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Longitudinal studies of children and youth *Implications for future studies*

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Over recent decades, some indicators of the health and wellbeing of children and young people in Australia have improved. However, in other areas, the evidence suggests that children's outcomes have remained constant, or have even declined.

There are areas of particular concern. Mental health problems affect up to 20 per cent of young people, and when persistent, are associated with poor educational outcomes, relationship difficulties, high rates of welfare dependence, delinquency and criminality. Suicide rates in Australia are among the highest in the western world, especially for young men in rural settings. The wellbeing of marginalised groups such as children in protective care, juvenile offenders, the young homeless and those who drop out of school are cause for concern. There are atopic and chronic health problems such as asthma, obesity and myopia which are affecting growing numbers of young people, and which have been described as the "new plagues" of modern western societies. And preventable injuries during childhood and harmful health risk behaviours (such as substance abuse) during adolescence remain prevalent despite the introduction of a range of national health promotion and prevention initiatives.

These problems are distributed unequally within the Australian population and are more prevalent for children disadvantaged by low income, poor parental education, rural location, and single parent and Indigenous family status (see Nicholson, Tully and Vimpani 2000; Turrell et al. 1999; Vimpani et al. in this volume).

It has been argued that the changing nature of Australian childhood environments accounts for these patterns. A significant evolution has occurred in the structure and functioning of Australian families, the types and extent of child care services employed, physical environments, and the broader social and economic climate of the nation. Such societal changes and the resulting disruptions experienced by families and communities have been "sudden, dramatic and of unprecedented scope" (Keating and Hertzman 1999: 2), and show every sign of continuing at a similar pace.

The long-term impact of our rapidly changing society on young people and families is not well understood. Research is needed to identify the complex interactions between the resources of individuals and their families, the pressures exerted by their environments and social structures, and how these factors determine the wellbeing and health of future generations of Australians. Such information will be essential for developing social, health and other policies and preventive services to encourage the full and positive participation of young people and families in community life.

Longitudinal study designs

Our understanding of human development and wellbeing has been informed through the use of a range of research methodologies. Large cross-sectional studies are useful for providing data representative of populations (for example, prevalence rates, age differences). However, such studies do not track changes within individuals over time, and are therefore limited in their capacity to build causal models to explain outcomes (Bergman et al. 1989). Randomised controlled trials (RCTs) are one of the most powerful tools for identifying causal relationships. However, practical and ethical constraints (such as those associated with withholding interventions) may limit their usefulness, and RCT designs are generally restricted in the range and number of variables that can be explored simultaneously (Bergman et al. 1989). Longitudinal study designs have long been recognised as important vehicles for obtaining high quality evidence about the determinants of development across the lifespan (Farrington 1991; Rutter 1994).

According to Farrington (1991) and Rutter (1994), the advantages that longitudinal approaches have over other research designs include their ability to:

- track patterns of development over time including continuities, discontinuities and transition points;
- develop and test models of causal relationships between early events or characteristics and later outcomes;
- model and establish developmental sequences and pathways;
- identify different manifestations of the same underlying theoretical construct at different ages;
- identify “critical periods” in human development for exposures and risks, and establish optimal times for intervention to interrupt maladaptive pathways; and
- tease out the relative contributions of the multitude of factors that impact on development.

Longitudinal studies come in a variety of shapes and sizes each of which have strengths and weaknesses (Loeber and Farrington 1994; Magnusson et al. 1994; Menard 1991). The key designs are illustrated in Table 3.1 using hypothetical studies of early childhood. For each design, examples of the ages of the study cohorts are shown at various waves of data collection.

Single-cohort studies

The most common longitudinal study design is a single-cohort design in which a sample of a defined age is recruited at one point in time and followed up at subsequent intervals (or data collection waves). Especially in early childhood, the age range within each cohort is typically narrow (less than one year). The time intervals between data collection waves vary across studies. Ideally, these are determined by the research questions, but also often by convenience and available resources. As with all longitudinal studies, this design enables the prospective collecting of data and thereby minimises retrospective reporting biases.

The single-cohort design has the advantage of simplicity, and allows tracking of developmental pathways for the group involved. Since cohort members move simultaneously through major developmental periods, the need to introduce new measures and undertake data collection within new settings (for example,

Table 3.1. Longitudinal study designs		Illustrative ages for cohorts at four assessment points			
<i>Design</i>	<i>Cohorts (C)</i>	1	2	3	4
Single-cohort	C1	birth	2 years	4 years	6 years
Cross-lagged	C1	birth	2 years	4 years	6 years
	C2		birth	2 years	4 years
	C3			birth	2 years
Cross-sequential	C1	birth	2 years	4 years	6 years
	C2	2 years	4 years	6 years	8 years
	C3	4 years	6 years	8 years	10 years
Single-cohort, multiple-age		0 years	1 year	2 years	3 years
		1 year	2 years	3 years	4 years
		2 years	3 years	4 years	5 years
		3 years	4 years	5 years	6 years

Source: The authors, 2002.

when the child commences school) occurs simultaneously for all study participants. This makes data collection changes easier to implement in a practical sense than for the other designs described below.

However, in single-cohort designs, age effects, cohort effects, and time-of-measurement effects are confounded and cannot be distinguished. Age effects refer to developmental changes associated with the age of the cohort members (for example, from infancy to toddlerhood). Cohort effects are changes that arise from characteristics unique to the particular cohort examined (for example, a cohort born in 1990 versus one born in 2000). Time of measurement effects reflect changes in the broader social or environmental influences that occur at the times at which data are collected (for example, changes in unemployment rates, political events, environmental conditions).

As an illustration, consider the case of an observed increase in computer literacy over time in a particular cohort. This trend may be due to: the maturation of cohort members; or the specific conditions experienced by the cohort (for example, rapid increase in children’s exposure to computers over the lifespan of the cohort); or the specific times at which computer literacy is assessed (for example, the waxing and waning popularity of computer-based activities); or any combination of these. This confounding limits the degree of confidence with which findings from single-cohort studies can be generalised to other (earlier or later) cohorts (Farrington 1991).

Another limitation of the single-cohort design is that these studies are relatively slow at producing results on long-term or later life outcomes. Researchers need to be patient and wait for the cohort to mature before findings about the impact of early factors on later development are available. Because of the time lag involved, there is the danger that changes in policy and social environments will reduce the relevance of findings for current policy and practice. In addition, measurement techniques may become obsolete over time, and measures that were introduced at the start of the study may no longer be cutting edge as the study progresses.

Despite these limitations, single-cohort longitudinal study designs remain popular. As discussed below, single-cohort studies have made an impressive contribution to our knowledge of children's health and development. Studies such as the Australian Temperament Project, the Christchurch Health and Development Study, the Dunedin Multidisciplinary Health and Development Study, and the Mater-University Study of Pregnancy (see Table 3.2) have remained influential information sources into their second and third decades of data collection.

Cross-lagged studies

A cross-lagged (or "cohort-sequential") design is one of a class of "accelerated longitudinal" or "longitudinal sequence" designs (Schaie 1965). In this design, one cohort is recruited at the initial age of interest and followed forward for one or more assessments, at which time a second cohort is recruited at the initial age of interest and followed forwards simultaneously. Further cohorts can be added in a similar manner at later time points, as shown in Table 3.1.

With this design, data are available from two or more cohorts at the same age, but from different times of measurement. Therefore, the design makes it possible to distinguish between age effects and time-of-measurement or cohort effects, although it is still not possible to differentiate fully between the latter two. If these latter effects are not evident, it is also sometimes possible to combine data collected from the different cohorts at the same age for specific analyses. This increases the overall sample size, improving analytic power and facilitating the investigation of rare events. As with the single-cohort design, the introduction of new assessment methods is staggered by the age of the first cohort, which eases the demands on the researchers (when compared with cross-sequential designs, below). However, the time lag remains, and this design does not provide any more rapid answers to issues about the long-term outcomes than is the case for single-cohort studies.

Cross-lagged designs have been employed relatively infrequently in Australian research on the development of children and youth. One of the few local examples of this design is the Youth in Transitions Study (Fleming and Marks 1998) which examines early adulthood outcomes for four nationally representative age cohorts that were each recruited during adolescence (see Table 3.2).

Cross-sequential and single-cohort, multiple-age studies

A further elaboration of "accelerated longitudinal" or "longitudinal sequence" designs is a cross-sequential design. In this design, two or more cohorts of differing ages are selected at the start of the study, and each is followed forwards, as shown in Table 3.1. For a time-limited study, a cross-sequential design may involve the second cohort being the same age at the beginning of the study as the first cohort is at the end of the study (see Farrington 1991).

This design provides data on all target age groups in a shorter space of time. For example, cohort one may be followed from 0 to 4 years, cohort two from 4 to 8 years, and cohort three from 8 to 12 years, effectively providing data over a 12-year developmental period from only four years of data collection. An alternative approach is shown in Table 3.1, where data on a ten-year age period is collected in six years and all cohorts run forward for as long as research needs and funding dictate.

A variation on this design is a single-cohort, multiple-age design. In this design, a single sample covering a broad age range is recruited, and cohort members of all ages are followed forwards (Table 3.1). For example, the National Longitudinal Survey of Children and Youth conducted in Canada has recruited children ranging in ages from birth to 11 years. Due to its very large sample size (more than 22,000), this cohort can be divided into age groups, and analyses conducted that treat each age group as a separate cohort (Table 3.3).

The Promoting Adjustment in Schools cohort is a local example of a single-cohort, multiple-age design (Table 3.2). Respondents were recruited from schools in two waves one year apart, with stratification by school year, and recruitment across preschool and Years 1 to 3, and followed forwards for three years. Analyses may be conducted for the whole sample, or by recruitment wave, year cohort, age group, or some combination of these.

Both the cross-sequential and single-cohort, multiple-age designs are complex and challenging to execute, especially at the start-up phase. Recruitment methods and assessment instruments for each age group need to be developed and administered simultaneously, and measurement approaches need to remain consistent across waves in order to retain comparability across samples.

However, they also hold substantial advantages over simple single-cohort designs. In the case where there is considerable overlap in the ages of children in the different cohorts at various follow-up points, these designs allow for separate assessments of age effects, time-of-measurement effects, and cohort effects. Again, where time-of-measurement and cohort effects are minimal, the data from multiple cohorts collected at the same age can be combined to increase sample size and hence analytic power.

This design has the further advantage of providing data on later developmental periods and pathways without needing to wait for a single cohort to mature. Because results are produced more quickly, there is less concern that theories, instruments and policy issues will be out of date before the results are available. Importantly, follow-up of more than one cohort (or age group) increases confidence in the generalisability of results.

These advantages help to explain why these designs are increasingly being employed in current longitudinal research both within Australia and internationally.

Review of longitudinal studies involving children and adolescents

Tables 3.2 and 3.3 summarise major longitudinal studies conducted in Australia and New Zealand, and internationally, respectively. The tables are not comprehensive, but aim to provide an overview of most influential studies. Studies were included if they met the following criteria: they commenced no earlier than 1970; data were collected prospectively on at least three occasions; and sample size exceeded 500.

In general, the studies included have involved representative samples, and either no intervention or the intervention component has not been a major focus of the study. However, we have allowed ourselves to include some exceptions to these criteria when the studies are useful illustrations of alternative designs, and/or when they have been high-impact studies. The tables do not include

details of studies that are in development or have commenced recently, since three waves of data collection were needed to count as an actual longitudinal study. However, information on some of these new studies is given in the text.

Information on studies was collected from published information and websites, as well as through personal contacts of the authors. In addition, for some studies, two of the authors (JN and LR) obtained responses to a brief survey from study investigators which included a series of open-ended questions about the strengths and limitations of the study, study outputs, and funding issues.

Australian and New Zealand studies

Table 3.2 lists 14 Australian and New Zealand longitudinal studies of childhood and/or adolescence. The table summarises the key characteristics of the studies, including sample sizes, research foci, and frequency of data collection. Single-cohort studies are presented first followed by cross-lagged, cross-sequential or single-cohort, multiple-age studies. As illustrated by the table, Australian and New Zealand researchers have clearly established themselves as world leaders in longitudinal studies, with a predominance of single-cohort studies commencing in early life. Some interesting differences appear between the types of studies conducted in the two countries, and these are described below.

New Zealand has produced two of the most internationally well-recognised birth cohort studies – the Dunedin Multi-Disciplinary Health and Development Study (Silva and Stanton 1996), and the Christchurch Health and Development Study (Fergusson et al. 1989; Horwood and Fergusson 1998). Both are broadly focused epidemiological studies, one with annual measurement throughout childhood (Christchurch) and the other with biennial but more comprehensive assessments (Dunedin). The studies have reduced the frequency of data collection as the cohorts have entered early adulthood to every five and six years (Christchurch and Dunedin respectively). Both studies have been prolific and influential, and have maintained exceptional levels of cohort participation. The Dunedin study has produced in excess of 800 publications over nearly 30 years, and the Christchurch study has produced more than 250 publications in nearly 25 years.

These two studies provide an interesting contrast in management and funding models.

The Christchurch study has been funded almost exclusively from New Zealand research funding sources, and is the product of a small, stable core team of three to four researchers. Collaborative publications with researchers outside the core team have been more common in recent years, but are still rare. It has been suggested that this approach produces a high degree of focus and consistency in the research questions and data analytic strategies employed (Fergusson, personal communication, June 1999). The quality of the publications from this study (primarily in top ranking, international journals) suggests that the narrow control has not detracted from the relevance and importance of the data produced.

While the Dunedin study was initially funded by New Zealand research funding sources, it diversified in later years to also receive substantial international funding. Data collection is intensive, and correspondingly costly. For example, the 26-year follow-up involved the assessment of four people per day in the laboratory, with biological samples collected, and participants paid for their time (Poulton 1999). This type of research exceeds the funding typically

Table 3.2. Australian and New Zealand longitudinal studies of children and young people commenced since 1970 with sample size > 500										
Study	Location	Year began	Sample size	Special criteria	Foci	Age at start	Follow ups	Age at last follow up	Data collection *	
<i>Sigle-cohort studies</i>										
Aboriginal Birth Cohort (Sayers & Powers 1997)	Darwin, Northern Territory, Australia	1987	686	Aboriginal ethnicity	Relationship between birth antecedents, peri-natal indices and a range of growth, nutritional and health outcomes	Birth	Multiple	10-13 years, ongoing	MR; HR; HP; DA	
Australian Temperament Project (Prior et al. 2000)	Victoria, Australia	1983	2,433	Representative of Victoria	Temperament, emotional/ behavioural developmental pathways	4-8 months	12	18 years, ongoing	MR, HP; EP; SR, OR	
Christchurch Health and Development Study (Fergusson et al. 1989)	Christchurch, New Zealand	1977	1,265	Representative of Christchurch	Epidemiology of child health and wellbeing; family studies; health services research	Birth	20	21 years, ongoing	MR; HR; EP; SR; PR; OR	
Dunedin Multidisciplinary Health and Development Study (Silva & Stanton 1996)	Dunedin, New Zealand	1972	1,037	Representative of Dunedin	Development and epidemiology of developmental disorders and health problems, and health behaviours	Birth	11	26 years, ongoing	MR; EP; SR; HR; DA	
Mater-University of Queensland Study of Pregnancy (Bor et al. 1993; Najman et al. 1997)	Brisbane, Queensland, Australia	1981	8,556	All births in a single hospital	Determinants of health and wellbeing; health inequalities; obstetric outcomes; mother's health	Pregnancy	5	21 years, ongoing	MR; HR; DA; SR	
Plunket National Child Health Study (Alison et al. 1993)	National New Zealand	1990	4,286	Stratified by Maori/non-Maori	Health care practices and services in early childhood	Pregnancy	9	4 years	MR	
Port Pirie Cohort Study (McMichael et al. 1992; Tong et al. 1996)	Port Pirie South Australia	1979-1982	723	Focus on lead exposure	Effects of pre-natal and post-natal lead exposure on neuropsychological development	Birth	10	13 years	MR; DA; HR	

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Tasmanian Infant Health Study (Dwyer et al. 1995; Ponsoy et al. 1994)	Tasmania, Australia	1988-1995	10,562	Focus on Sudden Infant Death Syndrome	Causal factors in fetal and infant determinants of childhood disease	Birth	4	8 years, follow-up with partial samples, ongoing	MR; HR; DA
WA Pregnancy Cohort (Raine) Study (Newnham et al. 1993; Blake et al. 2000)	Perth, Western Australia	1989	2,860	Initially an RCT to test ultra-sound during pregnancy	Currently examining factors influencing language development, learning and behaviour	Pregnancy	5	10 years, ongoing	MR; DA; HP
Cross-lagged, cross-sequential and single-cohort, multiple-age studies									
Australian Youth Survey (DEET) 1991	National, Australia	1989	5,500, + 4 annual samples of 1200	Representative samples, one multi-aged (1989); 4 additional single-age, new samples of 16-year-olds; cross-lagged design	Causes and consequences of educational participation	16-19 years	9	19 - 27	SR
Longitudinal Surveys of Australian Youth (www.acer.edu.au/research/vocational/lsay/intro.html)	National, Australia	1995 1998	6,000	Two representative year level cohorts, cross-lagged design	Influences on patterns of participation in education, training and employment	Year 9	6 3	21 18, ongoing	SR, EP
Promoting Adjustment in Schools (PROMAS) (Nicholson et al. 2002.	Brisbane Queensland, Australia	1998, 1999	1,024	Representative random sample, dis-advantaged communities, stratified by age and gender	Influences of family risk factors on mental health and receipt of school-based interventions	Preschool, Years 1-3	4-8	6-10 years	PR; EP
Victorian Adolescent Health Cohort Study (Patton et al. 1998)	Victoria, Australia	1992-2001	2,032	Stratified sample by school type; clustered by school class	Adolescent mental disorder, substance abuse, antisocial behaviour, social outcomes	14-15 years	7	20-21 years, ongoing	SR, PaRR
Youth in Transition Cohorts (Fleming & Marks 1998)	National, Australia	1978 1981 1985 1989	6,000	4 representative samples, variation on cross-lagged design	Influences on patterns of participation in education, training and employment	17 16 15 14	17 15 11 13	33 30 25 26	SR; EP
<p>Note: * BS = biological samples; DA = direct assessment; EA = environmental assessments (physical measures); EP = education professional; FR = father report; HP = health professional; HR = health records; MR = mother report; Obs = Observation; OR = other records (e.g. justice); PR = partner report; PaRR = Parent Report; PeerR = Peer report; SR = self report. Source: The authors, 2002.</p>									

available from local research sources. The study's policy has been to engage in collaborations in which research agendas of mutual interest are negotiated, allowing external researchers to "buy in" to future data collections (Poulton 1999). The research team is large, varied and located internationally, necessitating a complex governance structure. The study has had considerable international input and impact, and high productivity.

Most Australian studies have differed from the New Zealand studies by having larger cohorts, a more narrowly defined initial focus, and evidence of greater challenges in attracting stable ongoing funding. Two health studies which commenced with a narrow focus have made significant international contributions. The Port Pirie Cohort Study examined the effects of pre-natal and post-natal lead exposures for a pre-birth cohort followed to age 13 years (Table 3.2). The Tasmanian Infant Health Study was initially designed to identify risk factors for sudden infant death syndrome (SIDS) but expanded to explore other causes of infant morbidity and mortality, and determinants of childhood diseases such as asthma. It has followed children for 12 years to date (Table 3.2). These two studies have been highly successful in meeting their initial aims. They have been influential in changing public health knowledge and practices, and have produced in excess of 30 publications each in leading international journals.

In common with the Tasmanian study, several other Australian studies commenced with a relatively narrow focus, but have evolved to examine new areas or have been informative to areas outside the original focus.

As noted in Table 3.2, the WA Pregnancy Cohort (Raine) Study was established as a randomised controlled trial to identify any adverse effects of ultrasound during pregnancy. No effects were found, and the study has continued to follow the initial birth cohort to look at a range of developmental outcomes.

The Australian Temperament Project (Table 3.2) was initially established to examine the relationship between temperament and emotional and behavioural development. However, its foci broadened over time to include social, school-related and emotional problems as well as positive developmental outcomes such as social competence and civic mindedness. The study has tapped a wide range of child, family, school and social predictors and outcomes, with a focus on risk, resilience and developmental pathways (Prior et al. 2000), and is now addressing transitions to work, relationship formation, and intergenerational issues. Over 70 publications have arisen from the study.

Two other large single-cohort studies have been established in Australia (Table 3.2). The Mater-University of Queensland Study of Pregnancy involved a cohort of over 8,000 Brisbane-born children from pregnancy to early adulthood and has examined determinants of a range of health and wellbeing outcomes. The Victorian Adolescent Health Cohort Study commenced with a cohort of over 2000 14–15-year-olds and has addressed continuities and social consequences of psychosocial disorders of youth including emotional and behavioural disorders, suicide risk, accidental injury and obesity.

New Zealand funding bodies have shown commitment to supporting large, broadly focused longitudinal studies, including studies of Indigenous and other high risk ethnic populations across early childhood, such as the Plunket National Child Health Study (Table 3.2). A new study that commenced in 2000 is the Pacific Islands Families Study, which is recruiting a cohort of

approximately 1400 children of Pacific Island ethnicity in Auckland to be followed throughout childhood. This latter study will examine a range of health, psychological and family/cultural factors.

In Australia, three smaller studies of high risk populations have been conducted (two of which are not included in Table 3.2 due to small sample size). The Aboriginal Birth Cohort Study (Table 3.2) studied the health of Indigenous children up to age 10–13 years. While data collection from the 686 participants was only collected at one follow-up time, the study has involved ongoing collection of health record data. The Brunswick Family Study was a study of 304 families drawn from a multi-ethnic, low socioeconomic community in Melbourne, Australia (Williams and Carmichael 1990). Data collection finished in 1991 at age 11 years, and involved assessment of a range of determinants of health, educational and psychosocial outcomes. The Life Chances Study, undertaken by the Brotherhood of St Laurence, has followed up 167 children born in Melbourne in 1990 to examine the influence of low family income on life opportunities and outcomes for young people (Taylor and MacDonald 1998); data have so far been collected up to age ten years.

Investigators from these Australian studies have reported challenges in attracting funding for continuing data collection at older ages and for maintaining sufficient staff to analyse data and produce outputs in a timely fashion.

We are not aware of any New Zealand longitudinal studies of children or young people that have used designs other than single cohorts. In Australia, relatively few studies have used other than a single-cohort design, but among these, the studies conducted by the Australian Council for Educational Research predominate (Table 3.2). The Council's Youth in Transition study involved four cohorts of adolescents born in 1961, 1965, 1970 and 1975, contacted initially in school at 17, 16, 15 and 14 years of age respectively, and then by mail. It thus adopted a variation of a cross-lagged design, allowing analysis of changing patterns of participation in education and the labour force, and transitions within and between education and work. The Australian Youth Survey and its predecessor, the Australian Longitudinal Survey, were conducted by Commonwealth education authorities, but the data are now held at the Council. They involved a nationally representative multiple-aged sample of young people aged 16–19, augmented by the addition of four new groups of 16-year-olds at annual intervals. The focus of research is on the causes and consequences of educational participation among different groups in the Australian population, and how these patterns have changed over time.

In 1995 both the Youth in Transition and Australian Youth Survey were brought together as the Longitudinal Surveys of Australian Youth which operates with larger samples and with a broader research focus. Using a cross-lagged design, nationally representative samples of Year 9 students from almost 300 schools were recruited in 1995 and 1998. Data include reading and numeracy test results, adolescent self-reports, and school-based information about curricula, school climate and school organisation. It is planned to continue to follow these cohorts until members are approximately 25 years of age, as well as adding new cohorts, so that the study retains relevance for policy development.

Another new study using a cross-lagged design is the International Youth Development Study. This comparative longitudinal study of 6000 participants is being conducted in the states of Victoria in Australia and Washington in the

United States. It addresses the social determinants of substance abuse in youth and has intakes at Year 5 (9–10 years), Year 7 (11–12 years), and Year 9 (13–14 years) (Toumbourou et al. 2002). Thus both cross-national and cross-cohort analyses will be possible. This study is not included in Table 3.2 since only one wave of data collection has been completed to date.

In considering these Australian and New Zealand studies, the concentration on single-cohort, early childhood studies is notable. This in part reflects recognition of the importance of early years of life for later development. Although a range of data sources are employed in these studies, parental report is generally the key source of information, and family factors are investigated as critical influences on the child's development.

Coverage of later childhood and adolescence developmental outcomes arises via two methods. First, the long-term nature of several of the large-scale studies described above which have followed their cohorts through adolescence (for example, the Australian Temperament Project and the Christchurch and Dunedin studies) has allowed them to investigate adolescent-relevant pathways and outcomes such as substance use, delinquency, civic mindedness and occupational choice. Second, some studies have enrolled their samples in adolescence (for example, Youth in Transition, Longitudinal Surveys of Australian Youth). These have tended to focus on educational and occupational outcomes, and more recently on mental health issues. Among the adolescence-focused studies, school and peers are seen as prime contextual influences of interest and there has been less emphasis on family context. Sampling and data collection has typically been based on schools, with teachers and the adolescents themselves as the key informants.

Collectively the studies in Table 3.2 illustrate the tremendous potential that exists for longitudinal cohort designs to examine a great variety of factors influencing the health and development of Australian children and their families. The studies are expensive to establish, but once they have commenced, they have the potential to produce a wealth of information beyond that envisaged at the outset (National Centre for Epidemiology and Population Health 1999). Indeed, it appears to be the exception rather than the rule for studies, having collected three waves of data, to fail to continue indefinitely. To our knowledge the only studies in Table 3.2 that do not have follow-ups planned for the future are the Port Pirie and Plunket studies which ran for 13 years and four years respectively.

The impact of these longitudinal studies on the provision of services and development of policy is hard to determine. The most easily recognisable influence on policy and practice has come from two health studies focused on specific issues – the Port Pirie study of lead exposure and the Tasmanian Infant Health Study. For example, findings from the Tasmanian study contributed to changed recommendations for infant care practices, notably infant sleeping position. Thus studies designed to address specific research questions with direct policy and practice implications can influence health and other policies and practices to the benefit of population health and wellbeing.

At other times, initially unplanned analyses have resulted in findings whose implications have been taken up in policy and practice. For example, Australian Temperament Project findings on the strong relationships between reading acquisition and pre-existing child behavioural problems led to increased focus on the “whole child” in determining readiness to learn and early school progress.

More generally, all the studies following cohorts from early childhood have demonstrated the early origins of many later problematic outcomes, and have contributed to the recognition of the importance of the early years, and hence of early intervention and prevention, by policy makers and service providers.

International studies

Table 3.3 summarises some of the influential international studies meeting similar criteria to the Australian and New Zealand studies listed in Table 3.2. In general, the international studies have all commenced since 1970, involved representative samples of at least 500 children or young people, involved prospective data collection across at least three time points, and either no intervention was provided or this is not the primary focus of the study. However, we have included some exceptions to these criteria when the studies have been informative and influential. Information on some more recently established studies is provided separately in the text.

The studies reviewed in Table 3.3 include a number of cross-lagged and cross-sequential designs, although single-cohort studies still predominate. It is not possible to describe comprehensively all studies in the text, so we have chosen to discuss a few selected studies to illustrate general trends in international studies, key designs, strengths and issues which need further attention in the Australian research context.

The National Institute of Child Health and Human Development Study (NICHD) Study of Early Child Care (Table 3.3) is an example of a multiple cohort study initiated in 1989 to answer fundamental scientific and social policy questions about the effects of early childhood experiences on children's development. In 1991, a team of researchers working cooperatively to design and implement the study recruited a single birth cohort of 1364 children at ten locations across the United States. Researchers are assessing the children's development at frequent intervals from birth through their sixth year in school. The sampling has been designed to ensure adequate representation of major socio-economic niches.

An example of a study using a cross-sequential design (although not with a representative sample) is the Pittsburgh Youth Study (Table 3.3), which investigated patterns of and risk factors for youth delinquency, mental health problems and substance use (see overview in Loeber et al. 1998). The study commenced in 1987–1988 with the enrolment of three samples of inner-city boys in Grades 1, 4 and 7, oversampling for boys initially high in antisocial behaviour. There were approximately 500 boys in each sample. Five waves of data were collected at six-monthly intervals on all three samples, thus allowing assessment of behavioural trajectories from Grades 1 to 10 within three years. After this point, there were varying numbers and intervals of follow-up for each sample up to the age of 20 years. A further strength of this study has been its use of parallel instruments to a number of other large ongoing longitudinal studies conducted at other sites (for example, Rochester, Denver), leading to the compilation of across-study findings and facilitating value-adding, replication and increased statistical power.

Also listed in Table 3.3 is the Canadian National Longitudinal Survey of Children and Youth (NLSCY). Commenced in 1994, this is principally a single cohort study, but two samples of infants were added in the second and third waves, allowing it to be considered as a cross-lagged design. Further, it has potential to

Table 3.3. Some influential overseas longitudinal studies										
Study	Location	Year began	Sample size	Special criteria	Foci	Age at start	Follow ups	Age at last follow up	Data collection *	
<i>Sigle-cohort studies</i>										
Avon Longitudinal Study of Pregnancy and Childhood (ALSPAC) Golding 1990; Mumford 1999 www.ich.bris.ac.uk	England	1991	14,893		Environmental, social, psychological, biological and genetic influences	Pregnancy	18	9 years	MR; FR; SR; HP; HR; DA; BS; EA	
The Baltimore Study Kellam et al. 1994	USA	1985-1986	1,197	2-year intervention component for approximately half the sample	Early aggression and adolescent mental and behavioural disorders	Grade 1 (5.0 - 9.7 years)	5	11 - 16 years	EP; PeerR; SR; Obs	
Chicago Longitudinal Study Reynolds 1999	USA	1985-1986	1,539	High poverty neighbourhoods; 93% African-American; Intervention focus	Individual, family and school factors promoting educational success	Preschoolers	10	14 years	ParR; EP; SR; OR; Obs	
Finnish Family Competence Study Hyssala et al. 1993	Finland, single province	1986	1,443	Stratified randomised cluster sample	Health behaviours and outcomes of young Finnish families and children	Pregnancy	10	6 years	FR; MR; DA; HP	
Kauai Longitudinal Study Werner & Smith 1992	Kauai, Hawaii	1955	698	Ethnically diverse sample, about half living in poverty	Biological factors, environmental adversity and development	Birth	6	32 years, ongoing	MR; EP; SR; OR; DA	
Montreal Longitudinal-Experimental Study Tremblay et al. 1992	Canada	1984	1847	Over sampled low SES areas and disruptive children; includes intervention	Health risk behaviour, antisocial behaviour	Grade 1	6	16 years	MR; EP; SR; PeerR; OR	

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National Institute of Child Health and Human Development Study (NICHD) Study of Early Child Care http://www.nichd.nih.gov/about/od/secc/index.htm	USA	1991	1,364	10 sites across USA	Relationship between child care and child outcomes	Birth	11	3 years	MR; SR; DA; EP; PR if contact > 10hrs per week
Simmons Longitudinal Study Carbonell et al. 1998	USA	1975	763	Kindergarten sample; from one US school district	Emotional and behavioural disorders, risk and resilience	4 years	6	22 years	SR, MR, TR, OR
Seattle Social Development Project Hawkins, Catalano et al. 1992	USA	1981	808	Over sampled high crime areas; includes intervention	Risk and protective factors for delinquency and substance use	Grade 1	11	21 years	ParR; EP; SR,
Single-cohort studies, multiple ages at recruitment									
National Longitudinal Survey of Youth – Child Supplement (NLSY – CS) Baydar & Brookes-Gunn 1991; Garrett et al. 1994	USA	1986	4,953		Children of women in the NLSY	Children age from less than 1 year to 15 years	8	22 years	MR; SR; DA; HR; HP; EP; PR
National Longitudinal Survey of Children and Youth (Canada) NLSY Canada 1999 www11.hrdc-dihc.gc.ca/edd/NLSY.shtml	Canada	1994	22,861	Multi-aged sample	Range of factors influencing child growth and development, with reports from multiple sources	0-11	4	6 – 17 years	PR; MR; EP; HP; DA
Zuid, Holland; Verhulst, et al. 1993	Holland	1983	2,076	Multi-aged sample	Behavioural and emotional disorders, stability and change, risk factors, comorbidity	4 -16 years	3	10 to 22 years	ParR; DA; EP; SR

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Table 3.3 continued

Some influential overseas longitudinal studies									
Study	Location	Year began	Sample size	Special criteria	Foci	Age at start	Follow ups	Age at last follow up	Data collection *
<i>Cross-lagged or cross-sequential studies</i>									
Carolina Longitudinal Study Cairns & Cairns 1994	USA	1981-1983	695	Cross-sequential design	Development of antisocial and prosocial behaviour	2 cohorts; Grade 4 and Grade 7	7 or 9 waves	24 years	EP; SR; PeerR; IR; OR
Durham, North Carolina Coie et al. 1992	USA	1984, 1985	1,147	African-American sample, cross-lagged design	Early peer relationships aggression and adolescent disorders	2 cohorts, Grade 3	3	Grade 10	ParR; PeerR; SR
Oregon Youth Study Patterson et al. 1992	USA	1983-4; 1984-5	206	Cross lagged design	Individual and family contributions to maladjustment	2 cohorts; 9-10 years	6	23-24 years	MR; EP; SR; PeerR; DA; Obs
Pittsburgh Youth Study Loeber et al. 1998	USA	1987-1988	500	Cross-sequential design, inner city, half were antisocial	Protective and risk factors for delinquency	3 cohorts; Grades 1, 4 and 7	6	Grades 4, 7 and 10	ParR; SR
<i>Linked studies</i>									
European Longitudinal Study of Pregnancy and Childhood (ELSPAC) http://www.ich.bris.ac.uk/ELSPAC/	Greece, Britain, Czech Republic, Isle of Man, Russia, Slovakia, Ukraine	Various 1991-1995	Various From about 1,300 to 14,000		As for ALSPAC. Collaboration of studies, including ALSPAC, using same study design. Under umbrella of WHO, coordinated from Bristol.	Pregnancy	As for ALSPAC Some variation by study site	Various	As for ALSPAC Some variation by study site

Note: * BS = biological samples; DA = direct assessment; EA = environmental assessments (physical measures); EP = education professional; FR = father report; HP = health professional; HR = health records; MR = mother report; Obs = Observation; OR = other records (e.g. justice); PR = partner report; PeerR = Peer report; SR = self report.
Source: The authors, 2002.

be treated as a cross-sequential design because the wide age range of child participants at recruitment (newborn to 11 years) and large sample size (more than 22,000) will permit the examination of age, stage and time-of-measurement effects (although no such analyses appear to have been published as yet). The survey uses biennial assessments and aims to develop a national database of Canadian children's development and life experiences, and to examine the influence of various biological, social and environmental factors on development from birth to adulthood. It is designed to be large enough to capture national trends, as well as to provide sufficient power to support state or community level analyses, or analyses of particular sub-groups (Statistics Canada 1996).

One notable feature of these studies is the focus on maladjustment and poor health outcomes and this was also true of most of the studies in Table 3.2. Antisocial behaviour has been a very common focus, particularly in the United States. Few studies have seriously addressed developmental pathways to positive psychosocial outcomes, which can provide valuable knowledge about healthy environments and protective processes. An exception is the Kauai study (Werner and Smith 1992, see Table 3.3), which was ground-breaking in its attention to resilience in the face of adversity.

It is also notable that some studies, such as the Oregon Youth Study (Table 3.3), have adopted a more microanalytic methodology that has sacrificed breadth (sample size) for depth (intensive multi-method data collection). Arguably these studies have contributed as much to theory and practice as large-scale but less intensive studies. However, these studies are only informative about the determinants of relatively common outcomes, and the extent to which their findings can be generalised remains problematic. Ideally, funding should be sufficient to allow intensive data collections (depth) to occur with sufficiently large samples (breadth).

As with the Australian and New Zealand studies, international studies starting in later childhood or adolescence have often used schools as the sampling location. This has proved efficient and appropriate for some outcomes (for example, educational). However, school-based cohort studies do not lend themselves easily to data collection from multiple sources outside the school context (such as parents or communities), which is desirable both to establish validity and to tap the multiple contexts of a child's life.

It is also notable that some of these studies are examining areas that have not been well-addressed in Australian and New Zealand studies. These include: first, an examination of the role of fathers on child health and development, with direct data collection from fathers (for example, the Avon ALSPAC, the Finnish Family Competence Study, and the NICHD child care study); and second, more extensive measurement of environments outside the family home to determine the influence of these environments on health and development (for example, the NICHD child care study, and the Canadian National Longitudinal Study of Children and Youth).

While some Australian and New Zealand studies have incorporated collection of biological samples to analyse genetic influences (such as DNA) fairly late in the life of the study (for example, the Australian Temperament Project, and the Christchurch and Dunedin studies), some of the newer international studies are including a focus on this issue from the start (for example, the Avon ALSPAC). The last-mentioned study is also including collection of physical samples from

child-rearing environments (for example, measures of air quality) to examine the effects of specific exposures, something that has only been done locally in the narrowly-focused Port Pirie study.

New international studies

Some large scale birth cohort studies just getting underway in Scandinavia and the United Kingdom are also instructive regarding the future directions of overseas research. Planning for the Scandinavian studies began in the early 1990s. These studies include the Danish Birth Cohort Study, the Norwegian Mother and Child Cohort Study, and the Swedish Olive Tree Project.

Data collection for the Norwegian Mother and Child Cohort Study began in 1999. It is intended that 100,000 families will be recruited, representing about one-third of the eligible population (Wiik, personal communication, February 2001), and that it will cover the entire life span. The multidisciplinary team of investigators includes epidemiologists, statisticians, public health and primary health care researchers, and the project is administered by the Norwegian National Institute of Public Health. The overall aim is to identify environmental and biological factors that singly and jointly contribute to, or protect from, disease, adopting the perspective of gene/environment interactions. Biological samples and maternal and paternal interviews comprise the initial data. Although the research agenda is primarily biological and health focused, parental lifestyle measures will allow questions of environmental influences on psychosocial outcomes to be addressed at a broad level. A large number of sub-projects (69), including nested case-control studies, are to be embedded within the larger cohort study. Any research group with relevant questions is able, in principle, to participate (Lie, personal communication, February 2001).

The linked Danish Birth Cohort Study also has a proposed sample size of 100,000 families, recruited when women are 12 weeks pregnant. It has similar aims to the Norwegian study, namely the identification of environmental and biological determinants of health and disease. At last report 65,000 women had been recruited. Data so far comprise blood samples and interviews with mothers during and after pregnancy, and the emphasis is again on health outcomes.

While a Swedish study which was initially planned to be linked to these two did not eventuate, a similar project (named The Olive Tree Project to reflect the long time between “planting” and “harvesting”) is now in the planning stages, involving researchers from medicine, psychology and sociology (Lie, personal communication, February 2001).

In the United Kingdom, a new Millennium Cohort Study commenced in 2000–2001 (Kelly, personal communication, October 2000). This study involves researchers from the Department of Epidemiology and Public Health at the University College of London, in association with several other research centres, and is funded under a tender from the Economic and Social Research Council. The study aims to recruit 15,000 infants over a 12-month period from England, Scotland, Wales and Northern Ireland, with oversampling from the latter two countries. The sample is being drawn from national birth records at age eight months, using stratified sampling at the community level. Follow-ups are planned for ages two and four years. The study aims to examine a range of factors affecting child health and development with a focus on deprivation and community-level influences.

Discussion

From these reviews, it is possible to draw some lessons for the current Australian context. While the gains from the “first generation” of Australian and overseas longitudinal studies have been substantial, their contributions to current understanding of children’s health and wellbeing have been limited in a number of ways.

Generalisability and breadth of the research

Generalisability can be limited by sample characteristics and by time of measurement and cohort effects. In terms of sample characteristics, most of the Australian and New Zealand studies involve samples from specific geographical locations, with the only national studies being the short-term Plunket Study in New Zealand and the studies conducted by the Australian Council for Educational Research in Australia which have focused on youth educational and employment outcomes. In Australia, where different states and territories can have quite different policy and service provision environments, the results from studies based in one location may be criticised for having limited or unknown generalisability to the rest of population.

This problem is being addressed in a number of the large overseas studies. The Canadian National Longitudinal Survey of Children and Youth, for example, has been specifically designed to address regional differences and influences. The European Longitudinal Study of Pregnancy and Childhood group have taken a unique approach to this by attempting to link a series of studies with common designs but independent research teams across several countries. The new Millennium Study in the United Kingdom may also be informative for the Australian context as it faces the challenges of working across countries within the UK with different policy and health service environments.

The second concern is that findings from single-cohort designs may have limited relevance by the time the data are available. This is lessened with the more complex designs such as cross-sequential designs which can control for time of measurement and cohort effects. These designs have been under-exploited in Australia, but they offer substantial advantages in terms of providing timely policy-relevant information which is still informed by across-time data, and also providing a check of generalisability through comparisons of the various cohorts involved.

Financial constraints

Compared with United States, New Zealand, Canadian and Scandinavian studies, Australian studies have suffered from deficiencies and vagaries of funding. For many Australian studies, investigators reported that follow-up contacts occurred at intervals that were as much determined by funding availability as by scientific merit, and for some studies (for example, the Tasmanian study) funding was only obtained for follow-ups with partial samples. Funding limitations and lack of guaranteed continuity have created challenges in providing continuous employment for core researchers and other staff. In turn, this has resulted in problems retaining expertise, and has been reported by investigators to have severely limited the use of the data.

It is notable that four studies in Table 3.2 have achieved substantially higher publications rates than any of the other studies, regardless of duration. These are the Australian Temperament Project, the Christchurch and Dunedin studies,

and Longitudinal Surveys of Australian Youth, which to our knowledge are the only studies in the listing to have had ongoing funding for one or more core staff positions.

Funding issues are likely to become more critical for future longitudinal studies. Changes to the culture of modern Australian tertiary institutions are resulting in researchers with academic appointments having less time available to devote to long-term research activities (despite increasing pressures to undertake research). Future studies will benefit to the extent that their funding includes ongoing support for senior staff to undertake study coordination, data management, data analysis and writing.

Lack of studies addressing modern families and environments

The New Zealand and Canadian research communities (and funding bodies) in particular have shown an ongoing commitment to longitudinal studies commencing in early life. For instance, the original New Zealand studies that commenced in the 1970s have been supplemented by two new cohort studies, commencing in 1990 and 2000, although neither are national in scope. In contrast, in Australia, all the early childhood studies commenced within one decade (1979–1989) with no large new studies initiated since then.

More recent Australian studies have all commenced with older age groups, and the lack of studies commencing around school entry and the primary school years is notable (the exception being the Promoting Adjustment in Schools Study). Given the considerable changes occurring in family lives and child-rearing environments, the relevance of existing studies to future Australian generations will become increasingly limited. It is interesting to note here that a number of the large new overseas studies, including the Scandinavian and European studies, have a significant biomedical focus and may collect comparatively limited data on families and social environments.

Lack of power to detect complex interactions

Many of the overseas studies listed in Table 3.3 have considerably larger sample sizes than the Australian and New Zealand studies. This is particularly true of the new Scandinavian studies now underway. While many of the research questions that could be addressed by longitudinal designs do not require very large samples, increasingly our understanding of the complex etiology of childhood problems is leading in the direction of very large samples. Large samples are also required to gain insight into developmental pathways for rare outcomes.

However, with fixed funding, the breadth (sample size and representativeness) needs to be balanced against depth (intensiveness of data collection). Some methods of data collection are very costly, and where the researchers are interested in simple associations and relatively common events, data collection may not be required for all participants. In such instances, nested studies involving data collection from a sub-sample of the main study cohort may prove the most cost-efficient approach.

Lack of a broad, multi-contextual perspective

As discussed, many studies, especially the Australian studies, have tended to be relatively narrow in their initial focus. Few of the studies adequately measure influences across multiple domains, which is necessary if, for example, a biopsychosocial or transactional view of the developmental process is accepted. Among the current Australian studies initiated in early childhood, data collection

has focused primarily on individual child, parent and family factors, with few studies collecting substantial data from or about other sources of influence including fathers, child care settings, school settings, and communities, let alone broader socio-cultural influences. As noted, the adolescence-oriented studies have focused on the school and peer group as influences. Inclusion of intergenerational influences and the development of methods for assessing variability in influences across the lifespan are areas identified as requiring more consideration in the development of new studies (Lynch and Kaplan 2000).

A focus on the whole child in their whole social environment implies that the research team needs to be multidisciplinary, which brings with it a particular set of organisational and intellectual challenges. However, some of the new international studies (for example, the Canadian National Longitudinal Survey of Children and Youth) are providing models for how this can be accomplished.

Failure to fully exploit the longitudinal nature of the data

In the last decade there have been several notable advances in statistical techniques for analysing longitudinal data which can shed light on developmental patterns and pathways (for example, latent growth modelling, multilevel analysis) (Hair et al. 1995; Stoolmiller 1995). Understandably, relatively few of the studies to date have fully exploited the opportunities offered by these techniques. Given current understandings of the complexity of causal pathways and the multiple trajectories that children can follow, new studies should be designed to take advantage of these analytic opportunities, supported by a research team possessing the statistical expertise to use the analytic techniques effectively.

Failure to make systematic comparisons across studies

Most of the studies reviewed have operated in isolation from each other, hence there are too many non-replicated findings which may be cohort-specific. Close coordination across studies would be highly advantageous. For example, recent comparison of data in the Dunedin study and the Australian Temperament Project (McGee et al. in press), where there has been overlap on several measurement domains, has demonstrated replication of findings across the two studies. The NICHD multi-site study, the Pittsburgh Youth Study, and the European Longitudinal Study of Pregnancy and Childhood are international examples of the deliberate use of common instruments and methodologies to allow testing of replicability.

Opportunities for greater cross-study comparison may be facilitated by making the study design details and measurement instruments publicly accessible. Several international studies (for example, the Canadian National Longitudinal Survey of Children and Youth, the Avon ALSPAC, and the NICHD child care study) have made their instruments available on the web (see Table 3.3 for addresses).

Conclusion

Notable lessons that can be learned from the new international studies include:

- the long time required for planning theoretically well-grounded, relevant, large-scale research (as illustrated by the Scandinavian studies);
- the extremely large sample sizes required to study the development of low-prevalence outcomes and to model multiple determinants across the life-course;

- the value of matching data collection approaches across studies to enable analysis of replicability;
- the recognition of the importance of a partnership of researchers across a broad spectrum of disciplines to address the complex research questions now confronting us; and
- the challenges of covering all domains adequately and of coordinating multidisciplinary, cross-sectoral research teams, demanding strong central leadership.

Several additional observations can also be made. First, the particular research questions to be addressed by a study should be the drivers in determining where the balance between depth and breadth should lie. For some questions, intensive investigation of small samples has been very effective in providing policy-relevant information. Similarly, studies with intervention components have been able to contribute to knowledge effectively. Second, the research questions of interest, the demands of the policy environment, and the resources available should drive decisions about the appropriate longitudinal design to adopt. Finally, creativity and attention to theory are needed in deciding on the most useful outcomes to study. The typical focus on “things that go wrong” has often blinded researchers to the lessons to be learnt from “things that go right” – that is, on the requirements for healthy development and resilience.

Well-designed and well-funded longitudinal studies have consistently proved to be invaluable information resources for tracking changes in health and wellbeing across the lifespan, and for identifying the factors (and combinations of factors) that cause poor outcomes or that protect individuals from harm. While relatively few in number, past Australian longitudinal studies have made important contributions to our knowledge of the factors that influence health and wellbeing. Moreover, these studies have been ongoing over a longer period of time, and have collected a breadth of data beyond that envisioned at the outset, informing social and public policy across a range of welfare, health, education and other domains.

In conclusion, Australia has not had a broadly focused, *national* study that has tracked the developmental health and wellbeing of young Australians and their families over time. It appears timely that we embark on such a study. International experience is providing valuable pointers regarding “who” should conduct such a study (a well-coordinated multidisciplinary and cross-sectoral team), “how” it should be conducted (on a large scale, taking a long-term perspective, and with appropriate resources), and “what” should be the foci (a broad range of positive as well as problematic health and developmental outcomes).

Given the major changes in Australian society in recent years, and recent advances in scientific thinking and methodologies, a study of this sort could promise to deliver valuable new knowledge about developmental processes which can guide and inform policy.

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Longitudinal Surveys of Australian Youth (LSAY)
www.acer.edu.au/research/vocational/lsay/intro.html

National Institute of Child Health and Human Development Study (NICHD)
Study of Early Child Care
<http://www.nichd.nih.gov/about/od/secc/index.htm>

National Longitudinal Survey of Children and Youth (NLSCY)
<http://www.hrhc-drhc.gc.ca/nlscy-elnej/home.shtml>

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