On our selection: Australian longitudinal research studies

Ann T Gregory, Ruth M Armstrong, Tanya D Grassi, Bronwyn Gaut and Martin B Van Der Weyden

The association between smoking and lung cancer is now an accepted fact. Every day, doctors base management decisions on cardiovascular risk calculated using the Framingham equation. It is because of such findings and practical implications that the British doctors study and the Framingham Heart Study from the United States are among the world's best known longitudinal studies. The stories of these landmark studies in the fields of epidemiology and public health have already been told;[1,2] but longitudinal researchers have also been at work in Australia, with implications for our particular population and the wider world. We selected just a few of these (Box 1) — studies that have already demonstrated some longevity and which we judged would be of particular interest to our readership — and interviewed some of their key investigators. What are their stories? How will they make their mark in medicine?

The Australian Diabetes, Obesity and Lifestyle Study (AusDiab)

Interviewee: Professor Paul Zimmet

"How many Australians suffer from diabetes? How many new cases are diagnosed annually? … How many people have complications of diabetes that are threatening to their vision or even to their life? … These are not questions from 'Trivial Pursuit' nor is the answer to each of these questions readily available", wrote Professor Paul Zimmet in the *Medical Journal of Australia* in 1985.[3] At that time, Zimmet was frustrated that there had been little research into the growing problem of diabetes in Australia. Even Papua New Guinea, then one of the poorest countries in the world, had better diabetes data.

Zimmet's involvement in the epidemiology of diabetes had begun a decade earlier when, in 1975, he had gained funding from the US National Institutes of Health (NIH) to conduct a diabetes prevalence survey on Nauru, a Central Pacific island. The President of Nauru, Hammer DeRoburt, had invited Pincus Taft — his Australian physician and a colleague of Zimmet's — to the island because he thought diabetes was a problem on Nauru; he was right! Zimmet and Taft's survey found the highest prevalence of diabetes in the world — about a third of the adult population were affected.[4] With further NIH funding, Zimmet and his team were able to survey other Pacific countries and Mauritius, and also, in 1985, to set up the International Diabetes Institute (IDI) in Melbourne as a World Health Organization collaborating centre for the epidemiology of diabetes. "It was really that NIH funding which allowed me to create the institute and establish the framework and the infrastructure that was then able to do AusDiab", said Zimmet.

In 1996, Australia's health ministers agreed that diabetes would become one of the national health priorities. Spearheaded by Dr

1 On our selection: characteristics of some Australian longitudinal studies

Study title	Location	Year of initiation	No. in baseline cohort(s)	Funding*		No. of publications†	Study website
				Initial funding	Total funding		
The Australian Diabetes, Obesity and Lifestyle Study (AusDiab)	National	1999	11 247	$1 500 000	$2 600 000	80	http://www.diabetes.com.au/research.php?regionID=181
Bettering the Evaluation And Care of Health (BEACH)	National	1998	na	$1 200 000	$11 000 000	53	http://www.fmrc.org.au/beach.htm
The Blue Mountains Eye Study (BMES)	Blue Mountains, NSW	1992	3654	$163 819	$7 255 400	332	http://www.cvr.org.au/bmes.htm
The Busselton Health Study	Busselton, WA	1966	5008	£6000	> $7 600 000	> 250	http://www.busseltonhealthstudy.com
The Dubbo Study	Dubbo, NSW	1988	2805	$250 000	$400 000	51	http://www.dubbostudy.org
Tasmanian Longitudinal Health Study (TAHS)	National	1968	45 900	nd	$4 000 000‡	30	—
Wittenoom cohort studies	Wittenoom, WA	1974	11 684	$50 000	> $4 000 000	100	http://www.sph.uwa.edu.au/go/research-programs/oee/schools-and-centres/schools/school-of-population-health/projects#asb
Women's Health Australia (WHA)	National	1995	41 616	$3 500 000	> $18 000 000	252	http://www.alswh.org.au

na = not applicable. nd = data not available. NSW = New South Wales. WA = Western Australia. * Amounts shown are estimates and may not include institutional funding for costs such as investigator salaries or postgraduate students, and may comprise a mix of federal funding, support from trusts and industry, and in-kind support from various states and territories. Total funding is an estimate of funding received so far. † Number of published (or in press) articles in peer-reviewed journals only. See study websites for details of other publications. ‡ TAHS funding information is only available since 1992. ◆

Michael Wooldridge, the then federal Minister for Health and Aged Care, the National Diabetes Strategy was launched in 1998. Arising from (but only partly funded by) the Strategy, the Australian Diabetes, Obesity and Lifestyle Study (AusDiab) was commissioned, with Zimmet and Professor Timothy Welborn as the lead investigators.

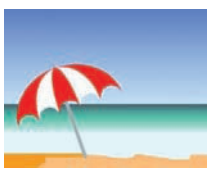
AusDiab was a population-based, cross-sectional survey of the national prevalence of diabetes and associated risk factors in people aged 25 years or older. The study involved an initial household interview, followed by a biomedical examination that included an oral glucose tolerance test, and questionnaires. It was conducted between May 1999 and December 2000 in 42 randomly selected districts in the six states and the Northern Territory of Australia.

"It was akin to an army exercise", said Zimmet. Team members would go in advance to work out logistics of transport, motels and meals, as well as to identify suitable study centres, which might be schools, town halls or local bowling clubs. Blood sugar-level tests were done immediately on site at a mini-lab, and blood samples were then sent by car or plane to the main lab for other testing and storage.

In the initial cohort, 11 247 people attended the biomedical examination. The most alarming finding was that almost a million Australian adults had diabetes — equating to 7.4% of the adult population and a 300% increase since 1981.[5] A further 16.3% had pre-diabetes, and there was a 60% prevalence of overweight and obesity and a high prevalence of untreated hypertension.

Further funding, now with Professor Jonathan Shaw from Melbourne as co-investigator, allowed a 5-year follow-up study of 6537 participants in 2004–2005. This determined, among other things, that about 100 000 adults in Australia develop diabetes each year; that is, about 275 people every day.

AusDiab is the largest national study of diabetes in the world. To ease ongoing funding concerns and to provide critical infrastructure, the IDI has recently merged with the Baker Heart Research Institute in Melbourne. There is no longer any argument that diabetes is a global epidemic with devastating human and socioeconomic effects. However, Zimmet says other questions related to diabetes now need answers, such as "Will preventing type 2 diabetes prevent cardiovascular disease?"



Bettering the Evaluation And Care of Health (BEACH)

Interviewees: Associate Professor Helena Britt, Associate Professor Graeme Miller

Each year in Australia, more than 100 million general practice services are provided to about 85% of the population — to the tune of about $4 billion in Medicare payments.[6] What really happens in these consultations? What is being diagnosed? In whom? And how is it being treated? Although Medicare statistics can provide some information about general practice services, it is data from the Bettering the Evaluation And Care of Health (BEACH) program that have been able to inform health care policy and clinical practice by answering these questions.

Now in its 11th year, the BEACH program is a continuous national study of general practice activity in Australia — the only such study in the world — conducted by the Australian General Practice Statistics and Classifications Centre, a collaborating unit of the University of Sydney and the Australian Institute of Health and Welfare. Since its inception in 1998, 100 000 encounters between general practitioners and patients from a random, changing sample of 1000 GPs have been added to the BEACH database each year. The database now includes details of more than a million encounters.

The BEACH program has provided independent data about a range of often controversial topics, including consultation length, payment structures, doctors' prescribing practices, and adverse drug events, to various stakeholders, including researchers, educators, government departments and agencies, pharmaceutical companies and health care professional organisations. The program has produced 23 books (freely available for download from the BEACH website) and about 100 articles published in recognised journals. Most recently, the group has reported on the prevalence and patterns of chronic disease in Australia, finding that one in four Australians suffer from two or more chronic conditions.[7]

When asked to comment on the program's impressive productivity, Associate Professor Helena Britt was quick to point out that: "What makes the productivity level so high is a fantastic team of excellent health services researchers". There were also many years of methodological development and validation before BEACH was launched. "We didn't land on the BEACH without preparation. It did take 20 years to get to that point … and some more from [Emeritus Professor] Charles Bridges-Webb before that."

Between 1978 and 1990, Britt, a research psychologist by training, worked in the University of Sydney's teaching and research general practice. The practice, run by Bridges-Webb, used a continually evolving data collection system that was based on his work in the 1960s and 70s with patient-based data collection from all general practices in the Victorian town of Traralgon.

In 1990, the team successfully secured funding from the National Health and Medical Research Council (NHMRC) and the General Practice Evaluation Program for the first national study of general practice for more than two decades, and for a comparative study of rural and metropolitan general practice. These studies were reported in supplements to the *MJA*. Thanks to their distinctive covers, they became known as the purple report (*Morbidity and treatment in general practice in Australia 1990–1991*) and the green report (*A comparison of country and metropolitan general practice*).[8,9]

Some very lean years followed these two studies, with the team only managing to stay together by taking on smaller jobs from different groups, such as doing quality research for clinical trials for pharmaceutical companies, and, from 1993, by offering (for a fee) the method they'd developed as a quality assurance option to about 4000 GPs, thus gaining further evidence for and experience in using their method. Then, in 1997, with growing interest in how new drugs were being used in clinical practice, the team managed to "stitch together" sufficient funds from government and other sources, including the pharmaceutical industry, to launch the BEACH program the following year.

Since the launch of BEACH, funding has remained mixed and uncertain, being renegotiated with all involved parties on an annual or biennial basis. In 2004, the government contribution to funding was withdrawn and, in 2006, there was a real concern that the program would be forced to close. However, this fear was not realised, as the government's contribution to the program was re-established in mid 2007.[6]

Why does the BEACH team keep persisting in its efforts despite the ongoing funding challenges? According to the Centre's Medical

Director, Associate Professor Graeme Miller: "It's a commitment to the importance of general practice, and of reliably describing general practice to justify what it's doing and its place in the health care system".

The Blue Mountains Eye Study (BMES)

Interviewee: Professor Paul Mitchell

Does smoking cause blindness? What effect does visual impairment have on daily living? Observing the impact of eye disease on individual patients might explain why a clinical ophthalmologist would develop an interest in epidemiological research. The notion becomes even less surprising when one learns that Australian legend Professor Fred Hollows is one of two mentors whom ophthalmologist Professor Paul Mitchell credits with inspiring him to develop the Blue Mountains Eye Study (BMES) — the first large Australian population-based study of eye disease. Mitchell says that it was Hollows who talked him into doing an MD in Newcastle, New South Wales, in the 1980s, to research the prevalence of and risk factors for diabetic retinopathy. His other mentor is US-based Professor Ron Klein, who began (and still runs) the Wisconsin Epidemiologic Study of Diabetic Retinopathy in 1979 and the Beaver Dam Eye Study in 1987. When the two met at a diabetes conference in Australia, Klein invited Mitchell to the US to see how the Beaver Dam Eye Study had been done.

It was after being appointed to the University of Sydney's Department of Ophthalmology in 1990 that Mitchell designed the initial BMES to study visual impairment and common eye diseases in a representative older Australian community sample, and obtained NHMRC funding. Study participants were identified in two postcode areas in the Blue Mountains region, west of Sydney. The area was ideal because of the residents' demographic similarity to the overall Australian population (for most characteristics); and its geographical separation from Sydney meant that publicity could be well targeted.

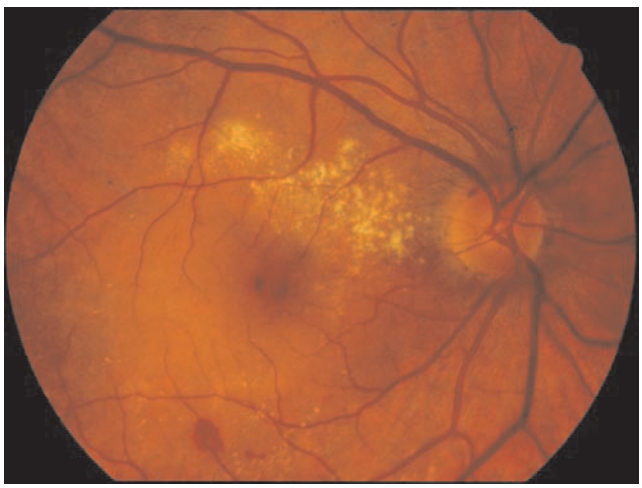
In the first wave of the study (BMES-1), 3654 residents aged 49–97 years were examined during 1992–1994, with Mitchell personally conducting the eye examination for all participants. There have since been 5-year and 10-year follow-up studies, and an extension study in 1999–2000 of further residents who became eligible to participate (BMES-E). A 15-year follow-up study is currently underway. Since 2001, the BMES has been incorporated into the research activities of the Westmead Millennium Institute's Centre for Vision Research in Sydney.

When asked about the study's highlights, Mitchell nominates the finding that visual impairment has an impact on quality of life that is similar to that from most major systemic conditions, and doubles the need for earlier institutionalised care; it is also associated with about an 80% risk of increased mortality. Further, the BMES was among the first studies in the world to demonstrate the link between smoking and blindness (now a warning on cigarette packets sold in Australia and elsewhere) (Box 2).[10] Among the most important of more than 300 papers published from the study, Mitchell includes a *New England Journal of Medicine* report of the link between using inhaled steroids and developing cataracts.[11]

According to Mitchell, one of the core strengths of the BMES is the collection of objective data. All eye photographs are graded using standard protocols developed for the Beaver Dam Eye Study, which allows for the independent assessment and pooling of data from the BMES with data from other national and international cohorts. A further strength is that, right from the start, the BMES was designed to be much bigger than "just an eye study". A wide array of data was collected and then expanded upon in the follow-up studies, including fasting blood tests, various detailed questionnaires, and hearing assessments, with the project also extending into genetic studies.

Ever looking forward, Mitchell believes that a valuable area for future investigation is a possible link between basic vascular signs in the eye and systemic events, particularly cardiovascular events, stroke and mortality. "The eye is the only place you can see vessels — microvascular vessels — naked", said Mitchell. "These microvascular signs are quite important for a whole range of diseases, and can now be imaged very easily without dilating the pupil and assessed automatically with computer programs."

2 Macular degeneration



Neovascular macular degeneration in the right eye of a 71-year-old woman who smoked heavily. ◆

The Busselton Health Study

Interviewees: Dr Digby Cullen, Associate Professor Alan James, Professor Bill Musk

Who should benefit from a community-based study? Most obviously, "the general population", but Busselton-based GP Dr Kevin Cullen, who founded the Busselton Health Study in 1966, nominated the community itself. One of the study's five original aims specified that the study should "provide a community service in the detection, treatment and prevention of disease and in the education of a population".

For more than 40 years, and persisting beyond Dr Cullen's death in 1994, the study's dedication to the people of Busselton, a picturesque coastal town in the south-west of Western Australia (Box 3), has been returned in kind. This has not only been in terms of study participation, but also in enthusiastic ongoing support, fund-raising and volunteering. As an example — at one time, the local milkman was delivering bottles of glucose solution for the recipients to drink before blood testing for diabetes on the same day.[12]

The Busselton Health Study is now one of the longest running epidemiological research programs in the world. The predominantly Anglo-Saxon adult community of Busselton Shire took part in cross-sectional health surveys every 3 years from 1966 to 1981, with surveys of all schoolchildren each following year. A "hiatus" for a few years was followed by several surveys of special groups; and, in 1992, a specific family-based genetic study was conducted. In 1994–1995, 5500 surviving participants from the early surveys were successfully recalled. In 2005–2007, an NHMRC project grant enabled a further study of a randomised sex- and age-stratified sample of adults and of all schoolchildren, followed by studies of chronic airflow obstruction and sleep apnoea, with ongoing studies of diabetes and healthy ageing in "baby boomers". So far, a total of around 16 000 people have been studied at least once.

The earliest descriptive reports in Australia of the prevalence of common diseases including asthma and other lung problems (the study has always had an emphasis on respiratory disease), diabetes and coronary heart disease are those from the "population laboratory" of Busselton. Numerous papers have been published: interviewees Professor Bill Musk, Associate Professor Alan James and Dr Digby Cullen (son of Kevin) nominated research describing the decline in lung function related to asthma and cigarette smoking,[13] and genetic studies into asthma[14,15] and haemochromatosis[16] as their recent favourites.

From the community perspective, there has always been a policy of providing feedback to survey participants, with recommendations made to seek medical advice from the family doctor if indicated. Dr Digby Cullen said, "We have made an attempt to create a therapeutic community in Busselton and to a significant extent I think we have been successful … certainly, when you look at the health statistics of Busselton, there is good evidence for a creation of a therapeutic community with, for instance, very low rates of smoking in the population — about 12% in our most recent survey". In addition, the prevalence of coronary artery disease has been shown to be lower in Busselton than in the nearby state capital, Perth.

What of the future? Since 1966, Busselton has grown sixfold from a small town with a population of about 5000 to one of around 30 000, as people, particularly retirees, have moved into the area. However, the population has remained relatively stable, ethnically and socioeconomically speaking, and wine growing, tourism and farming remain the main industries. The Busselton genetic resource is in international demand. Associate Professor James said, "We're now matching the phenotypes that we have collected in Busselton with genotyping in our own studies and with an expanding number of international collaborators; there's plenty of scope for genetic epidemiology to go from strength to strength in Busselton".

Regardless of how the study develops, the community focus will persist. Professor Musk said, "We very much feel the community around us and behind us. All of us worked with Kevin Cullen briefly or for various times before he died. He instilled in me, and I'm sure in plenty of other people, that our first duty was to the community. We plan to keep that, as a mantra, if you like, into the future".

3 Busselton, Western Australia

At nearly 2 km, Busselton's iconic jetty is the longest in the southern hemisphere. ◆

The Dubbo Study

Interviewee: Professor Leon Simons

Who among us will live to a ripe old age, physically well and mentally able? In the 1980s, when Associate Professor Leon Simons of St Vincent's Hospital, Sydney, decided to conduct a longitudinal study, he was aware that older age groups had been relatively neglected in research studies up to that time. He also realised that by studying "survivors", some characteristics of healthy "long-livers" might be identified.

The decision to embark on the Dubbo Study of the Health of the Elderly — now known more simply as the Dubbo Study — was preceded by a raft of other decisions. Initially a neurophysiologist, then a lipid clinician–researcher, Simons followed the 1980s evolution in his field by retraining as an epidemiologist while on sabbatical in Jerusalem. Simons' Israeli mentor, Professor Yechiel Friedlander, remains a collaborator to this day.

A key decision was where to locate the study. Simons said, "We selected Dubbo [a major regional centre in NSW, home of the renowned Western Plains Zoo] in reverse, after working out the size of the town we needed — a community of 35 000 to 40 000 people". Another decision was what data to collect. At the time, there was much data available in the form of aggregated health statistics — how many people each year go to hospital, how many go home, how many die — but not much was known about the people themselves. "We decided to study what is loosely called 'healthy ageing' but with a focus on cardiovascular disease risk factors, because they were a little bit more controversial — did what we knew in middle-aged people also apply to senior citizens?" said Simons. "And when you study the elderly, you open up a Pandora's box of sociology."

Thus, the Dubbo Study came into being as a prospective, longitudinal community study of the health of all non-institutionalised residents of the Dubbo local government area who were born before 1 January 1930. The cohort, first examined in 1988, was composed of 2805 residents (1233 men and 1572 women) aged 60 years or older. Initial study aims included identifying patterns and predictors of mortality, hospitalisation and the need for residential care. As well as extensive biomedical investigation, including a resting electrocardiograph, peak expiratory flow measurement, and blood testing for lipid and glucose levels, there was also to be a social science investigation of healthy ageing and health service use. Cardiovascular diseases and dementia were conditions of special interest. Subsequent data collections were

made in 2000 and 2002–2003 as part of the Study of Assets and Health Dynamics Among the Oldest Old (AHEAD) investigation; and there has been continuing "cold pursuit" of death, hospitalisation and residential care data.

Pragmatically, Simons' favourite reports are those most recently published[17] or currently in preparation. Our favourite may be the 2005 article which reported that having a "green thumb" (daily gardening) can guard against dementia.[18]

Less than half of those in the original cohort are still living, making further active data collection unlikely. Nevertheless, more papers are on the way to add to the 50 already published. Today, as the shape of Australia's population pyramid changes to reflect our ageing population, there is heightened interest in healthy ageing and the provision of health care and other services to our older citizens. Over the next 10 to 15 years, as the most resilient of the cohort retire to their gardens, Simons anticipates that the Dubbo Study's database will continue to be accessed and continue to contribute to our knowledge of ageing.

Tasmanian Longitudinal Health Study (TAHS)

Interviewees: Associate Professor Shyamali Dharmage, Professor John Hopper, Professor E Haydn Walters

How do childhood factors affect adult-onset asthma? How do issues around the time of puberty influence the risk of breast cancer? When a disease "runs in the family", is it because of environmental or genetic reasons? Today, the Tasmanian Longitudinal Health Study (TAHS) is attempting to answer these questions and more. However, very different questions were at the forefront when the study began in the late 1960s.

The study, originally known as the Tasmanian Asthma Survey, was the brainchild of Dr Heather Gibson, a pioneering doctor working with the school medical service in Tasmania. Professor Haydn Walters, one of the current TAHS team, said: "At that time, the main interest was in how much asthma and how much other respiratory morbidity there was in young children, and what the risk factors were". The baseline study in 1968 surveyed all 8500 schoolchildren in Tasmania who were born in 1961 and were then 7 years old. Particularly novel for the time were the lung function tests performed on all of these schoolchildren, known as probands. The probands' brothers, sisters and parents were also surveyed, taking the total number of participants at the time of original survey to 45 900.

Follow-up studies were conducted in 1974, 1979, 1992 and 1996, often involving a specific subset of the original participants. The first time that blood samples were collected from participants in the TAHS was in 1996, from a relatively small sample of families. The aim of the current and next phases of the study is to investigate the total original cohort of 45 900. Ninety per cent of the probands have now been traced, with 80% of them participating in a recently completed follow-up study. The sibling follow-up is underway, with 70% traced so far, and 60% of them participating in the study. The TAHS researchers are seeking to collect blood samples from all probands and siblings for genetic testing, to tease out the different effects of "nature" versus "nurture". Today, the original probands are around 47 years of age, and include such prominent figures as a Deputy Lord Mayor and leading medical researchers.

The TAHS researchers say their most cited article to date is one published in the *BMJ* in 1994. It reported that only one in four probands who had asthma in childhood continued to have asthma at age 32, and that one in 10 probands who didn't have asthma as a child developed it later on.[19] Among more recent interesting findings, the TAHS found that, for girls, being overweight at 7 years of age triples the risk of developing adult-onset asthma.[20]

The TAHS is unique internationally because it is the world's largest and longest running respiratory health study. However, because of the population-complete nature of the cohort, the length of follow-up and the opportunities for a general health study, research is now extending to other areas such as breast cancer, eye disease and social science. As TAHS team members say, on the one hand, "It's now a very rich dataset in terms of early life exposure … and the original questionnaires asked about symptoms rather than diagnosis — a real strength from a research point of view". On the other hand, "In terms of a cohort, the group are now starting to get very interesting because they're getting older. They've gone through the healthy part of their life and now the major diseases are starting to emerge". In keeping with the study's original respiratory focus, the TAHS will enable the study of lung ageing.

Although the TAHS was originally (and, essentially, still is) a Tasmanian study, 30% of the original probands now live outside Tasmania — mostly on the eastern Australian mainland in Victoria, NSW and Queensland — and, as current TAHS team leader Associate Professor Shyamali Dharmage explained, the study now involves a national collaborative family of researchers. But the TAHS has always been a family study. As Professor John Hopper, a long-standing TAHS team member, said, "The thing that differentiates this from a lot of other longitudinal studies is that it involves families, and its strength is that Australian families tend to know where each other are. The next stage will be to study the offspring".

Wittenoom cohort studies

Interviewees: Professor Nick de Klerk, Associate Professor Lenore Layman, Professor Michael Hobbs, Professor Bill Musk

What would you do if you could see an accident waiting to happen that would hasten the deaths of hundreds of people? In 1948, Dr (later, Professor) Eric Saint, who had emigrated from the United

4 Wittenoom miners

Underground Wittenoom miners having a lunch break in a dusty crypt room. ◆

Kingdom to Australia, was horrified by dust levels in the crocidolite (blue asbestos) mine and mill at Wittenoom in the Pilbara region of Western Australia, more than 1000 km north of Perth (Box 4). Saint wrote to the head of the WA Health Department advising that the mine would produce the greatest crop of asbestosis the world had ever seen. Unfortunately, responsibility for any decision to halt mining in the area rested with the Department of Mines, and the Health Department could only stand on the sidelines in frustration.

Tragically, in time it became clear that there was another even more lethal health risk to the workers and residents of Wittenoom. The first Wittenoom-related case of mesothelioma was diagnosed in 1960,[21] shortly after the initial suggestion of a link between exposure to crocidolite and mesothelioma.[22] However, the Wittenoom mine continued to operate until 1966 when, ironically, it was closed for economic rather than health reasons. The mine may have been losing money then; today, the loss in life continues.

In the mid 1970s, when it became apparent that an epidemic of asbestos-related disease was emerging in Wittenoom workers, Australian researchers began a cohort study. Mine workers' employment records, giving detailed information about the identity of the workers, their length of employment and the duties they performed, were made available to the research team. Although only several hundred people were employed at any time, about 7000 workers (mostly men) had passed through the mine or mill over the years. Most worked for only a few months; many were post-war migrants, several hundred of whom returned (and were traced) to Italy. Resulting studies have reported that asbestos-related diseases, particularly malignant mesothelioma, lung cancer and pneumoconiosis, continue to be the main causes of excess mortality in the former blue asbestos miners and millers of Wittenoom. Further, mesothelioma appeared much earlier in these people than had been seen after exposure to other types of asbestos in UK industrial studies.

By the early 1980s, people who had lived in the town of Wittenoom without working in the mine or mill were also developing asbestos-related disease at an alarming rate. In the 1950s and 60s, crocidolite tailings had been spread around the town as a cheap gravel and sand substitute. Professor Bill Musk said, "They brought the crocidolite in from the gorges and laid it around the township to counter the dust or the mud, depending on whether it was raining or not. So everybody living in town was exposed". Professor Michael Hobbs continued, "The school playground had been layered with asbestos tailings as a better surface for children to be running about on, rather than hard dirt". Thus, a residents cohort study involving more than 4500 former residents of Wittenoom, including Indigenous residents, was embarked upon. Intervention and other studies have continued in that group to this day, giving, as Associate Professor Lenore Layman said, "some support and comfort to people who live with this terrible fear about their children getting mesothelioma".

Together, the Wittenoom studies have provided evidence that (unlike with smoking) the risks of mesothelioma do not diminish with increasing time since exposure. Most importantly, Professor Nick de Klerk says that dose–response curves were able to determine, once and for all, that, "When it comes to blue asbestos, there is no such thing as a 'safe' level of exposure".

The evidence from these studies has influenced asbestos policy in Australia, assisted in legal deliberations, inspired a hit song by Australian rock band Midnight Oil ("Blue sky mine"), and even led to Wittenoom becoming a designated contaminated site that has been literally wiped off the map. However, asbestos is still being used in developing countries around the world. Hobbs said: "The first world has sort of recognised the dangers of asbestos and stopped using it. I think we have a moral obligation to go on pushing this barrow to make sure that our colleagues in China and India are equally armed with the information they need to try and stop things happening there. Because, if not, whereas we've seen hundreds of cases of mesothelioma, they will see thousands".

Women's Health Australia (WHA)

Interviewees: Professor Julie Byles, Professor Annette Dobson

"I am woman, hear me roar; in numbers too big to ignore …" proclaimed the lyrics of Australian-born Helen Reddy's song "I am woman". The song won Reddy a Grammy Award in 1973 and is now famous as the anthem of the Women's Movement. But how much did we really know then about ordinary women's lives and the influences on their health? In 1985, after much lobbying, Prime Minister Bob Hawke's government committed to forming a National Women's Health Policy. The Policy, which would provide a framework and planned strategy to improve the health of women in Australia, was to incorporate a wide perspective — recognising that women's health was much more than just reproductive and sexual health.

In the early 1990s, a tender was put out by the federal government for a national longitudinal study on women's health — one that could collect scientifically valid information relevant to the development of health policy and practice, and that would enable women to gain greater power over shaping the nature of health care. On seeing the advertisement for the tender, a group of researchers from different academic disciplines (including medicine, sociology, psychology and statistics) met over coffee in Newcastle, NSW, and decided to put in a submission. Thus began Women's Health Australia (WHA), also known as the Australian Longitudinal Study on Women's Health.

The study's overall goal was (and still is) to clarify relationships between women's health and a range of biological, psychological, social and lifestyle factors. Professor Annette Dobson said: "We've never claimed to have just one clear hypothesis. Rather, what we felt was needed was enough power in the study to be able to address new questions as they emerged. We did have some concrete examples of the sorts of hypotheses that could be answered, but we didn't say this was a study to address this or that question. We were saying it's a study to look generally at factors that influence the health of women".

Extensive surveys have been mailed at regular intervals to a national sample of thousands of women in three different age cohorts (18–23, 45–50 and 70–75 years at baseline in 1996). These age groups were chosen because they represented times before which major changes could be expected in women's lives; so, for example, there would be baseline data for young women before most of them had babies. Further, the women were recruited from the national Medicare database, allowing a link to health services data.

More than 41 000 women (14 792 young women, 14 200 middle-aged women and 12 624 older women) responded to the baseline surveys in 1996;[23] and now, about 10 000 completed questionnaires are received each year. Over time, themes

explored have included health-related behaviour (eg, diet and exercise), time use (eg, paid and unpaid work, and leisure), life stages and key events (eg, childbirth, divorce and widowhood), violence against women, and chronic disease.

Because WHA does not focus on a specific exposure, disease outcome or social problem, publications are highly diverse (http://www.alswh.org.au/public.html). Dobson said, "We're contributing to the story of the health of Australian women". There is sustained work on overweight, obesity and physical activity, and in the unfashionable area of incontinence. Professor Julie Byles said, "We're dispelling the myth that incontinence is just a condition for older people". WHA is also one of the significant studies of ageing in Australia. In addition, there are add-on studies and collaborations.

WHA has passed the 10-year mark and is currently funded to last the desired 20 years. However, the researchers see possibilities for expansion and extension. Byles said, "We have found that the cohorts' experiences are likely to be different as they age, so we have put a suggestion to the Department [of Health and Ageing] that we recruit a new young cohort — precisely because of those differences". The WHA study has certainly fulfilled Reddy's command that women not be ignored. And, to make sure of it, Byles would like the study to "hang around" at least until the older women reach the milestone age of 100.

Australians advancing

These eight longitudinal studies, all conducted "on our selection" (to borrow an Australianism from Steele Rudd), have already contributed much to our knowledge of diseases in Australia. Although they cover disparate topics and range in cohort size from several thousand to many tens of thousands of participants, there are some common elements to their stories: committed investigators who are capable of thinking into the future; dedicated and often longstanding research teams; sustained support and enthusiastic participation from the community; and the need to endure and persist through periods of extreme funding uncertainty.

A striking feature of these longitudinal studies is their capacity to produce valuable results with relatively little funding overall — many of those interviewed said that their work had been conducted on "the smell of an oily rag". Reports from the studies have been published in prestigious high-impact journals, such as *Nature*, the *New England Journal of Medicine* and the *BMJ*, as well as high audience-impact journals, such as the *MJA*, thus influencing discourse, attitudes and policy. These Aussie battlers are rightfully proud of their achievements, as are we.

Despite some successes, none of the researchers are content to rest on their laurels. All are eyeing a future for their studies, carefully watching the emergent literature for new ideas that may be a natural fit for their study populations. Many are actively engaging productive collaborators in cutting-edge areas, like genetics, and seeking a greater international contribution through the integration and comparison of their data with those of others. Both of these advances are enabled by making their data available online.

Does a longitudinal study have a natural lifespan? Maybe, but all our interviewees are more concerned that it will be a lack of funding rather than relevance or researcher interest that sounds the death-knell for their study. If these studies are stopped too soon, we will all miss out on "the gold coins at the end of the rainbow". As Miller (from BEACH) said, "Enough of the past must be seen before we can begin to predict the future with any certainty".

To achieve sustainability, many argue that a different kind of funding is needed than that usually available to epidemiological researchers. Hopper (TAHS) said, "The work is generally funded by project grants, scientific project grants, but what is needed is core funding". Several interviewees said there needed to be some sort of formal research policy providing long-term support to cohort studies.

Whatever the lifespan of their own study turns out to be, most of the researchers want a future that is better for all longitudinal study investigators. WHA has published a practical guide to conducting longitudinal studies — how to store data, track people, manage collaborators and more.[24] Dharmage (TAHS) dreams of establishing a supportive collaboration of longitudinal researchers, all helping each other forward.

What will be the next great Australian longitudinal study? Zimmet (AusDiab) says the time is ripe for Australia to establish a comprehensive longitudinal national health survey, conducted every 5 years, which would give an idea of the burden of disease and the opportunity to monitor interventions.

Hopper sees a future where the historically fostered culture of institutionalised non-cooperative research groups is turned on its head. "Even now, the concept of having national cohorts that are run as resources for the general scientific community is becoming more and more established. The general thinking is growing — not just in Australia but internationally — that these resources are precious, that they need to be open and accessible to a wide range of research; and that people who do research using these resources need to put that data back into the resource so that others can build on it."

Australian longitudinal research is making its mark in medicine at home and beyond. With renewed commitment, vision and adequate ongoing resources, we hope that these stories, and others like them, will continue.

Acknowledgements

We thank all the interviewees for their time and willing participation.

Competing interests

None identified.

Author details

Ann T Gregory, MB BS, GradDipPopHealth, Deputy Editor
Ruth M Armstrong, BMed, Deputy Editor
Tanya D Grassi, MB BS(Hons), BSc(Vet)(Hons), Deputy Editor
Bronwyn Gaut, MB BS, DCH, DA, Deputy Editor
Martin B Van Der Weyden, MD, FRACP, FRCPA, Editor
Medical Journal of Australia, Sydney, NSW.
Correspondence: **medjaust@ampco.com.au**

References

1 Doll R, Peto R, Boreham J, Sutherland I. Mortality in relation to smoking: 50 years' observations on male British doctors. *BMJ* 2004; 328: 1519-1528.
2 Richmond C. Thomas Royle Dawber [obituary]. *BMJ* 2006; 332: 122.
3 Zimmet P. Deficient diabetes data [editorial]. *Med J Aust* 1985; 143: 431-432.
4 Zimmet P, Taft P, Guinea A, et al. The high prevalence of diabetes mellitus on a Central Pacific Island. *Diabetologia* 1977; 13: 111-115.
5 Cameron AJ, Welborn TA, Zimmet PZ, et al. Overweight and obesity in Australia: the 1999–2000 Australian Diabetes, Obesity and Lifestyle Study (AusDiab). *Med J Aust* 2003; 178: 427-432.

6 Russell L, Leeder SR. The Bettering the Evaluation and Care of Health (BEACH) program may be left high and dry [editorial]. *Med J Aust* 2007; 187: 429-430.

7 Britt HC, Harrison CM, Miller GC, Knox SA. Prevalence and patterns of multimorbidity in Australia. *Med J Aust* 2008; 189: 72-77.

8 Bridges-Webb C, Britt H, Miles DA, et al. Morbidity and treatment in general practice in Australia 1990–1991. *Med J Aust* 1992; 157 (8 Suppl): S1-S56.

9 Britt H, Miles DA, Bridges-Webb C, et al. A comparison of country and metropolitan general practice. *Med J Aust* 1993; 159 (9 Suppl): S9-S64.

10 Mitchell P, Chapman S, Smith W. "Smoking is major cause of blindness" [editorial]. *Med J Aust* 1999; 171: 173-174.

11 Cumming RG, Mitchell P, Leeder SR. Use of inhaled corticosteroids and the risk of cataracts. *N Engl J Med* 1997; 337: 8-14.

12 Leeder SR. Preface. In: Welborn TA, editor. The Busselton study: mapping population health. Sydney: Australian Medical Publishing Co, 1998.

13 James AL, Palmer LJ, Kicic E, et al. Decline in lung function in the Busselton Health Study: the effects of asthma and cigarette smoking. *Am J Respir Crit Care Med* 2005; 171: 109-114.

14 Daniels SE, Bhattacharrya S, James A, et al. A genome-wide search for quantitative trait loci underlying asthma. *Nature* 1996; 383: 247-250.

15 Hui J, Oka A, James A, et al. A genome-wide association scan for asthma in a general Australian population. *Hum Genet* 2008; 123: 297-306.

16 Olynyk JK, Cullen DJ, Aquilia S, et al. A population-based study of the clinical expression of the hemochromatosis gene. *N Engl J Med* 1999; 341: 718-724.

17 Simons LA, Simons J, Friedlander Y, McCallum J. Usefulness of fasting plasma glucose to predict mortality or coronary heart disease in persons ⩾ 60 years of age without diabetes mellitus or in those with undiagnosed diabetes mellitus (from the Dubbo Study). *Am J Cardiol* 2008; 102: 831-834.

18 Simons LA, Simons J, McCallum J, Friedlander Y. Lifestyle factors and risk of dementia: Dubbo Study of the elderly. *Med J Aust* 2006; 184: 68-70.

19 Jenkins MA, Hopper JL, Bowes G, et al. Factors in childhood as predictors of asthma in adult life. *BMJ* 1994; 309: 90-93.

20 Burgess JA, Walters EH, Byrnes GB, et al. Childhood adiposity predicts adult-onset current asthma in females: a 25-yr prospective study. *Eur Respir J* 2007; 29: 668-675.

21 McNulty JC. Malignant pleural mesothelioma in an asbestos worker. *Med J Aust* 1962; 49: 953-954.

22 Wagner JC, Sleggs CA, Marchand P. Diffuse pleural mesothelioma and asbestos exposure in the North Western Cape Province. *Br J Ind Med* 1960; 17: 260-271.

23 Lee C, Dobson AJ, Brown WJ, et al. Cohort profile: the Australian Longitudinal Study on Women's Health. *Int J Epidemiol* 2005; 34: 987-991.

24 Loxton D, Byles J, Dobson A, Brown W, editors. Conducting longitudinal research: practical lessons from the Australian Longitudinal Study on Women's Health. *Int J Multiple Research Approaches* 2007; 1 (2).

(Received 12 Oct 2008, accepted 2 Nov 2008) ❑