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School starting age and child development in a state-wide, population-level cohort of children in their first year of school in New South Wales, Australia

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A B S T R A C T

In Australia's most populous state, New South Wales (NSW), children born between January and July have the choice to start school in the year they turn five, or delay entry until the year they turn six. We used linked administrative data for children who started school in NSW in 2009 or 2012 (N = 162,878) to identify child, family and area characteristics associated with delayed entry, and to explore the relationship between school starting age and five domains of child development, measured using the Australian Early Development Census (AEDC) in the first year of school. Among both the 2009 and 2012 cohorts, 26% of children delayed starting school until the year they turned six. Area-level rates of delay ranged from 8% to 54% across 198 areas in NSW, with lower levels in disadvantaged urban areas. Factors associated with delayed entry included male sex, a birth date close to the enrolment cut-off date, socioeconomic advantage, and having a mother born in Australia. There was a strong, significant relationship between school starting age and early childhood development: each month of maturity corresponded to an increase of approximately 3% in the probability of scoring above the 25th percentile in all five AEDC domains. Independent of school starting age, children who were older in relation to their classroom peers had better development outcomes. The potential for initial age-related differences to impact later school outcomes warrants further longitudinal research.

The best age to start formal schooling is a topic of recurring debate among parents, educators and policy makers, as reflected in the array of school starting age policies internationally. Delaying school entry, often referred to as 'holding back' or 'academic redshirting', is common in countries where there is flexibility to do so. Recent estimates of the incidence of delayed entry range from 2% to 8% in the United States of America (USA) (Bassok & Reardon, 2013; Fortner & Jenkins, 2017; Huang, 2015). Rates are notably higher in some Australian states: data from the Longitudinal Study of Australian Children found that, nationally, 14% of the 2005 school cohort delayed school entry, with estimated rates particularly high in New South Wales (NSW) where 31% of the study cohort were delayed (Edwards, Taylor, & Fiorini, 2011).

The practice of delayed school entry is ostensibly driven by the perception that children are better off starting school at an older age. Accordingly, some parents may delay school enrolment due to concerns about their child's school readiness—especially for younger children or boys, who are perceived to develop more slowly (Mergler & Walker, 2017; Noel & Newman, 2003; Serry et al., 2014). Other parents may delay simply to give their child the advantage of being among the older classroom members (Fortner & Jenkins, 2017). Research studies which control for selection effects consistently find that in the first few years of school older children do have better academic and socio-behavioural outcomes compared to their younger peers (Crawford, Dearden, & Meghir, 2010; Datar, 2006; Datar & Gottfried, 2015; Dee & Sievertsen, 2015; Dhuey & Lipscomb, 2010; Lubotsky & Kaestner, 2016). It is less

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clear, however, whether these initial age-related differences have any long-term impact. Some studies have found that younger children quickly catch up with their older peers (Buddelmeyer & Le, 2011; Datar & Gottfried, 2015; Lincove & Painter, 2006; Lubotsky & Kaestner, 2016; Martin, 2009), while other studies have found that, although initial gaps narrow over time, they can persist throughout schooling and even into early adulthood (Bedard & Dhuey, 2006; Black, Devereux, & Salvanes, 2011; Clarke, Crawford, Steele, & Vignoles, 2015; Fredriksson & Öckert, 2006; Kawaguchi, 2011).

The present study is set in Australia's most populous state, NSW. Delayed school entry is relatively common in NSW, and the enrolment eligibility criteria result in a range of eighteen months between the youngest and oldest school starters. We use linked administrative data for children who started school in NSW in 2009 or 2012 to address several research aims relating to school starting age. First, we document the child-, family- and area-level characteristics associated with the decision to delay entry in NSW. Second, we investigate the relationship between school starting age and a child's development in their first year of school. Third, we examine the relative contribution of initial school starting age and relative age in the classroom to children's development assessment.

1. Background

1.1. The decision to delay school entry

Not all children are equally likely to delay school entry. Across multiple studies, a consistent picture has emerged: the propensity to delay is higher for boys, children born closer to the enrolment cut-off, children from more economically advantaged backgrounds, native English speakers in the USA and Australia, and—in the USA—White rather than Black, Asian or Hispanic children (Bassok & Reardon, 2013; Edwards, Taylor, & Fiorini, 2011; Fortner & Jenkins, 2017; Graue & DiPerna, 2000; Herbst & Paweł, 2016; Huang, 2015; Winsler et al., 2012; Yeşil Dağli & Jones, 2012).

Fortner and Jenkins (2017) discuss two mechanisms which drive these patterns: negative and positive selection. Negative selection is the practice of delaying a child's school entry due to developmental concerns. Typically, parents of school-aged children informally assess their child's school readiness, and some schools also rely on formal assessments such as interviews or competency checklists. Children who are perceived to be less ready for school—often relatively young children and boys—are sometimes held back for an additional year as a result (Mergler & Walker, 2017; Noel & Newman, 2003; Serry et al., 2014). In contrast, positive selection refers to children who are delayed because of the perceived benefits of being older at the start of school. By delaying school entry, parents may bestow their child with an early advantage relative to their peers—the "gift of time" (Graue & DiPerna, 2000). However, delayed entry typically incurs a cost, either in additional childcare fees or lost wages, and for this reason positive selection may be less likely among lower income families (Bassok & Reardon, 2013). Several recent studies have found evidence of both positive and negative selection practices in the USA (Bassok & Reardon, 2013; Fortner & Jenkins, 2017; Huang, 2015). Huang (2015) found that in the state of Virginia, children with disabilities were twice as likely to delay school entry compared to students without an identified disability—an example of negative selection. Fortner and Jenkins (2017) found evidence of positive selection in North Carolina: children who delayed school entry were more likely to be academically or intellectually gifted compared to similar students who enrolled in kindergarten as scheduled.

While the discussion of positive and negative selection focuses on motivations to self-select into delayed entry, other mechanisms potentially encourage families to enrol their children as early as possible. For example, economic pressures might make early schooling an attractive option for disadvantaged families, as schools may offer access to free school meals and other resources, as well as forego costly preschool or childcare (Bassok & Reardon, 2013; Suziedelyte & Zhu, 2015). Where access to affordable high-quality preschools is limited, students with English as a Second Language (ESL) may benefit from being immersed in an English-speaking school environment earlier rather than later. Finally, children with cognitive and learning disabilities may benefit from starting school as soon as they are eligible so that their needs can be identified and supported from an earlier age (Fortner & Jenkins, 2018).

1.2. The effects of school starting age

Research suggests that, in the early school years, older children have an advantage compared to their younger peers, with more positive outcomes in cognitive (Altwicker-Hámori & Köllő, 2012; Black et al., 2011; Datar, 2006; Fortner & Jenkins, 2017; Fredriksson & Öckert, 2006; Herbst & Paweł, 2016; McEwan & Shapiro, 2008; Ponzo & Scoppa, 2014; Puhani & Weber, 2007), behavioural (Datar & Gottfried, 2015; Frazier-Norbury et al., 2015), and mental health measures (Dee & Sievertsen, 2015; Goodman, Gledhill, & Ford, 2003; Morrow et al., 2012).

It is less clear to what extent the initial disparity between younger and older school starters dissipates over time. Many studies have found that initial gaps do narrow, but that significant differences can persist throughout middle school (Bedard & Dhuey, 2006; Black et al., 2011; Clarke et al., 2015; Fredriksson & Öckert, 2006; McEwan & Shapiro, 2008; Puhani & Weber, 2007). For example, across OECD countries the estimated effect associated with a one-year increase in age on math and science scores ranged from 0.2 to 0.4 standard deviations (SD) at age nine, dropping to 0.1 to 0.2 SD by age 13 (Bedard & Dhuey, 2006). Comparable results have been found independently in several countries, using a variety of data sources and cognitive educational outcomes, including Germany (Puhani & Weber, 2007), Sweden (Fredriksson & Öckert, 2006), Chile (McEwan & Shapiro, 2008), England (Clarke et al., 2015), Norway (Black et al., 2011), Japan (Kawaguchi, 2011), Hungary (Altwicker-Hámori & Köllő, 2012), Italy (Ponzo & Scoppa, 2014), and Poland (Herbst & Strawinski, 2016). Some studies have also found evidence of school starting age effects persisting beyond adolescence with modest impacts on early adulthood outcomes, notably college participation rates (Bedard & Dhuey, 2006; Black et al., 2011; Clarke et al., 2015; Fredriksson & Öckert, 2006; Kawaguchi, 2011).

In contrast, other studies have found that early age-related differences—if present at all—quickly subside. For example, using nationally representative longitudinal survey data on over 15,000 American children, Lubotsky and Kaestner (2016) reported that after first grade, academic gaps closed between younger and older children. Datar and Gottfried (2015) reported a similar pattern of results for socio-behavioural outcomes. In a sample of nearly 4000 students aged 12 to 18 from seven Australian high schools, Martin (2009) found that being old for cohort was in fact associated with worse scores on measures of motivation, engagement and academic performance. Studies from the USA (Lincove & Painter, 2006) and Australia (Buddelmeyer & Le, 2011) have found no association between school age and college participation.

1.3. How age affects later outcomes

Researchers have proposed several mechanisms to explain why being older at the start of school may be beneficial. Hypothesised pathways include the effects of initial age, test age and relative age

(Cascio & Schanzenbach, 2016; Clarke et al., 2015; Fortner & Jenkins, 2017; Marsh, 2016).

The initial age effect is concerned with a child's age when they first enter school. In a series of papers, Cunha, Heckman and colleagues have argued that children's development is a cumulative and synergistic process whereby early skills foster later skills (Cunha & Heckman, 2007; Cunha, Heckman, & Schennach, 2010; Cunha, Heckman, Lochner, & Masterov, 2006). This theory emphasises the key role of complementarities in skill formation: non-cognitive skills such as perseverance can complement the formation of cognitive skills such as reading, and skills mastered early in life lay the foundation for later skills. Thus, children starting school before reaching a critical development stage may not have the requisite initial skills to successfully transition to formal schooling and thrive in their new environment, with cumulative effects for each subsequent year. Research evidence suggests that skill gaps that start early persist throughout childhood (Cunha et al., 2006). In Australia, for example, children who are assessed as developmentally vulnerable in the first year of school have worse outcomes in standardised reading and numeracy tests at ages 8, 10 and 12 (Brinkman et al., 2013).

Closely related to the initial age effect is the test age effect: children who start school at a younger age may be disadvantaged simply because they are chronologically younger, and therefore less developed, at each point they are assessed throughout their schooling. In jurisdictions with a fixed schedule of schooling, the effects of initial age and test age are highly correlated because test age equals initial age plus duration of schooling. The two effects can be separated when children repeat grades, or when assessments are not at a fixed point in time.

A third theorised mechanism through which school starting age may affect later outcomes is a child's age relative to their classroom peers. There are several competing theories for how relative age may advantage or disadvantage younger classroom members. Positive relative age effects may arise if being surrounded by older, more mature peers promotes better outcomes for younger children. Possible negative relative age effects could operate through the teacher or directly through the child. Teacher-driven mechanisms include ability-grouping, whereby younger children are clustered in lower-skill groups, leading to different educational opportunities (Campbell, 2013). There may also be negative implications for relatively younger children if teachers' norms and expectations around development and behaviour are benchmarked against older classroom members. This mechanism may explain the internationally-observed trend for higher rates of ADHD diagnosis and treatment among relatively younger classroom members (Elder, 2010; Morrow et al., 2012; Whitely, Lester, Phillimore, & Robinson, 2016; Zoëga, Valdimarsdóttir, & Hernández-Díaz, 2012). Negative relative age effects may also be shaped by children's frame of reference when making social comparisons, with the tendency for relatively young children to negatively compare themselves to their older classroom peers (Marsh, 2016).

Empirical research findings on relative age effects have been mixed. Fortner and Jenkins (2017) analysed state-wide administrative data on over 276,000 children from North Carolina and found that the proportion of delayed entrants in a classroom had no effect—positive or negative—on children's math and reading scores in third grade. Cascio and Schanzenbach (2016) explored relative age effects using novel data from a randomised experiment where children of the same age were randomly assigned to different classrooms, resulting in exogenous variation in relative age. They found that, comparing children of the same age, those with older classroom peers had higher tests scores up to eight years after kindergarten, and were more likely to apply for college. The authors concluded that, although the presence of older classmates seemed to benefit younger children, this benefit did not outweigh the penalty associated with being younger in absolute terms. In contrast, Marsh (2016) found evidence of negative relative age effects in most of the 41 countries participating in the 2003 Programme for International Student Assessment (PISA). In this study, students' academic self-concept—their self-belief in their own skills—was lower when surrounded by relatively older peers. This finding has been replicated using cross-sectional Australian data (Parker, Marsh, Thoemmes, & Biddle, 2018) and longitudinal data on German adolescents (Marsh et al., 2017).

The effects of initial age, relative age and test age typically arise in parallel—children who delay school entry will have an older initial age and be relatively older compared to their peers, for example. Consequently, it is usually difficult to attribute observed differences between younger and older students to any single cause. It is likely that these mechanisms interact in varied ways for different children. Attempts to separate these mechanisms suggest that absolute age—the combination of initial age and test age—is more important than relative age (Cascio & Schanzenbach, 2016; Elder & Lubotsky, 2009; Fredriksson & Öckert, 2006). Although the constituent effects are difficult to disentangle, doing so is of interest to parents and policy-makers. For example, the effects of relative age may be of interest to parents—even when parents don't delay their child's enrolment, other parent's decisions affect their child's relative age in the classroom. Policy discussions are primarily concerned with initial age effects, which are amenable to manipulation by raising or lowering the school entry age. Although it is often overlooked, policy decisions can also influence relative age effects. Any practical system of forming educational cohorts will result in an age variation in the classroom, but the degree of relative age differences can be influenced by broadening or narrowing the permissible age range for enrolment.

1.4. Starting school in NSW

Australia is divided into six states and two territories, with each jurisdiction taking responsibility for educational policy, including rules around school enrolment. Our study focuses on the most populous state, NSW, where the first year of formal schooling is referred to as Kindergarten. The Australian school year runs between late January and mid-December, and in NSW, children can start school in January provided they turn five on or before July 31st of that year. Children born between January and July are eligible to delay enrolment until the following year, starting school in the year they turn six, and the decision to delay rests with the child's parents or guardians. This means, for example, that a July-born child is equally eligible to start school among the youngest in their cohort, aged four years and six months, or wait an additional year and start among the oldest, aged five years and six months. Barring exceptional circumstances, children born August to December do not have the choice to delay school entry and must start school in January of the year they turn six.

The NSW enrolment policy has tangible impacts on classroom composition. Children born January to July who enrol when they first become eligible, aged four years six months to five years, are among the youngest children to enter formal primary education internationally (The World Bank, 2017). In addition, the policy allows a gap of up to 18 months between the youngest and oldest eligible children in a cohort. This variation in absolute and relative ages has consequences for teachers, children and parents. Teachers need to account for a diverse range of ages, abilities and development in the classroom; the youngest children must compete with peers up to eighteen months their senior; and parents face a difficult decision about whether their child is ready for school (Mergler & Walker, 2017).

The consequences of the NSW enrolment policy are poorly understood. If children from more advantaged families—who can better afford the cost of an additional year of preschool—are more likely to delay school entry, this may further contribute to inequities in early life outcomes between children from advantaged and disadvantaged backgrounds. This may include Indigenous Australian children, who are more likely to experience disadvantage in early childhood (Commonwealth of Australia, 2017) and are less likely to attend preschool (Biddle, 2007; O'Connor et al., 2016). Moreover, if there is a trend towards children starting in the first year they are eligible in more disadvantaged areas, the effect of a cluster of younger school starters, particularly coupled with other risk factors for poor education outcomes, may compound the effect of the child's school starting age on development outcomes.

1.5. Study approach

In this study, we begin by describing the distribution of school starting age across NSW and document the child-, family- and area-level factors associated with selection into delayed school entry in NSW Australia in 2009 and 2012. To achieve this first aim we use data for the subgroup of children born January to July who were eligible to start school either in the January of the year they turn five or the year they turn six. We then examine the association between age and early childhood development midway through the first year of school. To this end, we use a population measure of development which encompasses multiple domains related to school readiness (Janus & Offord, 2007) and is highly correlated with later academic outcomes (Brinkman et al., 2013). To avoid selection bias, we address this question primarily using data on the subgroup of children born August to December who were not eligible to delay school entry. Finally, we attempt to disentangle the relative importance of initial school starting age and relative age on a child's development in their first year of school. Different sources of variation allow us to separate these constituent effects. The first source of variation is the combination of birth month and selection into delayed entry, which results in a wide range of initial ages among children starting school in NSW. The second source of variation stems from the variable age composition of classrooms, which means that children with the same school starting age can have different relative ages with respect to their average classroom age. The final source of variation arises from the timing of the development census, which is completed at different dates during the second term of children's first year in school. Thus, unlike many settings, starting age and test age are not perfectly correlated.

2. Materials and methods

2.1. Data sources

This study used multiple cross-sectoral administrative datasets from the Seeding Success data resource (Falster et al., 2015, 2017), with information on individual children combined using probabilistic data linkage. Data on children starting school in NSW in 2009 or 2012 were available from the Australian Early Development Census (AEDC), a census of early childhood development carried out every three years since 2009 (Brinkman, Gregory, Goldfeld, Lynch, & Hardy, 2014; Janus et al., 2016Janus, Harrison, Goldfeld, Guhn, & Brinkman, 2016). Linked perinatal and early childhood information for children born in NSW was available from multiple routinely-collected administrative datasets, including the following used in this study: the NSW Births, Deaths and Marriages birth registration data (RBDM), the NSW Perinatal Data Collection (PDC), the NSW Admitted Patient Data Collection (APDC), the NSW Emergency Department Data Collection (EDDC), and the NSW Public School Enrolment data (PSE).

2.2. Participants

Participants included children starting school for the first time in NSW in either 2009 or 2012, with available date of birth information. The Seeding Success data resource includes 181,373 linked records for children starting school in 2009 or 2012. Comparing to publicly available data on kindergarten enrolments from the Australian Bureau of Statistics, this corresponds to approximately 98% of 2009/2012 school starters (Australian Bureau of Statistics, 2015). From this total we excluded 4709 children who were repeating kindergarten, 58 children with an implausible school starting age of less than four years or greater than seven years old, and 13,728 children for whom date of birth information was unavailable. Date of birth was missing for children who were born outside of NSW and did not have a linked NSW emergency department or hospital visit during early childhood. We used the data on the remaining 162,878 children—referred to as the NSW AEDC-Births dataset—to describe the overall patterns related to school starting age at a state, area and classroom level.

For more in-depth multivariate analyses, we restricted the sample to children who were born in NSW and enrolled in a NSW public school because key socio-demographic and perinatal information were collected and available for these children. To this end, we excluded 13,061 children who were born interstate or overseas and thus did not have linked perinatal data, and 44,817 children who attended a non-public school (Catholic or Independent) and did not have family-level socioeconomic information captured in the Public School Enrolment data. We also excluded 1208 children who started school outside of the mandated age range of four years six months to six years old. Such exemptions are occasionally granted for children with special needs or major health issues, or for intellectually gifted children who can be considered for early enrolment from age four. The restricted dataset, which we refer to as the study population, comprised 104,356 children—approximately 80% of 2009 and 2012 NSW public school enrolments. In terms of fully-observed demographic data, the profile of the NSW AEDC-births dataset and the study population were broadly similar (Online Supplemental Material, Table 1). Additional exclusions for specific sub-analyses are noted in the results section, but of particular interest, children with special needs were excluded in all models of the development outcome, because the AEDC instrument was not validated for this population. For the AEDC, children with special needs are those medically diagnosed as having additional needs due to chronic medical, physical or intellectually disabling conditions (e.g. Cerebral Palsy, Down Syndrome).

2.3. School starting age

School starting age was defined as the child's age in months and years in the January of their first year in school, noting that school usually commences at the end of January in NSW. We distinguished between three possible enrolment categories: children who started in the year they first became eligible (born January to July, and aged four years six months to five years at the start of school, $N = 35{,}650$); compulsory starters, who had no choice about their year of enrolment (born August to December, and aged five years one month to five years five months at the start of school, $N = 42{,}982$); and those who delayed the start of school until the second year they were eligible (born January to July, and aged five years six months to six years at the start of school, $N = 25{,}724$).

2.4. Child development outcomes

Early childhood development outcomes were measured in the AEDC using the Australian version of the Early Development Instrument (AvEDI), adapted from Canada (Janus & Offord, 2007), which

Table 1
Study population characteristics, and the proportion of delayed entrants (N = 104,356).

Variable	Category	N	Column %	% postponed
Total		104,356	100.0	24.7
Month of birth	January	8,742	8.4	9.6
	February	8,104	7.8	16.2
	March	9,123	8.7	27.9
	April	8,626	8.3	40.5
	May	8,944	8.6	55.3
	June	8,571	8.2	67.1
	July	9,264	8.9	73.8
	August	8,907	8.5	0.0
	September	8,962	8.6	0.0
	October	8,948	8.6	0.0
	November	8,086	7.8	0.0
	December	8,079	7.7	0.0
Sex	Male	53,643	51.4	28.1
	Female	50,713	48.6	21.0
Aboriginality[a]	Non-Aboriginal	96,762	92.7	24.7
	Aboriginal	7,594	7.3	24.2
Maternal age at childbirth (years)	<20	4,531	4.3	21.8
	20–24	16,463	15.8	21.7
	25–29	28,544	27.4	25.0
	30–34	33,580	32.2	25.9
	35+	21,234	20.4	25.1
	Missing	4	0.0	25.0
Mother's region of birth	Oceania and Antarctica[b]	80,465	77.1	27.5
	North-West Europe	3,656	3.5	26.0
	Southern and Eastern Europe	1,666	1.6	21.3
	North Africa and Middle East	3,646	3.5	7.0
	South-East Asia	5,170	5.0	10.8
	North-East Asia	3,900	3.7	13.1
	Southern and Central Asia	3,070	2.9	8.6
	Americas	1,317	1.3	23.0
	Sub-Saharan Africa	953	0.9	23.3
	Missing	513	0.5	31.2
Private patient/insurance at childbirth	No	71,083	68.1	23.1
	Yes	32,184	30.8	27.9
	Missing	1,089	1.0	27.5
Mother married/partnered at childbirth	No	19,218	18.4	24.0
	Yes	81,940	78.5	24.7
	Missing	3,198	3.1	26.7
Mother smoked during pregnancy	No	85,442	81.9	24.5
	Yes	17,156	16.4	24.8
	Missing	1,758	1.7	31.1
Antenatal care in first 20 weeks of pregnancy	No	11,544	11.1	22.0
	Yes	90,467	86.7	25.1
	Missing	2,345	2.3	20.2
Plurality	Singleton	100,261	96.1	24.5
	Twin/triplet	3,073	2.9	29.3
	Missing	1,022	1.0	29.5
Small for gestational age	No	91,693	87.9	24.6
	Yes	11,537	11.1	24.7
	Missing	1,126	1.1	28.7
Preterm birth (<37 week's gestation)	No	96,473	92.5	24.3
	Yes	6,839	6.6	28.3
	Missing	1,044	1.0	29.0
Resuscitated at birth	No	96,409	92.4	24.4
	Yes	6,717	6.4	27.2
	Missing	1,230	1.2	28.7
Admitted to NICU/SCN[c]	No	86,856	83.2	24.2
	Yes	16,347	15.7	26.4
	Missing	1,153	1.1	31.0
Maternal comorbidities during pregnancy[d]	No	92,016	88.2	24.6
	Yes	11,318	10.9	24.3
	Missing	1,022	1.0	29.5
Maternal school education[e]	≥10 years	89,443	85.7	25.1
	≤9 years	5,829	5.6	19.2
	Missing	9,084	8.7	23.6
Highest level of occupation of either parent[e]	Grades 1-3	71,709	68.7	25.9
	Grade 4/unemployed	25,331	24.3	21.5
	Missing	7,316	7.0	23.6
English as a second Language[f]	No	86,664	83.1	27.6
	Yes	17,692	17.0	10.2
Medically diagnosed special needs[g]	No	99,928	95.8	24.0
	Yes	4,428	4.2	39.1
Additional health and developmental needs[h]	No	88,324	84.6	23.8
	Yes	16,032	15.4	29.1

Table 1 (*Continued*)

Variable	Category	N	Column %	% postponed
Preschool[f]	No	25,384	24.3	18.5
	Yes	72,092	69.1	27.2
	Missing	6,880	6.6	20.6
Remoteness[i]	Major city	63,496	60.9	20.4
	Inner regional	29,600	28.4	31.2
	Outer regional	10,367	9.9	32.0
	Remote/very remote	893	0.9	26.2
Area-level disadvantage quintiles[j]	Q1 (Most disadvantaged)	10,192	9.8	21.8
	Q2	12,009	11.5	29.8
	Q3	36,882	35.3	24.2
	Q4	21,330	20.4	24.3
	Q5 (Most advantaged)	23,943	22.9	24.4
Census year	2009	49,625	47.6	24.6
	2012	54,731	52.5	24.7

[a] Defined as child or parent identified as Aboriginal on any of PDC, RBDM or APDC birth records, or AEDC school record.
[b] 95% Australia, 3% New Zealand, 2% Other.
[c] Neonatal Intensive Care/Special Care Nursery.
[d] Includes pre-existing and gestational-onset diabetes and hypertension.
[e] As reported by parent(s)/guardian(s) as part of the school's enrolment process.
[f] Based on the teacher's knowledge of the child or prefilled with information collected as part of the school's enrolment process.
[g] Children medically diagnosed as having high needs requiring special assistance due to chronic medical, physical or intellectually disabling conditions.
[h] A condition or impairment that influences the child's ability to do schoolwork in a regular classroom, including physical, visual, hearing, speech, learning, emotional or behavioural problems.
[i] Accessibility/Remoteness Index of Australia (ARIA+) based on child's statistical local area of residence at the start of school.
[j] Socio-Economic Indices for Areas (SEIFA) Index of Relative Socio-economic Advantage and Disadvantage population quintiles based on child's statistical local area of residence at the start of school.

comprises more than 100 items, and was completed by the child's teacher in the second term of the child's first year of full-time school (Brinkman et al., 2014). The AvEDI provides a population measure of early childhood development which underpins policy and planning at a national and community level. Five development domains are assessed: (1) physical health and wellbeing (e.g. would you say this child is well coordinated?); (2) social competence (e.g. how would you rate this child's ability to get along with peers?); (3) emotional maturity (e.g. would you say that this child is upset when left by parent/guardian?); (4) language and cognitive skills (e.g. would you say this child is able to attach sounds to letters?); and (5) communication skills and general knowledge (e.g. how would you rate this child's ability to tell a story?). These domains reflect dimensions underlying school readiness and have undergone rigorous psychometric development, including adaption for use among Aboriginal Australian children (Janus & Offord, 2007; Silburn et al., 2009).

AEDC outcomes are usually reported in terms of standard developmental categories, which are adjusted for the child's year of age at the time of assessment. To avoid this age adjustment, which would attenuate the relationship of interest between school starting age and development in our analysis, we derived analogous categories based on the raw domain scores which were not adjusted for age. Following the national standard definition of "on-track" development (Brinkman et al., 2014), we dichotomised the raw scores to identify children who scored above the 25th percentile in each domain, based on 2009 cut-offs. Children with scores in this range were considered to be developing as expected for the domain in question. We also analysed a composite binary outcome defined as children scoring above the 25th percentile in all five domains (henceforth referred to as 'positive development').

2.5. Covariates

Sociodemographic covariates available, or derived, from the linked data sources included child's sex, Aboriginality, English as a second language (ESL), presence of medically diagnosed special needs, presence of additional health/development needs, mother's age, region of birth, marital status and level of education, and parental occupation. ESL status was provided in the AEDC and based on the teacher's knowledge of the child or prefilled with information collected as part of the school's enrolment process. Mothers who left school before Year 10, the final year of compulsory schooling in Australia, were defined as having low maternal education. Parental occupation was based on the Australian Standard Classification of Occupations, a categorical skills-based taxonomy, ranging from 1 (highest) to 4 (lowest), with a fifth group for unemployed. For this study, low occupation level was defined as both parents (or a single parent in the case of one-parent families) being unemployed or working in the lowest skills category.

Available birth and perinatal covariates included mother and child's private health insurance/patient status at time of birth, receipt of antenatal care before 20 weeks' gestation, smoking during pregnancy, number of previous pregnancies, plurality, preterm birth (<37 weeks gestation), small for gestational age, 5-min Apgar score (a summary score of newborns health taken five minutes after birth), admission to special care nursery/neonatal intensive care unit (NICU) at birth, resuscitation at birth and maternal comorbidities during pregnancy (including pre-existing and gestational hypertension and/or diabetes).

Area-level variables were defined in terms of the child's statistical local area of residence (Australian Bureau of Statistics, 2010) when they started school (hereafter 'area'), and included remoteness, ascertained through the Accessibility/Remoteness Index of Australia (Australian Institute of Health & Welfare, 2004) and relative socioeconomic status, classified in quintiles of the ABS Index of Relative Socio-economic Advantage and Disadvantage (Australian Bureau of Statistics, 2011). More details on these variables are included in the footnotes to Table 1. Other area-level variables, derived using Census 2011 data and extracted using TableBuilder software (www.abs.gov.au/tablebuilder), included average income, unemployment, home ownership, education, and occupation.

Classroom-level variables were derived by aggregating children's data to the classroom level, using the encrypted teacher identifier available in the AEDC dataset as a proxy for classrooms. The following classroom-level proportions were calculated: male sex, Aboriginality, maternal age $\leq$19, mother born overseas, English as a second language, attended preschool in the year prior to kindergarten, low maternal education, and low ranking/unemployed parental occupation.

3. Statistical methods

3.1. Geographic and social variation in the tendency to delay the start of school

Statistical analyses were performed using Stata V12 (StataCorp, 2011). Descriptive statistics, including the median, minimum, maximum and inter-quartile range, were used to summarise the distribution of school starting age and the age range in classrooms. The proportion of students who delayed the start of school until the year they turned six (henceforth 'delayed') was calculated at a state level, and across 198 local areas in NSW. To describe the social and geographic variation in school starting age across NSW, the area-level statistics were (i) mapped and (ii) presented in scatterplots against the proportion of the area with low income. Logistic regression was used to estimate the crude and adjusted odds ratio of delayed entry associated with the characteristics of children, families and the areas where they live. This analysis was restricted to the subgroup of children, born January to July, who were eligible to delay school entry.

3.2. The relationship between school starting age and early childhood development

For each month of school starting age from four years six months to six years we calculated the proportion of children who scored above the 25th percentile on the individual domains of development, and in all five domains (the composite outcome of positive development). Logistic regression was used to model the association between school starting age and positive development. The model was fitted separately within the three categories of school starting age: those starting in the first year of eligibility, compulsory starters, and those delaying until the second year of eligibility. This model had the general form

$$logit\left(y_{ij}\right) = \beta_0 + \beta_1 a_{ij} + \boldsymbol{\beta}\mathbf{X}'_{ij} + u_j \mid Category_k \; (k = 1, 2, 3)$$

where y_{ij} is a binary indicator for child i in classroom j scoring above the 25th percentile in all domains, β_0 is the model intercept, a_{ij} is school starting age with corresponding parameter β_1, $\mathbf{X}$ is a vector of child family and area level statistical controls, with coefficient vector $\boldsymbol{\beta}$, and u_j are classroom terms. The classroom terms were alternatively treated as fixed or random effects, discussed in more detail later. The three categories $k = 1, 2, 3$ correspond to the three categories of school starting age, with the expectation that compulsory school starters ($k = 2$) will be free from selection bias. To make the coefficient β_1 interpretable and comparable across the stratified models, school starting age a_{ij} was coded as 1 (youngest) to 7 (oldest) among children born January to July, and 1 (youngest) to 5 (oldest) among children born August to December. School starting age was entered as a linear term in each model, so the exponentiated coefficient can be interpreted as the odds ratio associated with being one month older at the start of school.

The above model pools the constituent effects of age, including school starting age, test age and relative age. In the final analysis, we attempt to separate these factors. We modelled the composite binary outcome of development scores above the 25th percentile in all domains using models of the form

$$logit\left(y_{ij}\right) = \beta_0 + \beta_1 a_{ij} + \beta_2 a_{ij}^2 + \beta_3 r_{ij} + \beta_4 r_{ij} a_{ij} + \beta_5 t_{ij} + \boldsymbol{\beta}\mathbf{X}'_{ij} + u_j$$

where, as in the previous model, y_{ij} is a binary indicator for child i in classroom j scoring above the 25th percentile in all domains, β_0 is the model intercept, $\mathbf{X}$ is a vector of child family and area level statistical controls, with coefficient vector $\boldsymbol{\beta}$, and u_j are the classroom terms. School starting age in months $\left(a_{ij}\right)$ was coded as 1 (youngest) to 19 (oldest). Because this model was not stratified by school starting age category, age was entered into the model as a linear $\left(\beta_1\right)$ and quadratic $\left(\beta_2\right)$ term to capture the non-linear association between age and development across the full range of eligible school starting ages. An individual child's relative age $\left(r_{ij}\right)$ was calculated as their school starting age minus the average school starting age in the classroom, divided by the SD of ages in the classroom. This variable was entered into the model as a linear term $\left(\beta_3\right)$ and also interacted against school starting age $\left(\beta_4\right)$ to allow the effect of relative age to differ by school starting age. As a standardised variable, the parameter estimates for β_3 can be interpreted as the change associated with a one SD shift in relative age, which corresponds to moving from the average classroom age to approximately six months older than average. Test age $\left(t_{ij}\right)$ was entered into the model as a binary indicator for whether the child was relatively older when assessed, compared to other children with the same school starting age. Test age was recorded in the available data in three-month bands, and the strong positive correlation between school starting age and test age precluded us from entering test age directly into the model (Online Supplemental Material, Table 2).

Both model specifications described above capture the hierarchical structure inherent to many education datasets—children nested within classrooms—by including a classroom-level term u_j. This term represents unobserved classroom-level factors, which may affect the outcome of interest. In our models of early childhood development, this could encompass teacher quality, available resources, or classroom ethos, for example. Crucially, if these unobserved factors are also associated with the covariate(s) of interest, then ignoring this clustering will result in biased parameter estimates. In the case of model (1) above, for example, if $cov(y_{ij}, u_j) \neq 0$ and $cov(a_{ij}, u_j) \neq 0$ then the estimates for the parameter of interest β_1 will be biased. An association $cov\left(a_{ij}, u_j\right) \neq 0$could arise if children who delay entry are more likely to attend schools in relatively advantaged areas with more classroom resources.

Two possible modelling approaches to address this issue are fixed effects and random effect models (Wooldridge, 2010). Introducing fixed classroom effects overcomes any possible association $cov\left(a_{ij}, u_j\right) \neq 0$ by differencing out variation at the classroom level. Because this approach ignores between school variation, it comes at the cost of reduced precision in model estimates. Random effects models assume that $cov\left(a_{ij}, u_j\right) = 0$, which may not hold in practice, as discussed above. Departures from this assumption can be ameliorated by including observed classroom-level variables that are associated with u_j(Clarke et al., 2015). Following Clarke et al. (2015) we directly compare results from these alternative approaches to dealing with classroom-level effects.

4. Results

4.1. Descriptive statistics

Based on analysis of the NSW AEDC-Births dataset (N = 162,878), in both 2009 (N = 78,091) and 2012 (N = 84,787), the median school starting age was five years three months (IQR: five years to five years six months). Children's age in the first month of school ranged from four years old to six years 11 months, however, in both 2009 and 2012, over 99% of children started school aged four years six months to six years old—the age range dictated by the NSW enrolment criteria. Among both cohorts, 26% of children delayed starting school until the year they turned six, corresponding to 44% of children born January to July, who were eligible to start in multiple years. Of those born August to December, 98% started in the year they turned six, indicating high compliance with the NSW enrolment policy. The median age range in NSW classrooms, excluding children repeating kindergarten, was 13 months

(IQR = 11–15 months). In one quarter of classrooms, the age range was 15 months or greater; at the other extreme, one quarter of classrooms had a range of 11 months or less between the oldest and youngest student. Table 1 tabulates the available child, family and area characteristics for the study population. Of the 104,356 children in the study population, 24.7% delayed the start of school.

4.2. Geographic and social variation in the tendency to delay the start of school

There was considerable geographic variation in the tendency to delay the start of school across NSW, ranging from 8% to 54% of all school starters in an area (Fig. 1). A rural-urban divide was clear, with rates of delay generally lower in the Sydney metropolitan area compared with the rest of NSW, except for the most remote and sparsely populated areas in the North West of the state (Fig. 1A, 1B). Within Sydney there was evidence of geographic clustering, with the lowest rates of delay (0–15%) in the Western suburbs (Fig. 1B). The association between area-level disadvantage and delayed entry was similar in 2009 and 2012 but differed between the Sydney metropolitan area and the rest of NSW in both 2009 (Fig. 1C) and 2012 (Fig. 1D). In Sydney, the area-level tendency to postpone was negatively correlated with the proportion of individuals in an area earning less than \$250 per week ($\rho = -0.82/-0.84$ in 2009/2012); this association was less pronounced in the rest of NSW ($\rho = -0.12/-0.16$ in 2009/2012).

4.3. Factors associated with the propensity to delay the start of school

Analysis of the factors associated with the decision to delay school entry were restricted to children born January to July who were eligible to delay, and who had complete covariate data ($N = 48{,}662$). Table 2 presents the estimated odds ratios of delaying the start of school compared to enrolling when first eligible with 95% confidence intervals, both unadjusted and adjusted for available covariates. The factor most strongly associated with delayed school entry was month of birth, with delayed entry particularly common for July-born children (OR = 29.86, 95%CI = 27.11–32.89). The odds of delayed entry were also significantly higher among boys, families with access to private health insurance at the time of birth, children with medically diagnosed special needs, and children identified as having additional needs, such as hearing or communication impairment. Delayed entrants were also more likely to have experienced adverse perinatal outcomes, including being born small for gestational age, born preterm, and admission to a Neonatal Intensive Care Unit or Special Care Nursery (NICU/SCN) at birth. In terms of the characteristics of areas in which children lived, those who delayed were more likely to live in regional areas, and more likely to live in areas with a high area-level proportion of delayed school entry. Children who enrolled in the year they first became eligible were more likely to be born closer to January rather than the July cut-off, female, have a mother born in Asia, North Africa or the Middle East, speak English as a second language, and come from a socioeconomically disadvantaged background, as indicated by parents working in low-skilled occupations.

4.4. The relationship between school starting age and early childhood development

Descriptive analyses of development outcomes were based on the study population restricted to children without special needs, as the AvEDI has not been validated for this group ($N = 98{,}844$–$99{,}567$, depending on the outcome). Fig. 2 presents the proportion of children scoring above the 25th percentile (measured on the left-hand y-axis), with 95% confidence intervals, by each month of school starting age for each of the five AEDC developmental domains, and the aggregate outcome. These estimates are superimposed on the distribution of births by school starting age (measured on the right-hand y-axis), illustrating the varying proportion of births by month of age. The crude relationship between school starting age and early childhood development was broadly consistent across all development domains. The increase in the proportion of children with development scores above the 25th percentile was approximately linear with school starting age between four years six months and five years eight months, with a slight levelling off, or decline between five years nine months and six years.

Modelling analyses of the composite development outcome were based on the study population with complete covariate data. In addition, classrooms with no variation in the outcome by strata of school starting age were excluded, because these cannot be included in a fixed effects analysis. This resulted in a total sample size of $N = 55{,}427$. The estimated association between school starting age and positive early childhood development is presented in Table 3 for first eligible ($N = 19{,}563$), compulsory ($N = 24{,}211$) and delayed school starters ($N = 11{,}653$). As discussed, the estimates based on first eligible and delayed school starters are subject to selection bias. In contrast, the estimates for compulsory starters are free from selection bias because these children—born August to December—were not eligible to delay school entry. Consequently, we focus primarily on the parameter estimates for age from the model for compulsory school starters, although we present the estimates for the other groups for comparison. Among compulsory starters, the crude odds ratio associated with a one month increase in age was 1.070 [95% CI: 1.051,1.089]. The adjusted estimates accounting for clustering within classrooms using fixed effects (OR = 1.092 [95% CI: 1.068,1.166]) and random effects (OR = 1.083 [95% CI: 1.061,1.105]) were reasonably stable and indicated a statistically significant positive association between age and development. The range of odds ratios observed across the models for the compulsory school starters stratum corresponds to a relative increase of approximately 3% in the proportion of children scoring above the 25th percentile in all domains with each additional month of age between five years and five years five months.

The estimates from the first eligible and delayed entry strata reflect the crude associations illustrated in Fig. 1. For children starting school when first eligible, the magnitude of the association between school starting age and early development is higher than the estimate for compulsory starters, with odds ratios in the range of 1.12–1.14. There was no significant association between school starting age and development among children who delayed entry, either in the unadjusted models or in the models adjusting for selection bias.

Combined, these results confirm that older children are more developed than younger children in the first year in school, on average. This association between age and development is not driven solely by differences between the types of children who do and do not delay school, as it is clearly observed among children who had no choice when to start school, suggesting a causal effect of school starting age. Although the change in the developmental outcome associated with each month of age is small, it is larger when accumulated over a full year. This means that, on average, there will be development gaps between younger and older school starters, and between children who do and do not delay school entry.

4.5. School starting age, test age, and relative age

The analyses incorporating relative age were not disaggregated by category of school starting age; therefore, it was only necessary to exclude classrooms where there was no variation in outcome

Table 2
Child, family and area-level factors associated with delayed school entry, for children in the study population born January-July (N = 48,622).

		Delayed school entry			
Variable	Category	OR	(95% CI)	aOR[a]	(95% CI)
Month of birth		Reference		Reference	
	February	1.92	(1.73, 2.13)	2.08	(1.86, 2.32)
	March	3.95	(3.59, 4.35)	4.77	(4.31, 5.29)
	April	6.92	(6.30, 7.60)	9.35	(8.45, 10.35)
	May	12.79	(11.64, 14.04)	21.05	(18.99, 23.33)
	June	20.69	(18.80, 22.77)	38.62	(34.71, 42.98)
	July	29.86	(27.11, 32.89)	62.65	(56.17, 69.86)
Sex	Male	Reference		Reference	
	Female	0.61	(0.58, 0.63)	0.48	(0.46, 0.50)
Aboriginality[b]	Non-Aboriginal	Reference		Reference	
	Aboriginal	0.96	(0.89, 1.04)	0.76	(0.69, 0.84)
Maternal age at childbirth (years)	<20	Reference		Reference	
	20–24	1.03	(0.92, 1.14)	1.07	(0.93, 1.22)
	25–29	1.28	(1.15, 1.42)	1.40	(1.22, 1.61)
	30–34	1.38	(1.24, 1.53)	1.54	(1.34, 1.77)
	≥35	1.28	(1.15, 1.43)	1.47	(1.27, 1.69)
Mother's region of birth	Oceania and Antarctica[c]	Reference		Reference	
	North-West Europe	0.89	(0.81, 0.98)	0.88	(0.78, 0.99)
	Southern and Eastern Europe	0.58	(0.50, 0.68)	1.13	(0.94, 1.37)
	North Africa and Middle East	0.13	(0.12, 0.16)	0.32	(0.27, 0.39)
	South-East Asia	0.25	(0.23, 0.28)	0.47	(0.41, 0.54)
	North-East Asia	0.31	(0.28, 0.35)	0.70	(0.61, 0.82)
	Southern and Central Asia	0.19	(0.16, 0.21)	0.31	(0.26, 0.37)
	Americas	0.66	(0.56, 0.78)	0.83	(0.68, 1.02)
	Sub-Saharan Africa	0.69	(0.57, 0.84)	0.74	(0.59, 0.94)
Private patient/insurance at childbirth	No	Reference		Reference	
	Yes	1.37	(1.32, 1.43)	1.30	(1.23, 1.38)
Mother married/partnered at childbirth	No	Reference		Reference	
	Yes	1.06	(1.01, 1.11)	1.12	(1.04, 1.20)
Mother smoked during pregnancy	No	Reference		Reference	
	Yes	1.01	(0.96, 1.06)	0.78	(0.73, 0.84)
Antenatal care in first 20 weeks of pregnancy	No	Reference		Reference	
	Yes	1.20	(1.13, 1.28)	0.89	(0.82, 0.96)
Plurality	Singleton	Reference		Reference	
	Twins/triplet	1.37	(1.24, 1.52)	1.29	(1.12, 1.48)
Small for gestational age	No	Reference		Reference	
	Yes	1.01	(0.95, 1.07)	1.25	(1.16, 1.35)
Preterm birth (<37 week's gestation)	No	Reference		Reference	
	Yes	1.30	(1.20, 1.40)	1.19	(1.07, 1.32)
Resuscitated at birth	No	Reference		Reference	
	Yes	1.15	(1.07, 1.23)	1.03	(0.94, 1.13)
Admitted to NICU/SCN[d]	No	Reference		Reference	
	Yes	1.18	(1.12, 1.24)	1.11	(1.03, 1.20)
Maternal comorbidities during pregnancy[e]	No	Reference		Reference	
	Yes	0.91	(0.86, 0.96)	0.89	(0.83, 0.96)
Maternal school education[f]	≥10 years	Reference		Reference	
	≤9 years	0.66	(0.61, 0.72)	0.94	(0.84, 1.05)
Highest level of occupation of either parent[f]	Grades 1–3	Reference		Reference	
	Grade 4/unemployed	0.74	(0.71, 0.77)	0.90	(0.85, 0.96)
English Second Language[g]	No	Reference		Reference	
	Yes	0.21	(0.20, 0.23)	0.41	(0.38, 0.46)
Medically diagnosed special needs[h]	No	Reference		Reference	
	Yes	2.74	(2.49, 3.01)	3.72	(3.25, 4.25)
Additional health and developmental needs[i]	No	Reference		Reference	
	Yes	1.43	(1.36, 1.51)	1.22	(1.14, 1.32)
Preschool[g]	No	Reference		Reference	
	Yes	1.97	(1.88, 2.05)	1.72	(1.63, 1.82)
Remoteness[j]	Major City	Reference		Reference	
	Inner Regional	2.17	(2.09, 2.26)	1.14	(1.06, 1.22)
	Outer Regional	2.40	(2.26, 2.56)	1.19	(1.04, 1.35)
	Remote/Very Remote	1.49	(1.20, 1.85)	0.91	(0.67, 1.23)
Area-level disadvantage quintiles[k]	1 (Most disadvantaged)	Reference		Reference	
	2	1.67	(1.54, 1.81)	1.00	(0.90, 1.12)
	3	1.10	(1.02, 1.17)	0.92	(0.82, 1.04)
	4	1.11	(1.03, 1.19)	0.90	(0.77, 1.05)
	5 (Most advantaged)	1.12	(1.04, 1.20)	0.87	(0.70, 1.09)
Area % that delayed	(Standardised)	1.91	(1.87, 1.95)	1.85	(1.76, 1.95)
Area % with low income[l]	(Standardised)	0.87	(0.86, 0.89)	1.09	(1.01, 1.17)
Area % unemployed	(Standardised)	0.89	(0.88, 0.91)	0.93	(0.87, 0.99)
Area % homeowner	(Standardised)	1.36	(1.33, 1.38)	0.98	(0.94, 1.02)

Table 2 (*Continued*)

		Delayed school entry			
Area % with less than year 12 education[m]	(Standardised)	1.32	(1.29, 1.34)	0.99	(0.90, 1.09)
Area % professional/managerial occupation	(Standardised)	1.07	(1.05, 1.09)	0.93	(0.86, 1.01)
Census year	2009	Reference		Reference	
	2012	0.99	(0.95, 1.02)	1.05	(1.00, 1.10)

[a] Adjusted odds ratio.
[b] Defined as child or parent identified as Aboriginal on any of PDC, RBDM or APDC birth records, or AEDC school record.
[c] 95% Australia, 3% New Zealand, 2% Other.
[d] Neonatal Intensive Care/Special Care Nursery.
[e] Includes pre-existing and gestational-onset diabetes and hypertension.
[f] As reported by parent(s)/guardian(s) as part of the school's enrolment process.
[g] Based on the teacher's knowledge of the child or prefilled with information collected as part of the school's enrolment process.
[h] Children medically diagnosed as having high needs requiring special assistance due to chronic medical, physical or intellectually disabling conditions.
[i] A condition or impairment that influences the child's ability to do schoolwork in a regular classroom, including physical, visual, hearing, speech, learning, emotional or behavioural problems.
[j] Accessibility/Remoteness Index of Australia (ARIA+) based on child's statistical local area of residence at the start of school.
[k] Socio-Economic Indices for Areas (SEIFA) Index of Relative Socio-economic Advantage and Disadvantage population quintiles based on child's statistical local area of residence at the start of school.
[l] The proportion of an area earning <$250 per week based on aggregated 2006 Census Data.
[m] The final year of secondary schooling in Australia.

across the entire class, rather than within strata defined by school starting age, which resulted in a larger sample size ($N = 70{,}123$). The non-linear relationship between age and development was captured by specifying a main effect and squared term for school starting age. In the unadjusted model (Table 4), the exponentiated main effect of school starting age was significant and greater than one (OR = 1.218 [95% CI: 1.171, 1.266]), while the exponentiated squared term was significant and less than one (OR = 0.994 [95% CI: 0.992, 0.996]). These results are consistent with the previous set of models, and the descriptive results, and suggest that the association between age and development is strongest among the youngest children and becomes less important for older children. The relationship between initial school starting age and positive development was reasonably stable across all models.

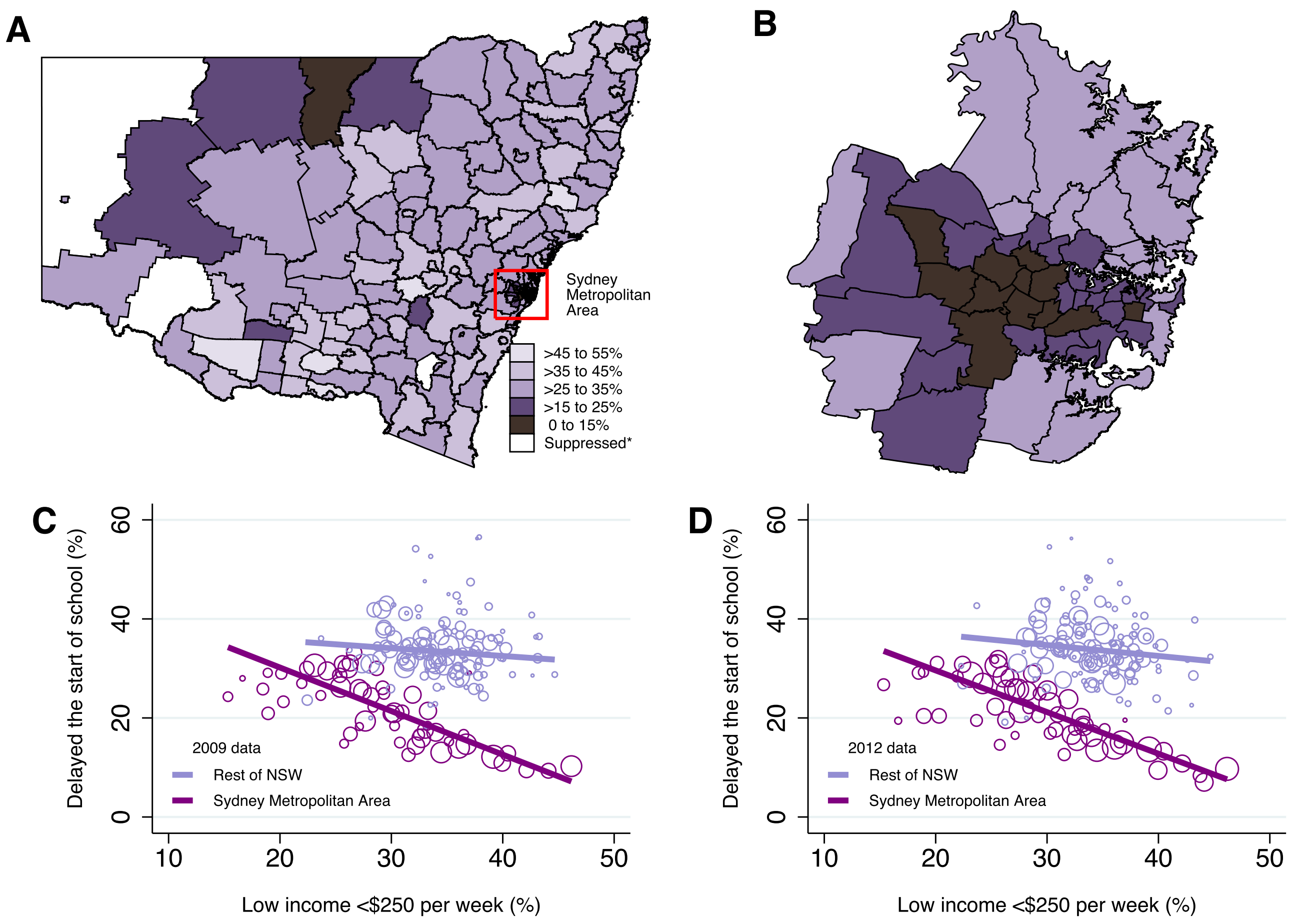

Fig. 1. Geographic and social variation in delayed school entry in New South Wales, Australia. A. Map of the proportion of children who delayed entry in 198 statistical local areas across NSW (2009 and 2012 combined). B. Map of the proportion of children who delayed entry in 57 statistical local areas in the Sydney metropolitan area (2009 and 2012 combined). C. Scatterplot of the area-level percentage of children who delayed in 2009, against the proportion of individuals in the area earning less than $250 per week. D. Scatterplot of the area-level percentage of children who delayed in 2012, against the proportion of individuals in the area earning less than $250 per week. * Suppressed due to small numbers of children or teachers.

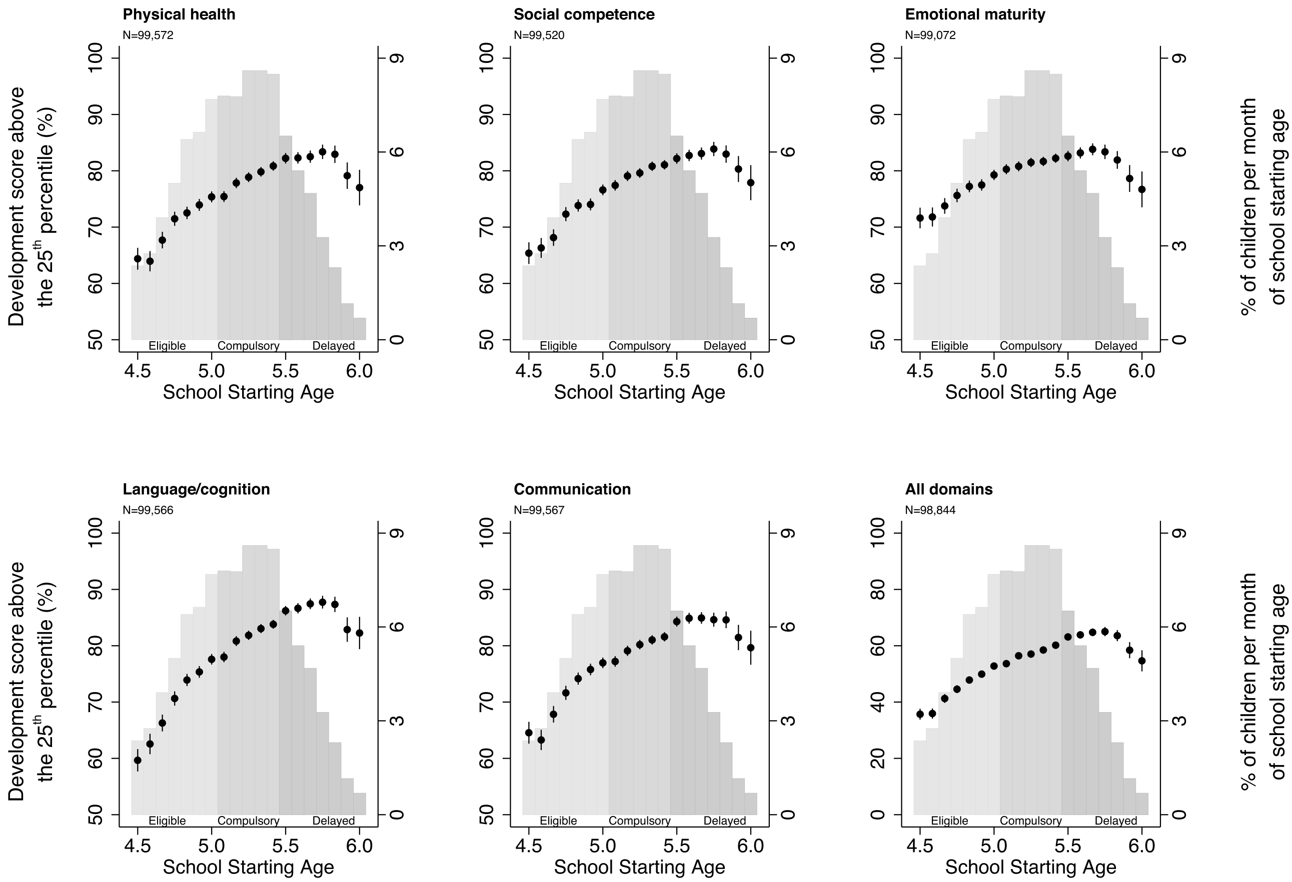

Fig. 2. The proportion of children with AEDC domain scores above the 25th percentile, and the total proportion of children by school starting age.

Table 3
Odds Ratios, and 95% confidence intervals, for AEDC scores above the 25th percentile on all five development domains associated with an additional month of age, stratified by school enrolment groups (i.e. First eligible, compulsory, delayed).

		First eligible		Compulsory		Delayed entry	
		Jan–July		*Aug–Dec*		*Jan–July*	
		4y6m–5y0m		*5y1m–5y5m*		*5y6m–6y0m*	
Model	Specification	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Model 1	Unadjusted	1.133	(1.116,1.150)	1.070	(1.051,1.089)	0.989	(0.967,1.011)
Model 2	Fixed Effects (FE)	1.133	(1.113,1.153)	1.084	(1.062,1.106)	0.983	(0.959,1.008)
Model 3	FE + individual-level controls[a]	1.143	(1.121,1.165)	1.095	(1.071,1.120)	1.027	(0.999,1.056)
Model 4	Random effects (RE)	1.136	(1.118,1.154)	1.074	(1.054,1.094)	0.989	(0.967,1.011)
Model 5	RE + classroom-level controls[b]	1.126	(1.108,1.144)	1.074	(1.054,1.094)	0.986	(0.964,1.008)
Model 6	RE + individual and classroom controls	1.132	(1.112,1.151)	1.084	(1.063,1.107)	1.016	(0.992,1.041)

[a] Individual-level controls included sex, Aboriginality, mother's region of birth, insurance status at time of birth, mother's partnership status at time of birth, maternal smoking during pregnancy, antenatal care in first 20 weeks of pregnancy, plurality, small for gestational age, preterm birth (<37 weeks), resuscitation at birth, admission to neonatal intensive care/special care nursery, maternal comorbidities at childbirth, maternal school education, highest occupation of either parent, English Second Language status, additional health and development needs, preschool attendance, geographic remoteness, area-level advantage/disadvantage and census year.

[b] Classroom-level controls included % male sex, % Aboriginal, % maternal age ≤19, % mother born overseas, % English as a second language, % attended preschool in the year prior to kindergarten, % low maternal education, and % low ranking/unemployed parental occupation. All classroom-level variables were standardised.

The estimated parameter associated with the dummy indicator for having an older test age was positive and significant in the unadjusted model (OR = 1.070 [95% CI: 1.036, 1.106]). In the subsequent adjusted models, the parameter was not statistically significant, however, which may reflect the modest variation in the underlying variable.

Turning to relative age, we see that in Model 1, the odds ratio associated with a one SD rise in relative age was statistically significant and less than one (OR = 0.881 [95% CI: 0.801, 0.970]). The estimate for the squared term was not statistically significant. This unadjusted result indicates that, on average, children with a higher relative classroom age were less likely to have positive development compared to their same aged peers. In the unadjusted fixed effects model, however, the estimate changed direction (OR = 1.365 [95% CI: 1.160,1.606]), suggesting positive development was associated with greater relative age. The random effects model including individual and classroom-level covariates produced a similar result (OR = 1.298 [95% CI: 1.126,1.495]). To understand why the estimate for relative age changed direction between Model 1 and Models 2–6, consider two children starting school at the same age, one in a class with many delayed-entry peers and one in a class with few delayed-entry peers. The child with few delayed-entry peers will be relatively older in their classroom compared to the child with many classmates who delayed

Table 4
Odds ratios (95% confidence intervals) of development scores above the 25th percentile on all five AEDC domains.

	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	Unadjusted		Fixed Effects		Fixed effects + individual-level covariates[a]		Random effects		Random effects + classroom-level covariates[b]		Random effects + individual[a] and classroom level covariates[b]	
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
School starting age	1.218	(1.171,1.266)	1.076	(1.013,1.142)	1.085	(1.018,1.157)	1.184	(1.127,1.243)	1.109	(1.055,1.166)	1.108	(1.050,1.170)
School starting age squared	0.994	(0.992,0.996)	0.998	(0.995,1.001)	0.998	(0.995,1.001)	0.996	(0.993,0.998)	0.997	(0.994,0.999)	0.997	(0.994,1.000)
Relative age[c]	0.881	(0.801,0.970)	1.365	(1.160,1.606)	1.367	(1.148,1.627)	1.011	(0.895,1.142)	1.255	(1.101,1.430)	1.298	(1.126,1.495)
Relative age squared	1.006	(0.996,1.016)	0.987	(0.974,0.999)	0.988	(0.975,1.001)	0.996	(0.985,1.008)	0.992	(0.980,1.003)	0.992	(0.980,1.005)
Older at age of test[d]	1.070	(1.036,1.106)	0.973	(0.933,1.015)	0.982	(0.939,1.027)	1.017	(0.978,1.057)	1.018	(0.979,1.058)	1.029	(0.986,1.072)
N	70,123		70,123			70,123	70,123		70,123		70,123	
Individual-level covariates	No		No		Yes		No		No		Yes	
Classroom-level covariates	No		No		No		No		Yes		Yes	
Classroom-level fixed effects	No		Yes		Yes		No		No		No	
Classroom-level random effects	No		No		No		Yes		Yes		Yes	

[a] Individual-level controls included sex, Aboriginality, mother's region of birth, insurance status at time of birth, mother's partnership status at time of birth, maternal smoking during pregnancy, antenatal care in first 20 weeks of pregnancy, plurality, small for gestational age, preterm birth (<37 weeks), resuscitation at birth, admission to neonatal intensive care/special care nursery, maternal comorbidities at childbirth, maternal school education, highest occupation of either parent, English Second Language status, additional health and development needs, preschool attendance, geographic remoteness, area-level advantage/disadvantage and census year.

[b] Classroom-level controls included % male sex, % Aboriginal, % maternal age ≤19, % mother born overseas, % English as a second language, % attended preschool in the year prior to kindergarten, % low maternal education, and % low ranking/unemployed parental occupation. All classroom-level variables were standardised.

[c] Relative age calculated as (school starting age – classroom average school starting age)/(classroom SD school starting age).

[d] Indicates child was assessed 1–3 months older compared to other children with the same month of birth. See Appendix A for further details.

entry. Because of the selection effects demonstrated previously, children who are relatively old for their class compared to other children with the same school starting are disproportionately concentrated in schools with few delayed entrants, i.e. schools in relatively disadvantaged, urban areas. Thus, the apparent negative association between relative age and positive development observed in the unadjusted model (Model 1) may be an artefact of the differential selection into delayed school entry. After controlling for this selection bias, either by adding fixed classroom effects or by including observed covariates in a random effects framework, our models suggest that children who are relatively older in their classroom are more likely to have positive development compared to same-aged children who are relatively younger in their classroom.

To aid interpretation, we calculated marginal probabilities with 95% confidence intervals based on the parameter estimates in Model 6 (Fig. 3). The marginal probability calculation assumes the random effect to be zero, so inferences are for "average" classrooms. For each month of school starting age, the marginal estimates were calculated at a higher and lower value of relative age. These values were separated by one SD unit and centred on the average relative age observed for that month of school starting age. For example, among children starting school aged five years, the marginal estimates were evaluated at the relative age values of −0.8 and 0.2, whereas for children starting school at age six, the marginal estimates were calculated at relative age values of 1.2 and 2.2. These values approximate the youngest and oldest possible relative ages observed for each month of school starting age.

The model-based marginal probability estimates presented in Fig. 3 illustrate the positive association between positive development and both school starting age and relative age. For example, the predicted probability of positive development—scoring above the 25th percentile in all five AEDC domains—for a child starting school aged four years six months with a below average relative classroom age was 0.35 (95% CI: 0.33, 0.37). The same child starting school at the same age, but with an above average relative classroom age, had a predicted probability of 0.40 (95% CI: 0.38, 0.43). The association between relative age and positive development was attenuated among older children, so that after about age five years five months the estimated confidence intervals overlapped. Combined, these modelling results suggest that a child's age relative to their classroom average is associated with development outcomes independent of their school starting age. The association is largest among younger students and attenuates for older children.

5. Discussion

5.1. Overview of key findings

In this population-level data linkage study, we found that a quarter of all children starting school in NSW in 2009 and 2012 had delayed school entry from the previous year, corresponding to nearly half of the January to July births who were eligible to delay. There was an 18-month age range within each cohort, with greater than one-year age gaps between the youngest and oldest class members in most NSW classrooms. We found substantial geographic variation in delayed school entry throughout NSW, including a strong negative association between average area-level rates of delay and area-level disadvantage in the Sydney metropolitan area. Children who delayed school entry until the year they turned six were more likely to be male, born closer to the July cut-off date, have an Australian-born mother, be a native English speaker, socioeconomically advantaged, born preterm, or have medically diagnosed special needs or other additional health and development needs.

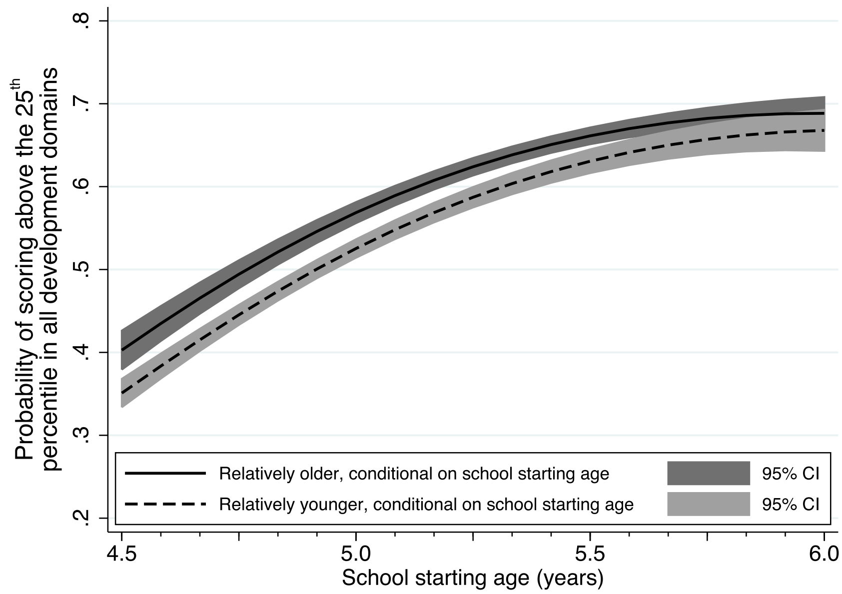

Fig. 3. Marginal probabilities of scoring above the 25th percentile in all five AEDC development domains, by school starting age and relative age, conditional on school starting age.

We observed a positive association between school starting age and all five development domains measured in the AEDC. Among the population of children born August to December, for whom there is no selection bias, we estimated that, on average, each additional month of age at the start of school increased the prevalence of scores above the 25th percentile on all five AEDC domains by approximately 3% per month. The analysis of relative age effects indicated that, conditional on school starting age, having a high relative classroom age was positively associated with the odds of scoring above the 25th percentile in all domains. This association was most pronounced for the youngest school starters and attenuated among children who delayed school entry, although, we cannot rule out the impact of unobserved confounders on these findings. That older children have better development outcomes at the time they start school is unsurprising, however, here we have quantified the magnitude of this relationship in the Australian context for the first time.

5.2. Findings in the context of other literature

In both the 2009 and 2012 school starter cohorts, 26% of children delayed entry to the year they turned six rather than starting in the year they turned five. This estimate is slightly lower than the estimated incidence of 31% based on a much smaller sample of 1057 children starting school in 2005, from the Longitudinal Study of Australian Children (Edwards et al., 2011). The incidence of delayed entry in NSW is much higher than that reported in other states and territories in Australia (Edwards et al., 2011; Mergler & Walker, 2017), and internationally (Bassok & Reardon, 2013; Fortner & Jenkins, 2017; Huang, 2015). This is most likely because the NSW enrolment policy explicitly offers greater flexibility about when to start school to a wider range of children (i.e. more than half the eligible cohort—those born January to July) compared to most other Australian states and territories, and other countries internationally.

We identified a high degree of geographic variation in the proportion of delayed students, ranging from 8% to 54% across areas in NSW. In comparison, area-level rates of delayed entry varied from 0% to 12% across school districts in North Carolina (Fortner & Jenkins, 2017). As with Fortner and Jenkins, we observed a negative correlation between the proportion of delayed students in an area and area-level socioeconomic disadvantage, although in our study the association was markedly stronger for areas within the Sydney Metropolitan Area compared to regional and remote areas of NSW. Area-level rates of delayed entry were lower in Sydney's more disadvantaged Western suburbs, and higher in the more advantaged Northern suburbs.

Many of the factors we identified as associated with delayed entry—including sex, proximity of birth date to the enrolment cut-off, mother's country of birth and socioeconomic advantage/disadvantage—were consistent with previous literature (Bassok & Reardon, 2013; Edwards et al., 2011; Fortner & Jenkins, 2017; Graue & DiPerna, 2000; Herbst & Paweł, 2016; Huang, 2015; Winsler et al., 2012; Yeşil Dağli & Jones, 2012). Our findings were also consistent with other recent studies reporting negative selection into delayed entry in the USA (Bassok & Reardon, 2013; Fortner & Jenkins, 2017; Huang, 2015)—we found that delayed school entry was associated with special and additional needs, and adverse perinatal outcomes recorded at birth, such as preterm birth and admission to neonatal intensive care. We also found strong area-level effects, with delayed entry of an individual child more likely in areas where a higher proportion of other children also delayed school entry, which may reflect the clustering of individuals or families with similar characteristics, or a culture of delayed entry within some communities.

Turning to developmental outcomes, our descriptive results showed that, across the spectrum of school starting age, positive early childhood development increased with each additional month of age between four years six months and around five years nine months and levelled off or declined thereafter. The decline in the percentage of children with development scores above the 25th percentile among older school starters may be related to negative selection, which results in a disproportionate number of children with developmental issues among this group. Much of the literature on estimating school starting age effects is concerned with overcoming the selection bias inherent to these underlying selection effects (e.g. Datar, 2006). In this study, we addressed the selection bias problem by focusing on the subset of NSW children born August to December, where there was no opportunity for parents to select into enrolment. Among this subgroup, we estimated that the probability of a child scoring above the 25th percentile on all domains increased by around 3% for each additional month of age.

That we found a significant positive relationship between age and development among Kindergarten children is consistent with several studies showing that older children have better cognitive and non-cognitive outcomes in the early school years (e.g. Bedard & Dhuey, 2006; Dee & Sievertsen, 2015).

Our analysis of relative age effects indicated that, conditional on school starting age, higher relative age was associated with better developmental outcomes. This result is consistent with Marsh et al (2016), who highlight the importance of children's frame-of-reference—that is, the comparisons children make between their own achievements and those of their peers. This theoretical perspective would suggest that, when surrounded by younger, less-developed children, relatively older children experience a positive impact on their self-belief and subsequent cognitive and non-cognitive outcomes. Our findings are in contrast to those of Cascio and Schanzenbach (2016) who reported that, conditional on school starting age, relatively younger children had better test and mathematics scores in Kindergarten and eighth grade. Consistent with Cascio and Schanzenbach (2016), however, the net effect of school starting age and relative age was positive in our study: on average, older children starting Kindergarten in NSW have better development outcomes than their younger peers. Our modelling results suggests that decisions which change the age composition of classrooms may have unintended effects on individual children starting their first year of formal schooling. In particular, the decision for some children to delay school entry increases the average classroom age and thus decreases relative age for peers who do not delay.

5.3. Policy implications

Under the current enrolment policy, NSW children start school aged from four years six months to six years. This policy allows for both a young absolute age, relative to international standards, and a large relative age. Our study reveals the resulting social and geographic variation in school starting age, and the large developmental gaps between the youngest and oldest school starters, in this policy environment.

For policy makers, two parameters amenable to change are the minimum eligible enrolment age and the range of eligible enrolment ages within each school year cohort. The minimum eligible enrolment age can be increased by bringing back the enrolment birthdate cut-off. Our results suggest that raising the enrolment age would remove the most developmentally vulnerable children from the formal schooling environment, and the average level of development in the first year of school would increase accordingly. Although moving the enrolment birthdate cut-off simply shifts the mantle of 'youngest starters' to a different birth month, the youngest children would be older in absolute terms, and consequently more developed on average. In addition, the gap between the youngest and oldest children would narrow. The range of eligible enrolment ages can also be narrowed by restricting enrolments to a twelve-month period, as seen in some other jurisdictions internationally, such as Japan (Kawaguchi, 2011) and parts of the UK (Frazier-Norbury et al., 2015). This approach removes the element of choice for parents entirely, eliminating systematic variation in school starting age across social groups and geographies.

Policy changes can have unintended as well as intended effects, however. For example, raising the school starting age may place added pressure on families to provide pre-school care, and/or restrict work-force participation for parents. A later start to school may also have long-run effects on the age that young adults enter the workforce. While our study documents the baseline age-developmental relationship as a foundation for future research, the full implications of any policy change would require evaluation and post-implementation monitoring. The diverse enrolment policies and growing data linkage capabilities across Australian jurisdictions offer potential for future quasi-experimental studies to investigate long-term consequences of school starting age policies.

5.4. Strengths and limitations

The main strengths of our study include the almost complete population coverage of our data and the comprehensive developmental outcome measure collected on a contemporary population of children in their first year of school. We also benefitted from rich linked birth and perinatal outcomes, which allowed us to examine patterns of negative selection using factors that predate school entry decisions. The high rate of delayed entry makes NSW a suitable jurisdiction to examine school entry decisions, while also providing the opportunity to estimate the age-development relationship without selection bias in a large subgroup of children that had no choice about when to start school.

Our study was limited to data items collected for administrative rather than research purposes. One implication of this is that family-level socioeconomic information was unavailable for children attending non-public schools and, as a result, our modelling analyses were restricted to the subgroup of public school children. Although this decreased our sample size, the crude relationship between age and development was similar in the two populations. A second limitation is that development outcomes were unavailable for children with special needs diagnoses, as the AvEDI instrument has not been validated for this group. The advantage of delayed school entry observed in the general population may not extend to some children with special needs, who may benefit from being in a school environment from an early age, where they can access appropriate supports and specialised services (Fortner & Jenkins, 2018). Similarly, our findings do not extend to children repeating kindergarten, who were excluded from the analysis. While repeaters may experience benefits of being relatively older (Marsh et al., 2017) the practice of grade repetition, as opposed to delayed school enrolment, is a separate issue, with different implications for children, families, parents and school policy, and warrants separate investigation. A further limitation is that the AEDC outcome is a population-level measure of early childhood development, therefore our findings apply to population groups and cannot be used to draw inferences for individual children. We were also restricted by the length of available follow up time: although children would have spent between three to six months with their classroom peers at the time of the development census, the effects of relative classroom age may accumulate over a longer period. This also meant we were unable to test the long-run effects of initial age differences. Finally, although test age and school starting age were separable, the test age variable was recorded in the AEDC data in broad 3-month age bands, which limited our ability to distinguish the two effects.

6. Conclusion

The strong age-development relationship observed in children in their first year of school in our study suggests that each month of maturation counts during this important transition period, as children continue to develop physically, socially, emotionally and cognitively. Children who start school in the year they turn six are more likely to have developed the skills and competencies needed to thrive in a formal learning environment, compared with their younger peers who start school in the year they turn five. Delayed school entry offers some children more time to 'catch up' developmentally, and while this mechanism undoubtedly benefits many children, the element of choice also introduces variation in school starting age across economic, ethnic and geographic demarcations. It is unclear how the confluence of family disadvantage, community disadvantage and the tendency to start school earlier affects long-term outcomes, although it could conceivably lead to different early learning trajectories for different children, for example, those attending schools in disadvantaged urban areas, where Kindergarten classrooms have a greater intake of children under the age of five. Further longitudinal research is needed to determine whether initial age-related developmental differences subside or persist beyond the first years of school in the NSW context, potentially contributing to later inequalities in cognitive and non-cognitive outcomes between different population groups, including Indigenous and socioeconomically disadvantaged children.

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Conflict of interest

None declared.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.ecresq.2019.01.008.

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