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Complete List of Authors:	Clifford, Susan; Murdoch Childrens Research Institute, Centre for Community Child Health; The University of Melbourne, Department of Paediatrics Davies, Sarah; Murdoch Childrens Research Institute, Centre for Community Child Health Wake, Melissa; Murdoch Childrens Research Institute; The University of Melbourne, Department of Paediatrics
Keywords:	Longitudinal studies, non-communicable disease, biological specimen bank, phenotype, cohort profile, reference values

Growing Up in Australia's Child Health CheckPoint cohort summary and methodology.

Susan A. Clifford[1, 2], Sarah Davies[1] and Melissa Wake[1-3], on behalf of the Child Health CheckPoint Team.

Child Health CheckPoint Team: Peter S. Azzopardi[1,2,4], Louise A. Baur[5], David P. Burgner[1,2,6], John B. Carlin[1,2], Michael Cheung[1,2,7], Terence Dwyer[1,2,8,9], Ben Edwards[10], Susan Ellul[1], Alanna N. Gillespie[1,2], Lisa Gold[11], Anneke C. Grobler[1], Jessica A. Kerr[1,2], Kate Lycett[1,2], Katherine Lange[1], Fiona K. Mensah[1,2,], Tim S. Olds[1,12], Sarath Ranganathan[1,2,13], Helen Rogers[14], Richard Saffery[1,2], Michael Sawyer[15,16], Peter J. Simm[1,2,17], Luke Stevens[1], Tien Y. Wong[18-20] and Stephen R. Zubrick[21,22].

Affiliations: [1]Murdoch Children's Research Institute, Parkville, Victoria, Australia; [2]Department of Paediatrics, The University of Melbourne, Parkville, Victoria, Australia; [3]Department of Paediatrics and The Liggins Institute, The University of Auckland, Grafton, Auckland, New Zealand; [4]Maternal and Child Health Program, International Development Discipline, Burnet Institute, Melbourne, Victoria, Australia; [5]The Discipline of Child and Adolescent Health, The University of Sydney, Westmead, New South Wales, Australia; [6]Department of Paediatrics, Monash University, Clayton, Victoria, Australia; [7]Cardiology Department, The Royal Children's Hospital, Parkville, Victoria, Australia; [8]Nuffield Department of Obstetrics and Gynaecology, The George Institute for Global Health, University of Oxford, Oxford, United Kingdom. [9]Institute for Medical Research, University of Tasmania, Hobart, Tasmania, Australia; [10]Australian National University Centre for Social Research and Methods, Canberra, Australian Capital Territory, Australia; [11]School of Health and Social Development, Deakin University, Geelong, Victoria, Australia; [12]Alliance for Research in Exercise, Nutrition and Activity, University of South Australia, Adelaide, South Australia, Australia; [13]Respiratory and Sleep Medicine Department, The Royal Children's Hospital, Parkville, Victoria, Australia; [14]National Centre for Longitudinal Data, Department of Social Services, Canberra, Australian Capital Territory, Australia; [15]School of Medicine, University of Adelaide, Adelaide, South Australia, Australia; [16]Research and Evaluation Unit, Women's and Children's Health Network, Adelaide, South Australia, Australia; [17]Endocrinology and Diabetes Department, The Royal Children's Hospital, Parkville, Victoria, Australia; [18]Singapore Eye Research Institute, Singapore National Eye Centre, Singapore; [19]Department of Ophthalmology, Yong Loo Lin School of Medicine, National University of Singapore and National University Health System, Singapore; [20]Ophthalmology

and Visual Sciences Academic Clinical Programme, Duke-NUS Medical School, National University of Singapore, Singapore; [21]Telethon Kids Institute, Subiaco, Western Australia, Australia. [22]Graduate School of Education, University of Western Australia, Crawley, Western Australia, Australia.

Correspondence to: Professor Melissa Wake,
Murdoch Children's Research Institute
The Royal Children's Hospital
50 Flemington Road, Parkville 3052, VIC Australia.
Telephone: +61 3 9345 5761
Email: melissa.wake@mcri.edu.au

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Abbreviations: ABS: Australian Bureau of Statistics; ACR: albumin-creatinine ratio; AQoL-8D: Assessment of Quality of Life 8D; BIA: Bioelectrical impedance analysis; BP: Blood pressure; Ca: California, USA; ECHO: US Environmental Influences On Child Health Outcomes Program; FrACT: Freiburg Visual Acuity and Contrast Test; ISCW: International Survey of Children's Wellbeing; kHz: kilohertz; LiH: Lithium Heparin; LiSN-S: Listening in Spatialised Noise – Sentence Test; LSAC: Longitudinal Study of Australian Children; MARCA: Multimedia Activity Recall for Children and Adults; MCRI: Murdoch Children's Research Institute; NaSSDA: National Secondary Students' Diet and Activity; NCD: non-communicable disease(s); NHMRC: Australian National Health and Medical Research Council; NIH: National Institutes of Health; NMR: nuclear magnetic resonance; NSW: New South Wales, Australia; NPVT: National Institute of Health Picture Vocabulary test; pQCT: Peripheral quantitative computed tomography; PedsQL: Pediatric Quality of Life; REDCap: Research Electronic Data Capture; SD: standard deviation; UK: United Kingdom; USA: United States of America; VO_2max: Maximum volume of oxygen consumed; 2D: Two dimensional; 3D: Three dimensional.

ABSTRACT

Objectives: *'Growing Up in Australia:* The Longitudinal Study of Australian Children' (LSAC) is Australia's only nationally-representative children's longitudinal study, focusing on social, economic, physical and cultural impacts on health, learning, social and cognitive development. LSAC's first decade collected wide-ranging repeated psychosocial and administrative data; here, we describe the Child Health CheckPoint, LSAC's dedicated biophysical module.

Design, setting, participants: LSAC recruited a cross-sequential sample of ≈5000 0-1 and ≈5000 4-5 year olds in 2004, since completing seven biennial visits. CheckPoint was a cross-sectional wave that travelled Australia in 2015-16, to reach LSAC's younger cohort at age 11-12 years between LSAC waves 6 and 7. Parent-child pairs participated in comprehensive assessments at 15 assessment centres nationwide or, if unable to attend, a shorter home visit.

Measures: CheckPoint's intergenerational, multidimensional measures were prioritised to show meaningful variation within normal ranges and capture non-communicable disease (NCD) phenotype precursors. These included anthropometry, physical activity, fitness, time use, vision, hearing, and cardiovascular, respiratory and bone health. Biospecimens included blood, saliva, buccal swabs (also from second parent), urine, hair and toenails. The epidemiology and parent-child concordance of many measures are described in separate papers.

Results: 1874 (54% of eligible) parent-child pairs and 1051 second parents participated. Participants' geographical distribution mirrored the broader Australian population; however, mean socioeconomic position and parental education were higher and fewer reported non-English speaking or Indigenous backgrounds. Completeness was uniformly high for phenotypic data (>92% of eligible), biospecimens (74-97%) and consent (genetic analyses 98%, accessing neonatal blood spots 97%, sharing 96%).

Conclusions: CheckPoint enriches LSAC to study how NCDs develop at the molecular and phenotypic levels before overt disease emerges, and clarify the underlying dimensionality of health at different life stages. Data can be examined as outcomes of early life exposures (LSAC waves 1-6) and predictors of later life health (waves 7 onward).

ARTICLE SUMMARY

Strengths and limitations of this study

- The Child Health CheckPoint aimed to enrich the ongoing Longitudinal Study of Australian Children (LSAC) with sophisticated health assessments and biological samples.
- Strengths include LSAC's existing rich decade-long exposure and administrative data for the child and both parents, and CheckPoint's collection of cross-generational parent-child assessments paired on time/date of assessment, protocols and equipment; timing of the module to capture early adolescence; and timely public release of data to researchers (within two years of collection).
- Families living in regional areas or with lower socioeconomic positions are under-represented; however, sample weights are available that enable analyses that are more reflective of the original design sample of Australian children and their families.
- For each child participant, only one parent (predominantly the mother) undertook the detailed paired assessments, but the second parent contributed a buccal (DNA) sample, where possible.
- Access policies are in place for future extraction of extensive additional data from the digital and biospecimen repositories held at the Murdoch Children's Research Institute.

INTRODUCTION

Worldwide there is a large and growing burden of non-communicable diseases (NCDs). Many have their genesis in early life, and develop over decades of cumulative exposures. This provides opportunities to prevent, slow or alter disease trajectories at multiple points of the lifecourse. Wide gradients within the normal range of phenotypes relevant to many later NCDs are already measurable across many body systems from childhood.

It is evident that family, social and other environmental factors interact with an individual's innate biology (including genetic profile) to create modifiable pathways (such as chronic inflammation) common to multiple NCDs.[1] Shonkoff's biodevelopmental framework of lifecourse determinants of health and their mechanisms proposes that health-promoting and health-threating environmental effects interact with genes and affect later health, via physiological adaptions during sensitive periods and cumulative effects over time.[1] These physiological adaptions are the key intermediary step, which may be measured years or decades before overt ill health develops.

'Big picture' research into physiological adaptions and objective health outcomes has shifted from narrowly-focused hypothesis-driven studies with a single outcome, towards multidisciplinary and/or multidimensional research with outcomes across multiple domains that recognise the interconnectedness of health.[2 3] Around the start of the millennium, many countries launched large-scale birth cohort studies (eg UK Millennium Cohort,[4] Growing Up in Ireland,[5] New Zealand,[6] Singapore[7]). Australia's study, *Growing Up in Australia:* The Longitudinal Study of Australian Children (LSAC) was intended to provide a strong evidence base for policy development and service delivery on a wide range of issues relating to children's development and lifetime wellbeing.[8]

LSAC is broad in scope, surveying lifetime pathways in health, learning and development. Its design incorporates frequent (biennial) and ongoing data collection; multiple study respondents; linkage to lifetime universal parent and child administrative data including health care (eg lifetime primary health services, medication prescriptions dispensed), education (eg national literacy and numeracy exam results) and census datasets; and open access to the datasets for researchers. The federal government investment into LSAC is yielding major returns that influence policy,[9] with several hundred publications in the first decade of the study (listed at http://flosse.fahcsia.gov.au/).

LSAC is a population-based cohort study from early childhood, and is the country's only nationally-representative children's longitudinal study. Adopting a dual cross-sequential design, LSAC recruited two cohorts in 2004, each comprising ~5000 children. At recruitment, the K cohort children were aged 4-5 years, and B cohort 0-1 year old. A two-stage clustered sampling design was applied, first randomly selecting 10% of postcodes (stratified by state and urban/rural locations), then in-age children within those postcodes from the Medicare database.[10] Medicare is an Australian government program within the universal health care system that reduces or covers medical visit and medication costs, into which 98% of children are enrolled by their first birthday.[10] Very remote postcodes and those with <20 children (n=874 postcodes, 3.2% of population) were excluded. Since 2004, there have been seven biennial waves of data collection via a 90 minute home interview, questionnaires (children, both parents, teachers) and time diaries. The B cohort included 5107 families (57.2% uptake) in its first wave, with 74% retention at wave 6 (Figure 1).

Like other government-implemented children's studies internationally, LSAC has mainly focused on psychosocial and demographic exposures, with all health items except anthropometry and blood pressure being parent- or self-reported. A physical health and biospecimens module was beyond the scope of the original study design. There was also uncertainty as to how such a biomarker module might impact (whether positively or negatively) on cohort retention and engagement.

To address this gap, we recently introduced an intergenerational physical health and biomarkers module, the Child Health CheckPoint. This one-off cross-sectional wave, nested between LSAC waves 6 and 7, was offered to the B cohort at child age 11-12 years. CheckPoint's intergenerational, multidimensional measures were prioritised to show meaningful variation within normal ranges and capture non-communicable disease (NCD) phenotype precursors both in adults and children. Wherever possible we captured raw digital data (eg images, traces) that would support additional extraction and analysis beyond the core phenotypic summary data (eg blood pressure readings). The broad set of paired measures, collected on parent-child dyads on the same day with identical equipment, was designed to allow researchers to simultaneously examine multiple phenotypes in both ages as well as the intergenerational transmission of health. In this paper, we describe the Child Health CheckPoint methods and sample characteristics. This allows researchers to understand and make best use of the robust dataset and biospecimens. Other papers in this BMJ Open Special

Issue explore the epidemiology and parent-child concordance of individual measures in greater depth.[11-24]

METHODS

Study design: LSAC is a longitudinal child cohort study conducted in partnership between the Australian Government Department of Social Services, the Australian Institute of Family Studies and the Australian Bureau of Statistics. It is funded by the Australian Government.

The Child Health CheckPoint was conducted between February 2015 and March 2016, at child age 11-12 years. In a context of limited funding, the CheckPoint was offered to the B cohort because: (a) it contains more detailed pregnancy and birth data; (b) LSAC's data collections span the children's entire postnatal lives; (c) by this child age, there is a wide range in normal values of risk factors predicting adult preclinical markers of disease; and (d) experience suggested that the health measurements would be of greater interest (and so attract higher uptake) to children and parents at this age than to the K-cohort of 15–16 year olds, an age when many birth cohorts experience heightened attrition.

Study development: In 2007, the Department of Social Services commissioned a scoping report on the potential value, content and cost of a physical health and biomarkers module.[25] A partnership was formed between LSAC senior management, LSAC researchers and child health researchers new to LSAC with physical health and biomarkers content expertise. In 2012, researchers at the Murdoch Children's Research Institute (MCRI) partnered with investigators at the University of South Australia, University of Adelaide and Deakin University to form the CheckPoint Investigator Team and to lead a successful application to the Australian National Health and Medical Research Council (NHMRC Project Grant 1041352, 2013-17). This core funding enabled the child cardiorespiratory measures and leveraged additional institutional, competitive (NHMRC Project Grant 1109355, 2016-2020) and philanthropic funding, such that the CheckPoint ultimately encompassed a much wider range of health domains underpinning NCDs across two generations.

Feasibility of core CheckPoint assessments were tested in 2014 within the '3C' study; a longitudinal study of ≈380 7-17 year olds in the MCRI's existing PEAS,[26] LEAP2[27] and HopSCOTCH[28] cohorts examining cardiovascular outcomes of lifecourse growth, diet and activity.[29 30]

Late in 2014, we tested the CheckPoint protocol with a vanguard of ≈50 Victorian LSAC families to fine-tune recruitment, visit flow, timing and feasibility, and test acceptability of

the centre-based suite of measures ahead of the much larger bulk of children due to attend in 2015-16. Child and parent participants prospectively rated enjoyment of each assessment and overall impressions (scored out of 10). Participants were also asked to rate how the CheckPoint module changed their feeling about being in LSAC overall, from 0 (Now I like it much less) to 10 (Now I like it much more).

Participants: LSAC B cohort families who completed a wave 6 home interview were eligible. The study child and one parent were invited to participate in comprehensive health assessments at an assessment centre or home visit. Choice of parent and whether or not biological was determined by the family; in practice this 'attending parent' was usually the mother. Second biological parents living with the child, if available, were also invited to participate after the visit by contributing a buccal swab.

Ethical approval and consent: The CheckPoint study was approved by The Royal Children's Hospital Melbourne Human Research Ethics Committee (33225D) and the Australian Institute of Family Studies Ethics Committee (14-26); the latter also provides ethical review and approval for LSAC at every wave. A parent or guardian provided written consent for their own and their child's participation in the study. Optional consent was requested for the collection, storage and non-genetic analysis of biospecimens; genetic analyses of these samples; sharing images and samples with other researchers; and access to the child's birth data and dried newborn heel-prick blood samples that are stored indefinitely by most Australian states. Non-attending biological parents provided written consent for the storage and non-genetic analysis of their buccal swab, and optional consent for genetic analysis was requested. Participants were aware that no health, genetic or other information would be returned to them, beyond a summary of physical health measurements (body mass index, blood pressure, etc.) provided at the end of the visit.

Procedure: Participation in the CheckPoint involved (i) an assessment centre or home visit for the child and attending parent, (ii) follow-up phone interview for the child, (iii) a week of wearing an accelerometer (physical activity monitor) for the child and attending parent, and (iv) a buccal (DNA) sample collection at home for the non-attending parent.

Sample recruitment: B cohort families were briefly introduced to the upcoming Child Health CheckPoint during the LSAC wave 6 home interview in 2014. A total of 3513 families (93% of wave 6 families and 69% of original cohort, see figure 1) gave written consent to be contacted by the CheckPoint team.

Assessment visit types and locations: The core CheckPoint data collection mechanism was the 'pop-up' Main Assessment Centre, set up in seven major Australian cities (supplementary figure 1) sequentially for between 2-8 weeks before being packed up and transported by road to the next location. On each operating day, up to 24 families were invited to attend the assessment centre for a 3½-hour visit.

Road transport between Australian cities can take days. To maximise the size and geographic reach of the sample, 'pop-up' Mini Assessment Centres operated in eight regional cities for up to a week while the bulk of equipment was in transit. The 2¾-hour Mini Assessment Centre visit included most of the assessments offered at the Main Assessment Centres, except those requiring large equipment unable to be checked in as personal luggage on commercial flights. Those unable to attend an assessment centre were offered a 1½-hour home visit with a subset of measures that could be conducted in the home by a research assistant (ie not a phlebotomist) using portable equipment. Home visits occurred in Main Assessment and Mini Assessment Centre cities, and other regional towns.

In total, the study visited over 30 cities and towns over the one-year data collection period (supplementary figure 1). Table 1 reports the assessments offered at each visit type, and figure 1 the sample size per visit type.

Table 1. Summary of measurements and biological samples collected in CheckPoint assessments

Construct & Measure	Main Ch	Main P	Mini Ch	Mini P	Home Ch	Home P	Station	Equipment/instrument*	Data/sample collection protocol in brief
Anthropometry									
Height[31 32]	●	●	●	●	●	●		Portable rigid stadiometer (Invicta IP0955, Leicester, UK).	Standing height without shoes or socks, measured x2, or x3 if first two measures differed by ≥ 0.5cm.
Weight and body composition[31 32]	●	●	●	●	●	●		4-limb segmental (InBody230, Biospace, Seoul, Korea) or 2-limb (Tanita BC-351, Kewdale, Australia) body composition scales.	Weight and body composition wearing light clothing without shoes or socks, measured once.
Waist circumference[31 32]	●	●	●	●	●	●		Steel anthropometric measuring tape (Lufkin Executive Diameter W606PM, Maryland, USA).	Waist circumference at the narrowest point between the 10th rib and iliac crest, or midpoint between if no visible narrowing. Measured x2, or x3 if first two differed by ≥1cm.
Pubertal status									
Pubertal development	●		●		●			Sexual Maturity Scale.[33] Pubertal Development Scale.[34]	Sexual maturity assessed using three sets of images (1 male and 2 female) showing stages of puberty. Pubertal progress assessed using five sex-specific questions.
Menstruation	●	●	●	●	●	●		Study-designed questions about menstruation.	Self-reported current menstruation (females only). Age of menstruation onset (girls only).
Acne	●		●		●			Modified Comprehensive Acne Severity Scale for the face.[35]	Current acne severity assessed using a sex-specific 5-point pictorial scale.
Bone and muscle measures									
Bone and muscle morphology, bone density[36 37]	●	●						Peripheral quantitative computed tomography (pQCT, Stratec XCT 2000L scanner and XCT 2000 software, Birkenfeld, Germany).	Two pQCT scans of the non-dominant lower leg to image bone and muscle density and morphology. Scans taken at 4% (above ankle) and 66% (mid-calf) length of the tibia.

Construct & Measure	Main Ch	Main P	Mini Ch	Mini P	Home Ch	Home P	Station	Equipment/instrument*	Data/sample collection protocol in brief
Cardiovascular measures									
Carotid intima-media thickness and distensibility[38 39]	●	●	●	●			Heart Lab	Portable ultrasound (GE Healthcare Vivid *i* BT06 with 10MHz linear array probe, Little Chalfont, UK) with ECG.	Performed in supine position with head turned 45 degrees to the left. Probe applied to right side of the neck to capture carotid artery wall images, with concurrent ECG trace.
Arterial stiffness and blood pressure[40]	●	●	●	●	●	●	Heart Lab	SphygmoCor XCEL (AtCor Medical, West Ryde, AUS).	Aortic-femoral pulse wave velocity measured x3, supine, using a tonometer on the neck and blood pressure (BP) cuff on the thigh. Pulse wave analysis (including BP) measured x3, 1 minute apart, using a BP cuff on the arm.
Microvascular structure[41]	●	●					See Here	Retinal camera (Canon CR-DGi, Tokyo, Japan), fitted with a digital SLR camera (Canon EOS 60D, Tokyo, Japan).	In a darkened room without mydriasis, two retinal photographs were taken per eye, one focused on the macula and one focused on the optic disc.
Respiratory measures									
Lung function	●	●	●	●	●	●	Lung Fun	Spirometer[42] (Vyntus, California (Ca), USA) and Sentry Suite software (Ca, USA) for collection (v2.10) and download (v2.17).	Children and parents perform 3-8 maximal exhalation manoeuvres. Children inhale 4 puffs of bronchodilator (Ventolin), wait 10 minutes, and repeat test.
Language									
Expressive and receptive language	●	●	●	●			Listen Up	Recalling Sentences subtest, Pearson Clinical Evaluation of Language Fundamentals–4th edition, Australian version,[43] iPad (Apple, Ca, USA) and headphones.	Participant recalls and repeats up to 32 recorded spoken sentences of varying length and syntactic complexity.
Receptive vocabulary	●	●	●	●	●	●	Bone Zone	National Institutes of Health Picture Vocabulary test[44] (NIH Toolbox software with Cognition package), iPad & headphones.	Participant hears word and selects picture best representing the words meaning. Adaptive test using computer-based algorithms to quickly approximate and then precisely pinpoint participant ability.

Construct & Measure	Main Ch	Main P	Mini Ch	Mini P	Home Ch	Home P	Station	Equipment/instrument*	Data/sample collection protocol in brief
Hearing									
Hearing threshold[45 46]	●	●	●	●			Listen Up	Audiometer (Oscilla USB-330, version 3.3.4, Taastrup, Denmark) and Oscilla headphones. Data exported using version 4.0.0.	In a soundproof booth with headphones, participant presses button on hearing sound. Adaptive test: sound presented at increasing and decreasing volume at 4 frequencies (1, 2, 4, 8 kHz). Each ear tested separately.
Middle ear function[47]	●	●	●	●			Listen Up	Tympanometer (Oscilla TSM300, Taastrup, Denmark) and AudioConsole software (Version 3.3.4).	Tympanometer in ear canal varies air pressure, vibrating the tympanic membrane to measure canal volume, middle ear pressure & compliance.
Speech reception threshold	●	●	●	●			Listen Up	Listening in Spatialised Noise – Sentences Test v1.104,[48 49] Phonak, NSW, Australia), laptop & headphones (Sennheiser HD215, Wedemark, Germany).	In a soundproof booth with headphones, participant repeats sentences at varying volume against fixed-volume background conversation. Adaptive test; computer algorithms pinpoints threshold.
Diet and food choices									
Food choices	●	●					Food Stop	Digital weight scales accurate to 1 gram (Acculab SVI-10A, Goettingen, Germany).	Participant provided with a food box with prepacked snack food items to eat during a 15-minute break. Boxes on different days randomised to differ by box size and food amount. Uneaten food weighed at end of session.
Physical activity and time use									
Physical activity, sedentary behaviour, sleep[50]	●	●	●	●	●	●	Endgames	Wrist-worn accelerometer (GENEActiv Original, Cambs, UK) and self-report activity log.	Tri-axial accelerometer on non-dominant wrist for 8 days. Participant records type of day (school, non-school), sleep times and activities with device off.
Time Use	●		●		●		About Time	Multimedia Activity Recall for Children and Adults[51-53] program.	Activities recalled from the previous 24-48 hours, in increments of >=5 minutes. 2-3 days recalled, including one school and one non-school day.

Construct & Measure	Main Ch	Main P	Mini Ch	Mini P	Home Ch	Home P	Station	Equipment/instrument*	Data/sample collection protocol in brief
Strength and fitness									
Eurofit broad jump[54]	•		•		•		Jumping Beans	Gym mat and measuring tape (Lufkin L610CME, Maryland, USA).	Participant jumps horizontally from a standing start with double-leg take off. Longest of 3 jumps (measured in cm) after practice jump recorded.
PWC170 VO_2 max test[55]	•						Bike Hike	Exercise bike (Monark 928G3, Manila, Philippines) and chest-worn heart rate monitor (Polar FT4, Smeaton Grange, Australia).	Warm up, then cycle at 60 RPM for 3x 2-min bouts. Resistance increases as per heart rate at end of each bout. Aerobic work capacity (VO_2max) estimated.
Vision									
Visual acuity	•	•	•	•			See Here	Computerised adaptive Freiburg Visual Acuity and Contrast Test[56] with Landolt C optotypes (FrACT 3.8.2, Breisgau, Germany).	Participant identifies optotypes (shapes) from 3 meters. Right and left eyes tested separately, without glasses or contact lenses. Adaptive test; computer algorithms adjust size of optotypes presented to determine visual acuity. If visual acuity < 1.0, test repeated with pinhole lens.
2D and 3D oral photography									
2D and 3D oral photography	•	•	•	•			Tooth Booth	*2D photography* - Digital SLR camera (Canon 70D, Tokyo, Japan). *3D photography* – 3-pod 3D camera (3dMD Trio system, Georgia, USA).	2D photos of the dorsum of extruded tongue; then with lip retractors in place, teeth in occlusion and slightly apart with lower incisal edges visible. 3D photo teeth in occlusion with lip retractors in place.
3D facial photography	•	•					Tooth Booth	3-pod 3D camera (3dMD Trio system, Georgia, USA).	3D photo of the face (neutral expression, hair pulled back in net to show hairline), ears and under chin.
Written story									
Handwriting, written language	•		•		•		Life at 25	Pen, paper. Using protocol adapted from 1958 National Child Development Study (UK).[57]	Child writes a short story about what they think their life will be like when they are 25 years old.

Construct & Measure	Main Ch	Main P	Mini Ch	Mini P	Home Ch	Home P	Station	Equipment/instrument*	Data/sample collection protocol in brief
Wellbeing and quality of life									
General wellbeing	•		•		•		Sit and Click	International Survey of Children's Wellbeing.[58 59] Pediatric Quality of Life (PedsQL) 4.0 General Wellbeing Scale.[60]	6-item measure of subjective wellbeing. 7-item measure of quality of life and general wellbeing.
Health related quality of life	•		•		•		Sit and Click	PedsQL 4.0 Generic Core Scale.[60]	23-item measure of physical and psychosocial health, yielding total, physical and psychosocial summary scores.
Health related quality of life		•		•		•	Parent Trap	Assessment of quality of life 8D Scale.[61]	35-item measure of health-related quality of life. Overall utility score and dimension scores calculated.
Health related quality of life	•	•	•	•	•	•	Sit and Click / Parent Trap	Child Health Utility 9D.[62]	9-item measure of health-related quality of life. Overall utility score calculated.
Pain									
Pain	•	•	•	•	•	•	Sit and Click / Parent Trap	Pain severity questions[63] with pain manikin adapted for on-line administration.[64]	Asked about pain >1 day in past month; if yes, when started, and (children only) which body regions.
Diet									
Diet	•	•	•	•	•	•	Sit and Click / Parent Trap	Adapted National Secondary Students' Diet and Activity[65] questions, supplemented with adapted International Study of Childhood Obesity, Lifestyle and Environment[66] items.	26-item brief food frequency survey of usual intake of a range of different foods including fruits and vegetables.
Allergy and eczema									
Family allergies and pet exposure		•		•		•	Parent Trap	Allergy and pet exposure questions from the HealthNuts study;[67 68] parent-reported.	Branched questionnaire items about child's siblings and parent's history of asthma, eczema, hay fever, latex/insect/food allergy, and the family's pets.
Eczema severity and treatment	•		•		•		Parent Trap	Eczema questions from the International Study of Asthma and Allergies in Childhood study;[69] parent-reported.	Branched questionnaire items about itchy rash, eczema, dry skin, and moisturisers and topical steroid use in the study child.

Construct & Measure	Main Ch	Main P	Mini Ch	Mini P	Home Ch	Home P	Station	Equipment/instrument*	Data/sample collection protocol in brief
Colouring									
Natural skin, hair and eye colouring	●	●	●	●	●	●	Parent Trap	Questions adapted to self-report format from Paediatric Autoimmune Disease study[70] colour chart; parent-reported.	3-item measure of the natural skin, hair and eye colour of both the child and parent.
Medications and supplements									
Current medications and supplements	●		●		●		Parent Trap	Medications and supplements questions modified from LSAC;[71] parent-reported.	Branched questionnaire items about the child's medication and supplement use.
Health, welfare and community services									
Hospital admissions and health insurance	●		●		●		Parent Trap	Child lifetime hospitalisations, health care card and insurance coverage questions modified from LSAC;[71] parent-reported.	Branched questionnaire items about child's lifetime hospital admissions (including age, diagnosis), and concession card/private health insurance coverage.
Health service use	●		●		●		Parent Trap	Use of services questions modified from LSAC;[71] parent-reported.	Branched questionnaire items about child's health service use and parent time spent on service use.
Community participation	●		●		●		Parent Trap	Community activity use questions modified from LSAC;[71] parent-reported.	Branched questionnaire on community activity participation (eg team sports, music) in last year.
Biological samples									
Venous blood	●	●	●	●			Young Bloods	S-Monovette vacutainers: 2.7ml K3 EDTA (05.1167.001), 9ml K3 EDTA (02.1066.001), 7.5ml Lithium Heparin liquid (01.1608.001), 9ml Serum Gel with Clotting Activator (02.1388.001), Sarstedt, Australia	Approximately 28mL blood from non-dominant arm of semi-reclining (45°), semi-fasted participants, processed into 0.5mL aliquots. Up to 6 EDTA plasma, 6 EDTA buffy coat, 6 LiH plasma, 6 LiH buffy coat (viable cells) and 6 serum per participant. In addition, *either* a whole blood clot *or* 3 whole blood aliquots and a dried blood spot (see next row). All stored at -80°C on site.

Construct & Measure	Main Ch	Main P	Mini Ch	Mini P	Home Ch	Home P	Station	Equipment/instrument*	Data/sample collection protocol in brief
Dried blood spot	●	●	●	●	●	●	Young Bloods	Lancet (1.6mm (#85.1018) or 1.8mm (#85.1016) depth, Sarstedt Australia), Guthrie card.	Card used for newborn screening is blotted with four drops of blood, collected via either a finger prick or pipetting a small amount of the venous whole blood sample. Stored at room temperature.
Urine	●	●	●	●	●	●	Lung Fun	70mL screw cap polypropylene sterile pot (#75.9922.731, Sarstedt, Australia)	Participant collects random urine sample into 30mL sterile urine pot, pipetted into 12x 0.7mL aliquots. Stored at -80°C on site.
Saliva	●	●	●	●			Lung Fun	50mL polypropylene sterile tube (#FAL352070, Falcon, Corning Inc., Corning, NY, USA)	Five minute passive saliva drool into sterile tube. Sample weighed, then pipetted into 6x 0.5mL aliquots. Stored at -80°C on site.
Buccal swab		○	●	○	●	○	Lung Fun	Buccal swab (Oracollect DNA OCR-100, The Hague, Netherlands. If not available, FloqSwab COPAN Flock Technologies, Brescia, Italy was used).	Participant rubs swab over gums/inner cheeks. *OCR-100*: Immerses swab in the preserving liquid, seals tube. Aliquoted into 2 x 0.5mL aliquots. *FloqSwab*: Seals swab in air-tight container. Stored at room temperature then -80°C.
Hair	●	●	●	●			Lung Fun	String, aluminium foil, envelope, scissors.	Two locks of hair (4mm in diameter) cut close to the scalp from the occipital area under the crown. Hair wrapped in aluminium foil (scalp end identified) and stored in a barcoded envelope at room temperature.
Toenails	●		●		●		Lung Fun	Scissors, envelope.	Clean toenails >3mm trimmed from right big toe (if not available, left big toenail or fingernails) and stored at room temperature in barcoded envelope.

Questionnaire measures are self-reported, unless indicated they were parent-reported. *All questionnaire items administered by iPad or laptop, except the pain manikin, which was completed on paper at home visits. For brevity, iPad or laptop is not listed for every questionnaire item. Open circles indicate sample collected from non-attending parent.

Ch: Data/sample collected relates to child participant; P: Data/sample collected relates to parent participant; BP: Blood pressure; Ca: California, USA; FrACT: Freiburg Visual Acuity and Contrast Test; kHz: kilohertz; LiH: Lithium Heparin; LSAC: Longitudinal Study of Australian Children; PedsQL: Pediatric Quality of Life; NaSSDA: National Secondary Students' Diet and Activity; NIH: National Institutes of Health; UK: United Kingdom; USA: United States of America; VO_2max: Maximum volume of oxygen consumed; 2D: Two dimensional; 3D: Three dimensional.

Assessment sequence: Participants completed the assessments in a standard sequence (Figure 2), designed to minimise interdependencies between measures. Bronchodilator administration (which may alter cardiovascular parameters) followed cardiovascular measures, and the snack station was scheduled after saliva and semi-fasting blood collection, but before exercise.

The visit started with the parent providing consent, while the child wrote their story at *Life at 25*. At assessment centres, participants were then given a carry bag containing an iPad to complete the questionnaire, water bottle and urine sample collection kit, and a lanyard showing the order of data collection stations to visit. Participants advanced every 15 minutes from one station to the next (except child *Lung Fun* which was 30 minutes duration), following the previous participant in their journey around the Centre. Most stations were conducted one-on-one, but in some the study child and attending parent were both present (*CheckPoint Check-in*, *Measure Up*, *Tooth Booth*, *Bone Zone*, child *Young Bloods* and *Endgames*, see figure 2), and two children could be present at any one time for *Life at 25*, *Jumping Beans* and *Bike Hike.*

Prior to the last station *Endgames*, participants could take extra time to complete their questionnaire or provide a urine sample. At *Endgames*, a staff member explained the contents of a take-home pack. The child and parent were fitted with their wrist-worn accelerometers, and a follow-up phone interview was booked/confirmed for the child to complete additional time use diaries.[51] The take-home pack also included a reply-paid express post satchel, child and parent activity log cards, non-attending parent buccal sample collection kit (as applicable), summary of health results collected on the day, and thank you gifts and token reimbursement for travel.

Home visit consent, assessments and take-home packs used the same protocol as the assessment centres and included at least one measure from every major health domain; however, some assessments were omitted (table 1). The home visit sequence generally mirrored the centre flow, with minor adjustments to allow one staff member to assess both child and parent within the available time. Dried blood spot, urine and buccal swabs were obtained, and urine processing was delayed when local laboratory facilities were not available.[72]

Assessments were undertaken by research assistants and students, after training by experts and under real-time quality checks. Inter- and intra-rater reliability for data transcription and

scoring was calculated, where relevant and possible. Data collection reliability was not available as the participant flow precluded repeated measures of same individual.

Measures: Measures and biological samples collected are briefly described in Table 1; other papers of this BMJ Open Special Issue[11-24] provide greater detail, epidemiological description and parent-concordance for many of these, and their rationale has been previously published.[73] Data were collected electronically via specialist medical equipment/software or, where not possible, staff entered data into REDCap (Research Electronic Data Collection tool).[74] REDCap was also used to administer the child and parent questionnaires on iPads. Data collection and data processing Standing Operating Procedures are available (see http://www.lsac-childhealthcheckpoint.org.au). Most measures were offered to both children and parents; however, the parent flow omitted the exercise stations (*Bike Hike* and *Jumping Beans*), time use diary, post-bronchodilator spirometry and toenail samples, and instead included a more detailed questionnaire.

Biospecimen collection and repository: Biospecimens collected are described in table 1. Samples (except buccal swabs) were processed within hours in an on-site laboratory set up at all Main Assessment and most Mini Assessment Centres. Samples for an entire assessment centre were stored appropriately prior to shipping as a single batch to the Melbourne Children's Bioresource Centre (MCRI) where they are stored in a de-identified manner until depletion. As of October 2017, completed biomarker analyses for all parents and children with relevant samples were serum metabolomics (http://www.nightingalehealth.com),[21 75 76] urinary albumin-creatinine ratio (ACR)[18] and telomere length;[15] genotyping analyses were under way; and funding had been secured for micronutrient and one-carbon pathway analyses.

Data access: The LSAC data are available to researchers under licence, and from early 2018 will include the first tranche of completed parent and child CheckPoint data (see table 3 for measures in the first CheckPoint data release). The LSAC website explains access to these data (http://www.growingupinaustralia.gov.au/data/dataaccessmenu.html).

It is intended that all further CheckPoint data and biospecimens will also be accessible to all researchers. Applications to undertake new data extraction and biosamples, or to collaborate with CheckPoint investigators on in-train funded new data, are considered by CheckPoint's Data/Biospecimens Access Committees (see http://www.lsac-childhealthcheckpoint.org.au).

Statistical analyses: Sample characteristics, sample size and consent rates were described as counts, proportions, means and standard deviations. Baseline demographic characteristics of LSAC families who did and did not participate in CheckPoint were compared to consider the representativeness of the maintained CheckPoint sample in relation to preceding LSAC waves.

Survey weights: CheckPoint survey weights were created[77] using similar methods to those used for previous waves of LSAC, and are provided in the CheckPoint dataset. These methods account for the selection probability of each child to establish the target design sample, initial non-response to the baseline survey and subsequent loss to follow-up. LSAC and CheckPoint survey weights have been estimated to reflect the likelihood of participation from wave to wave within the limits of the information available from study measures.

Applying LSAC survey weights produces analyses that will be as representative as possible for all Australian children born in 2004 and their parents. CheckPoint differs in that, for the majority of measures, only the attending parent (usually the mother) was assessed, and thus weighted analyses of the parent data are more difficult to interpret because the weighting does not estimate a representative sample of all parents.

RESULTS

In 2014, ahead of the main data collection wave, the vanguard families reported high levels of enjoying the CheckPoint visit (mean out of 10: child 8.8, parent 8.2), recommending it to others (child 7.7, parent 9.0) and valuing the child health report provided on the day (child 7.7, parent 8.2). On average, participants liked being in the LSAC study much more after their CheckPoint experience (mean: child 8.4, parents 7.7).

The CheckPoint sample size was fixed by LSAC retention to wave 6. Of a total of 3764 families who participated in wave 6, 3513 (93%) consented to CheckPoint contact, 3152 (84%) provided valid contact details and were invited into CheckPoint, and 1875 (50%) participated (figure 1). One family withdrew consent after assessment. Thus, the CheckPoint analytic sample included 1874 parent-child pairs, plus 1051 non-attending resident parents.

Most non-participation (60%) was due to inability to attend or reschedule a visit during the short period CheckPoint was in each location. Far fewer families declined (18%). Most families (72%) attended a Main Assessment Centre, 8% attended a Mini Assessment Centre and 20% completed a home visit.

Demographic characteristics of the CheckPoint sample and non-responders are summarised in table 2. Within the CheckPoint sample, 99% of attending parents and all non-attending participants were a biological parent of the study child. There was an equal distribution of boys and girls. However, the sample of attending parents was not equally or randomly comprised of mothers and fathers, since each family decided which parent or guardian attended and most (88%) attending parents were mothers. Almost 90% of attending parents were nominated 'Parent 1' (ie the parent who knows the child best and completes the main questionnaire) in previous LSAC waves. The majority of families lived in major cities, with a similar distribution across the states and territories to the Australian population. Larger proportions of families were in the higher socio-economic position quintiles than in the Australian population.

Compared to B cohort families who did not take part in the CheckPoint, table 2 shows that participating families at baseline (2004) reported higher socioeconomic position and parental education, and lower likelihood of non-English speaking or Indigenous backgrounds.

Table 2. Child Health CheckPoint sample characteristics

Characteristic Values are %, unless indicated	Sample characteristics at CheckPoint (2015-16)* n=1874 families	Baseline characteristics (2004)†	
		In CheckPoint n=1874 families	Not in CheckPoint n=3233 families
Child age in years, mean (SD)	12.4 (0.4)	0.8 (0.2)	0.8 (0.2)
Parent age in years, mean (SD)	44.4 (5.2)	32.1 (4.9)	30.4 (5.7)
Female child	49.0	49.0	48.9
Female parent	87.7	98.7	98.5
Child accompanied by biological parent	98.9	99.7	99.7
Child has Indigenous background§	2.0	2.0	6.0
Parent born in Australia‡	79.0	79.3	81.2
Parent home language not English‡	10.8	11.2	16.3
Area of residence[1]			
Major city	70.3	70.5	64.0
Inner regional	20.3	18.0	20.6
Outer regional	8.7	9.9	12.8
Remote	0.8	1.6	2.6
Australian state/territory of residence			
Australian Capital Territory	2.8	2.9	1.6
Northern Territory	1.6	2.4	1.3
New South Wales	28.6	29.9	32.6
Queensland	21.5	20.0	20.1
South Australia	8.0	7.5	6.4
Tasmania	3.3	3.2	1.6
Victoria	22.5	22.2	25.8
Western Australia	11.8	11.8	9.7
Socioeconomic position[2], mean (SD)‡	0.2 (1.0)	0.3 (1.0)	-0.2 (1.0)
Neighbourhood Disadvantage Index[3], mean (SD) and % in national quintiles	1023 (60)	1019 (61)	1003 (59)
1 (least disadvantaged quintile)	34.8	29.0	18.9
2	23.4	20.3	19.8
3	18.8	19.3	21.6
4	14.8	19.8	21.7
5 (most disadvantaged quintile)	8.2	11.6	18.1
Parent's highest level of education‡			
Did not complete high school	20.1	21.4	39.0
High school	44.4	42.3	39.9
Undergraduate degree (Bachelor)	23.6	26.6	15.5
Postgraduate degree	11.9	9.7	5.7
Attending parent's employment status‡			
Working full-time (≥30 hours/week)	46.9	31.8	22.4
Working part-time	37.4	2.7	1.6
Not currently working	15.7	65.5	76.0
Parent has a spouse/partner	88.1	95.7	91.3

*Data collected in CheckPoint 2015-16 wave, except data indicated as collected at ‡wave 6 (2014) or §wave 1 (2004). Parent data = CheckPoint 'attending parent'. †Data collected in wave 1 (2004). Parent data = 'Parent 1'. CheckPoint attending parent is the wave 1 Parent 1 for 89.3% of families. [1]Australian Bureau of Statistics (ABS) Remoteness Area Code (ref 78). [2]LSAC-derived Family socioeconomic position z-score (ref 79). Higher scores = greater advantage. [3]ABS 2011 Socio-Economic Indexes for Areas Index of Relative Socioeconomic Disadvantage (ref 80)

Data completeness for each measure was high (Table 3) at >92% of participants eligible for each measure, except for accelerometry and child pain. A shortage of accelerometers at certain points over the data collection period meant physical activity data was available for 74% of children and 77% of parents. Initial problems with the branching architecture of questions[72] meant pain data was available for only 85% of children (but 99% of parents). The most common reasons for missing data was the measure not being included in all visit types, followed by equipment unavailability, participant refusal and erroneous data removed in the preparation of the dataset.[72]

Table 3. Sample size by measure and participant group

Construct	Measure	Children	Parents		Parent-child pairs		2018
		n=1874	All n=1874	Biological n=1854	All n=1874	Biological n=1854	data release
Anthropometry	Height, weight	1873	1865	1845	1864	1844	●
	Body composition*	1859	1844	1824	1837	1817	●
Pubertal status	Puberty Development Scale, Sexual Maturity Scale	1807	-	-	-	-	●
	Menstruation†	844	1610	1598	740	733	●
	Modified Comprehensive Acne Severity Scale	1762	-	-	-	-	●
Bone, muscle	Peripheral quantitative computed tomography	1271	1250	1240	1231	1222	●
Cardiovascular	Carotid intima-media thickness	1489	1476	1463	1462	1449	●
	Pulse wave velocity, pulse wave analysis	1836	1790	1773	1769	1752	●
	Blood pressure	1777	1749	1732	1682	1666	●
	Microvascular structure (retinal photography)	1307	1317	1307	1292	1282	
Respiratory	Spirometry	1759	1774	1754	1688	1668	●
Language	Expressive & receptive language (Recall' Sent.)	1441	1446	1433	1415	1402	●
	Receptive vocabulary (NPVT)	1443	1457	1444	1401	1389	●
Hearing	Pure tone audiometry	1488	1493	1480	1480	1467	●
	Tympanometry	1099	1101	1092	1065	1056	●
	Speech reception threshold (LiSN-S)	1483	1482	1469	1466	1453	●
Diet and food choices	National Secondary Students' Diet & Activity	1846	1862	1846	1837	1821	●
	Snack observation	1294	1246	1235	1205	1195	●
Physical activity, time use	Accelerometry	1382	1440	1424	1223	1209	●
	Time use diary (MARCA)	1830	-	-	-	-	●
Strength and fitness	Eurofit broad jump	1771	-	-	-	-	●
	PWC170 VO_2max test	1301	-	-	-	-	●
Vision	Freiburg Visual Acuity Test	1494	1491	1478	1481	1468	●
2D and 3D photography	2D and 3D photos of teeth and tongue	1486	1480	1467	1478	1465	
	3D photos of face	1331	1316	1305	1313	1302	
Handwriting, written language	Handwritten story about life at age 25	1811	-	-	-	-	
General wellbeing	ISCW & PedsQL General Wellbeing	1860	-	-	-	-	●

Construct	Measure	Children	Parents		Parent-child pairs		2018
		n=1874	All n=1874	Biological n=1854	All n=1874	Biological n=1854	data release
Health related quality of life	PedsQL, Child Health Utility 9D, AQoL-8D[‡]	1854	1871	1853	1854	1836	●
Pain	Pain[§]	1586	1859	1843	1576	1562	●
Natural colouring	Skin, hair and eye colour	1859	1859	1843	1859	1843	●
Medications, supplements	Current medications and supplements	1853	-	-	-	-	●
Health, welfare and	Health service use, hospital admissions	1874	-	-	-	-	●
community services	Community participation and services	1822	-	-	-	-	●
Serum metabolites	NMR metabolomics platform	1180	1325	1313	1139	1133	●
Renal function	Urinary albumin and creatinine concentration	1579	1671	1653	1535	1518	●
Biological aging	Telomere length	1206	1343	1330	1151	1143	

Sample sizes pertain to those with data available. These may differ slightly from sample sizes presented in other CheckPoint papers in this BMJ Open Special Issue, where authors have restricted analyses to participants meeting specified levels of data quality or completeness. 'All parents' and 'all parent-child pairs' include biological and non-biological (eg step-, adoptive or biological relatives other than mother or father) parent-child relationships. Parent-child pairs include families where both the child *and* parent have data available for that measure. [*]381 children and 344 parents have body fat % measured using a 2-limb BIA scale at home visits; the remainder have detailed body composition measured using a 4-limb BIA scale. [†]Girls were asked 'has menstruation started' and 'are you menstruating today?' and women were asked 'are you menstruating today?' [‡]Children completed the PedsQL, parents completed the AQoL-8D, and both children and parents completed the Child Health Utility 9D. [§]Parents completed a subset of the pain questions completed by children.

AQoL-8D: Assessment of Quality of Life 8D; BIA: Bioelectrical impedance analysis; ISCW: International Survey of Children's Wellbeing; LiSN-S: Listening in Spatialised Noise – Sentence Test; MARCA: Multimedia Activity Recall for Children and Adults; NMR: nuclear magnetic resonance; NPVT: National Institute of Health Picture Vocabulary test; PedsQL: Pediatric Quality of Life.

Biospecimen collection rates was also high (table 4) for blood (venous or finger prick, 91% of children and 96% of attending parents) and other biological samples (>70%). Most (95%) of children and parents had either a saliva (collected when laboratory facilities were available) or buccal swab (stable for 60 days before processing) sample. Consent was obtained for ≥97% of samples collected to share with other researchers and undertake genetic analyses, and ≥94% of participants to access child perinatal birth data and child neonatal blood spots, and to share child and parent digital images. Buccal samples were also collected from 1051 non-attending parents (of whom 94% consented to share, and 98% to undertake genetic analyses). In total, 1021 (55%) families have at least one sample available for the child and both biological parents.

Table 4. Data/sample collection rates and consent for use of images/sample

Measure or sample	**Children** n=1874			**Attending Parents** n=1874		
	Data/ sample collected	Consent to share	Consent to genetic analyses	Data/ sample collected	Consent to share	Consent to genetic analyses
Digital images (photos)						
2D and 3D teeth	1486	1398	-	1480	1397	-
3D face	1331	1251	-	1316	1241	-
Retinal	1307	1229	-	1317	1240	-
Perinatal birth data*	1838	-	-	-	-	-
Newborn Guthrie card*	1810	1760	1775	-	-	-
Blood	1701	1646	1673	1791	1730	1761
Plasma	1230	1196	1211	1371	1331	1353
Serum	1192	1160	1174	1336	1297	1319
Whole blood/ clot	1223	1189	1204	1358	1318	1340
Guthrie card	1424	1382	1405	1467	1420	1445
Urine	1595	1548	1571	1685	1636	1661
Saliva	1375	1327	1350	1392	1347	1370
Buccal	398	385	392	390	378	383
Hair	1390	1343	1365	1439	1397	1418
Toenail	1586	1534	1561	-	-	-

*Access to these data has been consented to by participants, but not yet attempted by the study team as of October 2017.

DISCUSSION

Principal findings: The Child Health CheckPoint provides a paired cross-generational snapshot of the health of 11-12 year old Australian children and their parents. Data completeness was high amongst the nearly 2000 families who participated. The utility of the data and biospecimens is further enhanced by near-universal consent for genetic analysis and sharing with other researchers. Enriching LSAC's life-long environmental data with CheckPoint's biological data strengthens the utility of LSAC to address important questions on how NCDs develop phenotypically before overt disease is evident, and shed light on the underlying dimensionality of health at different life stages.

Key logistic challenges faced by the CheckPoint were its short time window both to plan and conduct (a fixed 12 months from February 2015), the sheer size of Australia (approximately the same as continental USA), and the limited funding allowing for only one set of heavy equipment and thus curtailing the period during which the CheckPoint was available to participants in each city.

Strengths and limitations: Strengths of LSAC include its large population-based sample, data linkage, historical repeated measures, and open data access. Strengths of the CheckPoint module include the sophistication of its health assessments, and the cross-generational child-parent assessments paired on time of assessment, protocols and equipment. Utility of the CheckPoint data is strengthened by its timing relative to child age (i.e. adolescence onset) and LSAC duration (i.e. ten years of data already available); and its timely release of curated data to researchers (within two years of data collection), with more to come as data scoring and biomarker analyses are completed. The CheckPoint is led by diverse and specialty-based researchers, who continue to develop multi-system hypotheses and discovery research. We have prioritized harmonisation of methods with other internationally-significant cohorts (eg utilisation of the Nightingale metabolomics and Illumina Global Screening Array genotyping platforms). Finally, the CheckPoint module was enjoyable for participants, and its impact on participant retention in future LSAC waves will be examined.

The sample reflects the broader Australian population in many attributes, including state/ territory of residence. A limitation (that can be partly addressed by using survey weights[77]) is that the majority of the parent sample are mothers, and families were more likely to live in major cities and have a higher socioeconomic status than non-participants and Australians in general. Due to sample attrition, the final number of parent-child dyads was only around

1900, limiting power for rare exposures and outcomes; this is partly offset by LSAC's common exposures, and CheckPoint's focus on continuous outcome measures. Almost all measures were collected from only one of the child's parents, although family studies will be possible for the 55% of families for whom we collected a DNA sample from both parents. A further potential limitation is that LSAC does not have prospective prenatal data on the children, although it does includes prospective data from very early life (child age at wave 1 spanned 3-19 months) and permission to link to birth data.

Implications and future research: The wealth and depth of longitudinal LSAC data available gives important context to CheckPoint's health and biomarker data. To commence a brand new cohort incorporating these measures is exceptionally expensive and would have set back the availability of such data by decades, at a time when other prominent efforts to do so internationally have failed.[81 82] Other internationally significant efforts, such as the US Environmental Influences On Child Health Outcomes (ECHO) Program,[83] are now taking a similar approach to CheckPoint. For example, ECHO is enriching existing traditional child cohorts with additional cutting-edge biophysical modules and forward harmonisation. This will add great value to these cohorts and to knowledge that can be generated from their interrogation.

In summary, the efficient addition of objective health measures and biospecimens into the open-access LSAC repository greatly increases the utility of this widely-used dataset. Analysis of the CheckPoint data holds great promise in integrating cutting-edge measures of mid-childhood physiology with lifetime trajectories of mental and physical health, growth, behaviour and healthcare within a single population study. The data's utility will continue to grow as ongoing waves of the main LSAC study accrue into adulthood, when CheckPoint health data will be able to be examined both as outcomes of early life exposures (LSAC waves 1-6) and predictors of later life health (LSAC waves 7 onward).

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REDCap (Research Electronic Data Capture) electronic data capture tools were used in this study. More information about this software can be found at: www.project-redcap.org.

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CONTRIBUTIONS: SAC is the study project manager, and planned and conducted the analyses, and drafted the initial manuscript. PA, LAB, DPB, JBC, MC, TD, BE, LG, JAK, FKM, TSO, SR, HR, RS, MS, PJS, LS, TYW and SRZ are study investigators involved in the conception and oversight of the Child Health CheckPoint, and provided expert advice and critical review of this manuscript. SD, SE, ANG, ACG, KLy and KLa are study staff or postdoctoral fellows and provided critical review of this manuscript. MW is the Principal Investigator of the Child Health CheckPoint, planned the analyses and provided critical review of this manuscript.

DATA SHARING STATEMENT: Dataset and technical documents available from *Growing Up in Australia*: The Longitudinal Study of Australian Children via low-cost license for bone fide researchers. More information is available at www.growingupinaustralia.gov.au

FIGURE CAPTIONS AND FOOTNOTES:

Figure 1. Participant flow chart

N = number of families. LSAC: Longitudinal Study of Australian Children.

Figure 2. Assessment sequence, by participant and visit type

Oblong box indicates child and parent attended the station together. Parents attended the *Young Bloods* stations twice; first for their own blood collection, then to accompany their child. *Food Stop* included consumption experiment at the Main Assessment Centre (ie data collected), but was simply offering refreshments at the Mini Assessment Centre (ie no data collected). The NIH Vocabulary Picture Test was administered in *Bone Zone* at the Main Assessment Centre, and as part of *Sit and Click* in Mini Assessment Centre and home visits. In home visits, *Sit and Click* (child questionnaire) had allocated time between other assessments; for the assessment centre visits, *Sit and Click* didn't have an allocated time or physical location (children completed the questionnaire in downtime at other stations). Post-visit activities (ie accelerometry, child follow-up phone interview and non-attending parent buccal swab) are not included in the diagram and followed the same protocol regardless of visit type.

SUPPLEMENTARY DOCUMENTS

Supplementary figure 1. Assessment centre and home visit locations

Values are number of families assessed. Main Assessment Centre locations are labelled in uppercase letters and blue colour. Mini Assessment Centre locations are labelled in sentence case letters and black colour. Home visits occurred in many locations, so the total number of home visits in each state or territory is provided inside the house symbol. No home visits occurred in the Australian Capital Territory.

REFERENCES

1. Shonkoff JP. Building a new biodevelopmental framework to guide the future of early childhood policy. *Child Dev* 2010;81(1):357-67.
2. Khoury MJ, Lam TK, Ioannidis JP, et al. Transforming epidemiology for 21st century medicine and public health. *Cancer Epidemiol Biomarkers Prev* 2013;22(4):508-16.
3. Lauer MS, Gordon D, Wei G, et al. Efficient design of clinical trials and epidemiological research: Is it possible? *Nat Rev Cardiol* 2017;14(8):493-501.
4. Connelly R, Platt L. Cohort profile: UK Millennium Cohort Study (MCS). *Int J Epidemiol* 2014;43(6):1719-25.
5. Greene S, Williams J, Layte R, et al. Growing Up in Ireland Background and Conceptual Framework. Dublin, Ireland: Office of the Minister for Children and Youth Affairs, Department of Health and Children 2010.
6. Morton SM, Atatoa Carr PE, Grant CC, et al. Cohort profile: Growing Up in New Zealand. *Int J Epidemiol* 2013;42(1):65-75.
7. Soh SE, Tint MT, Gluckman PD, et al. Cohort profile: Growing Up in Singapore Towards healthy Outcomes (GUSTO) birth cohort study. *Int J Epidemiol* 2014;43(5):1401-9.
8. Sanson A, Johnstone R, The LSAC Research Consortium & FaCS LSAC Project Team. Growing Up in Australia takes its first steps. *Family Matters* 2004;67:46-53.
9. Wake M. Tracking the health of the next generation: Sax Institute; 2016 [Available from: https://www.saxinstitute.org.au/news/tracking-the-health-of-the-next-generation/].
10. Soloff C, Lawrence D, Johnstone R. LSAC technical paper number 1: Sample design. Melbourne: Australian Institute of Family Studies, 2005.
11. Welsh L, Kathriachchige G, Raheem T, et al. Spirometry: Population epidemiology and concordance in 11-12 year old Australians and their parents. Submitted to BMJ Open October 2017.

12. Vlok J, Simm PJ, Clifford SA, et al. Bone health (pQCT): Population epidemiology and concordance in 11-12 year old Australians and their parents. Submitted to BMJ Open October 2017.
13. Vivarini P, Kerr JA, Grobler A, et al. Food choices: Population epidemiology and concordance in 11-12 year old Australians and their parents. Submitted to BMJ Open October 2017.
14. Smith J, Wang J, Grobler A, et al. Hearing, speech reception, vocabulary and language: Population epidemiology and concordance in 11-12 year old Australians and their parents. Submitted to BMJ Open October 2017.
15. Nguyen MT, Lycett K, Vryer R, et al. Telomere length: Population epidemiology and concordance in 11-12 year old Australians and their parents. Submitted to BMJ Open October 2017.
16. Matricciani L, Fraysse F, Grobler A, et al. Sleep and Time Use: Population epidemiology and concordance in 11-12 year old Australians and their parents. Submitted to BMJ Open October 2017.
17. Liu RS, Dunn S, Grobler A, et al. Carotid artery intima-media thickness, distensibility, and elasticity: Population epidemiology and concordance in Australian 11-12 year old Australians and their parents. Submitted to BMJ Open October 2017.
18. Larkins N, Kim S, Carlin J, et al. Albuminuria: Population epidemiology and concordance in 11-12 year old Australians and their parents. Submitted to BMJ Open October 2017.
19. Kahn F, Wake M, Lycett K, et al. Vascular function and stiffness: Population epidemiology and concordance in 11-12 year old Australians and their parents. Submitted to BMJ Open October 2017.
20. Fraysse F, Grobler A, Muller J, et al. Physical activity and sedentary activity: Population epidemiology and concordance in 11-12 year old Australians and their parents. Submitted to BMJ Open October 2017.
21. Ellul S, Wake M, Clifford SA, et al. Metabolomics: Population epidemiology and concordance in 11-12 year old Australians and their parents. Submitted to BMJ Open October 2017.
22. Dascalu J, Lui M, Lycett K, et al. Micro-vascular health (retinal microvasculature): Population epidemiology and concordance in 11-12 year old Australians and their parents. Submitted to BMJ Open October 2017.
23. Clifford SA, Gillespie AN, Grobler A, et al. Body composition: Population epidemiology and concordance in 11-12 year old Australians and their parents. Submitted to BMJ Open October 2017.
24. Catchpool M, Gold L, Grobler A, et al. Health-related quality of life: Population epidemiology and concordance in 11-12 year old Australians and their parents. Submitted to BMJ Open October 2017.
25. Wake M, Canterford L, Nicholson J, et al. Options for physical and biomarker augmentation in LSAC: Discussion paper, 2008.
26. Wake M, Gallagher S, Poulakis Z, et al. The Parent Education and Support (PEAS) Program: Final report. Melbourne, Australia: Centre for Community Child Health, Royal Children's Hospital, 2003.
27. Wake M, Baur LA, Gerner B, et al. Outcomes and costs of primary care surveillance and intervention for overweight or obese children: The LEAP 2 randomised controlled trial. *BMJ* 2009;339:b3308.
28. Wake M, Lycett K, Sabin MA, et al. A shared-care model of obesity treatment for 3-10 year old children: Protocol for the HopSCOTCH randomised controlled trial. *BMC Pediatr* 2012;12(1):39.

29. Hanvey AN, Mensah FK, Clifford SA, et al. Adolescent Cardiovascular Functional and Structural Outcomes of Growth Trajectories from Infancy: Prospective Community-Based Study. *Childhood Obes* 2017;13(2):154-63.
30. Hanvey AN, Clifford SA, Mensah FK, et al. Which body composition measures are associated with cardiovascular function and structure in adolescence? *Obesity Medicine* 2016;3:20-27.
31. Marfell-Jones M, Olds T, Stewart A, et al. *International Standards for Anthropometric Assessment*. Potchefstroom, RSA: North-West University, 2006.
32. World Health Organization. Physical status: The use of and interpretation of anthropometry: report of a WHO expert committee. WHO Technical Report Series. Geneva, 1995.
33. Morris NM, Udry JR. Validation of a self-administered instrument to assess stage of adolescent development. *J Youth Adolesc* 1980;9(3):271-80.
34. Petersen AC, Crockett L, Richards M, et al. A self-report measure of pubertal status: Reliability, validity, and initial norms. *J Youth Adolesc* 1988;17(2):117-33.
35. Tan JKL, Tang J, Fung K, et al. Development and Validation of a Comprehensive Acne Severity Scale. *J Cutan Med Surg* 2007;11(6):211-16.
36. Moyer-Mileur LJ, Quick JL, Murray MA. Peripheral quantitative computed tomography of the tibia: pediatric reference values. *J Clin Densitom* 2008;11(2):283-94.
37. Zemel BS. Quantitative computed tomography and computed tomography in children. *Curr Osteoporos Rep* 2011;9(4):284-90.
38. Stein JH, Korcarz CE, Hurst RT, et al. Use of carotid ultrasound to identify subclinical vascular disease and evaluate cardiovascular disease risk: A consensus statement from the American Society of Echocardiography Carotid Intima-Media Thickness Task Force endorsed by the Society for Vascular Medicine. *J Am Soc Echocardiogr* 2008;21(2):93-111.
39. Touboul P-J, Hennerici M, Meairs S, et al. Mannheim carotid intima-media thickness and plaque consensus (2004–2006–2011). *Cerebrovasc Dis* 2012;34(4):290-96.
40. Laurent S, Cockcroft J, Van Bortel L, et al. Expert consensus document on arterial stiffness: Methodological issues and clinical applications. *Eur Heart J* 2006;27(21):2588-605.
41. Zhang A-J, Yu X-J, Wang M. The clinical manifestations and pathophysiology of cerebral small vessel disease. *Neurosci Bull* 2010;26(3):257-64.
42. Miller M, Hankinson J, Brusasco V, et al. Standardisation of spirometry. *Eur Respir J* 2005;26:319-38.
43. Semel E, Wiig E, Secord W. Clinical evaluation of language fundamentals, fourth edition, Australian standardised edition (CELF-4 Australian). Harcourt Assessment, Marrickville (Australia), 2006.
44. Weintraub S, Dikmen SS, Heaton RK, et al. Cognition assessment using the NIH Toolbox. *Neurology* 2013;80(11 Supplement 3):S54-S64.
45. Niskar AS, Kieszak SM, Holmes A, et al. Prevalence of hearing loss among children 6 to 19 years of age: The Third National Health and Nutrition Examination Survey. *JAMA* 1998;279(14):1071-75.
46. Wake M, Poulakis Z, Hughes E, et al. Hearing impairment: A population study of age at diagnosis, severity, and language outcomes at 7–8 years. *Arch Dis Child* 2005;90(3):238-44.
47. Cone BK, Wake M, Tobin S, et al. Slight-mild sensorineural hearing loss in children: Audiometric, clinical, and risk factor profiles. *Ear Hear* 2010;31(2):202-12.

48. Cameron S, Glyde H, Dillon H. Listening in Spatialized Noise-Sentences Test (LiSN-S): Normative and retest reliability data for adolescents and adults up to 60 years of age. *J Am Acad Audiol* 2011;22(10):697-709.
49. National Acoustic Laboratories. Listening in Spatialised Noise Sentences Test (LiSN-S) 2016 [Available from: https://capd.nal.gov.au/lisn-s-about.shtml].
50. Esliger DW, Rowlands AV, Hurst TL, et al. Validation of the GENEA Accelerometer. *Med Sci Sports Exerc* 2011;43(6):1085-93.
51. Olds TS, Ridley K, Dollman J, et al. The validity of a computerized use of time recall, the multimedia activity recall for children and adolescents. *Pediatr Exerc Sci* 2010;22(1):34-43.
52. Ridley K, Ainsworth BE, Olds TS. Development of a compendium of energy expenditures for youth. *Int J Behav Nutr Phys Act* 2008;5:45.
53. Foley LS, Maddison R, Rush E, et al. Doubly labeled water validation of a computerized use-of-time recall in active young people. *Metabolism* 2013;62(1):163-9.
54. Ortega FB, Ruiz JR, Castillo MJ, et al. Physical fitness in childhood and adolescence: A powerful marker of health. *Int J Obes (Lond)* 2008;32(1):1-11.
55. Boreham CA, Paliczka VJ, Nichols AK. A comparison of the PWC170 and 20-MST tests of aerobic fitness in adolescent schoolchildren. *J Sports Med Phys Fitness* 1990;30(1):19-23.
56. Bach M. The Freiburg Visual Acuity test: Automatic measurement of visual acuity. *Optom Vis Sci* 1996;73(1):49-53.
57. Elliot J, Morrow V. Imagining the Future: Preliminary analysis of NCDS essays written by children at age 11. London: Centre for Longitudinal Studies, 2007.
58. Seligson JL, Huebner ES, Valois RF. Preliminary Validation of the Brief Multidimensional Students' Life Satisfaction Scale (BMSLSS). *Social Indicators Research* 2003;61(2):121.
59. Children's Worlds: International Survey of Children's Well-Being 2017 [Available from: http://isciweb.org].
60. Varni JW, Seid M, Kurtin PS. PedsQL 4.0: reliability and validity of the Pediatric Quality of Life Inventory version 4.0 generic core scales in healthy and patient populations. *Med Care* 2001;39(8):800-12.
61. Richardson J, Iezzi A, Khan MA, et al. Validity and Reliability of the Assessment of Quality of Life (AQoL)-8D Multi-Attribute Utility Instrument. *The Patient - Patient-Centered Outcomes Research* 2014;7(1):85-96.
62. Stevens K. Assessing the performance of a new generic measure of health-related quality of life for children and refining it for use in health state valuation. *Appl Health Econ Health Policy* 2011;9(3):157-69.
63. Derogatis LR, Lipman RS, Covi L. SCL-90: An outpatient psychiatric rating scale--preliminary report. *Psychopharmacol Bull* 1973;9(1):13-28.
64. Jones GT, Watson KD, Silman AJ, et al. Predictors of low back pain in British schoolchildren: A population-based prospective cohort study. *Pediatrics* 2003;111(4 Pt 1):822-8.
65. Flood VM, Webb K, Rangan A. Recommendations for short questions to assess food consumption in children for the NSW Health Surveys. 2005.
66. Saloheimo T, González S, Erkkola M, et al. The reliability and validity of a short food frequency questionnaire among 9–11-year olds: A multinational study on three middle-income and high-income countries. *Int J Obes Suppl* 2015;5:S22-S28.
67. Koplin JJ, Wake M, Dharmage SC, et al. Cohort Profile: The HealthNuts Study: Population prevalence and environmental/genetic predictors of food allergy. *Int J Epidemiol* 2015;44(4):1161-71.

68. Peters RL, Koplin JJ, Gurrin LC, et al. The prevalence of food allergy and other allergic diseases in early childhood in a population-based study: HealthNuts age 4-year follow-up. *J Allergy Clin Immunol* 2017.
69. Asher M, Keil U, Anderson H, et al. International Study of Asthma and Allergies in Childhood (ISAAC): Rationale and methods. *Eur Respir J* 1995;8(3):483-91.
70. Pezic A, Ponsonby AL, Cameron FJ, et al. Constitutive and relative facultative skin pigmentation among Victorian children including comparison of two visual skin charts for determining constitutive melanin density. *Photochem Photobiol* 2013;89(3):714-23.
71. Australian Institute of Family Studies. Longitudinal Study of Australian Children Data User Guide - November 2013. Melbourne: Australian Institute of Family Studies, 2013.
72. Davies S, Clifford SA, Gillespie AN, et al. LSAC's Child Health CheckPoint Data Issues Paper 2017. Melbourne, Australia: Murdoch Children's Research Institute, 2017.
73. Wake M, Clifford SA, York E, et al. Introducing Growing Up in Australia's Child Health CheckPoint. *Family Matters* 2014;94:15-23.
74. Harris PA, Taylor R, Thielke R, et al. Research electronic data capture (REDCap) - A metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform* 2009;42(2):377-81.
75. Soininen P, Kangas AJ, Wurtz P, et al. High-throughput serum NMR metabonomics for cost-effective holistic studies on systemic metabolism. *Analyst* 2009;134(9):1781-5.
76. Kettunen J, Tukiainen T, Sarin AP, et al. Genome-wide association study identifies multiple loci influencing human serum metabolite levels. *Nat Genet* 2012;44(3):269-76.
77. Ellul S, Mensah FK, Grobler AC, et al. Technical Paper 1: Development and Use of CheckPoint Sample Weights. Melbourne: Murdoch Children's Research Institute, 217.
78. Australian Bureau of Statistics. Australian Statistical Geography Standard (ASGS): Volume 5 - Remoteness Structure, July 2011 (cat. no. 1270.0.55.005): Australian Bureau of Statistics, 2011.
79. Blakemore T, Strazdins L, Gibbings J. Measuring family socioeconomic position. *Australian Social Policy No 8* 2009:121-68.
80. Australian Bureau of Statistics. Census of Population and Housing: Socio-Economic Indexes for Areas (SEIFA) Australia 2011 (cat. no. 2033.0.55.001) [Available from: http://www.abs.gov.au/websitedbs/censushome.nsf/home/seifa2011].
81. Pearson H. Massive UK baby study cancelled. *Nature* 2015;526:620-21.
82. Landrigan PJ, Baker DB. The National Children's Study--end or new beginning? *N Engl J Med* 2015;372(16):1486-7.
83. Schmidt CW. Growing a New Study: Environmental Influences on Child Health Outcomes. *Environ Health Perspect* 2015;123(10):A260-3.

LSAC B Cohort

Invited to participate in LSAC: n=8921

Refused participation: n=2844
Not contactable: n=970

Participated in Wave 1, 2004:
n=5107 (57.2% uptake)

Attrition: n=1343

Participated in Wave 6, 2014:
n=3764 (74% retention)

Refused contact from CheckPoint: n=163
Consent invalid or not returned: n=31
Not asked about CheckPoint contact: n=57

Gave permission to be contacted by
Child Health CheckPoint: n=3513

Declined participation: n=297
Interested but unable to attend or reschedule: n=980
Not contactable: n=361
Withdrew consent post-assessment: n=1

Child Health CheckPoint sample: n=1874
Main assessment centre n=1356
Mini assessment centre n=153
Home visit assessment n=365

n=number of families, LSAC=Longitudinal Study of Australian Children

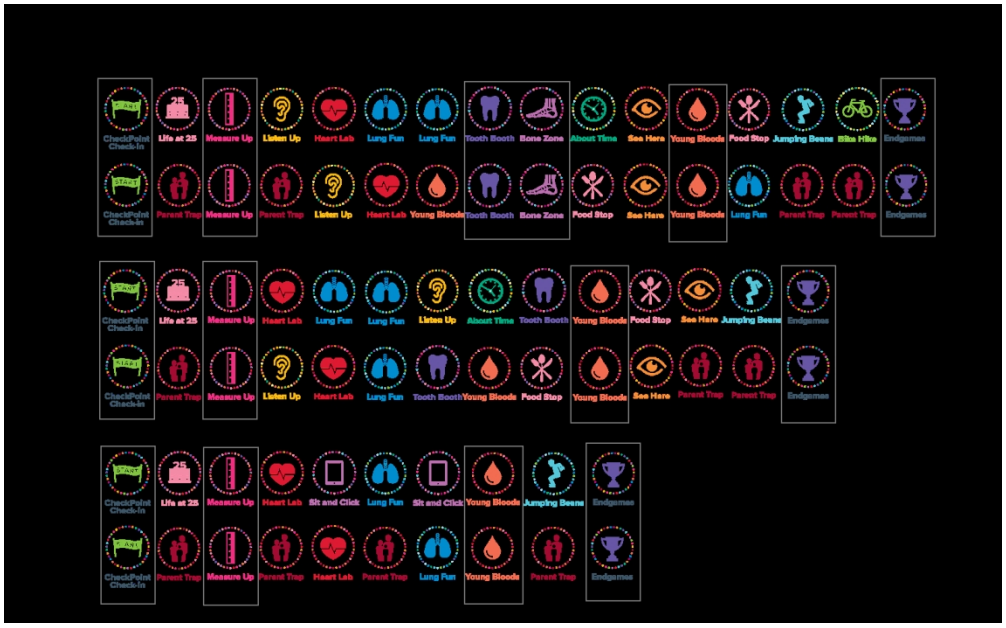

Figure 2. Assessment sequence, by participant and visit type
Oblong box indicates child and parent attended the station together. Parents attended the Young Bloods stations twice; first for their own blood collection, then to accompany their child. Food Stop included consumption experiment at the Main Assessment Centre (ie data collected), but was simply offering refreshments at the Mini Assessment Centre (ie no data collected). The NIH Vocabulary Picture Test was administered in Bone Zone at the Main Assessment Centre, and as part of Sit and Click in Mini Assessment Centre and home visits. In home visits, Sit and Click (child questionnaire) had allocated time between other assessments; for the assessment centre visits, Sit and Click didn't have an allocated time or physical location (children completed the questionnaire in downtime at other stations). Post-visit activities (ie accelerometry, child follow-up phone interview and non-attending parent buccal swab) are not included in the diagram and followed the same protocol regardless of visit type.

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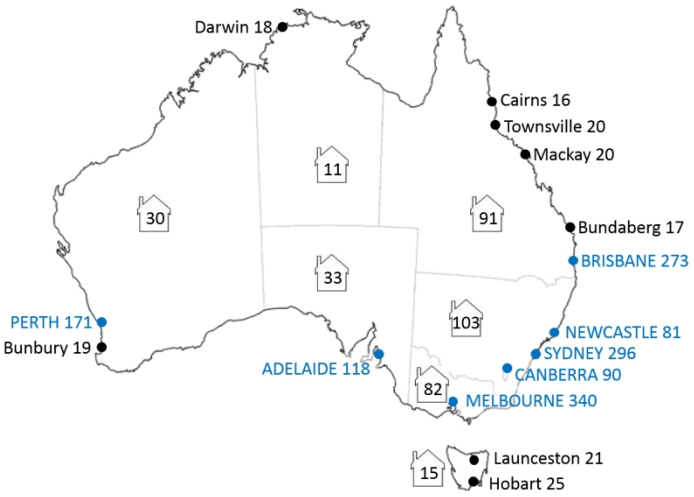

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STROBE Statement—checklist of items that should be included in reports of observational studies

Paper title: *Growing Up in Australia's* Child Health CheckPoint cohort summary and methodology

	Item No	Recommendation	Page number
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5-6
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7-9, Figure 1, Supp Figure 1
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	6, 8
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	10-16, 18
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	10-16
Bias	9	Describe any efforts to address potential sources of bias	19
Study size	10	Explain how the study size was arrived at	19
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	18
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	18
		(*b*) Describe any methods used to examine subgroups and interactions	N/A
		(*c*) Explain how missing data were addressed	N/A
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed	19-20
		(*e*) Describe any sensitivity analyses	N/A

			Page number
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	19, Figure 1
		(b) Give reasons for non-participation at each stage	19, Figure 1
		(c) Consider use of a flow diagram	Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	19-21
		(b) Indicate number of participants with missing data for each variable of interest	23-25
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	Figure 1
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	N/A
		Cross-sectional study—Report numbers of outcome events or summary measures	N/A
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	21
		(*b*) Report category boundaries when continuous variables were categorized	21
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	26
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	26-27
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	26-27
Generalisability	21	Discuss the generalisability (external validity) of the study results	N/A
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	28-29

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Child Health CheckPoint: Cohort summary and methodology of a physical health and biospecimen module for the Longitudinal Study of Australian Children

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Keywords:	Longitudinal studies, non-communicable disease, biological specimen bank, phenotype, cohort profile, reference values

Child Health CheckPoint: Cohort summary and methodology of a physical health and biospecimen module for the Longitudinal Study of Australian Children.

Susan A. Clifford[1, 2], Sarah Davies[1] and Melissa Wake[1-3], on behalf of the Child Health CheckPoint Team.

Child Health CheckPoint Team: Peter S. Azzopardi[1,2,4], Louise A. Baur[5], David P. Burgner[1,2,6], John B. Carlin[1,2], Michael Cheung[1,2,7], Terence Dwyer[1,2,8,9], Ben Edwards[10], Susan Ellul[1], Alanna N. Gillespie[1,2], Lisa Gold[11], Anneke C. Grobler[1], Jessica A. Kerr[1,2], Kate Lycett[1,2], Katherine Lange[1], Fiona K. Mensah[1,2], Tim S. Olds[1,12], Sarath Ranganathan[1,2,13], Helen Rogers[14], Richard Saffery[1,2], Michael Sawyer[15,16], Peter J. Simm[1,2,17], Luke Stevens[1], Tien Y. Wong[18-20] and Stephen R. Zubrick[21,22].

Affiliations: [1]Murdoch Children's Research Institute, Parkville, Victoria, Australia; [2]Department of Paediatrics, The University of Melbourne, Parkville, Victoria, Australia; [3]Department of Paediatrics and The Liggins Institute, The University of Auckland, Grafton, Auckland, New Zealand; [4]Maternal and Child Health Program, International Development Discipline, Burnet Institute, Melbourne, Victoria, Australia; [5]The Discipline of Child and Adolescent Health, The University of Sydney, Westmead, New South Wales, Australia; [6]Department of Paediatrics, Monash University, Clayton, Victoria, Australia; [7]Cardiology Department, The Royal Children's Hospital, Parkville, Victoria, Australia; [8]Nuffield Department of Obstetrics and Gynaecology, The George Institute for Global Health, University of Oxford, Oxford, United Kingdom. [9]Institute for Medical Research, University of Tasmania, Hobart, Tasmania, Australia; [10]Australian National University Centre for Social Research and Methods, Canberra, Australian Capital Territory, Australia; [11]School of Health and Social Development, Deakin University, Geelong, Victoria, Australia; [12]Alliance for Research in Exercise, Nutrition and Activity, University of South Australia, Adelaide, South Australia, Australia; [13]Respiratory and Sleep Medicine Department, The Royal Children's Hospital, Parkville, Victoria, Australia; [14]National Centre for Longitudinal Data, Department of Social Services, Canberra, Australian Capital Territory, Australia; [15]School of Medicine, University of Adelaide, Adelaide, South Australia, Australia; [16]Research and Evaluation Unit, Women's and Children's Health Network, Adelaide, South Australia, Australia; [17]Endocrinology and Diabetes Department, The Royal Children's Hospital, Parkville, Victoria, Australia; [18]Singapore Eye Research Institute, Singapore National Eye Centre, Singapore; [19]Department of Ophthalmology, Yong Loo Lin School of Medicine, National

University of Singapore and National University Health System, Singapore; [20]Ophthalmology and Visual Sciences Academic Clinical Programme, Duke-NUS Medical School, National University of Singapore, Singapore; [21]Telethon Kids Institute, Subiaco, Western Australia, Australia. [22]Graduate School of Education, University of Western Australia, Crawley, Western Australia, Australia.

Correspondence to: Professor Melissa Wake,
Murdoch Children's Research Institute
The Royal Children's Hospital
50 Flemington Road, Parkville 3052, VIC Australia.
Telephone: +61 3 9345 5761
Email: melissa.wake@mcri.edu.au

Keywords: Cohort profile; non-communicable disease; biological specimen bank; phenotype; reference values; parents; children; epidemiologic studies; cross-sectional studies; longitudinal studies.

Word count: 5043

Abbreviations: ABS: Australian Bureau of Statistics; ACR: albumin-creatinine ratio; AQoL-8D: Assessment of Quality of Life 8D; BIA: Bioelectrical impedance analysis; BP: Blood pressure; Ca: California, USA; ECHO: US Environmental Influences On Child Health Outcomes Program; FrACT: Freiburg Visual Acuity and Contrast Test; ISCW: International Survey of Children's Wellbeing; kHz: kilohertz; LiH: Lithium Heparin; LiSN-S: Listening in Spatialised Noise – Sentence Test; LSAC: Longitudinal Study of Australian Children; MARCA: Multimedia Activity Recall for Children and Adults; MCRI: Murdoch Children's Research Institute; NaSSDA: National Secondary Students' Diet and Activity; NCD: non-communicable disease(s); NHMRC: Australian National Health and Medical Research Council; NIH: National Institutes of Health; NMR: nuclear magnetic resonance; NSW: New South Wales, Australia; NPVT: National Institute of Health Picture Vocabulary test; pQCT: Peripheral quantitative computed tomography; PedsQL: Pediatric Quality of Life; REDCap: Research Electronic Data Capture; SD: standard deviation; UK: United Kingdom; USA: United States of America; VO_2max: Maximum volume of oxygen consumed; 2D: Two dimensional; 3D: Three dimensional.

ABSTRACT

Objectives: *'Growing Up in Australia:* The Longitudinal Study of Australian Children' (LSAC) is Australia's only nationally-representative children's longitudinal study, focusing on social, economic, physical and cultural impacts on health, learning, social and cognitive development. LSAC's first decade collected wide-ranging repeated psychosocial and administrative data; here, we describe the Child Health CheckPoint, LSAC's dedicated biophysical module.

Design, setting, participants: LSAC recruited a cross-sequential sample of 5107 0-1 and 4983 4-5 year olds in 2004, since completing seven biennial visits. CheckPoint was a cross-sectional wave that travelled Australia in 2015-16, to reach LSAC's younger cohort at age 11-12 years between LSAC waves 6 and 7. Parent-child pairs participated in comprehensive assessments at 15 Assessment Centres nationwide or, if unable to attend, a shorter home visit.

Measures: CheckPoint's intergenerational, multidimensional measures were prioritised to show meaningful variation within normal ranges and capture non-communicable disease (NCD) phenotype precursors. These included anthropometry, physical activity, fitness, time-use, vision, hearing, and cardiovascular, respiratory and bone health. Biospecimens included blood, saliva, buccal swabs (also from second parent), urine, hair and toenails. The epidemiology and parent-child concordance of many measures are described in separate papers.

Results: 1874 (54% of eligible) parent-child pairs and 1051 second parents participated. Participants' geographical distribution mirrored the broader Australian population; however, mean socioeconomic position and parental education were higher and fewer reported non-English speaking or Indigenous backgrounds. Application of survey weights partially mitigates that the achieved sample is less population-representative than previous waves of LSAC due to non-random attrition. Completeness was uniformly high for phenotypic data (>92% of eligible), biospecimens (74-97%) and consent (genetic analyses 98%, accessing neonatal blood spots 97%, sharing 96%).

Conclusions: CheckPoint enriches LSAC to study how NCDs develop at the molecular and phenotypic levels before overt disease emerges, and clarify the underlying dimensionality of health in childhood and mid-adulthood.

ARTICLE SUMMARY

Strengths and limitations of this study

- The Child Health CheckPoint aimed to enrich the ongoing Longitudinal Study of Australian Children (LSAC) with sophisticated health assessments and biological samples.
- Strengths include LSAC's existing rich decade-long exposure and administrative data for the child and both parents, and CheckPoint's collection of cross-generational parent-child assessments paired on time/date of assessment, protocols and equipment; timing of the module to capture early adolescence; and timely public release of data to researchers (within two years of collection).
- Families living in regional areas or with lower socioeconomic positions are under-represented; however, sample weights are available that enable analyses that are more reflective of the original design sample of Australian children and their families.
- For each child participant, only one parent (predominantly the mother) undertook the detailed paired assessments, but the second parent contributed a buccal (DNA) sample, where possible.
- Access policies are in place for future extraction of extensive additional data from the digital and biospecimen repositories held at the Murdoch Children's Research Institute.

INTRODUCTION

Worldwide there is a large and growing burden of non-communicable diseases (NCDs). Many have their genesis in early life, and develop over decades of cumulative exposures. This provides opportunities to prevent, slow or alter disease trajectories at multiple points of the lifecourse. Wide gradients within the normal range of phenotypes relevant to many later NCDs are already measurable across many body systems from childhood.

It is evident that family, social and other environmental factors interact with an individual's innate biology (including genetic profile) to create modifiable pathways (such as chronic inflammation) common to multiple NCDs.[1] Shonkoff's biodevelopmental framework of lifecourse determinants of health and their mechanisms proposes that health-promoting and health-threating environmental effects interact with genes and affect later health, via physiological adaptions during sensitive periods and cumulative effects over time.[1] These physiological adaptions are the key intermediary step, which may be measured years or decades before overt ill health develops.

'Big picture' research into physiological adaptions and objective health outcomes has shifted from narrowly-focused hypothesis-driven studies with a single outcome, towards multidisciplinary and/or multidimensional research with outcomes across multiple domains that recognise the interconnectedness of health.[2 3] Around the start of the millennium, many countries launched large-scale birth cohort studies (eg UK Millennium Cohort,[4] Growing Up in Ireland,[5] New Zealand,[6] Singapore[7]). Australia's study, *Growing Up in Australia:* The Longitudinal Study of Australian Children (LSAC) was intended to provide a strong evidence base for policy development and service delivery on a wide range of issues relating to children's development and lifetime wellbeing.[8]

LSAC is a population-based cohort study from early childhood, and is the country's only nationally-representative children's longitudinal study. It is broad in scope, surveying lifetime pathways in health, learning and development. Its design incorporates frequent (biennial) and ongoing data collection; multiple study respondents; linkage to lifetime universal parent and child administrative data including health care (eg lifetime primary health services, medication prescriptions dispensed), education (eg national literacy and numeracy exam results) and census datasets; and open access to the datasets for researchers. The federal government investment into LSAC is yielding major returns that influence policy,[9] with several hundred publications in the first decade of the study (listed at http://flosse.fahcsia.gov.au/). Adopting a dual cross-sequential design, LSAC recruited two cohorts in 2004, each comprising ~5000

children. At recruitment, the K cohort children were aged 4-5 years (n=4984 families, 50.4% update; figure 1), and B cohort 0-1 year old (n=5107 families, 57.2% uptake). A two-stage random sampling design was applied, first randomly selecting 10% of postcodes (stratified by state and urban/rural locations), then in-age children within those postcodes from the Medicare database.[10] Medicare is an Australian government program within the universal health care system that reduces or covers medical visit and medication costs, into which 98% of children are enrolled by their first birthday.[10] Very remote postcodes and those with <20 children (n=874 postcodes, 3.2% of population) were excluded. At wave 6 (child age 10-11), 74% of the original B cohort were retained; families with Indigenous or non-English speaking backgrounds, or incomes less than $1000 per week were under-represented in later waves.[11]

Like other government-implemented children's studies internationally, LSAC has mainly focused on psychosocial and demographic exposures, with all health items except anthropometry and blood pressure being parent- or self-reported. A physical health and biospecimens module was beyond the scope of the original study design. There was also uncertainty as to how such a biomarker module might impact (whether positively or negatively) on cohort retention and engagement.

To address this gap, we recently introduced an intergenerational physical health and biomarkers module, the Child Health CheckPoint. This one-off cross-sectional wave, nested between LSAC waves 6 and 7, was offered to the B cohort at child age 11-12 years. CheckPoint's intergenerational, multidimensional measures were prioritised to show meaningful variation within normal ranges and capture non-communicable disease (NCD) phenotype precursors both in adults and children. Wherever possible we captured raw digital data (eg images, traces) that would support additional extraction and analysis beyond the core phenotypic summary data (eg blood pressure readings). The broad set of paired measures, collected on parent-child dyads on the same day with identical equipment, was designed to allow researchers to simultaneously examine multiple phenotypes in both ages as well as the intergenerational transmission of health. In this paper, we describe the Child Health CheckPoint methods and sample characteristics. This allows researchers to understand and make best use of the robust dataset and biospecimens. Other papers in this BMJ Open Special Issue explore the epidemiology and parent-child concordance of individual measures in greater depth.[12-25]

METHODS

Study design: LSAC is a longitudinal child cohort study conducted in partnership between the Australian Government Department of Social Services, the Australian Institute of Family Studies and the Australian Bureau of Statistics. It is funded by the Australian Government.

The Child Health CheckPoint was conducted between February 2015 and March 2016, at child age 11-12 years. The CheckPoint was offered to the B cohort because: (a) it contains more detailed pregnancy and birth data; (b) LSAC's data collections span the children's entire postnatal lives; (c) by this child age, there is a wide range in normal values of risk factors predicting adult preclinical markers of disease; and (d) experience suggested that the health measurements would be of greater interest (and so attract higher uptake) to children and parents at this age than to the K-cohort of 15–16 year olds, an age when many birth cohorts experience heightened attrition.[26-28]

Study development: In 2007, the Department of Social Services commissioned a scoping report on the potential value, content and cost of a physical health and biomarkers module.[29] A partnership was formed between LSAC senior management, LSAC researchers and child health researchers new to LSAC with physical health and biomarkers content expertise. In 2012, researchers at the Murdoch Children's Research Institute (MCRI) partnered with investigators at the University of South Australia, University of Adelaide and Deakin University to form the CheckPoint Investigator Team and to lead a successful application to the Australian National Health and Medical Research Council (NHMRC Project Grant 1041352, 2013-17). This core funding enabled the child cardiorespiratory measures and leveraged additional institutional, competitive (NHMRC Project Grant 1109355, 2016-2020) and philanthropic funding, such that the CheckPoint ultimately encompassed a much wider range of health domains underpinning NCDs across two generations.

Feasibility of core CheckPoint assessments were tested in 2014 within the '3C' study; a longitudinal study of 378 7-17 year olds in the MCRI's existing PEAS,[30] LEAP2[31] and HopSCOTCH[32] cohorts examining cardiovascular outcomes of lifecourse growth, diet and activity.[33 34]

Late in 2014, we tested the CheckPoint protocol with a vanguard of 52 Victorian LSAC families to fine-tune recruitment, visit flow, timing and feasibility, and test acceptability of the centre-based suite of measures ahead of the much larger bulk of children due to attend in 2015-16. Child and parent participants prospectively rated enjoyment of each assessment and overall

impressions (scored out of 10). Participants were also asked to rate how the CheckPoint module changed their feeling about being in LSAC overall, from 0 (Now I like it much less) to 10 (Now I like it much more).

Participants: LSAC B cohort families who completed a wave 6 home interview were eligible. The study child and one parent were invited to participate in comprehensive health assessments at an Assessment Centre or home visit. Choice of parent and whether or not biological was determined by the family; in practice this 'attending parent' was usually the mother. Second biological parents living with the child, if available, were also invited to participate after the visit by contributing a buccal swab.

Ethical approval and consent: The CheckPoint study was approved by The Royal Children's Hospital Melbourne Human Research Ethics Committee (33225D) and the Australian Institute of Family Studies Ethics Committee (14-26); the latter also provides ethical review and approval for LSAC at every wave. A parent or guardian provided written consent for their own and their child's participation in the study. Optional consent was requested for the collection, storage and non-genetic analysis of biospecimens; genetic analyses of these samples; sharing images and samples with other researchers; and access to the child's birth data and dried newborn heel-prick blood samples that are stored indefinitely by most Australian states. Non-attending biological parents provided written consent for the storage and non-genetic analysis of their buccal swab, and optional consent for genetic analysis was requested. Participants were aware that no health, genetic or other information would be returned to them, beyond a summary of physical health measurements (body mass index, blood pressure, etc.) provided at the end of the visit.

Patient and Public Involvement: Because LSAC is a population-based longitudinal study, no patient groups were involved in its design or conduct. To our knowledge, the public was not involved in the study design, recruitment or conduct of LSAC study or its CheckPoint module. Parents received a summary health report for their child and themselves at or soon after the CheckPoint assessment visit. They consented to take part knowing that they would not otherwise receive individual results about themselves or their child.

Procedure: Participation in the CheckPoint involved (i) an Assessment Centre or home visit for the child and attending parent, (ii) follow-up phone interview for the child, (iii) a week of wearing an accelerometer (physical activity monitor) for the child and attending parent, and (iv) a buccal (DNA) sample collection at home for the non-attending parent. Assessments and phone interviews were conducted by trained research assistants and students.

Sample recruitment: B cohort families were briefly introduced to the upcoming Child Health CheckPoint during the LSAC wave 6 home interview in 2014. A total of 3513 families (93% of wave 6 families and 69% of original cohort, see figure 1) gave written consent to be contacted by the CheckPoint team.

Assessment visit types and locations: The core CheckPoint data collection mechanism was the 'pop-up' Main Assessment Centre, set up in seven major Australian cities (supplementary figure 1) sequentially for between 2-8 weeks before being packed up and transported by road to the next location. On each operating day, up to 24 families were invited to attend the Assessment Centre for a 3½-hour visit.

Road transport between Australian cities can take days. To maximise the size and geographic reach of the sample, 'pop-up' Mini Assessment Centres operated in eight regional cities for up to a week while the bulk of equipment was in transit. The 2¾-hour Mini Assessment Centre visit included most of the assessments offered at the Main Assessment Centres, except those requiring large equipment unable to be checked in as personal luggage on commercial flights. Those unable to attend an Assessment Centre were offered a 1½-hour home visit with a subset of measures that could be conducted in the home by a trained research assistant (ie not a phlebotomist) using portable equipment. Home visits occurred in Main Assessment and Mini Assessment Centre cities, and other regional towns.

In total, the study visited over 30 cities and towns over the one-year data collection period (supplementary figure 1). The Assessment Centre operated in 15 cities and towns. This number was constrained by the fixed data collection window and budget (i.e. substantial time and costs of setting up in each location, regardless of the number of participants seen). The specific locations chosen were the cities and towns with the largest clusters of B cohort participants. Using mapping software, we plotted participants residing within 2 hours travel radius of each regional city. If the regional city had the necessary infrastructure for a Mini Assessment centre and at least 40 eligible families within the radius, we set up a centre; otherwise we offered Home Visits.Most families (72%) attended a Main Assessment Centre, 8% attended a Mini Assessment Centre and 20% completed a home visit. Table 1 reports the assessments offered at each visit type, and figure 1 the sample size per visit type.

Table 1. Summary of measurements and biological samples collected in CheckPoint assessments

Construct & Measure	Main Ch	Main P	Mini Ch	Mini P	Home Ch	Home P	Station	Equipment/instrument*	Data/sample collection protocol in brief
Anthropometry									
Height[35 36]	●	●	●	●	●	●		Portable rigid stadiometer (Invicta IP0955, Leicester, UK).	Standing height without shoes or socks, measured x2, or x3 if first two measures differed by ≥ 0.5cm.
Weight and body composition[35 36]	●	●	●	●	●	●		4-limb segmental (InBody230, Biospace, Seoul, Korea) or 2-limb (Tanita BC-351, Kewdale, Australia) body composition scales.	Weight and body composition wearing light clothing without shoes or socks, measured once.
Waist circumference[35 36]	●	●	●	●	●	●		Steel anthropometric measuring tape (Lufkin Executive Diameter W606PM, Maryland, USA).	Waist circumference at the narrowest point between the 10th rib and iliac crest, or midpoint between if no visible narrowing. Measured x2, or x3 if first two differed by ≥1cm.
Pubertal status									
Pubertal development	●		●		●			Sexual Maturity Scale.[37] Pubertal Development Scale.[38]	Sexual maturity assessed using three sets of images (1 male and 2 female) showing stages of puberty. Pubertal progress assessed using five sex-specific questions.
Menstruation	●	●	●	●	●	●		Study-designed questions about menstruation.	Self-reported current menstruation (females only). Age of menstruation onset (girls only).
Acne	●		●		●			Modified Comprehensive Acne Severity Scale for the face.[39]	Current acne severity assessed using a sex-specific 5-point pictorial scale.
Bone and muscle measures									
Bone and muscle morphology, bone density[40 41]	●	●						Peripheral quantitative computed tomography (pQCT, Stratec XCT 2000L scanner and XCT 2000 software, Birkenfeld, Germany).	Two pQCT scans of the non-dominant lower leg to image bone and muscle density and morphology. Scans taken at 4% (above ankle) and 66% (mid-calf) length of the tibia.

Construct & Measure	Main Ch	Main P	Mini Ch	Mini P	Home Ch	Home P	Station	Equipment/instrument*	Data/sample collection protocol in brief
Cardiovascular measures									
Carotid intima-media thickness and distensibility[42 43]	●	●	●	●			Heart Lab	Portable ultrasound (GE Healthcare Vivid *i* BT06 with 10MHz linear array probe, Little Chalfont, UK) with ECG.	Performed in supine position with head turned 45 degrees to the left. Probe applied to right side of the neck to capture carotid artery wall images, with concurrent ECG trace.
Arterial stiffness and blood pressure[44]	●	●	●	●	●	●	Heart Lab	SphygmoCor XCEL (AtCor Medical, West Ryde, AUS).	Aortic-femoral pulse wave velocity measured x3, supine, using a tonometer on the neck and blood pressure (BP) cuff on the thigh. Pulse wave analysis (including BP) measured x3, 1 minute apart, using a BP cuff on the arm.
Microvascular structure[45]	●	●					See Here	Retinal camera (Canon CR-DGi, Tokyo, Japan), fitted with a digital SLR camera (Canon EOS 60D, Tokyo, Japan).	In a darkened room without mydriasis, two retinal photographs were taken per eye, one focused on the macula and one focused on the optic disc.
Respiratory measures									
Lung function	●	●	●	●	●	●	Lung Fun	Spirometer[46] (Vyntus, California (Ca), USA) and Sentry Suite software (Ca, USA) for collection (v2.10) and download (v2.17).	Children and parents perform 3-8 maximal exhalation manoeuvres. Children inhale 4 puffs of bronchodilator (Ventolin), wait 10 minutes, and repeat test.
Language									
Expressive and receptive language	●	●	●	●			Listen Up	Recalling Sentences subtest, Pearson Clinical Evaluation of Language Fundamentals–4th edition, Australian version,[47] iPad (Apple, Ca, USA) and headphones.	Participant recalls and repeats up to 32 recorded spoken sentences of varying length and syntactic complexity.
Receptive vocabulary	●	●	●	●	●	●	Bone Zone	National Institutes of Health Picture Vocabulary test[48] (NIH Toolbox software with Cognition package), iPad & headphones.	Participant hears word and selects picture best representing the words meaning. Adaptive test using computer-based algorithms to quickly approximate and then precisely pinpoint participant ability.

Construct & Measure	Main Ch	Main P	Mini Ch	Mini P	Home Ch	Home P	Station	Equipment/instrument*	Data/sample collection protocol in brief
Hearing									
Hearing threshold[49 50]	●	●	●	●			Listen Up	Audiometer (Oscilla USB-330, version 3.3.4, Taastrup, Denmark) and Oscilla headphones. Data exported using version 4.0.0.	In a soundproof booth with headphones, participant presses button on hearing sound. Adaptive test: sound presented at increasing and decreasing volume at 4 frequencies (1, 2, 4, 8 kHz). Each ear tested separately.
Middle ear function[51]	●	●	●	●			Listen Up	Tympanometer (Oscilla TSM300, Taastrup, Denmark) and AudioConsole software (Version 3.3.4).	Tympanometer in ear canal varies air pressure, vibrating the tympanic membrane to measure canal volume, middle ear pressure & compliance.
Speech reception threshold	●	●	●	●			Listen Up	Listening in Spatialised Noise – Sentences Test v1.104,[52 53] Phonak, NSW, Australia), laptop & headphones (Sennheiser HD215, Wedemark, Germany).	In a soundproof booth with headphones, participant repeats sentences at varying volume against fixed-volume background conversation. Adaptive test; computer algorithms pinpoints threshold.
Diet and food choices									
Food choices	●	●					Food Stop	Digital weight scales accurate to 1 gram (Breville, BSK500BSS).	Participant provided with a food box with prepacked snack food items to eat during a 15-minute break. Boxes on different days randomised to differ by box size and food amount. Uneaten food weighed at end of session.
Physical activity and time use									
Physical activity, sedentary behaviour, sleep[54]	●	●	●	●	●	●	Endgames	Wrist-worn accelerometer (GENEActiv Original, Cambs, UK) and self-report activity log.	Tri-axial accelerometer on non-dominant wrist for 8 days. Participant records type of day (school, non-school), sleep times and activities with device off.
Time Use	●		●		●		About Time	Multimedia Activity Recall for Children and Adults[55-57] program.	Activities recalled from the previous 24-48 hours, in increments of >=5 minutes. 2-3 days recalled, including one school and one non-school day.

Construct & Measure	Main Ch	Main P	Mini Ch	Mini P	Home Ch	Home P	Station	Equipment/instrument*	Data/sample collection protocol in brief
Strength and fitness									
Eurofit broad jump[58]	●		●		●		Jumping Beans	Gym mat and measuring tape (Lufkin L610CME, Maryland, USA).	Participant jumps horizontally from a standing start with double-leg take off. After a practice jump, the distance of 3 jumps (measured in cm) are recorded.
PWC170 VO_2 max test[59]	●						Bike Hike	Exercise bike (Monark 928G3, Manila, Philippines) and chest-worn heart rate monitor (Polar FT4, Smeaton Grange, Australia).	Warm up, then cycle at 60 RPM for 3x 2-min bouts. Resistance increases as per heart rate at end of each bout. Aerobic work capacity (VO_2max) estimated.
Vision									
Visual acuity	●	●	●	●			See Here	Computerised adaptive Freiburg Visual Acuity and Contrast Test[60] with Landolt C optotypes (FrACT 3.8.2, Breisgau, Germany).	Participant identifies optotypes (shapes) from 3 meters. Right and left eyes tested separately, without glasses or contact lenses. Adaptive test; computer algorithms adjust size of optotypes presented to determine visual acuity. If visual acuity < 1.0, test repeated with pinhole lens.
2D and 3D oral photography									
2D and 3D oral photography	●	●	●	●			Tooth Booth	*2D photography* - Digital SLR camera (Canon 70D, Tokyo, Japan). *3D photography* – 3-pod 3D camera (3dMD Trio system, Georgia, USA).	2D photos of the dorsum of extruded tongue; then with lip retractors in place, teeth in occlusion and slightly apart with lower incisal edges visible. 3D photo teeth in occlusion with lip retractors in place.
3D facial photography	●	●					Tooth Booth	3-pod 3D camera (3dMD Trio system, Georgia, USA).	3D photo of the face (neutral expression, hair pulled back in net to show hairline), ears and under chin.
Written story									
Handwriting, written language	●		●		●		Life at 25	Pen, paper. Using protocol adapted from 1958 National Child Development Study (UK).[61]	Child writes a short story about what they think their life will be like when they are 25 years old.

Construct & Measure	Main Ch	Main P	Mini Ch	Mini P	Home Ch	Home P	Station	Equipment/instrument*	Data/sample collection protocol in brief
Wellbeing and quality of life									
General wellbeing	●		●		●		Sit and Click	International Survey of Children's Wellbeing.[62 63]	6-item measure of subjective wellbeing.
								Pediatric Quality of Life (PedsQL) 4.0 General Wellbeing Scale.[64]	7-item measure of quality of life and general wellbeing.
Health related quality of life	●		●		●		Sit and Click	PedsQL 4.0 Generic Core Scale.[64]	23-item measure of physical and psychosocial health, yielding total, physical and psychosocial summary scores.
Health related quality of life		●		●		●	Parent Trap	Assessment of quality of life 8D Scale.[65]	35-item measure of health-related quality of life. Overall utility score and dimension scores calculated.
Health related quality of life	●	●	●	●	●	●	Sit and Click / Parent Trap	Child Health Utility 9D.[66]	9-item measure of health-related quality of life. Overall utility score calculated.
Pain									
Pain	●	●	●	●	●	●	Sit and Click / Parent Trap	Pain severity questions[67] with pain manikin adapted for on-line administration.[68]	Asked about pain >1 day in past month; if yes, when started, and (children only) which body regions.
Diet									
Diet	●	●	●	●	●	●	Sit and Click / Parent Trap	Adapted National Secondary Students' Diet and Activity[69] questions, supplemented with adapted International Study of Childhood Obesity, Lifestyle and Environment[70] items.	26-item brief food frequency survey of usual intake of a range of different foods including fruits and vegetables.
Allergy and eczema									
Family allergies and pet exposure		●		●		●	Parent Trap	Allergy and pet exposure questions from the HealthNuts study;[71 72] parent-reported.	Branched questionnaire items about child's siblings and parent's history of asthma, eczema, hay fever, latex/insect/food allergy, and the family's pets.

Construct & Measure	Main Ch	Main P	Mini Ch	Mini P	Home Ch	Home P	Station	Equipment/instrument*	Data/sample collection protocol in brief
Colouring									
Natural skin, hair and eye colouring	●	●	●	●	●	●	Parent Trap	Questions adapted to self-report format from Paediatric Autoimmune Disease study[73] colour chart; parent-reported.	3-item measure of the natural skin, hair and eye colour of both the child and parent.
Medications and supplements									
Current medications and supplements	●		●		●		Parent Trap	Medications and supplements questions modified from LSAC;[74] parent-reported.	Branched questionnaire items about the child's medication and supplement use.
Health, welfare and community services									
Hospital admissions and health insurance	●		●		●		Parent Trap	Child lifetime hospitalisations, health care card and insurance coverage questions modified from LSAC;[74] parent-reported.	Branched questionnaire items about child's lifetime hospital admissions (including age, diagnosis), and concession card/private health insurance coverage.
Health service use	●		●		●		Parent Trap	Use of services questions modified from LSAC;[74] parent-reported.	Branched questionnaire items about child's health service use and parent time spent on service use.
Community participation	●		●		●		Parent Trap	Community activity use questions modified from LSAC;[74] parent-reported.	Branched questionnaire on community activity participation (eg team sports, music) in last year.

Construct & Measure	Main Ch	Main P	Mini Ch	Mini P	Home Ch	Home P	Station	Equipment/instrument*	Data/sample collection protocol in brief
Biological samples									
Venous blood	●	●	●	●			Young Bloods	S-Monovette vacutainers: 2.7ml K3 EDTA (05.1167.001), 9ml K3 EDTA (02.1066.001), 7.5ml Lithium Heparin liquid (01.1608.001), 9ml Serum Gel with Clotting Activator (02.1388.001), Sarstedt, Australia	Approximately 28mL blood from non-dominant arm of semi-reclining (45°), semi-fasted participants, processed into 0.5mL aliquots. Up to 6 EDTA plasma, 6 EDTA buffy coat, 6 LiH plasma, 6 LiH buffy coat (viable cells) and 6 serum per participant. In addition, *either* a whole blood clot *or* 3 whole blood aliquots and a dried blood spot (see next row). All serum, plasma and clot samples frozen directly at -80°C on site, while buffy coat aliquots were prepared in a freeze mix (10% fetal bovine serum + 10% DMSO in BME) and placed within CoolCells (Biotools, Australia) prior to control the rate of freezing at -80C to maximize cell viability
Dried blood spot	●	●	●	●	●	●	Young Bloods	Lancet (1.6mm (#85.1018) or 1.8mm (#85.1016) depth, Sarstedt Australia), Guthrie card.	Card used for newborn screening is blotted with four drops of blood, collected via either a finger prick or pipetting a small amount of the venous whole blood sample. Stored at room temperature.
Urine	●	●	●	●	●	●	Lung Fun	70mL screw cap polypropylene sterile pot (#75.9922.731, Sarstedt, Australia)	Participant collects random urine sample into 30mL sterile urine pot, pipetted into 12x 0.7mL aliquots. Stored at -80°C on site.
Saliva	●	●	●	●			Lung Fun	50mL polypropylene sterile tube (#FAL352070, Falcon, Corning Inc., Corning, NY, USA)	Five minute passive saliva drool into sterile tube. Sample weighed, then pipetted into 6x 0.5mL aliquots. Stored at -80°C on site.
Buccal swab		○	●	○	●	○	Lung Fun	Buccal swab (Oracollect DNA OCR-100, The Hague, Netherlands. If not available, FloqSwab COPAN Flock Technologies, Brescia, Italy was used).	Participant rubs swab over gums/inner cheeks. *OCR-100*: Immerses swab in the preserving liquid, seals tube. Aliquoted into 2 x 0.5mL aliquots. *FloqSwab*: Seals swab in air-tight container. Stored at room temperature then -80°C.

Construct & Measure	Main Ch	Main P	Mini Ch	Mini P	Home Ch	Home P	Station	Equipment/instrument*	Data/sample collection protocol in brief
Hair	●	●	●	●			Lung Fun	String, aluminium foil, envelope, scissors.	Two locks of hair (4mm in diameter) tied with string and cut close to the scalp from the occipital area under the crown. Hair wrapped in aluminium foil (scalp end identified) and stored in a barcoded envelope at room temperature.
Toenails	●		●		●		Lung Fun	Scissors, envelope.	Clean toenails >3mm trimmed from right big toe (if not available, left big toenail or fingernails) and stored at room temperature in barcoded envelope.

Questionnaire measures are self-reported, unless indicated they were parent-reported. *All questionnaire items administered by iPad or laptop, except the pain manikin, which was completed on paper at home visits. For brevity, iPad or laptop is not listed for every questionnaire item. Open circles indicate sample collected from non-attending parent.

Ch: Data/sample collected relates to child participant; P: Data/sample collected relates to parent participant; BP: Blood pressure; Ca: California, USA; FrACT: Freiburg Visual Acuity and Contrast Test; kHz: kilohertz; LiH: Lithium Heparin; LSAC: Longitudinal Study of Australian Children; PedsQL: Pediatric Quality of Life; NaSSDA: National Secondary Students' Diet and Activity; NIH: National Institutes of Health; UK: United Kingdom; USA: United States of America; VO_2max: Maximum volume of oxygen consumed; 2D: Two dimensional; 3D: Three dimensional.

Assessment sequence: Participants completed the assessments in a standard sequence (Figure 2), designed to minimise interdependencies between measures. Bronchodilator administration (which may alter cardiovascular parameters) followed cardiovascular measures, and the snack station was scheduled after saliva and semi-fasting blood collection, but before exercise.

The visit started with the parent providing consent, while the child wrote their story at *Life at 25*. At Assessment Centres, participants were then given a carry bag containing an iPad to complete the questionnaire, water bottle and urine sample collection kit, and a lanyard showing the order of data collection stations to visit. Participants advanced every 15 minutes from one station to the next (except child *Lung Fun* which was 30 minutes duration), following the previous participant in their journey around the Centre. Most stations were conducted one-on-one, but in some the study child and attending parent were both present (*CheckPoint Check-in*, *Measure Up*, *Tooth Booth*, *Bone Zone*, child *Young Bloods* and *Endgames*, see figure 2), and two children could be present at any one time for *Life at 25*, *Jumping Beans* and *Bike Hike.*

Prior to the last station *Endgames*, participants could take extra time to complete their questionnaire or provide a urine sample. At *Endgames*, a staff member explained the contents of a take-home pack. The child and parent were fitted with their wrist-worn accelerometers, and a follow-up phone interview was booked/confirmed for the child to complete additional time-use diaries.[55] The take-home pack also included a reply-paid express post satchel, child and parent activity log cards, non-attending parent buccal sample collection kit (as applicable), summary of health results collected on the day, and thank you gifts and token reimbursement for travel.

Home visit consent, assessments and take-home packs used the same protocol as the Assessment Centres and included at least one measure from every major health domain; however, some assessments were omitted (table 1). The home visit sequence generally mirrored the centre flow, with minor adjustments to allow one staff member to assess both child and parent within the available time. Dried blood spot, urine and buccal swabs were obtained, and urine processing was delayed when local laboratory facilities were not available.[75]

Research assistants and students were trained by experts, and real-time quality checks were undertaken throughout the data collection period. These checks included data range checks integrated into the data entry forms; dynamic data completeness checks for each participant during and at the end of their visit, with gaps redressed by a dedicated staff member before

departure; weekly completeness checks for the study overall and ongoing process modifications to address all causes of missing data identified; random visual checks of the data to identify and fix any developing departures from protocol; and ongoing staff training, time trials and testing knowledge of Standard Operating Procedures. Inter- and intra-rater reliability for data transcription and scoring was calculated, where relevant and possible. Data collection reliability was not available as the participant flow precluded repeated measures of same individual.

Measures: Measures and biological samples collected are briefly described in Table 1. Other papers of this BMJ Open Special Issue[12-25] provide greater detail, epidemiological description and parent-concordance for many of these; and their rationale has been previously published.[76] Data were collected electronically via specialist medical equipment/software or, where not possible, staff entered data into REDCap (Research Electronic Data Collection tool).[77] REDCap was also used to administer the child and parent questionnaires on iPads. Data collection and data processing Standing Operating Procedures are available (see http://www.checkpoint-lsac.mcri.edu.au measures were offered to both children and parents; however, the parent flow omitted the exercise stations (*Bike Hike* and *Jumping Beans*), time-use diary, post-bronchodilator spirometry and toenail samples. Instead, parents completed a more detailed questionnaire about their child's healthcare (including hospitalisations), medications and use of community services; and their own health-related quality of life.

Biospecimen collection and repository: Biospecimens collected are described in table 1. Samples (except buccal swabs) were processed within hours in an on-site laboratory set up at all Main Assessment and most Mini Assessment Centres. Blood and saliva samples were generally processed within an hour (blood: range 1 minute to 3.8 hours, median 53 minutes; saliva: range 1 minute to 5.7 hours, median 44 minutes). Urine sample processing was delayed if collected away from a laboratory; 56% of urine samples processed within three hours (range 1 minute to 9 days, median 71 minutes).[75] At the completion of each Assessment Centre, a single batch of all frozen samples were shipped on dry ice to the Melbourne Children's Bioresource Centre (at the MCRI) for long term storage at -80°C (except buffy coat aliquots are stored in vapour phase liquid nitrogen). A temperature data logger was included in each shipment to confirm optimal temperature throughout. All other samples, kept at room temperature, were transported at the same time. All samples are stored in a de-identified manner and are only identified for extraction from the repository. Newly derived biospecimen data is linked to the participant by an external staff member using a linkage key. . Samples

were tracked using QR code scanners and FreezerPro Enterprise (RuRo, Maryland, USA) software. Frozen samples are stored in boxes of 96 aliquots, and aliquot picking is undertaken by hand (i.e. not automated by robot). As of January 2018, completed biomarker analyses for all parents and children with relevant samples were serum metabolomics (http://www.nightingalehealth.com),[22 78 79] urinary albumin-creatinine ratio (ACR)[19] and telomere length;[16] genotyping and micronutrient analyses were under way; and funding had been secured for one-carbon pathway analyses.

Data access: The LSAC data are available to researchers under licence, and from early 2018 will include the first tranche of completed parent and child CheckPoint data. The LSAC website explains access to these data (http://www.growingupinaustralia.gov.au/data/dataaccessmenu.html).

It is intended that all further CheckPoint data and biospecimens will also be accessible to all researchers. Applications to undertake new data extraction and biosamples, or to collaborate with CheckPoint investigators on in-train funded new data, are considered by CheckPoint's Data/Biospecimens Access Committees (see http://www.checkpoint-lsac.mcri.edu.au).

Statistical analyses: Sample characteristics, sample size and consent rates were described as counts, proportions, means and standard deviations. Baseline demographic characteristics of LSAC families who did and did not participate in CheckPoint were compared to consider the representativeness of the maintained CheckPoint sample in relation to preceding LSAC waves.

Survey weights: CheckPoint survey weights were created[80] using similar methods to those used for previous waves of LSAC, and are provided in the CheckPoint dataset. These methods account for the selection probability of each child to establish the target design sample, initial non-response to the baseline survey and subsequent loss to follow-up. LSAC and CheckPoint survey weights have been estimated to reflect the likelihood of participation from wave to wave within the limits of the information available from study measures.

Applying LSAC survey weights produces analyses that will be as representative as possible for all Australian children born in 2004 and their parents. CheckPoint differs in that, for the majority of measures, only the attending parent (usually the mother) was assessed, and thus weighted analyses of the parent data are more difficult to interpret because the weighting does not estimate a representative sample of all parents.

RESULTS

Below we summarise the vanguard participants' evaluation of the CheckPoint module. We then describe B cohort recruitment and reasons for non-participation in the CheckPoint module, and demographic characteristics of CheckPoint participants and non-responders. Lastly, we summarise data completeness for each measure, and biospecimen collection and consent rates.

In 2014, ahead of the main data collection wave, the vanguard families reported high levels of enjoying the CheckPoint visit (mean out of 10: child 8.8, parent 8.2), recommending it to others (child 7.7, parent 9.0) and valuing the child health report provided on the day (child 7.7, parent 8.2). Children and parents were also asked if participating in the CheckPoint had changed how they feel about being in the LSAC study (from 1 'Like it much less' to 10 'Like it much more'); on average, participants liked LSAC more after their CheckPoint visit (mean: child 8.4, parents 7.7).

The CheckPoint sample size was fixed by LSAC retention to wave 6. Of a total of 3764 families who participated in wave 6, 3513 (93%) consented to CheckPoint contact, 3152 (84%) provided valid contact details and were invited into CheckPoint, and 1875 (50%) participated (figure 1). One family withdrew consent after assessment. Thus, the CheckPoint analytic sample included 1874 parent-child pairs, plus 1051 non-attending resident parents.

Most non-participation (60%) was due to inability to attend or reschedule a visit during the short period CheckPoint was in each location. Far fewer families declined (18%).

Demographic characteristics of the CheckPoint sample and non-responders are summarised in table 2. Within the CheckPoint sample, 99% of attending parents and all non-attending participants were a biological parent of the study child. There was an equal distribution of boys and girls. However, the sample of attending parents was not equally or randomly comprised of mothers and fathers, since each family decided which parent or guardian attended and most (88%) attending parents were mothers. Almost 90% of attending parents were nominated 'Parent 1' (ie the parent who knows the child best and completes the main questionnaire) in previous LSAC waves. The majority of CheckPoint families lived in major cities, with a similar distribution across the states and territories to the Australian population. Larger proportions of families were in the higher socio-economic position quintiles than in the Australian population. Detailed comparisons of the LSAC sample to the Australian population have been published previously.[11 81]

Compared to B cohort families who did not take part in the CheckPoint, table 2 shows that participating families at baseline (2004) reported higher socioeconomic position and parental education, and lower likelihood of non-English speaking or Indigenous backgrounds.

Table 2. Child Health CheckPoint sample characteristics

Characteristic Values are %, unless indicated	Sample characteristics at CheckPoint (2015-16)* n=1874 families	Baseline characteristics (2004)†	
		In CheckPoint n=1874 families	Not in CheckPoint n=3233 families
Child age in years, mean (SD)	12.4 (0.4)	0.8 (0.2)	0.8 (0.2)
Parent age in years, mean (SD)	44.4 (5.2)	32.1 (4.9)	30.4 (5.7)
Female child	49.0	49.0	48.9
Female parent	87.7	98.7	98.5
Child accompanied by biological parent	98.9	99.7	99.7
Child has Indigenous background§	2.0	2.0	6.0
Parent born in Australia‡	79.0	79.3	81.2
Parent home language not English‡	10.8	11.2	16.3
Area of residence[1]			
Major city	70.3	70.5	64.0
Inner regional	20.3	18.0	20.6
Outer regional	8.7	9.9	12.8
Remote	0.8	1.6	2.6
Australian state/territory of residence			
Australian Capital Territory	2.8	2.9	1.6
Northern Territory	1.6	2.4	1.3
New South Wales	28.6	29.9	32.6
Queensland	21.5	20.0	20.1
South Australia	8.0	7.5	6.4
Tasmania	3.3	3.2	1.6
Victoria	22.5	22.2	25.8
Western Australia	11.8	11.8	9.7
Socioeconomic position[2], mean (SD)‡	0.2 (1.0)	0.3 (1.0)	-0.2 (1.0)
Neighbourhood Disadvantage Index[3], mean (SD) and % in national quintiles	1023 (60)	1019 (61)	1003 (59)
1 (least disadvantaged quintile)	34.8	29.0	18.9
2	23.4	20.3	19.8
3	18.8	19.3	21.6
4	14.8	19.8	21.7
5 (most disadvantaged quintile)	8.2	11.6	18.1
Parent's highest level of education‡			
Did not complete high school	20.1	21.4	39.0
High school	44.4	42.3	39.9
Undergraduate degree (Bachelor)	23.6	26.6	15.5
Postgraduate degree	11.9	9.7	5.7
Attending parent's employment status‡			
Working full-time (≥30 hours/week)	46.9	31.8	22.4
Working part-time	37.4	2.7	1.6
Not currently working	15.7	65.5	76.0
Parent has a spouse/partner	88.1	95.7	91.3

*Data collected in CheckPoint 2015-16 wave, except data indicated as collected at ‡wave 6 (2014) or §wave 1 (2004). Parent data = CheckPoint 'attending parent'. †Data collected in wave 1 (2004). Parent data = 'Parent 1'. CheckPoint attending parent is the wave 1 Parent 1 for 89.3% of families. [1]Australian Bureau of Statistics (ABS) Remoteness Area Code (ref 82). [2]LSAC-derived Family socioeconomic position z-score (ref 83). Higher scores = greater advantage. [3]ABS 2011 Socio-Economic Indexes for Areas Index of Relative Socioeconomic Disadvantage (ref 84)

Data completeness for each measure was high (Table 3) at >92% of participants eligible for each measure, except for accelerometry and child pain. A shortage of accelerometers at certain points over the data collection period meant physical activity data were available for 74% of children and 77% of parents. Initial problems with the branching architecture of questions[75] meant pain data were available for only 85% of children (but 99% of parents). The most common reasons for missing data were the measure not being included in all visit types, followed by equipment unavailability, participant refusal and erroneous data removed in the preparation of the dataset.[75] Data from all of the measures listed in Table 3 will be included in the first CheckPoint data release in early 2018, except the handwritten story, and retinal, oral and facial photographs.

Table 3. Sample size by measure and participant group

Construct	Measure	Children	Parents		Parent-child pairs		2018 data release
		n=1874	All n=1874	Biological n=1854	All n=1874	Biological n=1854	
Anthropometry	Height, weight	1873 (99.9)	1865 (99.5)	1845 (98.5)	1864 (99.5)	1844 (98.4)	●
	Body composition*	1859 (99.2)	1844 (98.4)	1824 (97.3)	1837 (98.0)	1817 (97.0)	●
Pubertal status	Puberty Development, Sexual Maturity Scales	1807 (96.4)	-	-	-	-	●
	Menstruation†	844 (45.0)	1610 (85.9)	1598 (85.3)	740 (39.5)	733 (39.1)	●
	Modified Comprehensive Acne Severity Scale	1762 (94.0)	-	-	-	-	●
Bone, muscle	Peripheral quantitative computed tomography	1271 (67.8)	1250 (66.7)	1240 (66.2)	1231 (65.7)	1222 (65.2)	●
Cardiovascular	Carotid intima-media thickness	1489 (79.5)	1476 (78.8)	1463 (78.1)	1462 (78.0)	1449 (77.3)	●
	Pulse wave velocity, pulse wave analysis	1836 (98.0)	1790 (95.5)	1773 (94.6)	1769 (94.4)	1752 (93.5)	●
	Blood pressure	1777 (94.8)	1749 (93.3)	1732 (92.4)	1682 (89.8)	1666 (88.9)	●
	Microvascular structure (retinal photography)	1307 (69.7)	1317 (70.3)	1307 (69.7)	1292 (68.9)	1282 (68.4)	
Respiratory	Spirometry	1759 (93.9)	1774 (94.7)	1754 (93.6)	1688 (90.1)	1668 (89.0)	●
Language	Expressive & receptive language (Recall' Sent.)	1441 (76.9)	1446 (77.2)	1433 (76.5)	1415 (75.5)	1402 (74.8)	●
	Receptive vocabulary (NPVT)	1443 (77.0)	1457 (77.7)	1444 (77.1)	1401 (74.8)	1389 (74.1)	●
Hearing	Pure tone audiometry	1488 (79.4)	1493 (79.7)	1480 (79.0)	1480 (79.0)	1467 (78.3)	●
	Tympanometry	1099 (58.6)	1101 (58.8)	1092 (58.3)	1065 (56.8)	1056 (56.4)	●
	Speech reception threshold (LiSN-S)	1483 (79.1)	1482 (79.1)	1469 (78.4)	1466 (78.2)	1453 (77.5)	●
Diet and food choices	National Secondary Students' Diet & Activity	1846 (98.5)	1862 (99.4)	1846 (98.5)	1837 (98.0)	1821 (97.2)	●
	Snack observation	1294 (69.1)	1246 (66.5)	1235 (65.9)	1205 (64.3)	1195 (63.8)	●
Physical activity, time use	Accelerometry	1382 (73.7)	1440 (76.8)	1424 (76.0)	1223 (65.3)	1209 (64.5)	●
	Time-use diary (MARCA)	1830 (97.7)	-	-	-	-	●
Strength and fitness	Eurofit broad jump	1771 (94.5)	-	-	-	-	●
	PWC170 VO_2max test	1301 (69.4)	-	-	-	-	●
Vision	Freiburg Visual Acuity Test	1494 (79.7)	1491 (79.6)	1478 (78.9)	1481 (79.0)	1468 (78.3)	●
2D and 3D photography	2D and 3D photos of teeth and tongue	1486 (79.3)	1480 (79.)	1467 (78.3)	1478 (78.9)	1465 (78.2)	
	3D photos of face	1331 (71.0)	1316 (70.2)	1305 (69.6)	1313 (70.1)	1302 (69.5)	

Construct	Measure	Children		Parents		Parent-child pairs		2018 data release
		n=1874		All n=1874	Biological n=1854	All n=1874	Biological n=1854	
Handwriting, written language	Handwritten story about life at age 25	1811 (96.6)		-	-	-	-	
General wellbeing	ISCW & PedsQL General Wellbeing	1860 (99.3)		-	-	-	-	●
Health related quality of life	PedsQL, Child Health Utility 9D, AQoL-8D‡	1854 (98.9)		1871 (99.8)	1853 (98.9)	1854 (98.9)	1836 (98.0)	●
Pain	Pain§	1586 (84.6)		1859 (99.2)	1843 (98.3)	1576 (84.1)	1562 (83.4)	●
Natural colouring	Skin, hair and eye colour	1859 (99.2)		1859 (99.2)	1843 (98.3)	1859 (99.2)	1843 (98.3)	●
Medications, supplements	Current medications and supplements	1853 (98.9)		-	-	-	-	●
Health, welfare and	Health service use, hospital admissions	1874 (100.0)		-	-	-	-	●
community services	Community participation and services	1822 (97.2)		-	-	-	-	●
Serum metabolites	NMR metabolomics platform	1180 (63.0)		1325 (70.7)	1313 (70.1)	1139 (60.8)	1133 (60.5)	●
Renal function	Urinary albumin and creatinine concentration	1579 (84.3)		1671 (89.2)	1653 (88.2)	1535 (81.9)	1518 (81.0)	●
Biological aging	Telomere length	1206 (64.4)		1343 (71.7)	1330 (71.0)	1151 (61.4)	1143 (61.0)	

Value are n (%) of participants or pairs with data available. These may differ slightly from sample sizes presented in other CheckPoint papers in this BMJ Open Special Issue, where authors have restricted analyses to participants meeting specified levels of data quality or completeness. 'All parents' and 'all parent-child pairs' include biological and non-biological (eg step-, adoptive or biological relatives other than mother or father) parent-child relationships. Parent-child pairs include families where both the child *and* parent have data available for that measure. *381 children and 344 parents have body fat % measured using a 2-limb BIA scale at home visits; the remainder have detailed body composition measured using a 4-limb BIA scale. †Girls were asked 'has menstruation started' and 'are you menstruating today?' and women were asked 'are you menstruating today?' ‡Children completed the PedsQL, parents completed the AQoL-8D, and both children and parents completed the Child Health Utility 9D. §Parents completed a subset of the pain questions completed by children.

AQoL-8D: Assessment of Quality of Life 8D; BIA: Bioelectrical impedance analysis; ISCW: International Survey of Children's Wellbeing; LiSN-S: Listening in Spatialised Noise – Sentence Test; MARCA: Multimedia Activity Recall for Children and Adults; NMR: nuclear magnetic resonance; NPVT: National Institute of Health Picture Vocabulary test; PedsQL: Pediatric Quality of Life.

Biospecimen collection rates were also high (table 4) for blood (venous or finger prick, 91% of children and 96% of attending parents) and other biological samples (>70%). Most (95%) of children and parents had either a saliva (collected when laboratory facilities were available) or buccal swab (stable for 60 days before processing) sample. Consent was obtained for ≥97% of samples collected to share with other researchers and undertake genetic analyses, and ≥94% of participants to access child perinatal birth data and child neonatal blood spots, and to share child and parent digital images. Buccal samples were also collected from 1051 non-attending parents (of whom 94% consented to share, and 98% to undertake genetic analyses). In total, 1021 (55%) families have at least one sample available for the child and both biological parents.

Table 4. Data/sample collection rates and consent for use of images/sample

Measure or sample	**Children** n=1874			**Attending Parents** n=1874		
	Data/ sample collected	Consent to share	Consent to genetic analyses	Data/ sample collected	Consent to share	Consent to genetic analyses
Digital images (photos)						
2D and 3D teeth	1486 (79.3)	1398 (94.1)	-	1480 (79.)	1397 (94.4)	-
3D face	1331 (71.0)	1251 (94.0)	-	1316 (70.2)	1241 (94.3)	-
Retinal	1307 (69.7)	1229 (94.0)	-	1317 (70.3)	1240 (94.2)	-
Perinatal birth data*	1838 (98.1)	-	-	-	-	-
Newborn Guthrie card*	1810 (96.6)	1760 (97.2)	1775 (98.1)	-	-	-
Blood	1701 (90.8)	1646 (96.8)	1673 (98.4)	1792 (95.6)	1731 (96.6)	1762 (98.3)
Plasma	1230 (65.6)	1196 (97.2)	1211 (98.5)	1371 (73.2)	1331 (97.1)	1353 (98.7)
Serum	1192 (63.6)	1160 (97.3)	1174 (98.5)	1336 (71.3)	1297 (97.1)	1319 (98.7)
Whole blood/ clot	1223 (65.3)	1189 (97.2)	1204 (98.4)	1358 (72.5)	1318 (97.1)	1340 (98.7)
Guthrie card	1424 (76.0)	1382 (97.1)	1405 (98.7)	1468 (78.3)	1421 (96.8)	1446 (98.5)
Urine	1595 (85.1)	1548 (97.1)	1571 (98.5)	1686 (90.)	1637 (97.1)	1662 (98.6)
Saliva	1375 (73.4)	1327 (96.5)	1350 (98.2)	1392 (74.3)	1347 (96.8)	1370 (98.4)
Buccal	398 (21.2)	385 (96.7)	392 (98.5)	390 (20.8)	378 (96.9)	383 (98.2)
Hair	1390 (74.2)	1343 (96.6)	1365 (98.2)	1439 (76.8)	1397 (97.1)	1418 (98.5)
Toenail	1586 (84.6)	1534 (96.7)	1561 (98.4)	-	-	-

Values are n (%). Data/sample collected % is the proportion of the sample (x/1874). Consent % is the proportion of participants who provided data/sample(s)

*Access to these data has been consented to by participants, but not yet attempted by the study team as of October 2017.

DISCUSSION

Principal findings: The Child Health CheckPoint provides a paired cross-generational snapshot of the health of 11-12 year old Australian children and their parents who took part in the CheckPoint assessment (mostly mothers). Data completeness was high amongst the nearly 2000 families who participated. The utility of the data and biospecimens is further enhanced by near-universal consent for genetic analysis and sharing with other researchers. Enriching LSAC's life-long environmental data with CheckPoint's biological data strengthens the utility of LSAC to address important questions on how NCDs develop phenotypically before overt disease is evident, and shed light on the underlying dimensionality of health at different life stages.

Key logistic challenges faced by the CheckPoint were its short time window both to plan and conduct (a fixed 12 months from February 2015), the sheer size of Australia (approximately the same as continental USA), and the limited funding allowing for only one set of heavy equipment and thus curtailing the period during which the CheckPoint was available to participants in each city.

Strengths and limitations: Strengths of LSAC include its large population-based sample, data linkage, historical repeated measures, and open data access. Strengths of the CheckPoint module include the sophistication of its health assessments, and the cross-generational child-parent assessments paired on time of assessment, protocols and equipment. Utility of the CheckPoint data is strengthened by its timing relative to child age (i.e. adolescence onset) and LSAC duration (i.e. ten years of data already available); and its timely release of curated data to researchers (within two years of data collection), with more to come as data scoring and biomarker analyses are completed. The CheckPoint is led by diverse and specialty-based researchers, who continue to develop multi-system hypotheses and discovery research. We have prioritized harmonisation of methods with other internationally-significant cohorts (eg utilisation of the Nightingale metabolomics and Illumina Global Screening Array genotyping platforms). Finally, the CheckPoint module was enjoyable for participants, and its impact on participant retention in future LSAC waves will be examined.

The sample reflects the broader Australian population in many attributes, including state/ territory of residence. A limitation (that can be partly addressed by using survey weights[80]) is that families were more likely to live in major cities and have a higher socioeconomic status than non-participants and Australians in general. The limitation that the majority of the parent

sample are mothers reflects the design of the study and cannot be addressed using survey weights so should be considered and noted in all analyses of parents. Due to sample attrition, the final number of parent-child dyads was only around 1900, limiting power for rare exposures and outcomes; this is partly offset by LSAC's common exposures, and CheckPoint's focus on continuous outcome measures. Almost all measures were collected from only one of the child's parents, although family studies will be possible for the 55% of families for whom we collected a DNA sample from both parents. A further potential limitation is that LSAC does not have prospective prenatal data on the children, although it does includes prospective data from very early life (child age at wave 1 spanned 3-19 months) and permission to link to birth data.

Implications and future research: The wealth and depth of longitudinal LSAC data available gives important context to CheckPoint's health and biomarker data. To commence a brand new cohort incorporating these measures is exceptionally expensive and would have set back the availability of such data by decades, at a time when other prominent efforts to do so internationally have failed.[85 86] Other internationally significant efforts, such as the US Environmental Influences On Child Health Outcomes (ECHO) Program,[87] are now taking a similar approach to CheckPoint. For example, ECHO is enriching existing traditional child cohorts with additional cutting-edge biophysical modules and forward harmonisation. This will add great value to these cohorts and to knowledge that can be generated from their interrogation.

In the study's first decade, over 500 papers have been published using LSAC data. Child health is one of the most common topics of LSAC papers,[81] and many of these health-related research questions could be extended upon now that the CheckPoint data are available. For example, research papers on the parent-reported health comorbidities of overweight[88] or short sleep duration[89] published by our group could be extended to include comprehensive objective measures of segmental body composition, 24-hour time-use including sleep and a range of health outcomes (e.g. serum blood parameters, arterial structure and function). The greater precision brought by using these measures may reveal nuances in the associations not detectable using reported measures. Many new health-related questions are also now able to be examined, as LSAC's broad range of early life exposures are reflected in peripubertal metabolic health and development of a wide range of body systems. In addition, the CheckPoint dataset will be augmented with genetic data in late 2019, which will facilitate gene-environment analyses for the first time in this cohort.

In summary, the efficient addition of objective health measures and biospecimens into the open-access LSAC repository greatly increases the utility of this widely-used dataset. Analysis of the CheckPoint data holds great promise in integrating cutting-edge measures of mid-childhood physiology with lifetime trajectories of mental and physical health, growth, behaviour and healthcare within a single population study. The data's utility will continue to grow as ongoing waves of the main LSAC study accrue into adulthood, when CheckPoint health data will be able to be examined both as outcomes of early life exposures (LSAC waves 1-6) and predictors of later life health (LSAC waves 7 onward).

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REDCap (Research Electronic Data Capture) electronic data capture tools were used in this study. More information about this software can be found at: www.project-redcap.org.

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CONTRIBUTIONS: SAC is the study project manager, and planned and conducted the analyses, and drafted the initial manuscript. PA, LAB, DPB, JBC, MC, TD, BE, LG, JAK, FKM, TSO, SR, HR, RS, MS, PJS, LS, TYW and SRZ are study investigators involved in the conception and oversight of the Child Health CheckPoint, and provided expert advice and critical review of this manuscript. SD, SE, ANG, ACG, KLy and KLa are study staff or postdoctoral fellows and provided critical review of this manuscript. MW is the Principal Investigator of the Child Health CheckPoint, planned the analyses and provided critical review of this manuscript.

DATA SHARING STATEMENT: Dataset and technical documents available from *Growing Up in Australia*: The Longitudinal Study of Australian Children via low-cost license for bone fide researchers. More information is available at www.growingupinaustralia.gov.au

FIGURE CAPTIONS AND FOOTNOTES:

Figure 1. Participant flow chart

N = number of families. LSAC: Longitudinal Study of Australian Children.

Figure 2. Assessment sequence, by participant and visit type

Oblong box indicates child and parent attended the station together. Parents attended the *Young Bloods* stations twice; first for their own blood collection, then to accompany their child. *Food Stop* included consumption experiment at the Main Assessment Centre (ie data collected), but was simply offering refreshments at the Mini Assessment Centre (ie no data collected). The NIH Vocabulary Picture Test was administered in *Bone Zone* at the Main Assessment Centre, and as part of *Sit and Click* in Mini Assessment Centre and home visits. In home visits, *Sit and Click* (child questionnaire) had allocated time between other assessments; for the Assessment Centre visits, *Sit and Click* didn't have an allocated time or physical location (children completed the questionnaire in downtime at other stations). Post-visit activities (ie accelerometry, child follow-up phone interview and non-attending parent buccal swab) are not included in the diagram and followed the same protocol regardless of visit type.

SUPPLEMENTARY DOCUMENTS

Supplementary figure 1. Assessment centre and home visit locations

Values are number of families assessed. Main Assessment Centre locations are labelled in uppercase letters and blue colour. Mini Assessment Centre locations are labelled in sentence case letters and black colour. Home visits occurred in many locations, so the total number of home visits in each state or territory is provided inside the house symbol. No home visits occurred in the Australian Capital Territory.

REFERENCES

1. Shonkoff JP. Building a new biodevelopmental framework to guide the future of early childhood policy. *Child Dev* 2010;81(1):357-67.
2. Khoury MJ, Lam TK, Ioannidis JP, et al. Transforming epidemiology for 21st century medicine and public health. *Cancer Epidemiol Biomarkers Prev* 2013;22(4):508-16.
3. Lauer MS, Gordon D, Wei G, et al. Efficient design of clinical trials and epidemiological research: is it possible? *Nat Rev Cardiol* 2017;14(8):493-501.
4. Connelly R, Platt L. Cohort profile: UK Millennium Cohort Study (MCS). *Int J Epidemiol* 2014;43(6):1719-25.
5. Greene S, Williams J, Layte R, et al. Growing Up in Ireland Background and Conceptual Framework. Dublin, Ireland: Office of the Minister for Children and Youth Affairs, Department of Health and Children 2010.
6. Morton SM, Atatoa Carr PE, Grant CC, et al. Cohort profile: growing up in New Zealand. *Int J Epidemiol* 2013;42(1):65-75.
7. Soh SE, Tint MT, Gluckman PD, et al. Cohort profile: Growing Up in Singapore Towards healthy Outcomes (GUSTO) birth cohort study. *Int J Epidemiol* 2014;43(5):1401-9.
8. Sanson A, Johnstone R, The LSAC Research Consortium & FaCS LSAC Project Team. Growing Up in Australia takes its first steps. *Family Matters* 2004;67:46-53.
9. Wake M. Tracking the health of the next generation: Sax Institute; 2016 [Available from: https://www.saxinstitute.org.au/news/tracking-the-health-of-the-next-generation/.
10. Soloff C, Lawrence D, Johnstone R. LSAC technical paper number 1: Sample design. Melbourne: Australian Institute of Family Studies, 2005.

11. Cusack B, Defina R. LSAC technical paper number 10: Wave 5 weighting and non response. Melbourne: Australian Institute of Family Studies, 2013.
12. Welsh L, Kathriachchige G, Raheem T, et al. Spirometry: Population epidemiology and concordance in 11-12 year old Australians and their parents. Submitted to BMJ Open October 2017.
13. Vlok J, Simm PJ, Clifford SA, et al. Bone health (pQCT): Population epidemiology and concordance in 11-12 year old Australians and their parents. Submitted to BMJ Open October 2017.
14. Vivarini P, Kerr JA, Grobler A, et al. Food choices: Population epidemiology and concordance in 11-12 year old Australians and their parents. Submitted to BMJ Open October 2017.
15. Smith J, Wang J, Grobler A, et al. Hearing, speech reception, vocabulary and language: Population epidemiology and concordance in 11-12 year old Australians and their parents. Submitted to BMJ Open October 2017.
16. Nguyen MT, Lycett K, Vryer R, et al. Telomere length: Population epidemiology and concordance in 11-12 year old Australians and their parents. Submitted to BMJ Open October 2017.
17. Matricciani L, Fraysse F, Grobler A, et al. Sleep and Time Use: Population epidemiology and concordance in 11-12 year old Australians and their parents. Submitted to BMJ Open October 2017.
18. Liu RS, Dunn S, Grobler A, et al. Carotid artery intima-media thickness, distensibility, and elasticity: Population epidemiology and concordance in Australian 11-12 year old Australians and their parents. Submitted to BMJ Open October 2017.
19. Larkins N, Kim S, Carlin J, et al. Albuminuria: Population epidemiology and concordance in 11-12 year old Australians and their parents. Submitted to BMJ Open October 2017.
20. Kahn F, Wake M, Lycett K, et al. Vascular function and stiffness: Population epidemiology and concordance in 11-12 year old Australians and their parents. Submitted to BMJ Open October 2017.
21. Fraysse F, Grobler A, Muller J, et al. Physical activity and sedentary activity: Population epidemiology and concordance in 11-12 year old Australians and their parents. Submitted to BMJ Open October 2017.
22. Ellul S, Wake M, Clifford SA, et al. Metabolomics: Population epidemiology and concordance in 11-12 year old Australians and their parents. Submitted to BMJ Open October 2017.
23. Dascalu J, Lui M, Lycett K, et al. Micro-vascular health (retinal microvasculature): Population epidemiology and concordance in 11-12 year old Australians and their parents. Submitted to BMJ Open October 2017.
24. Clifford SA, Gillespie AN, Grobler A, et al. Body composition: Population epidemiology and concordance in 11-12 year old Australians and their parents. Submitted to BMJ Open October 2017.
25. Catchpool M, Gold L, Grobler A, et al. Health-related quality of life: Population epidemiology and concordance in 11-12 year old Australians and their parents. Submitted to BMJ Open October 2017.
26. Boyd A, Golding J, Macleod J, et al. Cohort Profile: the 'children of the 90s'--the index offspring of the Avon Longitudinal Study of Parents and Children. *Int J Epidemiol* 2013;42(1):111-27.
27. Straker L, Mountain J, Jacques A, et al. Cohort Profile: The Western Australian Pregnancy Cohort (Raine) Study-Generation 2. *Int J Epidemiol* 2017;46(5):1384-85j.

28. Australian Institute of Family Studies. Longitudinal Study of Australian Children Data User Guide - November 2015. Melbourne: Australian Institute of Family Studies, 2015.
29. Wake M, Canterford L, Nicholson J, et al. Options for physical and biomarker augmentation in LSAC: Discussion paper, 2008.
30. Wake M, Gallagher S, Poulakis Z, et al. The Parent Education and Support (PEAS) Program: Final report. Melbourne, Australia: Centre for Community Child Health, Royal Children's Hospital, 2003.
31. Wake M, Baur LA, Gerner B, et al. Outcomes and costs of primary care surveillance and intervention for overweight or obese children: the LEAP 2 randomised controlled trial. *BMJ* 2009;339:b3308.
32. Wake M, Lycett K, Sabin MA, et al. A shared-care model of obesity treatment for 3-10 year old children: Protocol for the HopSCOTCH randomised controlled trial. *BMC Pediatr* 2012;12(1):39.
33. Hanvey AN, Mensah FK, Clifford SA, et al. Adolescent Cardiovascular Functional and Structural Outcomes of Growth Trajectories from Infancy: Prospective Community-Based Study. *Childhood Obes* 2017;13(2):154-63.
34. Hanvey AN, Clifford SA, Mensah FK, et al. Which body composition measures are associated with cardiovascular function and structure in adolescence? *Obesity Medicine* 2016;3:20-27.
35. Marfell-Jones M, Olds T, Stewart A, et al. *International Standards for Anthropometric Assessment*. Potchefstroom, RSA: North-West University, 2006.
36. World Health Organization. Physical status: The use of and interpretation of anthropometry: report of a WHO expert committee. WHO Technical Report Series. Geneva, 1995.
37. Morris NM, Udry JR. Validation of a self-administered instrument to assess stage of adolescent development. *J Youth Adolesc* 1980;9(3):271-80.
38. Petersen AC, Crockett L, Richards M, et al. A self-report measure of pubertal status: Reliability, validity, and initial norms. *J Youth Adolesc* 1988;17(2):117-33.
39. Tan JKL, Tang J, Fung K, et al. Development and Validation of a Comprehensive Acne Severity Scale. *J Cutan Med Surg* 2007;11(6):211-16.
40. Moyer-Mileur LJ, Quick JL, Murray MA. Peripheral quantitative computed tomography of the tibia: pediatric reference values. *J Clin Densitom* 2008;11(2):283-94.
41. Zemel BS. Quantitative computed tomography and computed tomography in children. *Curr Osteoporos Rep* 2011;9(4):284-90.
42. Stein JH, Korcarz CE, Hurst RT, et al. Use of carotid ultrasound to identify subclinical vascular disease and evaluate cardiovascular disease risk: a consensus statement from the American Society of Echocardiography Carotid Intima-Media Thickness Task Force endorsed by the Society for Vascular Medicine. *J Am Soc Echocardiogr* 2008;21(2):93-111.
43. Touboul P-J, Hennerici M, Meairs S, et al. Mannheim carotid intima-media thickness and plaque consensus (2004–2006–2011). *Cerebrovasc Dis* 2012;34(4):290-96.
44. Laurent S, Cockcroft J, Van Bortel L, et al. Expert consensus document on arterial stiffness: methodological issues and clinical applications. *Eur Heart J* 2006;27(21):2588-605.
45. Zhang A-J, Yu X-J, Wang M. The clinical manifestations and pathophysiology of cerebral small vessel disease. *Neurosci Bull* 2010;26(3):257-64.
46. Miller M, Hankinson J, Brusasco V, et al. Standardisation of spirometry. *Eur Respir J* 2005;26:319-38.

47. Semel E, Wiig E, Secord W. Clinical evaluation of language fundamentals, fourth edition, Australian standardised edition (CELF-4 Australian). Harcourt Assessment, Marrickville (Australia), 2006.
48. Weintraub S, Dikmen SS, Heaton RK, et al. Cognition assessment using the NIH Toolbox. *Neurology* 2013;80(11 Supplement 3):S54-S64.
49. Niskar AS, Kieszak SM, Holmes A, et al. Prevalence of hearing loss among children 6 to 19 years of age: The Third National Health and Nutrition Examination Survey. *JAMA* 1998;279(14):1071-75.
50. Wake M, Poulakis Z, Hughes E, et al. Hearing impairment: A population study of age at diagnosis, severity, and language outcomes at 7–8 years. *Arch Dis Child* 2005;90(3):238-44.
51. Cone BK, Wake M, Tobin S, et al. Slight-mild sensorineural hearing loss in children: audiometric, clinical, and risk factor profiles. *Ear Hear* 2010;31(2):202-12.
52. Cameron S, Glyde H, Dillon H. Listening in Spatialized Noise-Sentences Test (LiSN-S): normative and retest reliability data for adolescents and adults up to 60 years of age. *J Am Acad Audiol* 2011;22(10):697-709.
53. National Acoustic Laboratories. Listening in Spatialised Noise Sentences Test (LiSN-S) 2016 [Available from: https://capd.nal.gov.au/lisn-s-about.shtml.
54. Esliger DW, Rowlands AV, Hurst TL, et al. Validation of the GENEA Accelerometer. *Med Sci Sports Exerc* 2011;43(6):1085-93.
55. Olds TS, Ridley K, Dollman J, et al. The validity of a computerized use of time recall, the multimedia activity recall for children and adolescents. *Pediatr Exerc Sci* 2010;22(1):34-43.
56. Ridley K, Ainsworth BE, Olds TS. Development of a compendium of energy expenditures for youth. *Int J Behav Nutr Phys Act* 2008;5:45.
57. Foley LS, Maddison R, Rush E, et al. Doubly labeled water validation of a computerized use-of-time recall in active young people. *Metabolism* 2013;62(1):163-9.
58. Ortega FB, Ruiz JR, Castillo MJ, et al. Physical fitness in childhood and adolescence: a powerful marker of health. *Int J Obes (Lond)* 2008;32(1):1-11.
59. Boreham CA, Paliczka VJ, Nichols AK. A comparison of the PWC170 and 20-MST tests of aerobic fitness in adolescent schoolchildren. *J Sports Med Phys Fitness* 1990;30(1):19-23.
60. Bach M. The Freiburg Visual Acuity test: Automatic measurement of visual acuity. *Optom Vis Sci* 1996;73(1):49-53.
61. Elliot J, Morrow V. Imagining the Future: Preliminary analysis of NCDS essays written by children at age 11. London: Centre for Longitudinal Studies, 2007.
62. Seligson JL, Huebner ES, Valois RF. Preliminary Validation of the Brief Multidimensional Students' Life Satisfaction Scale (BMSLSS). *Social Indicators Research* 2003;61(2):121.
63. Children's Worlds: International Survey of Children's Well-Being 2017 [Available from: http://isciweb.org.
64. Varni JW, Seid M, Kurtin PS. PedsQL 4.0: reliability and validity of the Pediatric Quality of Life Inventory version 4.0 generic core scales in healthy and patient populations. *Med Care* 2001;39(8):800-12.
65. Richardson J, Iezzi A, Khan MA, et al. Validity and Reliability of the Assessment of Quality of Life (AQoL)-8D Multi-Attribute Utility Instrument. *The Patient - Patient-Centered Outcomes Research* 2014;7(1):85-96.
66. Stevens K. Assessing the performance of a new generic measure of health-related quality of life for children and refining it for use in health state valuation. *Appl Health Econ Health Policy* 2011;9(3):157-69.

67. Derogatis LR, Lipman RS, Covi L. SCL-90: an outpatient psychiatric rating scale--preliminary report. *Psychopharmacol Bull* 1973;9(1):13-28.
68. Jones GT, Watson KD, Silman AJ, et al. Predictors of low back pain in British schoolchildren: A population-based prospective cohort study. *Pediatrics* 2003;111(4 Pt 1):822-8.
69. Flood VM, Webb K, Rangan A. Recommendations for short questions to assess food consumption in children for the NSW Health Surveys. 2005.
70. Saloheimo T, González S, Erkkola M, et al. The reliability and validity of a short food frequency questionnaire among 9–11-year olds: a multinational study on three middle-income and high-income countries. *Int J Obes Suppl* 2015;5:S22-S28.
71. Koplin JJ, Wake M, Dharmage SC, et al. Cohort Profile: The HealthNuts Study: Population prevalence and environmental/genetic predictors of food allergy. *Int J Epidemiol* 2015;44(4):1161-71.
72. Peters RL, Koplin JJ, Gurrin LC, et al. The prevalence of food allergy and other allergic diseases in early childhood in a population-based study: HealthNuts age 4-year follow-up. *J Allergy Clin Immunol* 2017.
73. Pezic A, Ponsonby AL, Cameron FJ, et al. Constitutive and relative facultative skin pigmentation among Victorian children including comparison of two visual skin charts for determining constitutive melanin density. *Photochem Photobiol* 2013;89(3):714-23.
74. Australian Institute of Family Studies. Longitudinal Study of Australian Children Data User Guide - November 2013. Melbourne: Australian Institute of Family Studies, 2013.
75. Davies S, Clifford SA, Gillespie A, et al. LSAC's Child Health CheckPoint Data Issues Paper 2018. Melbourne, Australia: Murdoch Children's Research Institute, 2017.
76. Wake M, Clifford SA, York E, et al. Introducing Growing Up in Australia's Child Health CheckPoint. *Family Matters* 2014;94:15-23.
77. Harris PA, Taylor R, Thielke R, et al. Research electronic data capture (REDCap) - A metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform* 2009;42(2):377-81.
78. Soininen P, Kangas AJ, Wurtz P, et al. High-throughput serum NMR metabonomics for cost-effective holistic studies on systemic metabolism. *Analyst* 2009;134(9):1781-5.
79. Kettunen J, Tukiainen T, Sarin AP, et al. Genome-wide association study identifies multiple loci influencing human serum metabolite levels. *Nat Genet* 2012;44(3):269-76.
80. Ellul S, Hiscock R, Mensah FK, et al. Longitudinal Study of Australian Children's Child Health CheckPoint Technical Paper 1: Weighting and Non-Response. . Melbourne: Murdoch Children's Research Institute, 2018.
81. Edwards B. Growing Up in Australia: The Longitudinal Study of Australian Children Entering adolescence and becoming a young adult. *Family Matters* 2014;95:5-14.
82. Australian Bureau of Statistics. Australian Statistical Geography Standard (ASGS): Volume 5 - Remoteness Structure, July 2011 (cat. no. 1270.0.55.005): Australian Bureau of Statistics, 2011.
83. Blakemore T, Strazdins L, Gibbings J. Measuring family socioeconomic position. *Australian Social Policy No 8* 2009:121-68.
84. Australian Bureau of Statistics. Census of Population and Housing: Socio-Economic Indexes for Areas (SEIFA) Australia 2011 (cat. no. 2033.0.55.001) [Available from: http://www.abs.gov.au/websitedbs/censushome.nsf/home/seifa2011.
85. Pearson H. Massive UK baby study cancelled. *Nature* 2015;526:620-21.
86. Landrigan PJ, Baker DB. The National Children's Study--end or new beginning? *N Engl J Med* 2015;372(16):1486-7.
87. Schmidt CW. Growing a New Study: Environmental Influences on Child Health Outcomes. *Environ Health Perspect* 2015;123(10):A260-3.

88. Wake M, Clifford SA, Patton GC, et al. Morbidity patterns among the underweight, overweight and obese between 2 and 18 years: population-based cross-sectional analyses. *Int J Obes (Lond)* 2013;37(1):86-93.
89. Price AMH, Quach J, Wake M, et al. Cross-sectional sleep thresholds for optimal health and well-being in Australian 4-9-year-olds. *Sleep Med* 2016;22:83-90.

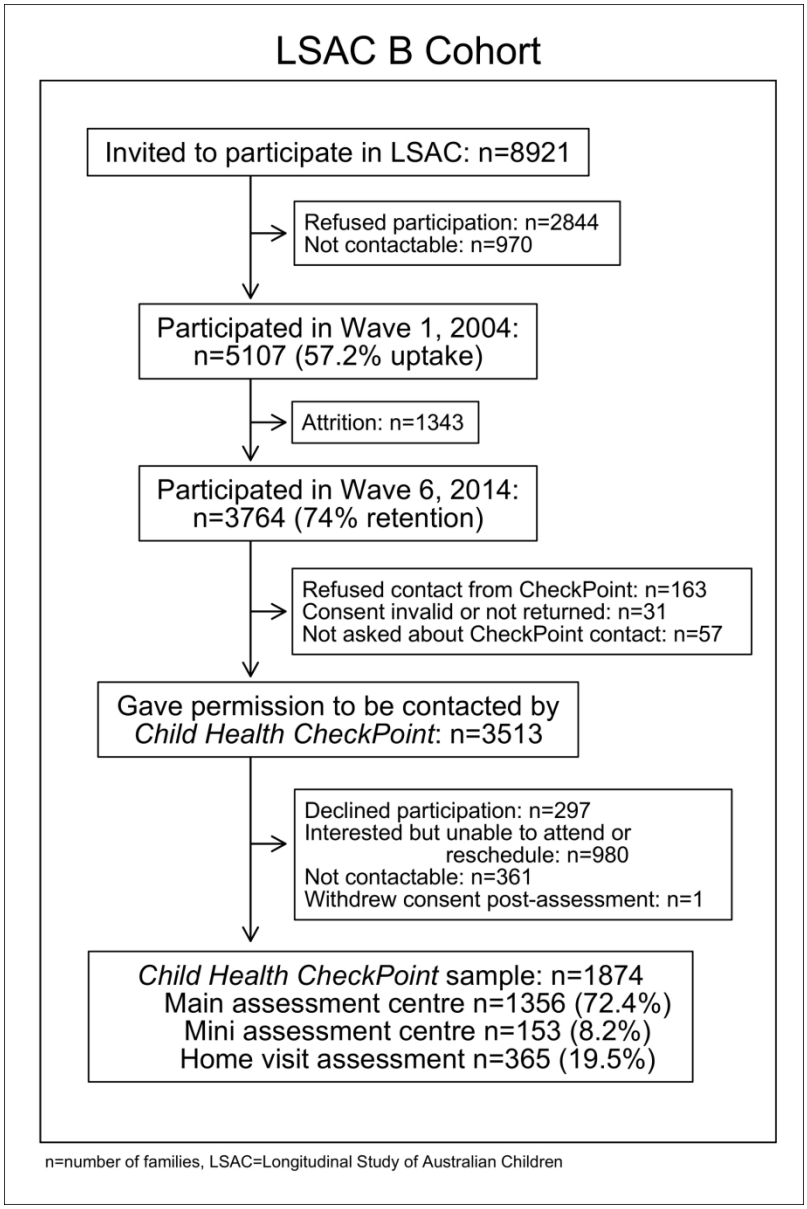

Figure 1. Participant flow chart
N = number of families. LSAC: Longitudinal Study of Australian Children.

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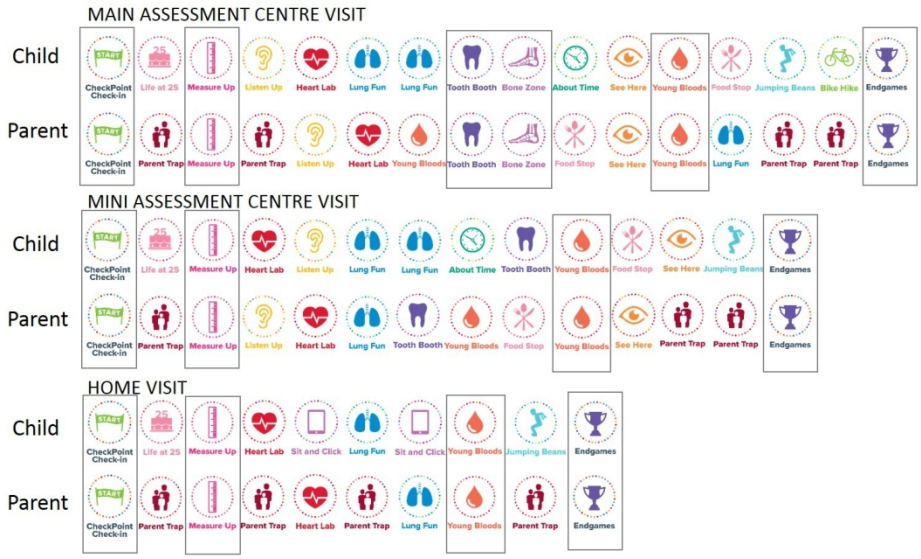

Figure 2. Assessment sequence, by participant and visit type
Oblong box indicates child and parent attended the station together. Parents attended the Young Bloods stations twice; first for their own blood collection, then to accompany their child. Food Stop included consumption experiment at the Main Assessment Centre (ie data collected), but was simply offering refreshments at the Mini Assessment Centre (ie no data collected). The NIH Vocabulary Picture Test was administered in Bone Zone at the Main Assessment Centre, and as part of Sit and Click in Mini Assessment Centre and home visits. In home visits, Sit and Click (child questionnaire) had allocated time between other assessments; for the Assessment Centre visits, Sit and Click didn't have an allocated time or physical location (children completed the questionnaire in downtime at other stations). Post-visit activities (ie accelerometry, child follow-up phone interview and non-attending parent buccal swab) are not included in the diagram and followed the same protocol regardless of visit type.

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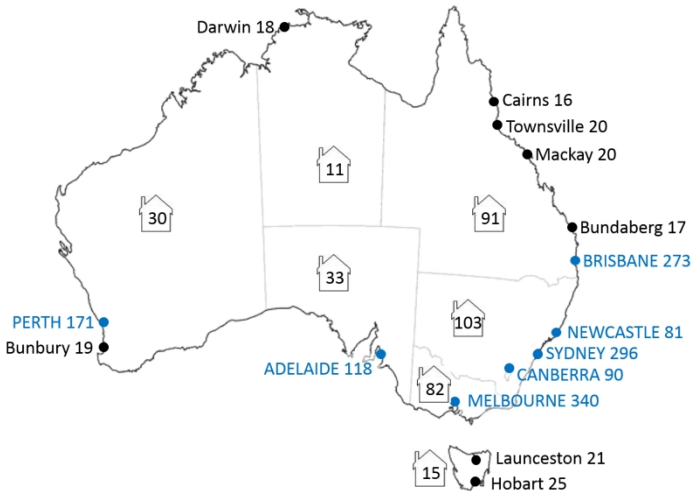

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STROBE Statement—checklist of items that should be included in reports of observational studies
Paper title: Child Health CheckPoint: Cohort summary and methodology of a physical health and biospecimen module for the Longitudinal Study of Australian Children.
Please note: page numbers The page numbers in the right-hand column relate to the page numbers found in the footer of the marked-up version of the manuscript.

	Item No	Recommendation	Page number
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1,3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5-7
Objectives	3	State specific objectives, including any prespecified hypotheses	6-7
Methods			
Study design	4	Present key elements of study design early in the paper	7-9
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7-9, Figure 1, Supp Figure 1
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	7-8
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	10-17, 19-20
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	10-17
Bias	9	Describe any efforts to address potential sources of bias	20
Study size	10	Explain how the study size was arrived at	19, Figure 1
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	21
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	20
		(*b*) Describe any methods used to examine subgroups and interactions	N/A
		(*c*) Explain how missing data were addressed	N/A
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed	20-21
		(*e*) Describe any sensitivity analyses	N/A

			Page number
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	21, Figure 1
		(b) Give reasons for non-participation at each stage	21, Figure 1
		(c) Consider use of a flow diagram	Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	21-23
		(b) Indicate number of participants with missing data for each variable of interest	25-26, 28
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	Figure 1
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	N/A
		Cross-sectional study—Report numbers of outcome events or summary measures	N/A
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	24, 27
		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	29
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	29-30
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	30-31
Generalisability	21	Discuss the generalisability (external validity) of the study results	N/A
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	32-33

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.