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QUT ihbi
Institute of Health and Biomedical Innovation

IHBI ADVANCES

IN THIS ISSUE

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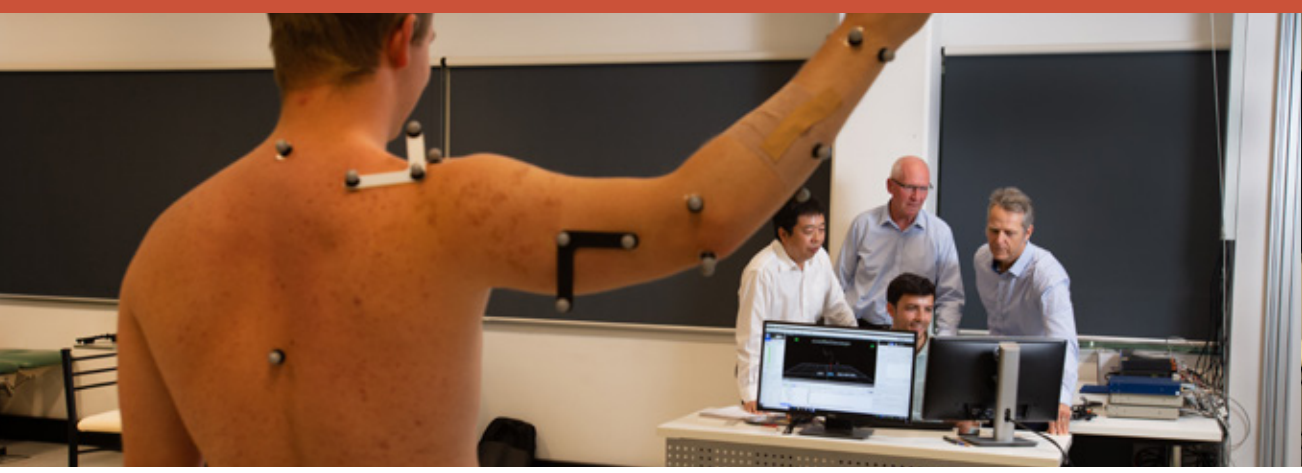
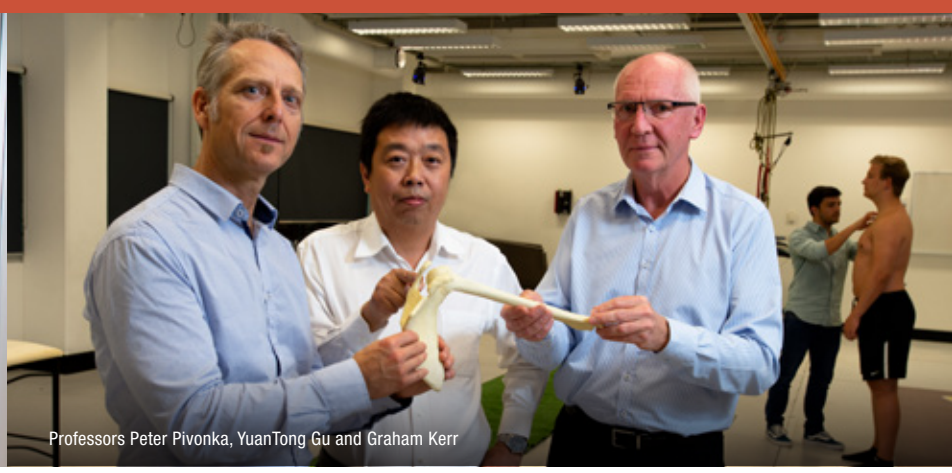




Professors Peter Pivonka, YuanTong Gu and Graham Kerr

Focus on orthopaedics combining research, training and collaboration

Joints in the human body fulfil complicated tasks and their replacement requires comprehensive understanding of biomechanical functions, anatomy and surgical techniques. IHBI researchers are part of an initiative encompassing research, training and collaboration with surgeons and patients.

IHBI researchers are leading a major new training centre that aims to improve understanding of joint biomechanics and treatment of Australians with osteoarthritis and other joint-related orthopaedic disorders.

Professors YuanTong Gu, Peter Pivonka and Graham Kerr are IHBI's lead investigators for the Australian Research Council (ARC) Industrial Transformation Training Centre for Joint Biomechanics, announced in October.

Professor Gu says the centre is bringing personalised surgical treatments a step closer.

ARC INDUSTRIAL TRANSFORMATION TRAINING CENTRE FOR JOINT BIOMECHANICS

Professor YuanTong Gu leads QUT and IHBI research as Training Centre Director. Professor Peter Pivonka is the centre's Deputy Director.

Also involving QUT professors Graham Kerr, You-Gan Wang, Cameron Brown and Yin Xiao; associate professors Travis Klein, Devakar Epari and Emilie Sauret; and Dr Neha S Gandhi.

Partners include the University of Queensland, the University of New South Wales and industry partners Wright Medical, Zimmer Biomet, Surgical Specialities and Logemas.

Collaboration extends overseas to the University of Stuttgart in Germany and the University of Western Ontario in Canada.

Establishing QUT and Queensland as a biomechanics hub in Australia.

ARC INDUSTRIAL TRANSFORMATION TRAINING CENTRE FOR CELL AND TISSUE ENGINEERING TECHNOLOGIES

Announced in October.

Led by Monash University and involving IHBI's Dr Laura Bray as Deputy Director.

Supporting new research into tissue engineering and regenerative medicine that will lead to better medical outcomes for patients through progressive new treatments for diseases.

'Most joint implants are now generic in size and treatment stops after surgery,' he says. 'We are working towards making them personalised for each patient in a way that best suits their individual anatomy and movement.

'Humans have greatly varying sizes and shapes. In addition to the specific anatomy of patients, the kinematics and kinetics—or forces and movements—experienced by the implant through its life must be considered.'

At the core of the centre's research is computer modelling and simulation, enabling the design and evaluation of patient-specific implants; and tools for pre-surgical planning and decision making, surgical training and post-surgical assessment.

'Surgical planning has evolved from 2D models such as X-rays to 3D visualisation models,' Professor Gu says. 'Present implant designs now rely heavily on computer modelling to adjust implants and ensure better biomechanical outcomes.'

Expert shoulder surgeons Dr Ashish Gupta and Dr Kenneth Cutbush are part of the collaboration, ensuring clinicians have the information needed about a patient's joint biomechanics, how surgery may affect functional outcomes, and the impact on post-operative recovery.

Design decisions that may need to be considered in a personalised treatment approach include features of the replacement implant and patient-specific instrumentation for the surgery.

Professor Pivonka says the centre will also train high-quality young scientists and engineers to develop Australia's next-generation biomedical engineering workforce.

He says the need for training, research and development is great, with osteoarthritis linked to more than 53 000 total knee replacements in Australia in 2016-17 and more than 32 000 hip replacements.

Osteoarthritis is the most common form of arthritis, typically affecting hands, knees, hips and the spine. It impacts about 2.2 million Australians, or about one in every 11 people.

Knee and hip replacements come with the risk of infection and implant loosening—the major causes of revision surgery.

The centre's computer simulation will investigate implant loosening due to a lack of osseointegration—the direct structural and functional connection between living bone and the surface of a load-bearing implant.

It will also play a role in replicating nano-scale features of naturally occurring materials with antibacterial properties for use on implant surfaces.

Simulation can also be leveraged to develop optimised tissue engineered scaffolds—implants made using bioink and populated with a patient's own cells that encourage the body to regenerate damaged tissue.

The scaffold provides a support matrix that ensures strength and withstands mechanical loading as the patient's tissue generates.It slowly and safely degrades as the tissue replaces it.

Understanding how to use plasma in cancer treatment

Chemotherapy is the most common cancer treatment, but it often involves side effects and is less likely to be successful when a cancer builds resistance. IHBI researchers are investigating the use of plasma to improve efficacy of cancer treatments.


Adjunct Associate Professor Kateryna Bazaka

Adjunct Associate Professor Kateryna Bazaka collaborates with IHBI teams working in different areas of cancer research, starting with a better understanding of cellular activity and ultimately aiming to improve treatment and survival rates.

Her research in plasma spans health, pollution, biofuels and in chemical manufacturing processes. She has been recognised with a 2019 Young Tall Poppy Science Award for Queensland. She is also one of four QUT researchers named as Australian Research Council (ARC) Future Fellows, joining IHBI's Dr Robyn Araujo and sharing in Federal funding to further their research.

YOUNG TALL POPPY SCIENCE AWARDS

Celebrating people who demonstrate scientific excellence and passion for science communication.

A collaboration between the Australian Institute of Policy and Science and the Office of the Queensland Chief Scientist.

14 Queensland awards recipients announced on September 13.

ASSOCIATE PROFESSOR JYOTSNA BATRA

Also included among the 14 Queensland awards recipients.

Awarded for her leading research identifying and characterising genetic variations associated with prostate cancer.

Aiming to improve testing and diagnosis and identify targets for therapeutic interventions.

Leading a team investigating single nucleotide polymorphisms (SNPs) that may help identify patients likely to have aggressive rather than slow-growing prostate cancer – and would therefore benefit the most from intensive treatment.

'My research is very much about taming the power of plasma and exploring novel ways to use it.' Associate Professor Bazaka says. 'Plasma technology is already used in a variety of applications, including in semiconductor device fabrication, plasma TV screens and neon signs.'

Associate Professor Bazaka says plasma shows promise in improving treatments in multiple cancers, potentially including melanoma, leukaemia, and colon, lung, breast, ovarian, cervical, bladder and pancreatic cancer.

Her IHBI collaborators include breast cancer researcher Professor Rik Thompson and DNA repair expert Professor Derek Richard.

The collaboration enables the identification of the types of cancer and patient groups most likely to benefit from treatments that use plasma.

'Plasma has a unique ability to both induce changes and adapt to changes in the material it contacts, so there are many potential uses for it,' Associate Professor Bazaka says.

Plasma is an ionised gas and is one of the four fundamental states of matter, along with solid, liquid and gas. Similar to gas, plasma does not have definite shape or volume. It is electrically conductive, produces magnetic fields and electric currents, and responds strongly to electromagnetic forces.

Cold atmospheric plasma (CAP) is one of two types of plasma, differentiated from thermal plasma because it is less than 40°C at the point of application.

Research has shown that CAP is effective in controlling cell activities critical to cancer progression, including apoptosis, a form of programmed cell death. The average healthy adult loses between 50 and 70 billion cells each day due to apoptosis.

Defective apoptotic processes are linked to a wide variety of diseases. Insufficient cell death results in rapid and uncontrolled cell production, such as occurs in cancer.

Chemotherapy works on cells that are dividing rapidly. Cancer cells divide and multiply rapidly but so do some healthy cells, such as those in a person's blood, mouth, digestive system and hair follicles. Side effects occur when chemotherapy damages the healthy cells.

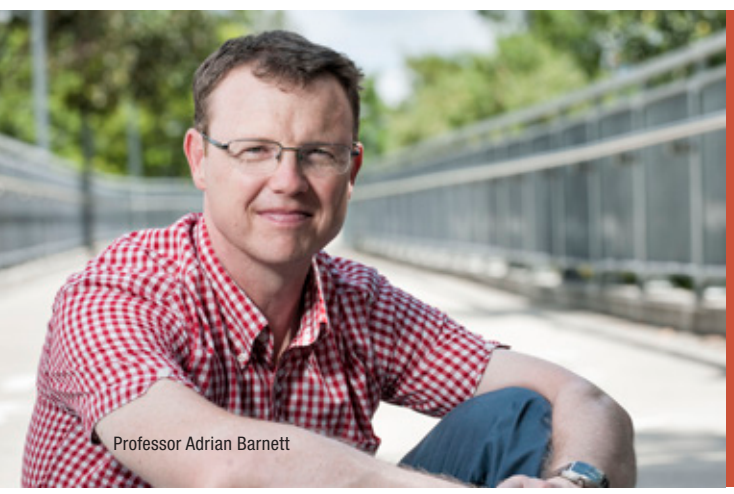
CAP has the potential to accurately target cancer cells, Associate Professor Bazaka says. 'The exact mechanism of CAP for selecting cancer cells is yet to be fully understood, but may be linked to genomic instability that is a hallmark of tumour cells.

`CAP is known to cause DNA damage in cancer cells and CAP treatment also appears to rewire tumour cells to a more chemo-sensitive state.'

It can selectively shrink tumours, restore chemo- and radio-sensitivities in resistant cells, stimulate immune functions, halt metastasis and push cancer stem cells into an apoptotic state.

Importantly, CAP can be used as a stand-alone therapeutic tool or in combination with established cancer treatment therapies.

For example, radiotherapy is known to damage healthy cells and harm the immune system. Adding CAP has demonstrated an ability to provide a mild yet effective stimulation of the immune system.


Professor Adrian Barnett

Supporting GPs to assess liver disease and avoid hospital stays

Chronic conditions play a major role in the more than 11 million hospital admissions in Australia each year. Multiple admissions can be stressful and inconvenient for patients and their families and costly for the health system.

IHBI Professor Adrian Barnett is leading research that aims to free capacity in the congested public hospital system.

His team's focus is on people with non-alcoholic fatty liver disease (NAFLD), the most common type of chronic liver disease in Australia.

NAFLD is an umbrella term for a range of liver conditions affecting people who have too much fat stored in liver cells which is not due to excessive alcohol consumption. It is strongly associated with obesity and diabetes.

RESEARCH PROJECT COLLABORATORS

Professor Adrian Barnett, IHBI

Professor James O'Beirne, University of the Sunshine Coast

Dr Ingrid Hickman, Queensland Health, Metro South Hospital and Health Service

Professor Elizabeth Powell, University of Queensland

Associate Professor Patricia Valery, QIMR Berghofer Medical Research Institute

Dr Sanjeewa Kularatna, IHBI

Dr David Brain, IHBI

Scarring, known as cirrhosis, is the most severe complication of NAFLD, causing permanent damage to the liver and resulting in loss of function. Cirrhosis takes years to develop and can lead to liver cancer.

The prevalence of NAFLD may be as high as 30 per cent of the Australian adult population. The disease is on the rise as it is mirroring rising obesity rates.

Figures suggest that between 60 and 90 per cent of people with NAFLD are not at risk of chronic liver disease and can safely be cared for in the community, rather than requiring hospital care.

Professor Barnett and his team will conduct a trial of a community-based patient assessment activity to assist general practitioners to determine which patients need to be referred to hospital for care and which they can manage themselves.

'Better assessment of low-risk patients will reduce referrals for hospital-based appointments,' he says. 'It will also ensure appropriate care is delivered close to a patient's home.

'For patients and carers, the economic benefit of receiving care close to home is well established. Receiving care close to home is of particular importance for Australians living outside of the major cities, where significant travel costs and lost productivity are incurred both by patients and carers who often access services far from their home.'

Conversely, providing better assessment tools is expected to mean that people with advanced disease have a faster referral to hospital. Such referrals will reduce the risk for those patients of disease progression, organ failure and avoidable hospital admission.

The research builds on an existing partnership with Sunshine Coast and Wide Bay Hospital and Health Services that has so far focused on hepatitis C virus (HCV) infection.

Figures from the HCV initiative show that more than 600 patients have been assessed and treated in the community, with successful treatment in more than 95 per cent of cases. In the process, more than 1500 unnecessary hospital appointments have been avoided.

'We believe that a similar model of care will work for people with NAFLD, who account for a larger, longer-term burden on the health system than people with HCV,' Professor Barnett says.

The research has National Health and Medical Research Council (NHMRC) Medical Research Future Fund support until 2022 as part of the Keeping Australians Out of Hospital initiative.

Collaborators in the research project have expertise in hepatology, a branch of medicine incorporating the study of the liver; clinical trials; research translation; population health; statistics and health economics.


Associate Professor Elizabeth Williams

Collaboration has focus on common, but forgotten, cancer

Bladder cancer is common, deadly and the most expensive cancer to treat, from diagnosis to death. Yet it has historically been under-represented in health policy, research and funding. IHBI researchers are collaborating widely to improve multiple aspects of the disease.

IHBI is leading research and collaboration as part of the Queensland Bladder Cancer Initiative (QBCI), bringing together researchers, clinicians, other healthcare workers, industry partners, patients, and their families and carers.

Cancer researcher Associate Professor Elizabeth Williams and urologic oncologist Dr Ian Vela established the initiative to tackle multiple aspects of translational research and build resources that will enable improvements in treatment and management of bladder cancer.

Driving the research is support through Princess Alexandra Hospital Research Foundation grants from 2018 and 2019. Support will continue through 2020 via donations raised as part of the inaugural PA Giving Day in 2019.

Associate Professor Williams says a major challenge is the inability to predict which cancer subtypes will spread deeper into the bladder and then to other tissues as part of metastasis. It means all bladder cancer patients require careful monitoring.

Molecular differences between bladder cancer subtypes have only recently been described and appear to be associated with different prognoses and responses to therapies, she says.

'Ongoing studies are investigating how molecular subtyping could be incorporated into clinical management.'

Adding to the knowledge is her team's research involving mini-tumours, generated using donated patient tissue and investigated in IHBI laboratories at the Translational Research Institute to understand factors enabling cancer cell growth and survival.

'Using the mini-tumours, we can study cancer biology and perform molecular analyses of clinical samples,' Associate Professor Williams says. 'We can predict which treatment a specific patient is likely to respond to. The ultimate goal is to inform choice of treatment.'

The QBCI also involves IHBI research to discover biomarkers—proteins found in the body that point to the presence of disease—that can be used in screening and monitoring bladder cancer. Tumour tissue, urine and blood will be used to look for the biomarkers.

'We are particularly keen on the possibilities of using urine, as this provides an opportunity to develop a truly non-invasive test that could potentially be delivered in the community.'

The research involves collaborations with University of Queensland Professor Matt Trau and his colleagues at the Australian Institute for Bioengineering and Nanotechnology.

Collaborators also include IHBI's Dr Amina Tariq, who is working on developing tailored support material and sensitive social media applications to improve the experience of people with bladder cancer.

'Patient surveys show the experience of those diagnosed with bladder cancer is one of the poorest compared to other cancers. This has been attributed to a number of factors, including delays in diagnosis, lack of emotional support and sense of isolation—contributed to by the low profile of bladder cancer in the community.'

Other major factors are that patients live with a lifelong threat of bladder cancer, have relatively limited treatment options, and have a five-year survival rate of 54 per cent.

Patient and clinician involvement in the QBCI is also key, through an interactive platform.

'We envisage people with bladder cancer reporting on their experiences and managing their consent to be involved in research,' Associate Professor Williams says. 'Clinicians will be able to efficiently identify people who may be eligible for clinical trials, enabling improved accuracy in study design and facilitating recruitment.

'That will ultimately enable the impact of research investment to be maximised to enable new discoveries and speedy translation from a research laboratory to a hospital treatment.'

BLADDER CANCER

The tenth most common cancer worldwide.

Sixth most commonly occurring cancer globally in men.

In 2019, it is estimated that the risk of someone dying from bladder cancer by their 85th birthday in Australia will be one in 202.

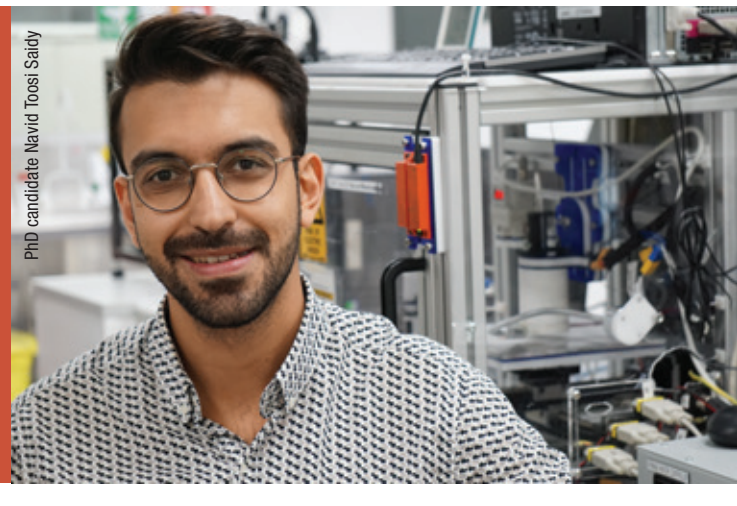
PA RESEARCH FOUNDATION GIVING DAY

Raised $850 000 for patient support, state-of-the-art equipment and medical research.

IHBI research supported on the day focused on bladder cancer, prostate cancer and breast cancer.

Technology mimicking human tissue at the heart of research

Surgical intervention is the predominant treatment for moderate to severe valvular heart disease. A present heart valve prosthetic has a limited lifespan and does not encourage the body to regenerate the damaged area of the heart.


PhD candidate Navid Toosi Saidy

PhD candidate Navid Toosi Saidy is part of an IHBI team, led by Adjunct Associate Professor Elena De-Juan-Pardo, that has developed a 3D-printed prototype of a tissue engineered heart valve potentially capable of growing and remodelling with a patient.

The prototype is developed using a fabrication technique called melt electrowriting (MEW) that can accurately deposit micrometric fibres with controlled arrangement, inspired by the wavy architecture of the collagen fibres found in the heart valves.

The prototype has mechanical properties comparable to that of a person's own heart valve tissue. Valves developed using MEW are showing excellent functionality, pointing to their potential for long-term use.

Mr Toosi Saidy says the results demonstrate the prototype has the potential to one day replace synthetic prosthetics, encouraging the body to regenerate the damaged heart tissue as the 3D-printed implant slowly and safely degrades.

Valvular heart disease is the third leading contributor to cardiovascular disease globally, resulting in more than five million deaths per year. It affects 12 per cent of geriatric patients and eight in every 1000 births.

Valves in the heart may be damaged as a result of infection, rheumatic heart disease or congenital defects. The affected valve cusps grow thick and brittle from scar tissue or calcium deposits, or become thin and weak, resulting in aninefficient valve.

The extent of the valve disease will determine if a patient needs surgery to have the valve repaired or replaced.

Mr Toosi Saidy says present synthetic and non-biodegradable prosthetics including metallic mechanical valves and decellularised biological valves can enhance quality of life and survival for geriatric patients. However, they have a limited lifespan and do not support tissue remodelling and regeneration. Multiple surgeries are often required, especially for paediatric patients.

'There has been two decades of intensive research in tissue engineered heart valves to overcome the disadvantages of the present prosthetics,' he says. 'The challenge is to develop a biocompatible replacement with anatomy, structure, function and adaptive mechanisms that closely mimic the human heart valve.'

His work has been recognised this year with a Postgraduate Student Researcher Award from the Australian Society for Medical Research. He also secured a student bursary from the World Biomechanics Congress to present his research in Dublin, Ireland. He also presented at the International Conference of Heart Valve Tissue Engineering in the Netherlands.

Mr Toosi Saidy is part of IHBI's Regenerative Medicine research group, under the leadership of centre director Distinguished Professor Dietmar W Hutmacher.

VALVULAR HEART DISEASE

Characterised by damage to, or a defect in, one of the four heart valves: the mitral, aortic, tricuspid or pulmonary.

MITRAL AND TRICUSPID VALVES

Control blood flow between the atria and the ventricles, the upper and lower chambers of the heart.

PULMONARY VALVE

Controls blood flow from the heart to the lungs.

AORTIC VALVE

Controls blood flow between the heart and the aorta – and ultimately the blood vessels to the rest of the body.

THE ROLE OF VALVES

Ensuring proper blood flows, including force, direction and timing. Affected in valvular heart disease.

STENOTIC VALVE

A valve that has become too narrow and hardened, forcing blood to back up in the adjacent heart chamber.

INCOMPETENT VALVE

A valve unable to close completely, allowing blood to leak back into the chamber it previously exited. To compensate, the heart muscle enlarges and thickens, thereby losing elasticity and efficiency.


Dr Margo Sendall

Unhealthy truckies at greater risk of chronic diseases

With more than 200 000 truck drivers in Australia, there are multiple studies about their safety but few about their health. IHBI researchers are investigating ways to improve the nutrition and physical activity of drivers.

Dr Margo Sendall is leading research at IHBI which aims to build a picture of truck driver health and find ways to improve nutrition and physical activity while at work.

Dr Sendall, Adjunct Associate Professor Phil Crane, research assistant Laura McCosker and undergraduate Summer Scholarship student Rahma Ahmed distributed a survey at the Brisbane Truck Show and gathered responses from 231 drivers. The responses are reported in an article in *The International Journal of Occupational and Environmental Medicine.*

THE STATISTICS

Australian regulations permit truck drivers to be behind the wheel for up to 12 hours per day, often without interruption.

Only one-tenth of study participants report meeting the Australian recommendations of more than five serves of vegetables per day.

More than 59 per cent of participants are classified as obese, compared to 27 per cent of the overall Australian population.

Despite having a poor diet and limited physical activity, more than 73 per cent of truck drivers perceive their health to be either good or very good.

Nearly all drivers report accessing health information frequently from general practitioners, friends and family members.

THE FULL REPORT

https://www.theijoem.com/ijoem/index.php/ijoem/article/view/1533/1118

Participants were almost all male and ranged in age from 20 to 71 years. The survey questioned drivers about their nutrition, physical exercise, sources of health information and self-awareness of health.

The study concludes truck drivers are among the nation's most overweight, unhealthy workers and are at increased risk of chronic diseases such as cardiovascular disease, diabetes and some cancers.

Dr Sendall says truck drivers are limited by their working environment, often underpinning their poor health choices. They frequently work long sedentary hours, have erratic schedules and are under extreme time pressures, she says. More than 85 per cent of drivers reported working more than nine hours each day.

'While on the road they have limited access to shops and healthy food options and turn to consuming foods high in saturated fat, with added salt or added sugar', she says.

Almost two-thirds eat unhealthy foods on two or more days of the week and consume at least one sugary drink per day.

'Of concern, almost 90 per cent of drivers had above the recommended body mass index. About 60 per cent were obese. That is almost double the proportion found in the general population.

'Due to working environments, truck drivers have very limited access to physical activity with more than two-thirds not meeting the Australian recommendations for moderate-intensity physical activity and nearly 80 per cent not meeting vigorous-intensity activity recommendations.'

Most participants recognise the importance of their health and are motivated to make changes to their lifestyle.

Dr Sendall says the key to implementing change is placing effective health promotion in the workplace.

'It has been shown that workplace health promotion can generate improvements in drivers' health knowledge, behaviours and self-reported health outcomes, as well as ease the burden on our public health system.

'Our research demonstrates a need for industry-wide adoption of this approach, along with some government incentives to encourage this Australia-wide.

'Truck drivers are a highly mobile, pressured and hard-to-reach group, and traditional health promotion strategies such as television campaigns are easily missed.

'Additionally, our previous research suggests the use of social media and digital technologies as a health promotion intervention for truck drivers has potential.'

Dr Sendall is working with Brisbane-based Team Transport and Logistics to implement change in the transport industry and increase awareness of importance of healthy behaviours which will lead to better health outcomes.

EXECUTIVE DIRECTOR'S REPORT

Successful researchers are not just scientists with expertise in specialised areas of medicine, biology, product development or new-generation materials. Success requires leadership in everything from networking and collaboration to business acumen and an ability to translate research from a laboratory to a hospital, clinic, aged care facility or community centre.

Professors YuanTong Gu, **Peter Pivonka** and **Graham Kerr** are leading a national joint biomechanics initiative encompassing research, training and collaboration.

Their Industrial Transformation Training Centre is one of only six receiving ARC support in 2019 to provide innovative postdoctoral training for research industries identified as vital to Australia's future.

The centre involves 29 researchers, tasked with driving growth, productivity and competitiveness while investigating ways to bring personalised surgical treatments a step closer for people with osteoarthritis and other joint-related orthopaedic disorders.

IHBI's **Dr Laura Bray** is Deputy Director of another such training centre in cell and tissue engineering, collaborating with researchers at Monash University and aiming to improve outcomes for patients through progressive new treatments.

Navid Toosi Saidy is benefiting from training at IHBI as part of his PhD studies, building an international network and presenting his research in developing a tissue-engineered heart valve. He is an integral part of an IHBI team developing a prototype that may one day replace synthetic prosthetics, enabling him to see how researchers collaborate with clinicians, incorporate business acumen to work with industry partners and make research translation a reality.

Associate Professor Elizabeth Williams and **Dr Ian Vela** are leading research as part of the Queensland Bladder Cancer Initiative to tackle multiple aspects of translational research and build resources that enable improvements in treatment and management.

Professor Adrian Barnett is taking a lead in extending a partnership with Sunshine Coast and Wide Bay Hospital and Health Services to free capacity in the congested public hospital system.

Adjunct Associate Professor Kateryna Bazaka is leading research in a relatively new field, working with a platform that has the potential to impact in health, pollution, biofuels and in chemical manufacturing processes.

She collaborates with IHBI teams to tame the power of plasma, shown to be effective in controlling cell activities critical to cancer progression.

Dr Margo Sendall aims to implement industry-wide change in transport, leading research that addresses high rates of truck driver obesity and risk of chronic diseases. Truck cabins and schedules can't be changed, so Dr Sendall is investigating workplace health promotion, in collaboration with industry partners.

Leadership requires a skillset unlike the scientific rigor applied in the laboratory, but IHBI researchers are using their initiative, flexibility and creativity to collaborate and ultimately translate.

This is the final edition of *IHBI Advances* for 2019. I would like to wish you a safe and healthy holiday period, a Merry Christmas and a Happy New Year.

Professor Lyn Griffiths
Executive Director, IHBI

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Institute of Health and Biomedical Innovation

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