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## STRAIGHT TO THE HEART

**Biomedical engineer Jacqui Savage likes to get to the core of the problem. And her latest invention, a non-invasive device to measure body temperature, does just that.**



Biomedical engineer Jacqui Savage. Pic: Josh Robenstone

**Problems, problems, everywhere you look and not enough trained problem-solvers. Problems at the cafe across the road from Melbourne's Swinburne University where Jacqueline Savage has allocated one hour to describe how she designed a world-first, lifesaving medical sensor but the waiter won't let you have a quiet booth unless you're ordering food. Problems with Google Maps not showing roadworks. Problems with trains running late. Problems with being a teenager and wondering what to do with your life, with falling off your horse and not being able to get back on because your back is broken. Problems, seven years ago, going to hospital every Friday, sitting with your best friend, watching her die of cancer before her 21st birthday and asking, *What can I do to help?***

Jacqui is an engineer. She's the 28-year-old head of MedCorp Technologies, a company she set up to make revolutionary medical products. Her flagship product is a wearable, non-invasive, wireless adhesive patch, about the size of a 50c coin, that measures core body temperature from the surface of the skin and sends that information to a phone. It sounds simple but until now no one had been able to crack the challenge of accurately measuring core body temperature without an invasive procedure (most doctors regard the "gold standard" measurement to be the temperature in the pulmonary artery, which carries blood from the heart to the lungs). Jacqui's invention was listed among the Top 100 Global Engineering Innovations by NASA's magazine *Tech Briefs*, and Jacqui was voted top entrepreneur at last year's Telstra Business Women's Awards.

The din of cafe music and the clinking of cutlery scooping up smashed avo creates an atmosphere at odds with the gravity of her work but one problem has been solved: a successful negotiation has led to a table by the window. It looks across the road to a glass-fronted testing facility called the Factory of the Future, inside Swinburne's Advanced Technologies Centre, where Jacqui's breakthrough took place. Clinical trials costing millions of dollars start soon. "It's a big pressure and it's all riding on me," she says calmly. She trusts her results. There's nothing like knowing you've got the winning ticket to settle the nerves.

**It wasn't always going to be engineering for Jacqui.** She was a horse-mad teenager and wanted an equestrian career. Her mother Gail remembers her at age 13 taking her saddle to school, walking to the tram stop after school, catching the

tram to South Yarra Station, getting a train for more than an hour and then walking three kilometres to where her horse was. The dream ended in Year 11 when she fell off during a jump and fractured a vertebra. She never regained her confidence.

A bigger turning point came at 21, while at Swinburne University studying for an engineering degree, when one of her best friends was diagnosed with blood cancer. Jacqui would visit every week and sometimes the talk would turn serious. “We started talking about technology and how we could improve what she was going through. I’d come up with ideas and talk about how great it would be if she could take treatments home, things like that.”

Recognising the opportunities in the medical sphere, she decided to specialise in biomedical engineering. She designed a device that could deliver chemotherapy drugs remotely, so patients could receive treatment at home. It’s since been patented and plans are in place to bring it to market. After finishing her degree she got a job as a product design engineer with Outerspace in Melbourne. Director Mark Johnson says she stood out from the outset, with “a great understanding of complex problems”.

Jacqui’s friend lost her battle and more sadness came the same year when a family friend also died from cancer. It was at this point that Jacqui started talking to oncologists. “They told me that infection is one of the primary causes of death in patients receiving chemotherapy,” she recalls. “Our friend would be alive today if his infection had been detected sooner.”

Dr Andrew Haydon, an oncologist at Alfred Hospital, says a wearable device that monitors the core body temperature of outpatients would be “very useful” as a rise in temperature is one of the first signs of infection. “Chemotherapy stops cells that are rapidly dividing, so it’s very common for patients to have a reduction in their white blood cell count,” he explains. “That leads to a reduction in your body’s ability to fight infections, because your immune system is so compromised.”

Haydon says that while temperature monitoring in hospitals is generally done well with thermometers, outpatients are expected to self-monitor and it doesn’t always work. “You’d be surprised how many people think they can tell their - temperature based on how they feel. You can’t rely on that at all.”

It was the unreliability of traditional thermometers and the fact they only give an estimate of your core body temperature that Jacqui says convinced her to design a device that went straight to the heart. “Devices that are currently used, like oral thermometers or tympanic [ear] thermometers, aren’t accurate indicators of core body temperature. All you need to do is have a glass of water and your temperature is different in your mouth. Even speaking will change it. Ear is not 100 per

cent accurate and if your thermometer isn't calibrated then it definitely isn't. Core body temperature is the one vital sign that's the most critical, and it's the hardest thing to do in terms of engineering because there are so many variables. Getting the accuracy is so hard."



Biomedical engineer Jacquie Savage. Pic: supplied

**What was needed was a way for doctors to** communicate directly with a patient's body via a wearable, non-invasive, continuously reporting core body temperature monitoring sensor that would alert them at the earliest sign of infection. Here was a problem to solve.

The journey from conceptualising new biomedical technology to the commercialisation of the finished product is long and difficult. For someone in their 20s with no experience in the field it should have been all but impossible. Jacqui quit her job at Outerspace, went to work at sailboat hardware manufacturer Ronstan and founded a baby product company called MioPlay after her sister had a baby, in order to “learn the commercialisation process from start to finish”, she says. “It was my crash course in an MBA.”

She also set up MedCorp Technologies, and in any spare time she worked on her sensor. Testing was done on healthy volunteers as well as in the lab, and all results showed the device was doing exactly what she wanted: continually measuring core body temperature. Part of her design will allow for alerts to be automatically sent to the phones of both doctor and patient whenever an elevated temperature is detected.

Jacqui felt ready to take a leap and quit her day job. People said she was crazy. “But my decision was made. You know where your heart is and what ignites that fire and motivation within you. Deep down I knew that was where I was going to go, because I'd never felt so inspired to work so hard and so long on something without getting paid.”

The next problem was how to pay for it. “There was a huge amount of money that needed to be brought in for testing equipment. Ordinarily you'd go out and raise capital, get investment, hire a space and build it. But my engineering brain was saying, ‘Let's look at *what* we need, not how much money we need’.” Jacqui engineered a deal with Swinburne University to use their facilities in return for MedCorp offering internships for PhD students. “It was a different way to think about the problem,” she says, showing her knack of transferring engineering skills to the business world. Meanwhile, MioPlay was taking off, with sales from the baby products helping to pay for the small team of MedCorp lab technicians. All that was needed now was proof the sensor worked.

The breakthrough was a slow burn, but the results lit up the lab. Proof came in a small tub of water, heated to various temperatures. The water represents the human heart, with aluminium and silicone sitting on top to simulate bone and - tissue. Jacqui places her sensor on top of that — simulating its position on the surface of the skin — and takes readings as the water is heated, comparing these readings with the actual water temperature.

“There was a wonderful moment when we received data showing that we were measuring core body temperature within plus or minus 0.1 of a degree, which has never been done before in the world. It’s the first time anyone’s been able to measure temperature at a depth below the skin with that degree of accuracy without being invasive.” Full clinical trials in hospitals are about to start. All going well, the device then goes up for regulatory approval in different countries (including the Therapeutic Goods Administration in Australia), after which it can be launched onto the market.

**Jacqui has always been a visual learner. She** rewrote every one of her uni text books by hand in a way that made sense to her. “A lot of people haven’t been taught how they learn,” she says. “I’m not somebody who can sit there and listen to someone talk for two hours and take it all in. I have to see it.” It’s the reason she spends so much time standing in front of high school students: so they can see her. By going into schools Jacqui is trying to solve a problem that might prove even harder than measuring core temperature: how to get more girls to study STEM subjects (science, technology, engineering, maths).

“This,” she says to the kids, swiping her arm across her body as if to declare opportunity open, “is what an engineer looks like.” She’s there to break down stereotypes of what engineering is, where it can take you, how it can help people. She wants girls to see that it’s not all hard-hats and building sites, pipes, bridges and sewers. “If you ask how many people want to be an engineer, not many hands will go up. But if you say, ‘Hands up if you want to work for Instagram or Snapchat’, hands will fly up. They’ll talk about things they want to create. Well, that’s engineering.”

Only 13 per cent of engineers in Australia are women. Peter McIntyre, CEO of industry body Engineers Australia, says the country is short of engineers and as we transition to innovation, technology and smart economies it’s stifling our progress. “We graduate around 10,000 engineers a year, and import about the same number. If you rely on tapping into overseas workers rather than producing your own stock, that’s a really risky strategy for the country. If we don’t get the right people at the right time, other countries around us will go forward and we’ll stagnate.” More women going into engineering means more engineers, which is why McIntyre is excited by Jacqui’s success. “What she did was some world-class thinking — to take a real, practical problem and turn it into a reality that benefits society. Jacqui shows that women [in this field] can succeed and make a profound impact on people’s lives.”

But how to get more girls into STEM subjects in a country where only six per cent of girls study advanced maths at high school? Helen Watt, professor of educational psychology at The University of Sydney, has studied the reasons children choose different subjects for many years. She says that despite similar levels of achievement, girls tend to believe they’re less capable than boys in maths and science. Another part of the problem is engagement. “Forty per cent of secondary

teachers teaching STEM subjects aren't qualified to do so. A big player when choosing subjects is the 'interestingness' of what they learn. That's when I get worried about that 40 per cent figure."

Watt has just completed a study of 1172 high school students across Melbourne and Sydney, asking them what was important in a career. Girls consistently said they wanted to make a social contribution. "I think that's a real lever for action. When making decisions about their future career it wasn't teachers or career counsellors, it was their mothers who had the greatest influence." Watt says there is strong evidence that role models — particularly those who are successful in their field — also have a powerful influence.

The University of NSW graduates the most engineers in Australia. Mark Hoffman, dean of engineering, says that like many tertiary institutions, UNSW has made a dedicated push to encourage more women into engineering. "We've set a target of 30 per cent," he says. "Three years ago we were at 19 per cent; 2018 will be 26 per cent. Our numbers of female engineers have increased 45 per cent since 2013." He says part of its success was in setting up summer camps for young women. "They're here for a week, they visit engineering workplaces, talk with female engineers, build that community. Word of mouth gets out there."

Funding from industry helps, too. UNSW has received \$2 million from industries to set up scholarships as part of its Women in Engineering program. A similar program is run by the University of Queensland, which now also boasts 26 per cent female engineering graduates.

**Jacqui's success doesn't surprise many people.** Not Outerspace's Mark Johnson, the first person to see her talents up close. "She's crazy but she's brave," he says. "She scares me sometimes. She's not afraid to try new things, and at such a young age ... it's pretty scary stuff she's doing." Not Jacqui's "fairy godmother", Professor Linda Kristjanson, the vice-chancellor of Swinburne, who sat Jacqui down when she was facing a crisis of confidence, went into her own network and found her mentors. And definitely not Jacqui's mother, Gail, who raised her three girls — Emilia, Lillian and Jacqui — on her own after splitting from her husband, boatbuilder John Savage, when Jacqui was two. Gail studied applied science and would take Jacqui to lectures when she was three; Jacqui would sit there and listen to the entire lecture. "She was interested in whatever was going on, and continually asking questions. It didn't matter what you'd be doing, she'd ask you why you were doing it like that."



Jacqui Savage with her mother Gail. Pic: courtesy Jacqui Savage

Jacqui says Gail is her biggest inspiration. “She went to a school where they expected the girls to drop out by the age of 15 and be pregnant. But she went on to do her masters. She is a brilliant artist, and the biggest advocate for education. She didn’t have a privileged upbringing, and she was determined to give her children every opportunity.”

Jacqui watched her sister Emmy battle epilepsy through her school years. Their mother showed Emmy that instead of viewing epilepsy as a burden she could use it as motivation to study behavioural neuroscience, which she did, eventually gaining a PhD. The girl who couldn’t study because of seizures, who spent much of her teen years distraught at her life prospects, is now Dr Savage. A different way to look at a problem. “To watch my sister do that ... I just thought, ‘I’ve got nothing to complain about’,” says Jacqui. Her other sister Lillian became a lawyer and consultant, and now acts as an adviser at MedCorp.

Gail saw the world through the prism of her own mother's independence. "She was a fitter and turner during World War II. Women were trained as engineers back then. She could do anything: paint, dressmaking, bake a cake, fix the sink ... I grew up thinking all that was normal. I didn't realise there was discrimination, that women got paid less and that certain jobs were just for men. We had the

most amazing workforce back then and it was all women. We lost that."

The story of Jacqui Savage is the story of five female believers, a remarkable family inspired by each other, who don't cower from problems. Problem-solvers. "Only people can inspire people," says Jacqui. "Unless you can show people real examples, you can't challenge the stereotypes they have. That's why I go into schools."

Gail wants her daughters to be the norm, not the exception. "In this country girls can do anything. We're not living in Saudi Arabia. That's what upsets me; children here have so many opportunities, and a lot of them are squandered. Education is power. The one thing I taught the girls was that you can lose money, people can take things off you, but they can't take away your education. It's a great time to be in Australia and be a woman."

Source: <http://www.theaustralian.com.au/life/weekend-australian-magazine/biomedical-engineer-jacqui-savage-says-her-body-core-temperature-device-is-a-life-saver/news-story/8b752f8cdfcaf305586451494d2c8bad?login=1>