open Tennis, which is rather exciting. [inaudible] And, what we're going to do is actually use a device something like this to measure the environmental conditions right on the court-side during the games in the Australian Open. So, when you're watching the games in January, keep an eye out for that lot over there, because they'll be helping me out. [inaudible]

And, with devices such as this, because the way in which we're going to be able to make sure that we're getting really accurate measurements of how hot it actually is down on the court, where the players are playing. OK. So, finally, I was going to talk about how we keep cool during extreme heat, without the use of air conditioning units. So, we've worked on a few things. One of the main things we've worked on is looking at moving air instead of chilling air. So, you chill it with an air conditioner, but you can move it with devices such as electric fans. And, the reason that electric fans are such an appealing solutions is because they use 50% times less electricity than an air conditioning unit. So, from an environmental perspective, it's far better. It's cheaper, it's more accessible. And, the most vulnerable in society can potentially access them. And, they're easy to use as well.

The trouble is that public health organisations have told us for years that we shouldn't be using fans during heat waves. The idea is that above 35 degrees Celsius, you're now blowing hot air onto the person, so skin temperatures typically run off 35 degrees Celsius when we're fully vasodilated. And, they make it-- they draw the analogy of a turkey in a convective oven, or fan-assisted oven. So, if you've got that meat in the oven, and you've got the fan running, it'll cook quicker. And, the idea is that you're accelerating the amount of heat that you're adding to the turkey to heat up, to cook. However, unlike turkeys, humans secrete sweat. And, fans are really beneficial when it comes to helping that sweat evaporate, other than sitting on the skin's surface. So, they can be very, very beneficial.

So, we've done some work showing that fans are actually really beneficial as it gets-- temperatures as high as 42 degrees Celsius. In fact, what we've found is that for young, healthy adults is that you're cooler with a fan at 42 degrees Celsius than you are without a fan at 56 degrees Celsius. That's how much additional cooling that fans can give you. So, I highly recommend using those devices as cooling strategies during the summer. Another thing you can do to help with thermal comfort, we're doing a few studies on that right now, is that you can use your air conditioning unit in conjunction with fans.

But, instead of setting the thermostat at 20 or 21 degrees Celsius, you can set it at 28 or 29 degrees Celsius, and have fans move air, and it will cool you down just as well. So, far cheaper. It's far less strain on the electricity grid, and you'll feel exactly the same with fans at 29 degrees Celsius as you do with air conditioning, and not moving air. So, that's something to, kind of, keep in mind. Couple of other things that we've looked at in a sporting context, so at the Australian Open last year, you might have seen players wearing these ice towels. So, this is a study that we did in our lab a couple of years ago. So, you've got damp towels, that have 3 kilogrammes of crushed ice inside. And, they're rolled up, and then, in between the sets, or in between the games, the odd games, they take these ice towels and they wrap it round the neck.

And, we found that that keeps you around about .4 to .5 degrees Celsius cooler than if you just drink cold water. We're often advised to drink cold water during extreme heat events. One thing that I think is very important to keep in mind, is that if you drink cold water, it will not keep you cooler. That's very hard for people to, kind of, get their head around. We've got thermosensors that line the mouth and the oesophagus that are very sensitive to changes in temperature. So, when you drink a glass of cold water, it feels really good. I'm not saying you shouldn't drink cold water. But, it feels really good, and it feels really cool, but it doesn't mean that you are actually cooler. And, sometimes it's very difficult for people to uncouple how they feel to how hot they actually are.

Now, in most circumstances, how you feel, and how comfortable you feel is the most important thing. That's fair enough. But, when it comes to the risk of heat stroke, and how hot you actually are, it can be problematic to think that you're cooler than you actually are. One thing we did [inaudible] we tested the old adage of drink a hot cup of tea on a hot day. Every heard of that? It's an old wives tale. We did a study, and it's true. You probably should. Yes. So, I'll briefly describe it. I know I'm running out of time here. I'm getting some looks.

Right, so basically you drink cold water, and you're losing heat to the ingested water to warm that water up to body temperature. The trouble is these thermoreceptors that are inside the body that are independent of core temperature, they reduce how much you sweat. So, not only-- you're increasing how much heat you're losing inside the body, but you're decreasing how much heat you're losing on the outside of the body, because you're sweating less. And, these pretty much balance out when you're drinking a cold drink. But, when you drink a hot drink, you're adding a little bit of heat to the body, but you're actually sweating disproportionately more. And, provided that extra sweat can evaporate, you'll actually be cooler with a hot drink than you will be with a cold drink.

I don't really recommend it as the main strategy during a heat wave. I don't want any emails in January saying that guy's a-- I don't recommend it. Another really good way of keeping cool in the heat, is, kind of, getting a fluid on the outside of the skin that serves the same purpose as sweating. So, I mentioned right at the start, is that the main way in which we keep cool during a heat wave is by sweating. It's the evaporation of that sweat that cools us down. But, there's nothing stopping us getting water, for example, and applying it to the skin surface. That then evaporates, and it does exactly the same job as sweating, without the physiological strain associated with having to sweat. And, also without having to reduce your hydration status as well. This is potentially a good solution for places where you can't drink the water, but it's safe enough to apply to the skin's surface.

So, that is a very, every effective way of keeping cool as well. So, taking advantage of evaporation. OK. So, I think I'm pretty much done. We'll take some questions shortly. I'll just finish off with this last thought. So, hopefully, now everybody is a little bit more informed, but maybe you were fully informed before you came in here, and [inaudible]. But, maybe a little bit more informed about the way in which extreme heat can affect human health. And, the way in which we can try to keep cool without resorting to those dirty air conditioners during heat waves. And, I'll leave with this one thought.

So, the number one risk factor for dying in the heat wave, is being over 75 years old, and living on your own. So, if everybody can think about, at the start of the next heat wave, the first heat wave of the year, which is typically the most deadly, if we can all think about maybe checking in on the elderly neighbour, and making sure that they're OK. Because you never know, it might save their life. Thank you very much.

[ Applause ]

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