

2017 ACTIVITY REPORT

The Western Australian Pregnancy Cohort (Raine) Study

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Executive Summary

Established in 1989, the Raine Study is one of the largest, most successful prospective cohorts of pregnancy, childhood, adolescence and now adulthood to be carried out anywhere in the world. The Raine Study is now a multi-generational life-course study with participation of the original parents (Generation 1), along with their now young adult children (Generation 2), and the children of the original children (Generation 3). The focus for 2017 was to update, revise and modernise the human and technical systems of the Raine Study, to create the basis for sustainable growth into the future.

Highlights from the Raine Study in 2017 include:

- Establishment of the Raine Study as a formal partnership between all the universities in Western Australia (University of Western Australia, Curtin University, Edith Cowan University, Murdoch University and University of Notre Dame) along with Women and Infants Research Foundation and Telethon Kids Institute. The Unincorporated Joint Venture structure provides strong governance and ownership of the Raine Study and was supported by the Raine Medical Research Foundation.
- Implementation of a new organisational structure with clearer operational and scientific roles for staff, portfolios and committees, including explicit terms of reference and position descriptions.
- Appointment of new staff into senior leadership roles of Operations Manager, Communications Manager and Scientific Officer along with new Data Officers.
- Creation of a new Special Interest Group structure and appointment of early/mid-career and senior/mentor researchers as leaders for each group to provide capacity building opportunities and encourage maximisation of data resource use.
- Development of a new project management system to ensure more efficient management of Raine Study research and enable continued growth in activity (ROSS – Raine Online Submission System).
- Piloting of a secure analysis system which will enable greater data security (SHAPE – Secure Health data Analysis and Processing Environment).
- The creation of strong participant involvement in all aspects of the new organisational structure including a specific participant committee, and participant representatives on the other substantial committees and the Unincorporated Joint Venture Board.
- Active data cleaning continued for Generation 1, with new data collection for Generation 2 on adiposity and economic areas and new data collection on Generation 3 on child development.

Activities planned for 2018

2018 will be the busiest year ever for data collection in the Raine Study, with a Generation 3 (the 'babies/children') data collection continuing, a Generation 2 data collection continuing along with 4 new Generation 2 sub study data collections, a Generation 1 (the 'parents') data collection starting, and, for the first time, a Generation 0 (the 'grandparents') data collection starting. The organisational focus for

2018 will be on continued capacity development, increasing community awareness and exploration of sustainable funding opportunities.

Activities aimed at creating system capacity will include:

- Strengthening the Unincorporated Joint Venture
- Strengthening new staff and committees
- Developing Special Interest Group leaders to build active researcher capacity for projects and student supervision
- Developing strong positive research culture in researchers with new researcher engagement policy
- Strengthening consumer engagement throughout Raine Study activities
- Shifting data to a new relational data base structure with high level quality control
- Further development of a 5 year strategic and implementation plan

Community awareness activities will include:

- Establishing a Translation Committee
- Working with UJV partners to increase traditional and new media coverage of the Raine Study

Exploration of sustainable funding opportunities will include:

- Working with UJV partners to develop funding opportunities.

General Information about the Raine Study

History of the Raine Study

In 1989 Professor John Newnham and colleagues invited more than 3000 pregnant women to join a National Health and Medical Research Council funded research study at King Edward Memorial Hospital to examine the possible beneficial effects of repeated fetal ultrasound imaging studies. Women were allocated at random into one of two groups – Regular Care or Intensive Care. Those in the Regular Care group had a single ultrasound imaging study at 18 weeks gestation, with further scans only if clinically indicated. The women in the Intensive Care group had ultrasound scans at 18, 24, 28, 34 and 38 weeks gestation. Along with Professor Newnham, a group of prominent investigators (Professor Fiona Stanley, Professor Lou Landau and Professor Con Michael) formed a group to establish these families into a cohort study, focusing on the child, to determine how events during pregnancy and childhood influence health in later life. This was initially supported with funding from the Raine Medical Research Foundation. The original cohort of 2868 children, the Raine Study cohort, is one of the largest, most successful prospective cohorts of pregnancy, childhood, adolescence and now adulthood to be carried out anywhere in the world. The participants have been followed closely over the last 27 years by a collaborative team of researchers from The University of Western Australia, Women and Infants Research Foundation, Telethon Kids Institute, Curtin University, Edith Cowan University, the University of Notre Dame, (and now also Murdoch University), the Lions Eye Institute, and many other national and international collaborators.

Organisational structure

The Raine Study was initially managed through King Edward Memorial Hospital, then in early childhood management shifted to the then Telethon Institute for Child Health Research. In 2007 a Memorandum of Understanding was signed to establish a clear collaborative governance structure based on an Executive Committee chaired by the Dean of Medicine at the University of Western Australia (initially Professor Ian Puddey) and supported by a Scientific Director (initially A/Professor Craig Pennell).

In 2017, the Unincorporated Joint Venture (UJV) Board replaced the previous Raine Study Executive Committee. The UJV is a collaborative partnership agreed between the [University of Western Australia](#), [Curtin University](#), [Edith Cowan University](#), [Murdoch University](#), [the University of Notre Dame](#), [Telethon Kids Institute](#) and the [Women and Infants Research Foundation](#). The Parties agreed to a governance structure for the Raine Study and a clear framework for the ownership, custodianship and control of assets of the Raine Study including data, biological samples and intellectual property. The Raine Study's host is the School of Population and Global Health headed by Prof Colleen Fisher, at the University of Western Australia. The Raine Study is also extremely proud to have Her Excellency, the Honourable Kerry Sanderson AC Governor of Western Australia, as its Patron. Her Excellency is the 32nd Governor of Western Australia and the inaugural female governor.

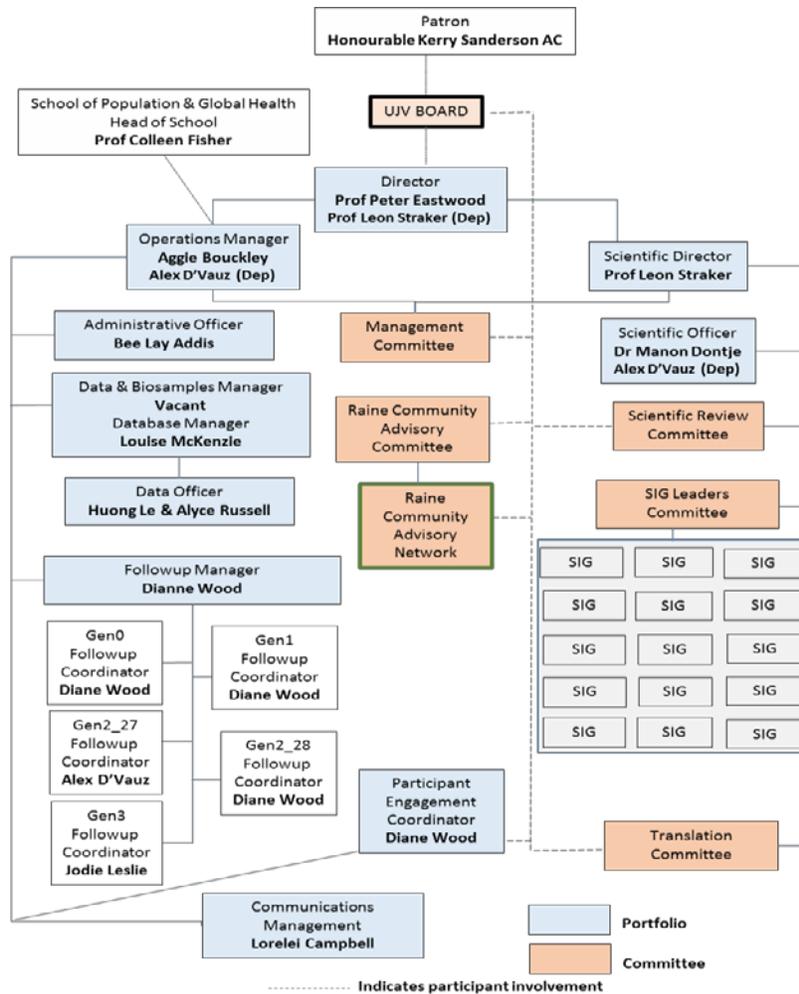


Figure 1 The Raine Study organisational structure

The Raine Study UJV Board

The Raine Study UJV Board is comprised of representatives of Partners to the Unincorporated Joint Venture Agreement, consumer/community representatives and an independent chair. The role of the members includes attending regular meetings (up to 4 per annum), being engaged in the initiatives and the outcomes being pursued by the Raine Study, being an advocate for the Raine Study and its purpose, and being committed to, and actively involved in, the Raine Study.

Scientific Review Committee

The Scientific Review Committee was set up to provide a high quality review of scientific projects and science strategy. The members provide expert advice on science, feasibility and significance of proposed projects, input on processes supporting and monitoring science activity, and input on curation and utilisation of biosamples and data.

SIG Leaders Committee

The Special Interest Group (SIG) leaders are a team of 2-3 people who have been selected and appointed by the Raine Study Directors. They work with the Raine Study team to maximise the utility and utilisation of data in their area of expertise. They guide researchers interested in their area to expand activities and look to identify: new expertise/researcher talent to attract to the SIG (local, national and international); opportunities to collaborate with other SIGS; new research projects; new funding opportunities; and student research opportunities. SIG leaders are also responsible for keeping the brief summary of the SIG's activities up to date.

Raine Study Community Advisory Committee

The Community Advisory Committee provides input and a community perspective into Raine Study activities. They are tasked with contributing to ideas for strategies to enhance participant engagement, identify areas of research that may be important to the Raine Study community and provide feedback on the relevance, understanding and value of the research. The committee was established to provide an important link to researchers from the Raine Study community.

Translation Committee

The Translation Committee has not yet been developed.

Raine Study Management Committee

The Raine Study Management Committee comprises of the Operations Manager, Director and Scientific Director, a community participant from Generation 1 and Generation 2, two Senior Research Officers, the Scientific Officer, the Data and Biosamples Manager and the Communications Manager. The committee assumes overall responsibility to facilitate the effective management and operations of the Raine Study including the key areas of administrative and financial support. The Raine Study Management Committee ensures communication and coordination between Operational and Scientific components.

Director

The Director provides scientific and operational leadership of the Raine Study. This includes working to maintain the reputation of the Raine Study and a sustainable framework for the protection and continuation of the cohort in the future. The Director also enhances discovery via engaging high quality researchers, supports the collection of new data and facilitates utilisation of existing data as well as working to secure and maintain partner funding to cover core management costs. This is notionally a 0.2FTE position.

Scientific Director

The Scientific Director provides leadership and strategic direction for Raine Study research activities. The Scientific Director's responsibilities include maximising utilisation of the Raine Study resources, maintaining productivity of high quality researchers, establishing and maintaining national and international collaboration and creating research opportunities for the Raine Study. This is notionally a 0.2FTE position.

Scientific Officer

The Scientific Officer works with the Scientific Director and Director to provide support for the scientific aspects of the Raine Study including the Scientific Review Committee, the Special Interest Group leaders and researchers and research project management. This was a 1.0 FTE position.

Deputy Scientific Officer

The Deputy Scientific Officer supports the Scientific Officer and Scientific Director in the scientific aspects of all portfolios including the Scientific Review Committee, the Special Interest Group leaders and researchers. The Deputy Scientific Officer acts as Scientific Officer when the incumbent is away for extended periods (e.g. annual leave, conference leave). This was a 0.1FTE position from April to December 2017.

Participant Engagement Coordinator

The Participant Engagement Coordinator co-ordinates participant engagement activities (formal and informal), is a participant advocate and is responsible for enhancing participant involvement and commitment to the Raine Study. They work with the Communications Manager, Operations Manager and Administrative Officer developing strategies for enhanced engagement, effective communication, as well as ensuring maintenance, confidentiality and security of the cohort details. This was a 0.1FTE position.

Communications Manager

The Communications Manager is responsible for promoting the Raine Study and providing effective external communications, developing key messages, branding and media releases targeting the community, government, researchers and participants. The Communications Manager consults regularly with the Raine Study Directors and research staff to develop plans and to advise on marketing and promotional strategies to enhance the Raine Study's reputation and improve stakeholder communications, engagement and retention. The Communications Manager role was filled in July at 0.2FTE.

Follow-up Manager

The Follow-up Manager oversees coordination of all follow-up activities and ensures efficient and high quality outcomes. They liaise with each follow-up coordinator to ensure consistency in procedures across follow-ups, pilot testing of data collection, provide updates along with study coordinators to lead investigators and work with the Raine Study team to coordinate all follow-up activities. The Follow-up Manager is responsible for ensuring a coordinated approach across all follow-ups to achieve the highest possible quality data and efficiency for the Raine Study. This was a 0.1FTE position.

Senior Research Officers

The two Senior Research Officers coordinate the cohort assessments and other affiliated research projects, as well as performing the assessments of cohort participants. The Senior Research Officers also train research staff in the collection of data and ensure the smooth running of the cohort follow-up process, they are responsible for liaising with and recruiting the study participants and for the co-ordination of follow-up assessments including the protection of the study participants, initial quality

control of data collection, co-ordination and scheduling of staff, database development and co-ordination of follow-ups. The total FTE of both positions is 1.6FTE.

Phlebotomist

The Raine Study Phlebotomist is responsible for the collection of blood and other biological samples from the Raine Study participants. They are also responsible for assisting with recruitment and research administration for the cohort follow-ups. This was a 0.7FTE position.

Research Assistants

The Research Assistants are responsible for all aspects of data collection including physical assessment and questionnaire data from Raine Study participants including the collection of anthropometry measurements, accelerometer data, blood pressures, DEXA and breast scans, the collection and processing of some biological specimens, and the collection of questionnaire data. Research Assistants also have responsibility for the recruitment, booking and co-ordination of the study participants. Their role also includes gaining consent from participants'. Across the various studies 18 Research Assistants were employed on full-time, part-time and a casual basis.

Sleep Scientists

Sleep Scientists performed polysomnography tests on sleeping participants (measures of brain, eye, muscle, heart and breathing activity) to aid in the diagnosis of sleep disorders. 5 Sleep Scientists were employed on a casual basis.

Overnight Assistants

Overnight Assistants supported the overnight Sleep Scientist in hosting the participants, gaining consents, preparing them for the study and carrying out housekeeping and data entry activities. 14 overnight assistants were employed on a casual basis.

Database Manager

The Database Manager was tasked with assisting with updating variable lists, ensuring data quality, answering queries from researchers on data availability and performing data extractions for approved projects. The responsibilities of this role were progressively taken over by the Data Officers from September 2017.

Data and Biosamples Manager

The Raine Study advertised extensively to fill the Data and Biosamples Manager position however the role was not filled due to a lack of suitably qualified applicants. The role was managed between the Scientific Officer, the Operations Manager, the Directors and in-kind support from researchers involved with the Raine Study.

Data Officers

The Data Officers are tasked with verification and accurate entry of data relating to the Raine Study follow-ups, as well as the archiving and storage of the data. Their responsibilities include assisting with creating central quality-controlled data sets, data extraction for specific projects, ensuring data quality,

answering queries from researchers on data availability and assisting with the provision of feedback in a meaningful way to study participants. The two Data Officers, employed at 0.5FTE and 0.4FTE, also provided support to the Data and Biosamples Manager role.

Data Entry Officer

The Data Entry Officer was responsible for ensuring accurate and complete data entry, assisting with preparing questionnaires, archiving and data retrieval for the Gen1 Sleep Study. The responsibilities of this role have been assumed by the Data Officer and Research Assistant positions. This position ended in July 2017. This was a 0.56FTE position.

Operations Manager

The Operations Manager for the Raine Study has senior responsibility for all operational matters including finance, human resources and corporate support and oversight of operational issues related to cohort follow-ups, data and biosample management, communications and participant engagement. The Raine Study Operations Manager reports to the Head of School of Population and Global Health and the Raine Study Director. This was a 0.8FTE position.

Deputy Operations Manager

The Deputy Operations Manager reports to the Operations Manager and the Director. The Deputy Operations Manager provides support to the Raine Study community when the Operations Manager is away and at other times as required. This was a 0.1FTE position from April to December 2017.

Administrative Officer

The Administrative Officer provides administrative support to operational and scientific activities in the leadership and management of the Raine Study. The Administrative Officer assists with research processes, maintains the online submission system, updates the website, coordinates and takes minutes at meetings, assists with financial and human resource management as well as travel and event coordination and general office administration. This is a 1.0FTE position.

Raine Study Staff

In 2017, the staff of the Raine Study consisted of:

Scientific Officer:

Manon Dontje
Alex D’Vauz (Deputy)

Participant Engagement Coordinator:

Diane Wood

Communications Manager:

Lorelei Campbell

Follow-up Manager:

Diane Wood

Senior Research Officers:

Alex D’Vauz, Diane Wood

Phlebotomist:

Suzanne Green, Kenneth Laycock

Research Assistants:

Monique Priston, Suzanne Green, Erica Hodgson, Michael Trown, Annabelle Gabb, Natalya Beer, Rose Huxtable, Sean Byrne, Emily Huynh, Kirsten Smith, Alex Burton, Gareth Lingham, Tina Barrow, Michael Furfaro, Lauren Reinders, Jacinta Saldaris, Beverley Hodgson, Rachel Lloyd.

Sleep scientists:

Athena Beck, Avijit Bose, Gemma Peagno, Madeleine Lowe, Azin Moshtaq

Overnight Assistants:

Kirsten Smith, Alex Burton, Zoe Marsen, Alice O’Connor, Renee Wood, Maddie Jones, Ruth Smith, Cara Lo, Jacinta a Saldaris, Sarah Finlay- Jones, Alyce Russel, Jodie Leslie, Upasana Javaraman, Julie Satori

Database Manager:

Louise McKenzie

Data Officers:

Huong Le, Alyce Russell

Data Entry Officer:

Carolyn Smargiassi

Operations Manager:

Aggie Bouckley
Alex D’Vauz (Deputy)

Administration Officer:

Bee Lay Addis

Raine Study Students

In 2017, there were 45 students working with Raine Study data, 15 of whom were enrolled for Doctor of Philosophy (PhD) (Figure 2). Four (4) of these students obtained their doctorate degrees in 2017.

1. Sunil Kumar Bhat, Family functioning and related psychosocial factors in pregnancy and early childhood as determinants of cardiovascular risk factors in a longitudinal Australian pregnancy cohort: The Raine Study.
2. Rachel Jones, Identification of novel risk variants for sarcoma and other cancers by whole exome sequencing analysis in cancer cluster families.
3. Katerina Maria Chin-A-Loy Lima, The biopsychosocial model of body image dissatisfaction in adolescent boys and girls: Cross-sectional and longitudinal associations from a population study.
4. Karen Richards, An investigation of neck posture clusters: Their relationship to neck pain and biopsychosocial factors.

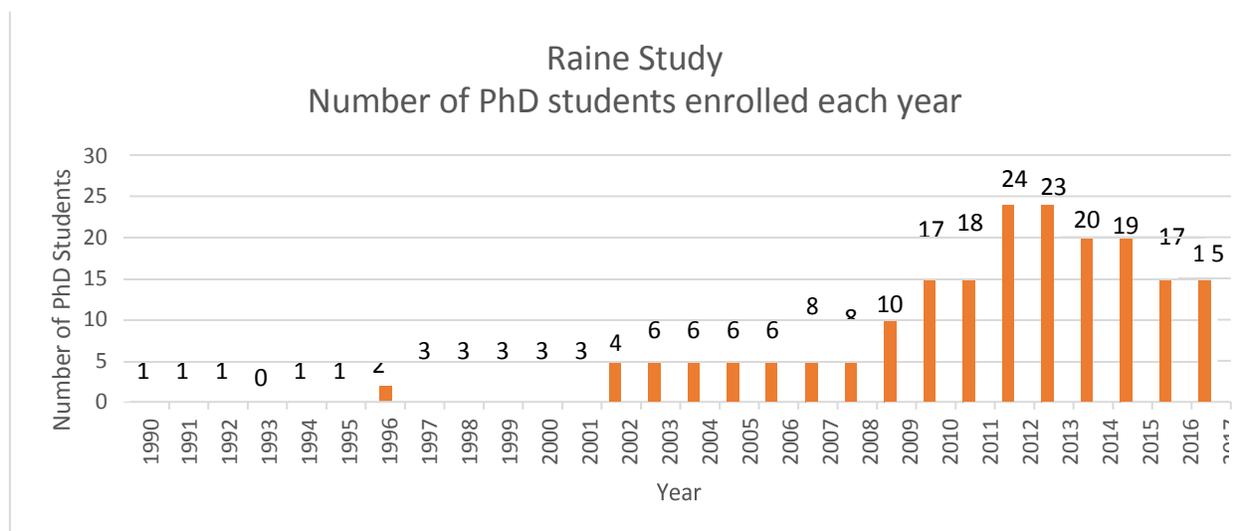


Figure 2 Raine Study PhD students: number of PhD students enrolled each year

Raine Study Participants 2017

The original Raine Study fetuses (Generation 2) were on average 27 years of age in 2017. 2,009 of them remain registered as “active” participants, meaning that they have agreed to remain in the study and be contacted for future assessment. 1,914 Generation 1 (parents) remain as “active” participants and to date 381 Generation 3 ‘babies/children’ have been born and are registered with the Raine Study.

Funding for the Raine Study

Background

In 2014 a five year funding commitment to Raine Study core management costs was obtained from the University of Western Australia (Faculty of Medicine, Dentistry and Health Sciences), University of

Western Australia DVC (Research), Curtin University, the Women and Infants Research Foundation, the Telethon Kids Institute and the Raine Medical Research Foundation. A three year commitment was also generously provided by Edith Cowan University. Additional core funding was obtained from the introduction of a 15% Raine Study access fee applied to all research grant applications.

The cost of core management of the Raine Study is approximately \$710K per annum. This cost includes management of the study and maintaining contact with the cohort and facilitating current and future projects. Core funding is separate to the costs associated with cohort assessment and data collection, which requires an additional \$500-\$700K per annum depending on the specific nature of the cohort assessment research protocols.

Core funding

Core management funding covers the costs associated with:

- Remuneration of the Raine Study core personnel: Director and Scientific Director, Operations Manager, Deputy Operations Manager, Administrative Officer, Scientific Officer, Data Officers, Communications Manager, Follow-up Manager, Participant Engagement Coordinator.
- Cohort retention and consumer consultation
- Raine Study PhD top up scholarships
- The Raine Study Annual Scientific Meeting
- The Raine Study website development and maintenance
- Management, curation and storage of previously collected data including biological samples and the purchase of storage freezers
- IT hardware and software
- Staff skills maintenance and training
- Other expenses not funded by research grant funding

Grant applications 2016 (for 2017 funding)

Thirteen grant applications totalling \$11.4 million were prepared and submitted in 2016 for research projects to commence in 2017. Three grant applications were successful, totalling \$4,394,928;

- NHMRC 1126494, 2017-2020, D Green, L Beilin, L Straker, P Eastwood, T Mori, P Ainslie, Developmental origins of adult cardiovascular disease: Vascular health in the Raine cohort, \$1,087,427.
- NHMRC 1121979, 2017-2020, D Mackey, A Hewitt, S MacGregor, C Hammond, Young adult myopia: genetic and environmental associations, \$809,270.
- NHMRC CRE1116360, D Mackey, J Craig, A Hewitt, K Burdon, R Jamieson, J Grigg, S Macgregor, F Chen, M Otlowski, D Schofield, NHMRC Centres of Research Excellence - From discovery to therapy in genetic eye diseases (Raine Study is part of this CRE), \$2,498,231.

Grant applications 2017 (for 2018 funding)

Thirteen grant applications totalling \$12.44 million were prepared and submitted in 2017 for research

projects to commence in 2018, of which four were successful totalling \$3.62 million (see Figure 3 and 4):

- NHMRC 1134894, 2018-2022, K Steinbeck, R Skinner, L Sancu, D Schofield, F Brooks, A Dawson, R Ivers, L Perry, B Liu, P Collin, M Kang, A Third, J Mooney-Somers, L Straker, S Gibson, P Hazell, L Baur, S Eades, S Sawyer, A Centre of Research Excellence in Adolescent Health: Making health services work for adolescents in a digital age, \$2,496,294
- Cancer Australia 1147677, 2018-2020, J Stone, C Saunders, D Sampson, M Hickey, L Lilge, G Cadby, J Shepherd, M Giorgi, M Cook, Measuring breast density in younger women to inform primary prevention and early detection of breast cancer, \$592,636.
- NHMRC 1142858, 2017-2021, RC Huang, R Foong, G Hall, A Lin, LIFECYCLE - Early Life Stressors and LifeCycle Health, \$453,811.
- Department of Health WA, 2018-2019, A Smith, Lumbar pathology – irrelevant finding or treatment target for low back pain? \$75,000.

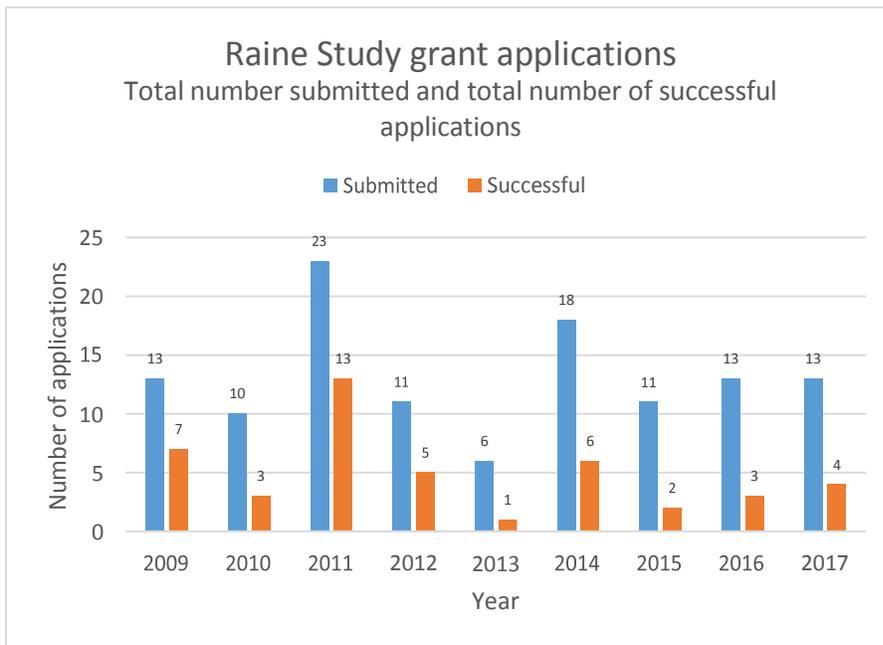


Figure 3 Raine Study grant applications. Total number submitted and total number of successful applications

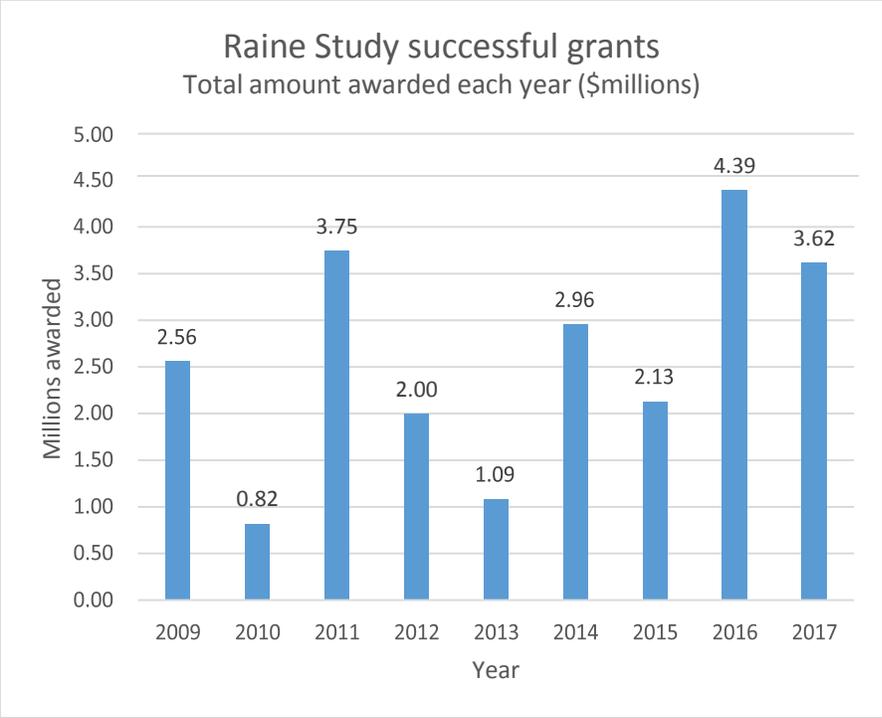


Figure 4 Raine Study successful grants. Total amount awarded each year (\$millions)

What happened in 2017?

Grant funded activities update

ARC 150103312, 2015-2018, S Parker, P Dunlop, L Straker, K Parkes, Work design matters: The dynamic interplay of work and person factors, \$334,119.

This project aims to examine the working environment and how this affects an individual's health, work performance and behaviour. The study looks at how personality and demographics, and their interactions, shape or constrain individuals' opportunities to undertake high quality work and vice versa. It also examines how family, education, and workplace factors affect the individual and their workplace. Analyses of data that were collected in 2016 have commenced, and results of two studies were presented at the 2017 Annual Scientific Meeting, one of which attracted the best student paper prize (Ms Anupama Bharadwaj). The project is focussed on personality and work change over time and the follow-up data will be collected in the first half of 2018 by online questionnaire, the second for this project.

NHMRC 1084947, 2015-2017, P Eastwood, D Hillman, E Moses, N McArdle, P Melton, Prevalence, phenotype and genotype of common sleep disorders, \$1,419,000.

This project commenced in January 2015. The grant funded the physical assessment and overnight sleep study of the parents (Generation 1) of the Raine Study index participants (Generation 2). Disturbed sleep is common in the Australian community and the objectives of the study are to establish the prevalence, phenotype and genetic basis of sleep disorders, particularly obstructive sleep apnoea, insomnia, restless legs syndrome and periodic leg movement syndrome in middle aged people. Together the parent and (previously collected) children datasets will determine associations between parent and child sleep disorders and lead to the discovery of genetic variants associated with common sleep disorders.

Parents of Raine Study participants who completed an overnight sleep study during the 22 year cohort follow were invited to attend an overnight sleep study at the UWA Centre for Sleep Science. In addition, other tests included eyesight measurements, a DXA scan, lung function testing, pressure and cold pain testing, computer based cognitive functioning test, blood pressure, anthropometric testing, accelerometry and the provision of a fasting blood sample. This testing was conducted in assessment rooms located in the Raine Study House and at the UWA Centre for Sleep Science. Data collection was completed in 2017 on a total of 1098 participants. Analysis of these data is underway.

NHMRC 1080492, 2015-2017, P Holt, E Hollams, A Bosco, D Strickland, Waxing and waning of asthma during transition from the teens to adulthood, \$649,492.

It is now recognized that late onset and persistent (early onset) asthma in young adults represent different forms of the disease that are likely to be driven by different mechanisms, and are therefore likely to need different treatment. However details of the underlying mechanisms driving progression of asthma in this age range, or the spontaneous remission which frequently occurs, are sparse. We are studying these in the Western Australian Pregnancy (Raine) Cohort, using clinical material collected in the 22 year follow-up of ~1000 participants, complementing a similar follow-up that took place at age 14 years. In addition to collecting clinical data relating to asthma, both follow-ups created an archive of cryobanked viable immune cell samples (peripheral blood mononuclear cells) that were collected from subjects at the time of clinical assessment, at both 14 and 22 years. We are continuing studies at both ages to identify immunological markers associated with remitting asthma, persistent asthma, and late-onset asthma. Data analyses will continue into 2018.

National Breast Cancer Foundation (NBCF), PS15040, 2015, J Stone, M Hickey, L Lilge, C Saunders, J Hopper, A novel method to measure breast density in young women, \$198,931.

Breast density is a strong predictor of breast cancer risk. Evidence of this has been derived from mammography, which is not recommended for younger women. New methods of measuring breast density are therefore needed to bridge large gaps in knowledge regarding breast density in young women. Members of the research team have developed Trans illumination Breast Spectroscopy (TiBS) which measures spectral differences in breast composition using visible and near infrared light. It correlates highly with mammographic breast density in women over 40 and is safe and easy to use. This study aims to test the feasibility and acceptability of the TiBS machine to measure breast density. The UWA HREC have granted permission for the study, Raine Study staff have been trained on the use of the TiBS device and recruitment is conducted at the Raine Study house, UWA. The investigators are inviting both volunteers (women aged 18-40) and Raine Study participants to have a TiBS scan. To date, a total of 339 Raine participants and another 504 pilot non-Raine participants have already completed their assessment.

NHMRC 1059711, 2014-2016, RC Huang, K Lillycrop, G Burdge, J Craig, L Beilin, T Mori, W Oddy, K Godfrey, J Holbrook, The cycle of obesity: Two generations of a pregnancy cohort to investigate obesity epigenetics, \$1,086,102.

This project is examining obesity epigenetics in two generations of the Raine Study. We have completed epigenome wide association studies in relation to obesity and related phenotypes. Pyrosequencing of hotspots in DNA samples from participants at age 17 and 20 and from parent samples and results have been done. We have participated in Pregnancy and Child Epigenetic Consortium (PACE) meta-analyses and papers related to asthma, gestational age, birthweight and maternal BMI. Publications to date include (1) Lillycrop et al. ANRIL Promoter DNA Methylation: A Perinatal Marker for Later Adiposity. *EBioMedicine* 2017 (19):60-72; (2) Holbrook et al. Is cellular heterogeneity merely a confounder to be removed from epigenome-wide association studies? *Epigenomics* (2017) 9(8), 1–8; (3) Sharp GC, Salas LA, Monnereau C, et al. Maternal BMI at the start of pregnancy and offspring epigenome-wide DNA methylation: findings from the pregnancy and childhood epigenetics (PACE) consortium. *Human Molecular Genetics* 2017;26:4067-85. (4) Felix JF, Joubert BR, Baccarelli AA, et al. Cohort Profile: Pregnancy And Childhood Epigenetics (PACE) Consortium. *International Journal of Epidemiology* 2018;47:22.

Multiple manuscripts are currently under journal review/in preparation, in addition to the 4 papers published and 7 conference presentations given in 2017.

NHMRC 1042269, 2012-2016, R Hart, C Pennell, D Doherty, M Robinson, R Norman, The long-term consequences of IVF treatment for the offspring - a prospective cohort study using the Raine cohort for comparison, \$1,552,096.

Short term follow-up of children born resulting from in-vitro fertilisation (IVF) has been well documented; however, the information about the health of these children as they grow up is very limited. The Growing Up Healthy Study (GUHS) aims to determine the long-term consequences of assisted reproduction upon the development of the offspring by comparing their growth, metabolic, respiratory, psychological, immunological and reproductive development at ages 13-15, 16-18 and 20-22 with a well-established representative sample of naturally conceived children –The Western Australian Pregnancy Cohort (Raine Study). Excellent response was received from the families involved, expressing their interest in the research and volunteering their time to attend the study assessments. Over 300 teenagers undertook the same age specific assessments as had previously been performed on the Raine Study cohort participants focusing on metabolic, respiratory, psychological, immunological and reproductive health.

In 2017 the recruitment phase of the study was finalised and we are continuing with data clean up and analysis in 2018. The above mentioned comparison will hopefully provide the answers we need to identify any long-term consequences of IVF.

CRC, A Whitehouse, The creation of the Australian Autism Biobank. Autism Cooperative Research Centre (1.002RC). \$130,000.

In 2013 the Commonwealth Department of Industry awarded \$31 million to establish a Cooperative Research Centre for Autism. One project within this CRC is to establish a detailed comprehensive characterisation of children with Autism Spectrum Disorder (ASD) and children without ASD. The children (Gen3) of the cohort participants (Gen2) were identified as a well-established cohort that could act as control sample of children without ASD. Assessments include a detailed questionnaire, parent interview and face-to-face testing of developmental ability, as well as assessment of physical activity, and collection of blood samples for later genotyping and biochemistry. As ASD is usually first established at around 2 years of age, all Raine Study Generation 3 children of 2 years and greater will be included. In 2017, 30 children were assessed, and it is anticipated that a further 70 children will be assessed by the time that the project concludes in June 2018.

NHMRC 1102106, 2016-2020, T Mori, L Beilin, E Moses, G Watts, L Adams, Genetic and early life predictors of ectopic fat and their association with cardiometabolic health and disease, \$1,706,136.

A 5-year NHMRC Project Grant that partially supports the 27-year old follow-up of Gen2 aims to examine the genetic, antenatal and childhood antecedents of ectopic fat depots in young adults, and the relative importance of different depots in relation to cardio metabolic health and novel markers of resolution of inflammation. Using Magnetic Resonance Imaging (MRI) the study is quantifying subcutaneous and visceral fat, as well as cardiac function and fat deposits associated with the liver, kidney, heart, adrenal glands and pancreas. Participants attend the Raine Study House for clinical assessments that include anthropometry measurements, skinfolds, blood pressure, fasting bloods, urine and faecal samples, a DXA scan and in females, a breast density screening test using Transillumination Breast Spectroscopy. Recruitment continued throughout 2017 with over 630 Gen2 having participated by the end of the year. Most had completed the online lifestyle and food frequency questionnaires. Approximately 95% had completed the clinical assessment and provided fasting bloods and a urine sample. More than 60% had provided a faecal sample. MRI measures performed by Envision Medical Imaging, Wembley were carried out in over 550 participants. Recruitment and data collection will continue in 2018.

NHMRC 1109057, 2016-2018, P Eastwood, A Mian, N McArdle, D Hillman, Predicting obstructive sleep apnoea using 3D craniofacial photography, \$424,715.

This project commenced in mid-2016. It is examining the relationships between the structure of the face, head and neck and the development and severity of obstructive sleep apnoea (OSA), a very common condition associated with snoring and collapse of the upper airway (throat) during sleep. Determining which characteristics of the face and neck are related to the development and severity of OSA could provide important information about the causes of OSA and may allow us to diagnose it using a simple 3-dimensional photograph of the face.

The study leverages off the unique combination of 3D photographs and laboratory-based measurements of OSA that have been obtained in 956 young adults from the 22 year follow-up and 1,098 of the parents (completed in 2017) of these young adults. These data will be combined with data sets from patients attending the Sleep Clinic at Sir Charles Gairdner Hospital. To date 1263 patients have been studied. Data collection is ongoing.

Projects update

New applications to use Raine Study data

In 2017, there were 62 new project applications (P forms) processed. Additionally there were 48 manuscripts forms reviewed.

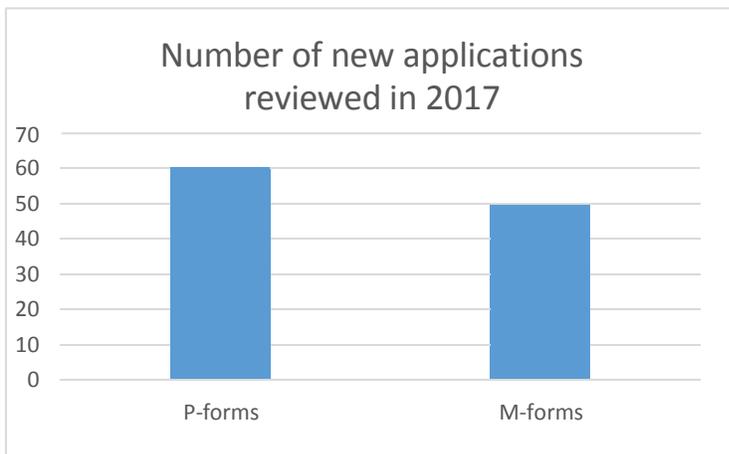


Figure 5 Number of new applications reviewed in 2017

Intergenerational studies

With the original parents (Generation 1) being followed-up for the first time independently of their children (Generation 2) with NHMRC grant 1084947, and the offspring (Generation 3) of the original children being followed-up for the first time with Autism Collaborative Research Centre funding, the multi-generation nature of the Raine Study has become prominent. The awarding of a Cancer Australia grant to include the grandparents of the original children extends the study to 4 generations. The naming convention that is now used is: Generation 0 being the grandparents (Gen0), Generation 1 the parents (Gen1), Generation 2 the index participants (Gen2) i.e. the original fetuses, and Generation 3 the offspring of the index participants (Gen3).

Western Australian Health Translation Network (WAHTN)

The Raine Study Directors worked with Professor John Challis, Director of the Western Australian Health Translation Network, to promote the excellent track record of the Raine Study and several other WA cohort studies. This led to the cohorts forming a substantial part of the WAHTN's successful application for NHMRC recognition as an Advanced Health Research and Translation Centre (AHRTC).

In 2017 the WAHTN provided phase 1 pilot study funding to the Raine Study to test a secure analysis space. Following the success of phase 1, the WAHTN provided funding for a phase 2 study for 2018.

ROSS – SHAPE – NEW DATA STRUCTURE

The Raine Online Submission System (ROSS) has been designed to facilitate more efficient research in the Raine Study. ROSS will make it easier for researchers to provide the information required for their project to be approved and to manage their involvement in use of data and/or biosamples, as well as analysis and reporting. Testing, continued development and initial use of ROSS occurred throughout 2017. All research projects conducted in the Raine Study now use ROSS and researchers follow the guidelines which are available on the Raine Study website.

During 2017 a new secure analysis system was developed and piloted. This system, called SHAPE (Secure Health data Analysis and Processing Environment) is aimed at providing greater electronic security for Raine digital data. This programme of activity will continue into 2018.

During 2017 two Data Officers worked on cleaning and preparing existing Raine Study data into a format suitable for exporting into a new relational database. Such a system is needed to ensure the security, reliability and accessibility of the growing Raine Study data resource. This work will continue into 2018.

Translation, dissemination & impact

Publications

In 2017 34 peer-reviewed papers were published, with 85% of these in journals with impact factors of 2 or greater (Figure 5). High Impact publications included (Appendix 3: List of publications)

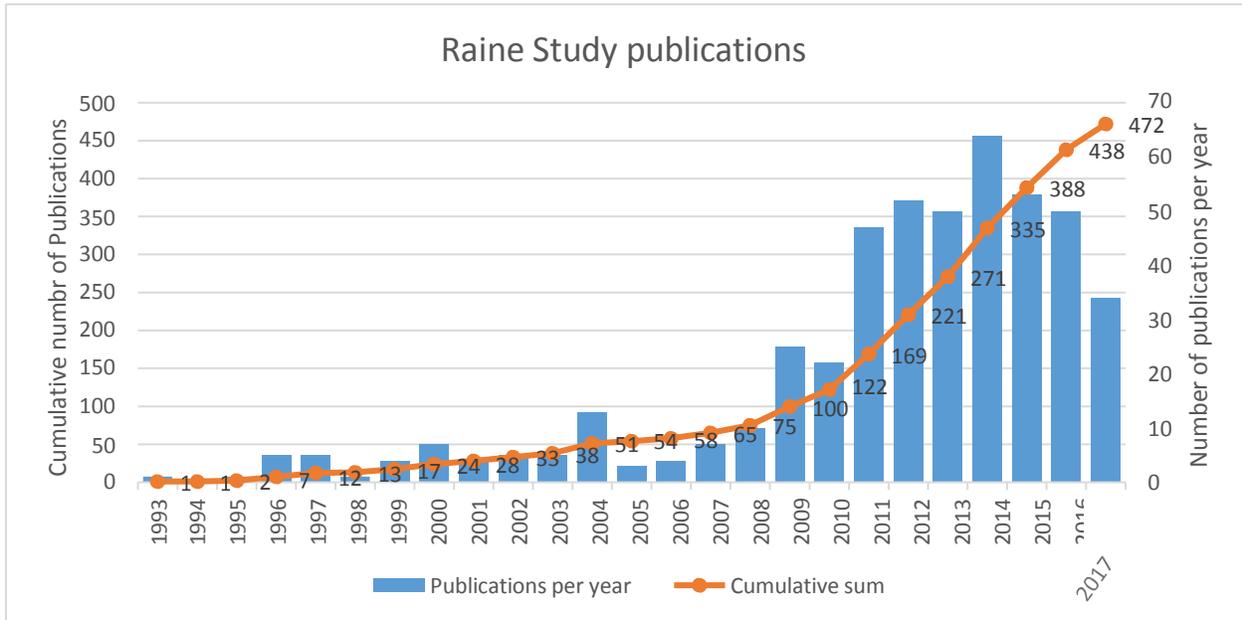


Figure 6 Number of Raine Study publications by year

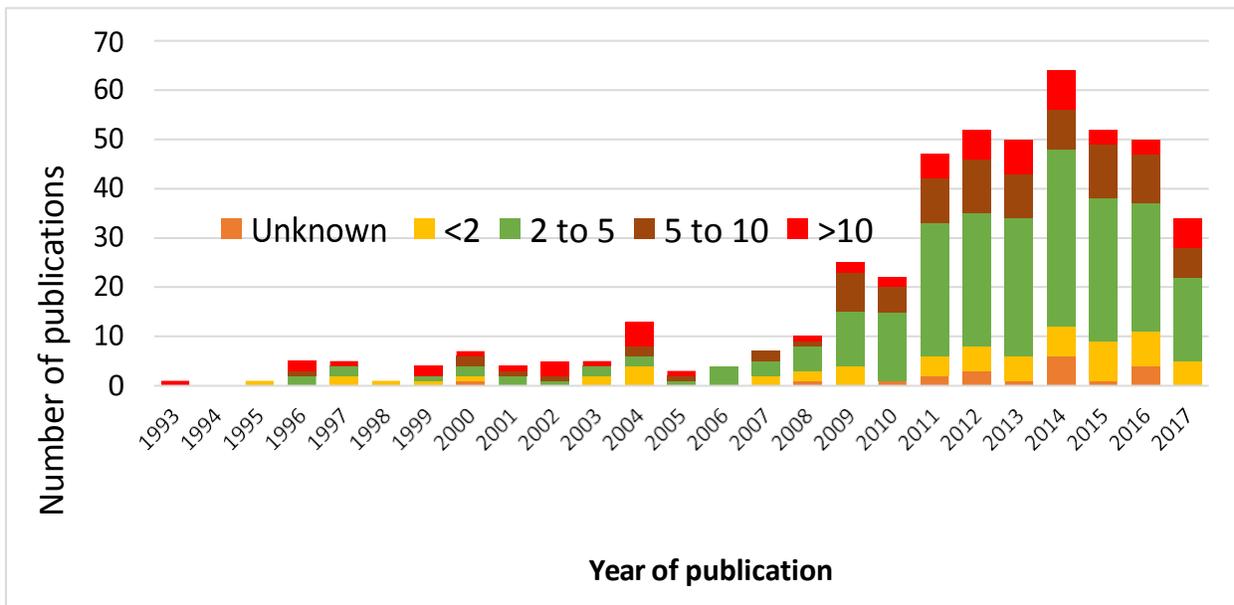


Figure 7 Number of Raine Study publications by year and impact factors

The Raine Study 10th Annual Scientific Meeting

A very successful 10th Raine Study Annual Scientific meeting was held on Friday 20th October 2017, at the University Club UWA. The meeting was formally opened by Her Excellency the Honourable Kerry Sanderson AC, Governor of Western Australia and patron of the Raine Study.

Four invited speakers did an excellent job presenting their research showing the multigenerational aspects of the Raine Study, followed by a live interview with a Raine Study family by Anne McKenzie of the Consumer and Community Health Research Network. Eleven more presentations were delivered over the course of the day that covered a wide variety of research areas. The Raine Medical Research Foundation prizes for the two best presentations by early career researchers were presented by the Raine Study Director Professor Peter Eastwood to Anupama Bharadwaj for her talk on work design, personality and rationalising unethical behaviour, and Robert Waller for his talk on musculoskeletal pain and pressure and cold pain sensitivity.



Figure 8 Her Excellency the Governor of Western Australia Kerry Sanderson, Professor Eastwood (far left), Professor Straker (far right), and Anne McKenzie with the Lim family (centre)



Figure 9 Professor Peter Eastwood and Anupama Bharadwaj



Figure 10 Professor Peter Eastwood and Robert Waller

Appendix 1. Grant applications submitted in 2016 for funding in 2017

1. NHMRC 1126494, D Green, L Beilin, L Straker, P Eastwood, T Mori, P Ainslie, Developmental origins of adult cardiovascular disease: Vascular health in the Raine cohort, \$ 1,087,427. **Funded.**
2. NHMRC 1121979, D Mackey, A Hewitt, S MacGregor, C Hammond, Young adult myopia: genetic and environmental associations, \$809,270. **Funded.**
3. NHMRC CRE1116360, D Mackey, J Craig, A Hewitt, K Burdon, R Jamieson, J Grigg, S Macgregor, F Chen, M Otlowski, D Schofield, NHMRC Centres of Research Excellence - From discovery to therapy in genetic eye diseases (Raine Study year 20 part of this CRE), \$2,498,232. **Funded.**
4. NHMRC 1124825, G Ambrosini, J Scot, G Trapp, B Boruss, F Bull, W Oddy, Why do young adults eat what they eat? Identifying determinants of dietary intake and eating behaviours in young adults to reduce chronic disease, \$781,638.
5. NHMRC 1102574, P O Sullivan, A Smith, J Karppinen, D Beales, L Straker et al, Understanding the role of lumbar spine structure in disabling low back pain MRI scan, \$1,188,982.
6. NHMRC 1127991, M Teichtahl, A Smith, Y Wang, L Straker, D Urquhart, I Ackerman, Obesity during the “growth spurt” – A window of preventive opportunity for femoroacetabular impingement, \$851,068.
7. NHMRC 1130187, P Cistulli, D Hillman, P Eastwood, A Pack, K Sutherland, N McArdle, B Singh, B Keenan, P de Chazal, Phenotypic characterisation of obstructive sleep apnoea (OSA): a pathway to precision medicine, \$668,707.
8. NHMRC 11288440, M Kavurma, L Adams, C Hawkins, T Griffith, On the trail of a fatty liver, \$359,930.
9. NHMRC 1120430, E Silins, J Horwood, W Hall, G Gattton, J Najman, J Toumbourou, R Skinner D Hutchinson, Informing universal risk assessment for persistent substance use and dependence in adulthood using population-based, integrated data from five Australasian cohorts, \$636,885.
10. NHMRC 1129411, R Skinner, J Mario, B Liu, D Doherty, M Hickey, F Zepf, Lifecourse determinants of sexual and other risky behaviours in young adulthood, \$539,200.
11. NHMRC 1125416, W Oddy, T Mori, G Ambrosini, K Smith, A Lin, K Sanderson, S Gall, RC Huang, G Trapp, C Blizzard, Nutritional pathways to adult depression via obesity, cardio-metabolic disease and inflammation: a collaborative study, \$488,739.
12. NHMRC 1127285, B Erbas, P Sly, P Holt, G Hall, The role of environmental exposures in the development of lung function in children and adolescents: a prospective study of 3 birth cohorts, \$227,707.
13. NHMRC 1120430, R Mattick, E Silins, J Horwood, G Patton, J Najman, J Toumbourou, S Skinner, D Hutchinson, W Hall, Informing universal risk assessment for persistent substance use and dependence in adulthood using population-based, integrated data from five Australasian cohorts, \$636,885.

Appendix 2. Grant applications submitted in 2017 for funding in 2018

1. NHMRC 1134894, K Steinbeck, R Skinner, D Schofield, S Lymer, R Ivers, L Baur, F Brooks, L Straker, J Marino, et al., A Centre of Research Excellence in Adolescent Health: Making health services work for adolescents in a digital age, \$2,496,295. **Funded.**
2. Cancer Australia 1147677, J Stone, C Saunders, L Lilge, D Sampson, M Hickey, G Cadby, J Shepherd, M Giorgi, M Cook, The TiBS Breast Density Study: Part II \$592,636.00. **Funded.**
3. NHMRC 1142858, RC Huang, R Foong, G Hall, A Lin, LIFECYCLE - Early Life Stressors and LifeCycle Health , \$453,811. **Funded.**
4. Dept of Health WA, Anne Smith, P O'sullivan, Y Wang, J Karppinen, D Samartzis, L Straker, P Kent, M Hancock, D Beales, S Linton, Lumbar pathology – irrelevant finding or treatment target for low back pain? \$75,000. **Funded.**
5. Endeavour Foundation, J McVeigh, L Straker, M Ciccarelli, C Harris, A detailed examination of physical activity and sedentary behaviour in children with Autistic Spectrum Disorder, \$43,727
6. UWA (2017 Faculty Small Research Grants Scheme for Early Career Researchers (UWA)), Manon Dontje, Leon Straker, Peter Eastwood, Jo McVeigh, Does inactivity run in the family? A feasibility study. \$19,451.
7. NHMRC 1147564, A Smith, P O'Sullivan, Y Wang, J Karppinen, D Samartzis, L Straker, P Kent, M Hancock, D Beales, S Linton, Lumbar pathology – irrelevant finding or target for treatment for low back pain? \$1,266,600.
8. Dept of Health WA, Anne Smith, P O'sullivan, Y Wang, J Karppinen, D Samartzis, L Straker, P Kent, M Hancock, D Beales, S Linton, Lumbar pathology – irrelevant finding or treatment target for low back pain? \$75,000.
9. NHMRC 1193162, J Olynyk, L Adams, D Trinder, R Newton, A Chua, E McKinnon, J Gummer, "Impaired iron bioavailability and haemoglobin production in young adults with nonalcoholic fatty liver disease: determining the mechanism and impact on physical activity", \$950,346.
10. NHMRC 1139830, G Ambrosini, G Trapp, J Scott, M Allman-Farinelli, B Boruff, W Oddy, E Malacova, J Kay, S Jebb, Identifying opportunities for supporting healthier eating to reduce obesity and chronic disease risk in young adults \$881,868.
11. NHMRC 1144892, R Skinner, J Marino, B Liu, D Doherty, S Lymer, R Tait, L Straker, M Hickey, L Sanci, K Steinbeck, C Olsson, M O'Connor, R Ivers, S Goldfeld, Understanding life course pathways to and economic implications of health and social harms in adolescence and young adulthood: a data linkage study of the Raine cohort \$1,353,047.
12. NHMRC1147581, P Cistuli, D Hillman, P Eastwood, A Pack, K Sutherland, N McArdle, B Singh, B Keenan Phenotypic Characterisation of Obstructive Sleep Apnoea \$894,733.
13. NIH, T Mori, G Ambrosini, L Beilin, W Oddy, S Sutcliffe, Expansion and validation of measures of distant adolescent dietary patterns, \$3,112,357.
14. NHRMC 1144545, B Erbas, R Hyndman, C Svanes, A Huete, J Davies, C Lodge, F Garden, M Abramson, "Pollen and lung function development: A multi-cohort study at birth and over the young adult life span" \$261,797.

Appendix 3. Publications list 2017

1. Armstrong RS, J. G.; Whitehouse, A. J. O.; Copland, D. A.; McMahon, K. L.; Arnott, W. Late talkers and later language outcomes: Predicting the different language trajectories. *International journal of speech-language pathology*. 2017;19(3):237-50.
2. Armstrong RW, A. J.; Scott, J. G.; Copland, D. A.; McMahon, K. L.; Fleming, S.; Arnott, W. A. Relationship between early language skills and adult autistic-like traits: evidence from a longitudinal population-based study. *Journal of autism and developmental disorders*. 2017;47(5):1478-89.
3. Ayonrinde OTO, W. H.; Adams, L. A.; Mori, T. A.; Beilin, L. J.; de Klerk, N.; Olynyk, J. K. Infant nutrition and maternal obesity influence the risk of non-alcoholic fatty liver disease in adolescents. *Journal of hepatology*. 2017;67(3):568-76.
4. Beales DK-M, S.; Smith, A.; O'Sullivan, P.; Pransky, G.; Linton, S.; Job, J.; Straker, L. Work productivity loss in young workers is substantial and is associated with spinal pain and mental ill-health conditions. *Journal of occupational and environmental medicine*. 2017;59(3):237-45.
5. Bhat SKB, L. J.; Robinson, M.; Burrows, S.; Mori, T. A. Relationships between depression and anxiety symptoms scores and blood pressure in young adults. *Journal of hypertension*. 2017;35(10):1983-91.
6. Brennan-Jones CGE, R. H.; Jacques, A.; Swanepoel, W.; Atlas, M. D.; Whitehouse, A. J.; Jamieson, S. E.; Oddy, W. H. Protective benefit of predominant breastfeeding against otitis media may be limited to early childhood: results from a prospective birth cohort study. *Clinical otolaryngology*. 2017;42(1):29-37.
7. Coenen PG, N.; Healy, G. N.; Dunstan, D. W.; Straker, L. M. A qualitative review of existing national and international occupational safety and health policies relating to occupational sedentary behaviour. *Applied ergonomics*. 2017;60:320-33.
8. Coenen PS, A.; Paananen, M.; Peter O'Sullivan, P.; Beales, D.; Leon Straker, P. Trajectories of low-back pain from adolescence to young adulthood. *Arthritis care & research*. 2017;69(3):403-12.
9. Foster ST, G.; Hooper, P.; Oddy, W. H.; Wood, L.; Knuiman, M. Liquor landscapes: Does access to alcohol outlets influence alcohol consumption in young adults? *Health & place*. 2017;45:17-23.
10. Goodwin RDR, M.; Sly, P. D.; Holt, P. G. Childhood atopy and mental health: a prospective, longitudinal investigation. *Psychological medicine*. 2017;47(2):317-25.
11. Grace TO, Wendy; Bulsara, Max; Hands, Beth. Breastfeeding and motor development: A longitudinal cohort study. *Human Movement Science*. 2017;51:9-16.
12. Herbison CEA, K.; Robinson, M.; Newnham, J.; Pennell, C. The impact of life stress on adult depression and anxiety is dependent on gender and timing of exposure. *Development and psychopathology*. 2017;29(4): 1443-54.
13. Hinney AK, M.; Jall, S.; Volckmar, A. L.; Focker, M.; Antel, J.; Gcan, Wtccc; et al. Evidence for three genetic loci involved in both anorexia nervosa risk and variation of body mass index. *Molecular psychiatry*. 2017;22(2):321-2.
14. Ing CH, M. K.; Perkins, J. W.; Whitehouse, A. J. O.; DiMaggio, C. J.; Sun, M.; Andrews, H.; Li, G.; Sun, L. S.; von Ungern-Sternberg, B. S. Duration of general anaesthetic exposure in early childhood and long-term language and cognitive ability. *British journal of anaesthesia*. 2017;119(3):532-40.
15. Ing, C.; Wall, M. M.; DiMaggio, C. J.; Whitehouse, A. J.; Hegarty, M. K.; Sun, M.; von Ungern-Sternberg, B. S.; Li, G.; Sun, L. S. Latent class analysis of neurodevelopmental deficit after exposure to anesthesia in early childhood. *J Neurosurg Anesthesiol*. 2017;29(3):264-273.

16. Kreiner EW, J.; Standl, M.; Brix, S.; Pers, T. H.; Couto Alves, A.; Warrington, N. M.; et al. Shared genetic variants suggest common pathways in allergy and autoimmune diseases. *The Journal of allergy and clinical immunology*. 2017;140(3):771-81.
17. Li JA, P.; Schafer, J.; Kendall, G.; Oddy, W. H.; Stanley, F.; Strazdins, L. Non-linear relationship between maternal work hours and child body weight: Evidence from the Western Australian Pregnancy Cohort (Raine) Study. *Social science & medicine*. 2017;186:52-60.
18. Mace AT, M. A.; Deelen, P.; Kristiansson, K.; Mattsson, H.; Noukas, M.; Sapkota, Y.; et al. CNV-association meta-analysis in 191,161 European adults reveals new loci associated with anthropometric traits. *Nature communications*. 2017;8(1):744.
19. Marouli EG, M.; Medina-Gomez, C.; Lo, K. S.; Wood, A. R.; Kjaer, T. R.; Fine, R. S.; et al. Rare and low-frequency coding variants alter human adult height. *Nature*. 2017;542(7640):186-90.
20. Morris SLOS, P. B.; Murray, K. J.; Bear, N.; Hands, B.; Smith, A. J. Hypermobility and musculoskeletal pain in adolescents. *The Journal of pediatrics*. 2017;181:213-21 e1.
21. Oddy WH. Breastfeeding, childhood asthma, and allergic disease. *Annals of nutrition & metabolism*. 2017;70 Suppl 2:26-36.
22. O'Sullivan PS, A.; Beales, D.; Straker, L. Understanding adolescent low back pain from a multidimensional perspective: implications for management. *The Journal of orthopaedic and sports physical therapy*. 2017;47(10):741-51.
23. Pena ASD, Dorota A.; Atkinson, Helen C.; Hickey, Martha; Norman, Robert J.; Hart, Roger. The majority of irregular menstrual cycles in adolescence are ovulatory: results of a prospective study. *Archives of Disease in Childhood*. 2017;0(1):1-5.
24. Rauschert SM, T. A.; Beilin, L. J.; Jacoby, P.; Uhl, O.; Koletzko, B.; Oddy, W. H.; Hellmuth, C. Early life factors, obesity risk, and the metabolome of young adults. *Obesity*. 2017;25(9):1549-55.
25. Rauschert SU, O.; Koletzko, B.; Mori, T. A.; Beilin, L. J.; Oddy, W. H.; Hellmuth, C. Sex differences in the association of phospholipids with components of the metabolic syndrome in young adults. *Biology of sex differences*. 2017;8:10.
26. Rzehak PO, W. H.; Mearin, M. L.; Grote, V.; Mori, T. A.; Szajewska, H.; Shamir, R.; Koletzko, S.; Weber, M.; Beilin, L. J.; Huang, R. C.; Koletzko, B.; W. P. working group of the Early Nutrition Project. Infant feeding and growth trajectory patterns in childhood and body composition in young adulthood. *The American journal of clinical nutrition*. 2017;106(2):568-80.
27. Skinner SRM, J.; Rosenthal, S. L.; Cannon, J.; Doherty, D. A.; Hickey, M. Prospective cohort study of childhood behaviour problems and adolescent sexual risk-taking: gender matters. *Sexual health*. 2017.
28. Smith AB, D.; O'Sullivan, P.; Bear, N.; Straker, L. Low back pain with impact at 17 years of age is predicted by early adolescent risk factors from multiple domains: analysis of the Western Australian Pregnancy Cohort (Raine) Study. *The Journal of orthopaedic and sports physical therapy*. 2017;47(10):752-62.
29. Straker LM, J.; Jacques, A.; White, S.; Smith, A.; Landau, L.; Stanley, F.; Newnham, J.; Pennell, C.; Eastwood, P. Cohort Profile: The Western Australian Pregnancy Cohort (Raine) Study-Generation 2. *International journal of epidemiology*. 2017.
30. Wain LVS, N.; Artigas, M. S.; Erzurumluoglu, A. M.; Noyvert, B.; Bossini-Castillo, L.; Obeidat, M.; et al. Genome-wide association analyses for lung function and chronic obstructive pulmonary disease identify new loci and potential druggable targets. *Nature genetics*. 2017;49(3):416-25.
31. White ECdK, N.; Hantos, Z.; Priston, M.; Hollams, E. M.; James, A.; Sly, P. D.; Holt, P. G.; Hall, G. L. Mannitol challenge testing for asthma in a community cohort of young adults. *Respirology*. 2017;22(4):678-83.
32. White SWE, P. R.; Straker, L. M.; Adams, L. A.; Newnham, J. P.; Lye, S. J.; Pennell, C. E. The Raine study had no evidence of significant perinatal selection bias after two decades of follow up: a

- longitudinal pregnancy cohort study. *BMC pregnancy and childbirth*. 2017;17(1):207.
33. Zhu, K.; Allen, K.; Mountain, J.; Lye, S.; Pennell, C.; Walsh, J. P. Depressive symptoms, body composition and bone mass in young adults: a prospective cohort study. *International journal of obesity*. 2016;41(4):576-581.
 34. Zhu KO, W. H.; Holt, P.; Ping-Delfos, W. C. S.; Mountain, J.; Lye, S.; Pennell, C.; Hart, P. H.; Walsh, J. P. Tracking of vitamin D status from childhood to early adulthood and its association with peak bone mass. *The American journal of clinical nutrition*. 2017;106(1):276-283.

Report Ends