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Maternal alcohol use disorder and child school attendance outcome: a population cohort record linkage study

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Abstract

Objectives: Examine the relationship between maternal alcohol-use disorder and child school attendance outcomes.

Design: Population cohort study.

Setting: Routinely collected linked administrative health and education data from Western Australia.

Participants: Those in-scope for the study were women with a birth recorded on the Western Australian Midwives Notification System (1989 – 2007). Women who had an alcohol related diagnosis (ICD 9/10) recorded on the Hospital Morbidity, Mental Health Outpatients and Drug and Alcohol Office datasets formed the exposed group. The comparison cohort were frequency matched to the exposed cohort based on maternal age within race, and child's year of birth.

Primary outcome measure: Child's school attendance.

Results: Maternal alcohol-use disorder was significantly associated with increased odds of poor school attendance in both non-Indigenous (OR = 1.61, 95% CI = 1.50-1.74) and Indigenous cohorts (OR = 1.66, 95% CI = 1.54 - 1.79). With adjustment for maternal and child factors, there was no significant difference between the timing of alcohol diagnosis relative to pregnancy and school attendance. The population attributable fraction was higher in the Indigenous cohort than the non-Indigenous cohort (6.0% vs 1.3%). The difference was due to a higher prevalence of alcohol related diagnoses in the Indigenous cohort.

Conclusions: Maternal alcohol-use disorder was associated with a significantly increased odds of poor school attendance. The strength of association was similar for each of the time periods where an alcohol related diagnosis was recorded. This suggests that the effect of maternal alcohol-use disorder may not be driven by the neurodevelopmental effects of alcohol, but may be mediated through family or social factors which we were unable to adjust for. Pre-pregnancy education regarding the impact of maternal alcohol-use on child outcomes is required. Further, ongoing support for families who are exposed to heavy maternal alcohol use is needed to improve child outcomes.

Strengths and limitations of this study

- A key strength of this analysis is the use of administrative linked data to obtain a large population cohort, which negates the use of retrospective recall of past behaviours, and removes responded bias.
- In addition, due to the frequency matching of the comparison group to the exposed cohort, both Indigenous and non-Indigenous estimates could be calculated.
- A limitation of the study is that there are women in the comparison group who may have drank heavily during the same time period, without receiving an alcohol related diagnosis, and this would bias estimates towards the null.

Background

It is well recognised that, in order to gain the skills necessary for academic and social success, children need to attend school regularly [1 2]. Previous research has identified that absences from school are linked with negative outcomes such as greater risk of poor academic performance, risk taking behaviours, delinquency and early school dropout [3 4]. Of note, children from disadvantaged backgrounds have been identified as more likely to have poor attendance patterns, and are disproportionately affected by absences compared with other children [1 5]. As poor school attendance in the early years is highly predictive of future absences [1], there has been substantial interest in identifying risk factors for absences in the early years of schooling with the aim of providing additional support and interventions to vulnerable children and families.

A number of factors have been associated with poor school attendance, including low socioeconomic status, low parental education and Indigenous status [1 3]. In addition Moore and McArthur identified that maternal and family risks such as family instability, mental illness and drug and alcohol issues, are associated with reduced child participation in school [6]. Poor school attendance can also indicate lack of engagement in schooling, on the part of both the child and their parents or carers.

The teratogenic effects of prenatal alcohol exposure on the developing brain can lead to neurodevelopmental deficits in the child [7]. At high levels of exposure, and during vulnerable time points during pregnancy, prenatal alcohol exposure has cognitive and behavioural impacts which may affect a child's academic performance and behaviour [8 9]. In addition to in-utero effects of alcohol, children exposed to heavy parental alcohol use postnatally have been identified as having abnormal developmental and social trajectories. This has been attributed to greater family instability, poor family functioning and communication, and greater levels of family stress. In addition, it has been identified that there is a higher risk of child abuse, and mental health problems in the offspring of parents who have heavy alcohol use [10-12]. Further, co-morbidities associated with heavy alcohol use, such as use of other substances and parental mental health problems [13], may add to an unstable home environment in which school attendance is not prioritised [12]. Previous research has identified that parental alcoholism is a risk factor for poor school performance, and school absenteeism [14]. Heavy maternal alcohol consumption is one of a range of factors that is negatively associated with parents' involvement in their children's education [15-17].

However, little research has examined whether heavy maternal alcohol use specifically, and the timing of alcohol use relative to pregnancy, impacts on a child's school attendance.

Therefore, the primary aim of this project was to determine whether maternal alcohol exposure contributed to poor school attendance, and to quantify the impact on school absenteeism. In addition, this project sought to determine whether the timing of a maternal alcohol related diagnosis in relation to pregnancy differentially affected a child's school attendance patterns. In order to investigate these relationships, we made use of routinely collected administrative education and health data. It was hypothesised that children whose mother had a diagnosis of an alcohol-use disorder, which provided a proxy for heavy drinking, would be at greater risk of poor attendance than other children.

Methods

Cohort

This analysis made use of routinely collected Western Australian administrative linked data. All women who had a birth recorded on the Western Australian Midwives Notification System (MNS) between 1989 and 2007 were in-scope for the study. Cohort selection has been described previously [18].

Mothers with an alcohol related diagnosis, based on the International Classification of Diseases Revisions 9/10, were considered to have an alcohol-use disorder and constituted the exposed group. An alcohol related diagnosis provided a proxy for heavy maternal alcohol use. Diagnoses were obtained from the following administrative datasets: Hospital Morbidity data system; Mental Health inpatients and Outpatients; and the Drug and Alcohol office.

The comparison cohort included a random selection of mothers, identified on the Western Australian MNS, who had no records of an alcohol related diagnosis. This cohort was frequency matched to the cohort of exposed mothers based on maternal age within race, and year of child's birth. The ratio of exposed to comparison mothers was 1:3 and 1:2 for non-Indigenous and Indigenous mothers respectively. It is important to note that, while maternal alcohol-use disorder is a proxy for heavy alcohol use, mothers in the comparison group may have consumed alcohol during the same time period, and some of these mothers may have consumed alcohol at high and at-risk levels without receiving an alcohol related diagnosis during a hospital or mental health service admission.

Records were linked by the Western Australian Data Linkage Branch using probabilistic matching [19]. Ethics approval for the conduct of the study was granted by the Princess Margaret Hospital Human Research Ethics Committee (no. 1244/EP), the WA Department of Health Human Research Ethics Committee (no. 2011/34) and the WA Aboriginal Health Ethics Committee (no. 134-04/06).

Data treatment

Alcohol exposure

Both the presence of an alcohol-use disorder and the timing of diagnosis relative to pregnancy were of interest. The presence of alcohol-use disorder was treated as a binary variable (yes/no). The

timing of exposure was categorised hierarchically. Categories included: (a) any alcohol related diagnosis during pregnancy. This may include women who have an additional diagnosis before and/or after pregnancy. For women who did not have an alcohol diagnosis recorded during pregnancy the categories included (b) A diagnosis within the year before pregnancy. As the coding was hierarchical, this group may include women with an additional exposure recorded more than one year before pregnancy or any exposure post-pregnancy; (c) A diagnosis up to one year after pregnancy. This may include women who had a recorded exposure for more than one year before or after pregnancy; (d) more than one year before pregnancy, and this could include exposure greater than one year post pregnancy; and (e) more than 1 year after pregnancy. This has previously been described [18].

School attendance

Attendance data were linked to MNS records for 11,430 exposed children and 26,850 children in the comparison cohort. Routinely collected attendance records were obtained from the Western Australian Department of Education. Records were available for the years 2008 through 2012 for children who attended public schools in Western Australia. No data were available for those children who attended independent or catholic schools.

Absence from school is classified by the Department of Education as either authorised, where the reason provided by the caregiver is considered adequate or legitimate by the principal, or unauthorised. Unauthorised absences refer to those where a student is absent without a reasonable explanation (e.g. truancy). Attendance is recorded as the number of half days attended in a single semester.

Attendance was calculated as the number of half days in attendance as a percentage of the total number of possible half-days within a single semester. In the case where children attended multiple schools, available days and absences were summed. Therefore, there was one attendance record per student per semester. In the reported models, 68,173 non-Indigenous semester records and 39,815 Indigenous semester records were included. The average number of semesters of data per child was three.

It has previously been identified that attendance records are less consistent for years 11 and 12 due to exams and work placements [1]. Therefore, in an attempt to reduce reporting error, the analysis was restricted to records for children in year 10 and below. In addition, students who had less than 30 per cent attendance were removed from the analysis to remove the impact of those leaving the Western Australian government school system or those who were not attending school.

The Department of Education provide the following categories for attendance: Regular (90-100% attendance), Indicated (80-89% attendance), Moderate (60-79% attendance) and Severe (less than 60% attendance). For the purpose of this analysis, poor attendance was defined differently for non-Indigenous and Indigenous cohorts. In non-Indigenous children poor attendance equated to an attendance rate less than 80% (i.e. severe or moderate attendance). This was approximately 10 per cent of the final, non-Indigenous sample. In Indigenous students, the overall attendance rate was substantially lower. As a result, poor attendance was defined as less than 60% attendance (i.e. severe attendance). This was approximately 18 percent of the final sample of Indigenous students. As absence from school impacts on a child's learning and academic outcomes, whether authorised or unauthorised, total absence represented the primary outcome.

School information

Available school information included school type (primary, secondary, combined), child's grade, and school area. School area refers to the school's location and categorised based on the Standing Council on School Education and Early Childhood Schools Geographic Location Classification System. These categories include metropolitan, provincial (large urban areas outside of the metropolitan area such as Kalgoorlie Boulder or Geraldton), remote and very remote locations. Further, the number of schools attended within the semester, and any history of school suspension was determined. Where multiple schools were attended within a single semester, school information was obtained from the school with most days attended.

Mother's socio-demographic information

Maternal demographic, mental health, and drug use information was obtained from the MNS, Hospital Morbidity Data System (hospital inpatients) and Mental Health Inpatient and Outpatients datasets. Demographic information included in this analysis was predominately from the time of the child's birth and included socioeconomic status, maternal age at child's birth, parity, Indigenous status, health service region (rural or metropolitan), and maternal marital status. In addition, record of any mental health problem or illicit drug use (ICD 9/10 codes), excluding those related to alcohol use, was available.

Child variables

In addition to school information, child gender, preterm status (<37 weeks gestation), and presence of Fetal Alcohol Spectrum Disorder and/or an intellectual disability were obtained from the MNS, Western Australian Register of Developmental Anomalies, and Intellectual Disability database respectively [20]. Further, proportion of optimal birth weight was calculated by comparing observed to optimal birth weight. This measure, which provides an indication of fetal growth, takes into account sex, gestational age, maternal height and parity [21]. Low proportion of optimal birth weight was defined as below the 10th percentile.

Statistical analysis

All analysis was carried out using SAS 9.3 (SAS Institute, Inc., Cary, NC).

Hierarchal generalized linear mixed models with a logit link were used to analyse the relationship between poor attendance and maternal alcohol use, socio-demographic and school characteristics, with models nested at the child and family level. Possible covariates were tested in a univariate model and those which were significant ($\alpha = 0.05$) were tested for significance in the multivariate model. The most parsimonious model was reported. Indigenous and non-Indigenous data were modelled separately. All models included the frequency matching variables (i.e. maternal age and baby year of birth).

In addition, generalised linear models were used to estimate the impact of maternal alcohol use on the number of days absent (total, authorised and unauthorised) within the exposed cohort. In order to estimate this, model parameters were used to score the data. This was completed twice, once with the data in its original form, and once with alcohol exposure set to zero. The difference between the estimated number of days absent was calculated. The difference between these two estimates was used to calculate the percentage of total absences which could be attributed to maternal alcohol use exposure.

The population attributable risk fraction, which is the difference in the rate of non-attendance between the exposed and comparison cohorts, was calculated. The population attributable risk fraction was calculated by adjusting for the matching ratio, and multiplying up to the Western Australian population.

Sensitivity analysis

As the minimum threshold for attendance (i.e. 30%) was not based on a pre-defined cut-point, and in order to test the stability of results, we re-ran the final models using different minimum cut-offs

for attendance. We examined two alternative models, one with a sample of children who attended a minimum of 20 per cent of days during the semester, and a second model which included children who attended a minimum of 40 per cent of available days during the semester. We assessed the change in the strength and direction of results compared to the final models.

Results

A higher proportion of mothers in the non-Indigenous comparison cohort were married (84% vs 72%) and were in the highest 25% of socioeconomic status (15% vs 9.5%) at the time of the child's birth compared with non-Indigenous mothers in the exposed cohort. However, there was little difference in socioeconomic status, health service region, and maternal age at birth between exposed and comparison Indigenous mothers. A substantially greater proportion of non-Indigenous mothers in the exposed cohort had a mental health diagnosis compared with comparison mothers (53.5% vs 11%) and/or a record of illicit drug use (41% vs 2%). Similar findings were observed for the Indigenous cohorts. While numbers were low, fetal alcohol spectrum disorder and intellectual disability were higher in the exposed group when compared to those whose mother did not have an alcohol use disorder diagnosis (Table 1).

When comparing the exposed and comparison children within the Indigenous and non-Indigenous cohorts there were similar proportions of students in schools in metropolitan, provincial and remote schools (Table 2). However, there were differences between Indigenous and non-Indigenous cohorts with a higher proportion of Indigenous students in remote and very remote locations compared to non-Indigenous students (44% vs 9%). A greater proportion of exposed than comparison children attended multiple schools and had a history of a school suspension. This was consistent between non-Indigenous (more than one school: 7% exposed vs 4% comparison, suspension: 11% vs 6%) and Indigenous cohorts (more than one school: 16% exposed vs 13% comparison, suspension: 21% vs 15%). It is important to note that school level data includes multiple records per child.

Attendance profiles by Indigeneity and maternal alcohol use exposure

Table 3 provides the distribution of students across attendance categories by Indigenous status and presence of a maternal alcohol-use disorder. Indigenous students had substantially worse attendance than non-Indigenous students (regular attendance: 30% vs 67%). The median number of authorised absences was 4 days in both non-Indigenous (comaprison:4, Q1-Q3 = 1.3-8.0, exposed:4.3, Q1-Q3 = 1.5-9.5) and Indigenous cohorts (comparison:4.1, Q1-Q3 = 1.0-10.1, exposed:3.7, Q1-Q3 = 1.0-10.1). Median number of days classified as unauthorised absences were substantially higher in the Indigenous cohort (comparison: 9.0 Q1-Q3 = 2.1-24.2, exposed:14.7, Q1-Q3 = 4.0-35.9) compared to the non-Indigenous cohort (comparison:0.0, Q1-Q3 = 0.0-2.6, exposed:1.1, Q1-Q3 = 0.0-5.3). Again, these data are reported at the semester level and, as a result, there are multiple records per child.

Predictors of poor attendance

The unadjusted odds of poor attendance associated with maternal alcohol use disorder were higher in the non-Indigenous cohort (OR = 2.11, 95% CI = 1.98 – 2.26) compared to the Indigenous cohort (OR = 1.70, 95% CI = 1.58 – 1.82). When maternal and child factors were accounted for, children whose mother has an alcohol-use disorder were more likely to be classified as having poor attendance compared with other children (non-Indigenous: OR = 1.61, 95% CI = 1.50 – 1.74, Indigenous: OR = 1.66, 95% CI = 1.54-1.79). As seen in tables 4 and 5, in models which adjusted for maternal and child factors, the odds of poor attendance did not significantly differ with the timing of alcohol diagnosis relative to pregnancy. When models were adjusted for significant school factors, in addition to maternal and child factors, the odds of poor attendance in the Indigenous and non-Indigenous exposed cohorts were the same (non-Indigenous cohort: OR = 1.57, 95% CI = 1.45- 1.69, Indigenous cohort: OR = 1.57, 95% CI =1.46 -1.69). A number of socio-demographic factors were significantly associated with poor school attendance (tables 4 and 5). In the non-Indigenous cohort, there was increasing odds of poor attendance with increasing socioeconomic disadvantage. Mothers under the age of 20 at the time of the child's birth were at greater risk of having a child with poor attendance compared with those in the 20 to 25-year-old age group (< 20 years: OR = 1.48 95% CI = 1.34-1.64). In contrast, having a mother over the age of 25 appeared protective. Further, children of unmarried mothers were at significantly greater odds of poor attendance compared with married mothers (never married: OR = 1.39, 95% CI = 1.28-1.51, Separated, widowed or divorced: OR = 1.54, 95% CI = 1.26-1.89). In the Indigenous cohort maternal age at birth (<20 years: OR = 1.41, 95% CI = 1.28 – 1.57), socio-economic status (most disadvantaged 10%: OR = 1.38, 95% CI = 1.19 – 1.60) and parity (3 or more siblings: OR = 1.86, 95% CI = 1.65 – 2.09) were associated with increased odds of poor attendance. In addition, Indigenous children born in rural health service regions were at greater odds of being classified as having poor attendance compared with Indigenous children born in metropolitan regions (rural: OR = 1.48, 95% CI = 1.37 – 1.60). Of note, in the non-Indigenous cohort a maternal mental health diagnosis was associated with increased odds of poor attendance (OR = 1.22, 95% CI = 1.13-1.32). However, in the Indigenous cohort a maternal mental health diagnosis, or a record of illicit drug use appeared protective (mental health diagnosis: OR = 0.90, 95% CI =0.82-0.99, illicit drug record: OR = 0.85, 95% CI =0.76-0.95).

There were a number of school factors which were significantly associated with poor attendance in both the non-Indigenous and Indigenous cohorts (Tables 6 and 7). Children in secondary school were at greater odds of poor attendance than children in primary school (non-Indigenous OR = 1.36, 95% CI = 1.19-1.56, Indigenous: OR = 1.66, 95% CI = 1.52-1.81). In addition, those attending a school in remote areas had a greater risk of poor attendance compared with other children in both non-Indigenous (remote/ very remote: OR =1.26, 95% CI =1.12 – 1.41) and Indigenous cohorts (remote:

OR =1.32, 95% CI =1.19-1.47, very remote: OR =1.62 95% CI =1.45-1.80). A higher number of schools attended within the semester, and a suspension record (non-Indigenous: OR = 2.36 95% CI =2.19-2.54, Indigenous: OR = 1.42 95% CI = 1.33 – 1.52), were also positively associated with likelihood of poor attendance.

Impact of maternal alcohol use on attendance rates

The population attributable fraction for poor attendance with any maternal alcohol diagnosis was estimated to be 1.3% (1.2-1.5) in the non-Indigenous population and 6.0% (95% CI = 5.0– 6.7) in the Indigenous population. It is important to note that poor attendance was defined as less than 80 percent attendance for non-Indigenous students, and less than 60 percent attendance for Indigenous students.

When the impact was estimated within the exposed cohort, maternal alcohol use disorder accounted for approximately 15 percent of total days absent in both Indigenous and non-Indigenous children (16% and 14% respectively). Further, maternal alcohol use accounted for 30 per cent of unauthorised absences in non-Indigenous children and 19 per cent in Indigenous children. Maternal alcohol-use disorder accounted for 8 and 2 per cent of the authorised absences in exposed non-Indigenous and Indigenous children respectively.

Sensitivity analysis

Sensitivity analysis, which made use of alternative minimum attendance thresholds for inclusion in modelling, suggested that the final models were relatively stable. The average difference between the results of these models was less than 11 percent, and the use of different minimum attendance thresholds did not change the direction or interpretation of the final models.

Discussion

As hypothesised, children whose mother had received a diagnosis of an alcohol-use disorder were significantly more likely to be classified as having poor attendance compared with children whose mother did not have a diagnosis. This finding was consistent in both Indigenous and non-Indigenous cohorts (non-Indigenous cohort: OR = 1.56, 95% CI = 1.45- 1.69, Indigenous cohort: OR = 1.57, 95% CI =1.46 -1.69). While any diagnosis of an alcohol-use disorder was associated with poor school attendance, in the final models there was little difference between the timing of diagnosis relative to pregnancy, or the strength of association with attendance outcomes. Of note, this finding differs from the result of previously published results which make use of data from this cohort. O'Leary and colleagues identified that the there was a significantly increased risk of birth defects and intellectual disability in children whose mother received an alcohol related diagnosis during pregnancy, compared to children whose mother received a diagnosis at other time points [20 22]. However, the results of this study suggest, that the relationship between exposure and attendance may be driven by maternal alcohol use disorder at any of the time periods in relation to pregnancy. This may be mediated through family and social environmental factors that we were unable to adjust for during pregnancy and/or pre and post pregnancy. Whilst the data do not provide detailed information about the family or household circumstances pre or post birth, previous research demonstrates that households with heavy parental alcohol use are at risk of instability, as well as concomitant risks such as abuse, poor family functioning, mental health problems and illicit substance use [10 13 23]. This is likely to be an environment in which school attendance is not prioritised. While results should be interpreted with caution, as an alcohol related diagnosis does not capture all women who drink during pregnancy, these findings suggest that providing social support for vulnerable families may be effective in reducing child non-attendance.

In addition to maternal alcohol use, there were a number of socio-demographic factors which were associated with poor attendance. Indigenous children had substantially worse attendance than non-Indigenous students. This attendance gap is well recognised in the literature, and exists in spite of targeted interventions which span a number of decades [24]. This significant gap has been attributed to several factors including greater family mobility, social and cultural reasons for absence, the higher rate of emotional and behavioural problems in Aboriginal children, the intergenerational legacy of past practices of exclusion of Aboriginal children from schools, and their impact on shaping family and community values regarding the importance of attending school in Indigenous families compared with non-Indigenous families [25-27]. Additional socioeconomic and school factors differed slightly between the Indigenous and non-Indigenous cohorts. However, low maternal age at child's birth, high parity and greater school mobility were consistently found to be associated with poor

attendance. Further, it was evident that there was a strong relationship between type of school and attendance, with children in secondary school at greater odds of poor attendance compared with children attending primary school. This in part may be due to children leaving school to attend workplace training, alternative education pathways, or greater autonomy in older age groups leading to increased truancy. However, it suggests that interventions to support children throughout their school career are needed to encourage higher rates of attendance, and student retention, through to school completion. Of note, in the Indigenous cohort, a diagnosis of a maternal mental health disorder or maternal record of illicit drug use in the administrative datasets was protective of poor attendance in the Indigenous cohort. While we are unable to investigate this further due to the nature of administrative data, this may reflect greater service use, increased likelihood of intervention, or increased support for families with a mother who has been identified to have a mental health or history of illicit drug use.

The population attributable fraction provides an estimate of reduction in the poor attendance that would occur if maternal alcohol use disorder were eliminated. This was estimated to be 1.3 percent in the non-Indigenous population and 6 percent in the Indigenous population. While the population attributable fraction was substantially higher in the Indigenous population compared with the non-Indigenous, this was due to the higher prevalence of maternal alcohol use disorder in Indigenous mothers within the community. Therefore, we also aimed to quantify the impact of maternal alcohol use disorder within the exposed population by estimating the percentage of days absent associated with maternal alcohol use disorder. We estimated the impact of maternal alcohol-use disorder on total, unauthorised and authorised absences in the exposed populations. These results suggest that maternal alcohol use disorder predominantly impacts unauthorised absences and the impact, when measured as the percentage of days absent, was greater in non-Indigenous children than Indigenous children. While the greatest effect appeared to be on unauthorised absences, eight percent of authorised absences in the non-Indigenous cohort could be attributed to maternal alcohol use disorder. Of note, while the population attributable fraction is higher in Indigenous cohorts, the impact is greater in non-Indigenous children. This finding supports the intervention programs which target both parent and child school engagement to reduce child non-attendance.

Strengths and limitations

A key strength of the project is the use of administrative data which avoids the use of self-reports of drinking behaviours which may be biased due to retrospective recall and social desirability. Further, we can be confident that mothers who received an alcohol related diagnosis were consuming alcohol at very high levels in order to be identified on administrative datasets. However, it is important to note that it is likely that there are a number of children who were exposed to

significant amounts of maternal alcohol use (as evidenced by the presence of cases of Fetal Alcohol Spectrum Disorder in the comparison cohort), and the associated social and environmental effects, which were not identified in the dataset. This dilution of the comparison group is likely to bias the findings towards the null. Further, information relating to ongoing alcohol use, or patterns of use during and post pregnancy, are unknown. In addition, comorbidities, the family environment, and additional unmeasured confounders not captured by administrative datasets cannot be included in the analysis. Therefore, it is difficult to ascertain all the underlying reasons for school non-attendance. Additional work is required to determine the reasons for non-attendance in families where there is maternal alcohol use problems, in order to develop and target effective interventions.

Conclusions

The causes of non-attendance are complex. However, this study indicates that a child whose mother has an alcohol related diagnosis is significantly more likely to have poor attendance problems than children whose mother does not have a diagnosis, after adjustment for a number of potential confounders. The strength of the association of poor school attendance was similar at each of the time periods where a maternal alcohol diagnosis was recorded and an alcohol diagnosis recorded during pregnancy was not strongly associated with poor school attendance. This result differs from previous studies which use this cohort, where exposure in pregnancy had a greater effect, and suggests that all children whose mother has an alcohol related diagnosis are at increased risk of poor school attendance [20 22]. These findings may indicate that the relationship between school attendance and maternal alcohol use disorders is not primarily driven by the neurobehavioral effects of alcohol during pregnancy, but rather a complex family and social environment in which school attendance is not a priority or not well monitored. Ongoing pre-pregnancy counselling regarding the impact of alcohol use on the offspring, as well as ongoing education and support regarding problematic or risky drinking behaviours throughout pregnancy and parenthood is imperative. However, it is important to note that, despite existing public health campaigns which promote abstinence from alcohol during pregnancy, it appears there is a portion of the population who continue to drink heavily during pregnancy and parenthood. In addition to programs aimed at reducing alcohol intake by mothers, additional social and parenting support for at risk families is required. Further research regarding why women continue to consume significant amounts of alcohol in these time periods despite health recommendations, as well as more effective methods to target, educate and support these women is needed. Finally, detailed and mandatory data collection regarding alcohol use during pregnancy, would not only improve the ability to intervene when risky drinking behaviours

are identified during pregnancy or post-pregnancy, but would also improve the quality of research and understanding regarding alcohol use and child outcomes.

Authorship Statement: CO, CB, JS and SZ conceptualized the study, obtained funding. KH completed the analysis and drafted the manuscript. DL provided expert advice, both in statistical analysis and the drafting of the manuscript. All authors contributed to the final manuscript.

Competing interests: We have read and understood BMJ policy on declaration of interests and declare that we have no competing interests.

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References

1. Hancock KJ, Shepherd CC, Lawrence D, et al. Student attendance and educational outcomes: Every day counts: Telethon Institute for Child Health Research 2013.
2. Dube SR, Orpinas P. Understanding Excessive School Absenteeism as School Refusal Behavior. *Children and Schools* 2009;31(2):87-95.
3. Daraganova G, Mullan K, Edwards B. Occasional Paper No. 51: Attendance in primary school: factors and consequences Canberra: Australian Government Department of Social Services, 2014.
4. Kearney CA. School absenteeism and school refusal behavior in youth: A contemporary review. *Clinical Psychology Review* 2008;28:451-71.
5. Romero M, Lee Y. A National Portrait of Chronic Absenteeism in the Early Grades. New York National Center for Children in Poverty, Columbia University, 2007.
6. Moore T, McArthur M. If only I, they, we had done things differently: Young people talk about school difficulties and crime. *Children and youth services review* 2014;44:249-55.
7. Vall O, Salat-Batlle J, Garcia-Algar O. Alcohol consumption during pregnancy and adverse neurodevelopmental outcomes. *Journal of epidemiology and community health* 2015:jech-2014-203938.
8. Goldschmidt L, Richardson GA, Stoffer DS, et al. Prenatal alcohol exposure and academic achievement at age six: a nonlinear fit. *Alcoholism: Clinical and Experimental Research* 1996;20(4):763-70.
9. Mattson SN, Riley EP. A review of the neurobehavioral deficits in children with fetal alcohol syndrome or prenatal exposure to alcohol. *Alcoholism: Clinical and Experimental Research* 1998;22(2):279-94.
10. Hutchinson DM, Mattick RP, Danya B, et al. The impact of alcohol use disorders on family life: a review of the empirical literature: National Drug and Alcohol Research Centre, University of New South Wales, 2014.
11. Burke S, Schmied V, Montrose M. Parental alcohol misuse and the impact on children - A literature review: Research, Funding & Business Analysis Division, Centre for Parenting & Research, 2006.
12. Dawe S, Harnett P, Frye S. Improving outcomes for children living in families with parental substance misuse: What do we know and what should we do. *National Child Protection Clearinghouse* 2008(29)
13. Burns L, Teesson M, Lynskey M. The epidemiology of comorbidity between alcohol use disorders and mental disorders in Australia: National Drug and Alcohol Research Centre.
14. Casas-Gil MJ, Navarro-Guzman JI. School characteristics among children of alcoholic parents *Psychological Reports* 2002(90):341-48.
15. Hill NE, Taylor LC. Parental school involvement and children's academic achievement pragmatics and issues. *Current directions in psychological science* 2004;13(4):161-64.
16. Barton AC, Drake C, Perez JG, et al. Ecologies of parental engagement in urban education. *Educational Researcher* 2004;33(4):3-12.
17. Peters M, Ken Seeds K, Goldstein A, et al. Parental involvement in children's education 2007: BMRB Social Research, Department for children, schools and families, 2008.
18. O'Leary CM, Watson L, D'Antoine H, et al. Heavy maternal alcohol consumption and cerebral palsy in the offspring. *Developmental Medicine & Child Neurology* 2012;54(3):224-30. doi: 10.1111/j.1469-8749.2011.04201.x
19. Holman CDAJ, Bass AJ, Rouse IL, et al. Population-based linkage of health records in Western Australia: development of a health services research linked database. *Australian and New Zealand Journal of Public Health* 1999;23(5):453-59. doi: 10.1111/j.1467-842X.1999.tb01297.x

20. O'Leary C, Leonard H, Bourke J, et al. Intellectual disability: population-based estimates of the proportion attributable to maternal alcohol use disorder during pregnancy. *Developmental Medicine & Child Neurology* 2013;55(3):271-77. doi: 10.1111/dmcn.12029
21. Blair EM, Liu Y, de Klerk NH, et al. Optimal fetal growth for the Caucasian singleton and assessment of appropriateness of fetal growth: an analysis of a total population perinatal database. *BMC pediatrics* 2005;5(1):1.
22. O'Leary CM, Elliott EJ, Nassar N, et al. Exploring the potential to use data linkage for investigating the relationship between birth defects and prenatal alcohol exposure. *Birth Defects Research Part A: Clinical and Molecular Teratology* 2013;97(7):497-504. doi: 10.1002/bdra.23142
23. Jacobson SW, Chiodo LM, Sokol RJ, et al. Validity of maternal report of prenatal alcohol, cocaine, and smoking in relation to neurobehavioral outcome. *Pediatrics* 2002;109(5):815-25.
24. Gray J, Beresford Q. A 'formidable challenge': Australia's quest for equity in Indigenous education. *Australian Journal of Education* 2008;52(2):197-223.
25. Bourke CJ, Rigby K, Burden J. Better Practise in School Attendance: Improving the school attendance of Indigenous Students: Monash University, 2000.
26. Purdie N, Buckley S. School Attendance and Retention of Indigenous Australian Students. Issues Paper No. 1: ERIC 2010.
27. Zubrick SR, Silburn SR, De Maio JA, et al. Western Australian Aboriginal Child Health Survey: Improving the educational experiences of Aboriginal children and young people. Perth: Curtin University of Technology and Telethon Institute for Child Health Research, , 2006.

Table 1. Characteristics of mothers and the time of their child's birth, by Indigenous status and maternal alcohol-use disorder exposure

	Non-Indigenous				Indigenous			
	Comparison		Exposed		Comparison		Exposed	
	n	percent	n	percent	n	percent	n	percent
*Maternal age**								
<20	2,364	14.3	854	12.4	2,515	24.5	1,004	22.1
20 < 25	5,123	30.9	2,054	29.8	3,306	32.2	1,475	32.5
25 < 30	4,502	27.1	1,950	28.3	2,495	24.3	1,129	24.8
30 < 35	3,017	18.2	1,354	19.7	1,361	13.3	668	14.7
35 < 40	1,320	8.0	576	8.4	535	5.2	246	5.4
40+	257	1.5	98	1.4	55	0.5	22	0.5
Marital status								
Married	13,971	84.2	4,969	72.2	6,770	65.9	2,782	61.2
Never married	2,447	14.8	1,637	23.8	3,215	31.3	1,609	35.4
Separated/divorced/widowed	146	0.9	236	3.4	209	2.0	101	2.2
Missing	19	0.1	44	0.6	73	0.7	52	1.1
Socioeconomic Status								
Highest > 10%	780	4.7	192	2.8	34	0.3	5	0.1
10-<25%	1,742	10.5	527	7.7	157	1.5	47	1.0
25-<50%	3,432	20.7	1,239	18.0	714	7.0	229	5.0
50-<75%	4,313	26.0	1,772	25.7	1,784	17.4	638	14.0
75-<90%	3,014	18.2	1,426	20.7	2,386	23.2	912	20.1
Lowest 10%	1,842	11.1	1,170	17.0	3,247	31.6	1,452	32.0
Missing / unknown	1,460	8.8	560	8.1	1,945	18.9	1,261	27.8
Health service region								
Perth metropolitan area	11,773	71.0	4,862	70.6	3,628	35.3	1,519	33.4
Rural / remote	4,810	29.0	2,024	29.4	6,639	64.7	3,025	66.6
Any mental health diagnosis								
No	14,761	89.0	3,205	46.5	8,947	87.1	3,071	67.6

Yes	1,822	11	3,681	53.5	1,320	12.9	1,473	32.4
Any Illicit drugs record								
No	16,224	97.8	4,085	59.3	9,554	93.1	3,315	73.0
Yes	359	2.2	2,801	40.7	613	6.0	1,229	27.0
Fetal Alcohol Spectrum Disorder								
No	16,583	100	6,882	99.9	10,256	99.9	4,487	98.8
Yes	0	0.0	4	0.1	11	0.1	57	1.3
Intellectual disability								
No	16,260	98.1	6,695	97.2	10,007	97.5	4,349	95.7
Yes	323	2.0	191	2.8	260	2.5	195	4.3
Total	*16,583*	*100*	*6,886*	*100*	*10,267*	*100*	*4,544*	*100*

*frequency matching variable

Table 2. School factors for all linked records, year 10 or below, by Indigenous status and maternal alcohol-use disorder exposure

	Non-Indigenous				Indigenous			
	Comparison		Exposed		Comparison		Exposed	
	n	percent	n	percent	n	percent	n	percent
Number of years per child								
1	2,699	18.2	1,083	17.6	1,710	18.7	821	20.3
2	2,570	17.3	979	15.9	1,558	17	704	17.4
3	2,418	16.3	1,037	16.8	1,447	15.8	658	16.3
4	2,268	15.3	974	15.8	1,452	15.8	660	16.3
5	4,878	32.9	2,090	33.9	2,998	32.7	1,205	29.8
School type								
Combined	1,797	3.7	961	4.7	3,254	10.9	1,475	11.5
Primary	33,145	68.3	13,391	65.3	18,316	61.1	7,839	60.9
Secondary	12,466	25.7	5,499	26.8	7,000	23.4	2,819	21.9
Other	1,147	2.4	647	3.2	1,395	4.7	735	5.7
School area								
Metropolitan	31,540	65	12,675	61.8	9,978	33.3	3,701	28.8
Provincial	46	26.4	5,892	28.8	7,265	24.2	2,916	22.7
Remote, very remote, school closed	4,181	8.6	1,913	9.3	12,722	42.5	6,251	48.6
Number of schools attended								
1 school	46,700	96.2	19,099	93.2	26,066	87	10,801	83.9
2 schools	1,771	3.7	1,312	6.4	3,461	11.6	1,823	14.2
3 or more schools	84	0.2	87	0.4	438	1.5	244	1.9
Suspension Record								
No	45,810	94.4	18,277	89.2	25,376	84.7	10,203	79.3
Yes	2,745	5.6	2,221	10.8	4,589	15.3	2,665	20.7

Note: 1 record per child per year attended within follow up period

Table 3. Attendance categories for all linked records year 10 and below, by Indigenous status and maternal alcohol-use disorder exposure

	Non-Indigenous				Indigenous			
	Comparison		Exposed		Comparison		Exposed	
	n	percent	n	percent	n	percent	n	percent
Regular (90-100% attendance)	35,163	72.4	12,459	60.8	9,769	32.6	3,254	25.3
Indicated (80-89% attendance)	9,295	19.1	4,697	22.9	6,915	23.1	2,382	18.5
Moderate (60-79% attendance)	3,199	6.6	2,354	11.5	7,366	24.6	3,309	25.7
Severe (<60% attendance)	898	1.9	988	4.8	5,915	19.7	3,923	30.5
Total	48,555	100.0	20,498	100.0	29,965	100.0	12,868	100.0

Note: 1 record per child per year attended within follow up period

Table 4. Adjusted odds ratios for alcohol use disorder exposure and demographic factors significantly associated with <80% attendance, Non-Indigenous

		OR*	95% confidence interval	
Alcohol diagnosis	No Alcohol diagnosis	Ref		
	During pregnancy	1.48	1.14	1.93
	>1 years post-pregnancy	1.61	1.47	1.77
	>1 year pre-pregnancy	1.66	1.50	1.84
	Up to 1 year post-pregnancy	1.42	1.09	1.85
	Up to 1 year pre-pregnancy	1.56	1.28	1.89
Maternal age at child's birth	20 < 25 years	Ref		
	<20 years	1.48	1.34	1.64
	25 < 30 years	0.83	0.76	0.9
	30 < 35 years	0.72	0.65	0.8
	35 < 40 years	0.68	0.59	0.78
	40+ years	0.79	0.6	1.04
Marital status	Married	Ref		
	Never married	1.39	1.28	1.51
	Separated, widowed, divorced	1.54	1.26	1.89
Socioeconomic status	Most Advantaged > 10%	Ref		
	Second Group 10% to <25%	1.21	0.94	1.57
	Third Group 25% to <50%	1.42	1.12	1.8
	Fourth Group 50% to <75%	1.58	1.25	1.99
	Fifth Group 75% to <90%	1.79	1.41	2.27
	Most Disadvantaged Bottom 10%	1.92	1.51	2.44
	Unknown	1.38	1.07	1.78
Parity	0	Ref		
	1	1.3	1.19	1.41
	2	1.82	1.64	2.02
	3+	2.68	2.39	3.02
Percentage of optimal birth weight	Greater or equal to 10th percentile	Ref		

	less than 10th percentile	1.25	1.13	1.37
Mental health diagnosis	No	Ref		
	Yes	1.22	1.13	1.32

OR= odds ratio adjusted for all other variables and baby year of birth (matching variable)

Table 5. Adjusted odds ratios for alcohol use disorder exposure and demographic factors significantly associated with <0 60% attendance, Indigenous

		OR*	95% confidence interval	
Alcohol diagnosis	No Alcohol diagnosis	Ref		
	During pregnancy	1.60	1.36	1.90
	>1 years post-pregnancy	1.83	1.66	2.01
	>1 year pre-pregnancy	1.48	1.31	1.67
	Up to 1 year post-pregnancy	1.34	1.06	1.68
	Up to 1 year pre-pregnancy	1.56	1.30	1.88
Maternal age at child's birth	20 < 25 years	Ref		
	<20 years	1.41	1.28	1.57
	25 < 30 years	0.77	0.70	0.85
	30 < 35 years	0.73	0.65	0.82
	35 < 40 years	0.74	0.62	0.87
	40+ years	0.88	0.56	1.38
Marital status	Married	Ref		
	Never married	1.18	1.09	1.27
	Separated, widowed, divorced	0.88	0.69	1.12
Socioeconomic status	>50% - most advantaged	Ref		
	50% to <75%	1.09	0.93	1.28
	75% to <90%	1.18	1.02	1.38
	Most disadvantaged 10%	1.38	1.19	1.60
	Unknown	1.94	1.67	2.26
Health region	Metropolitan	Ref		
	Rural	1.48	1.37	1.60
Parity	0	Ref		
	1	1.18	1.06	1.31
	2	1.29	1.14	1.46
	3+	1.86	1.65	2.09
Any maternal mental health	No	Ref		

	Yes	0.90	0.82	0.99
Any Illicit drug record	No	Ref		
	Yes	0.85	0.76	0.95
Child intellectual disability	No	Ref		
	Yes	1.23	1.00	1.52

OR= odds ratio adjusted for all other variables and baby year of birth (matching variable)

Table 6. Adjusted odds ratios for alcohol use disorder exposure, demographic and school factors significantly associated with <80% attendance, non-Indigenous mothers

		OR	95% confidence interval	
Alcohol diagnosis	No Alcohol diagnosis	Ref		
	During pregnancy	1.52	1.17	1.98
	>1 years post-pregnancy	1.55	1.41	1.70
	>1 year pre-pregnancy	1.62	1.46	1.80
	Up to 1 year post-pregnancy	1.36	1.04	1.78
	Up to 1 year pre-pregnancy	1.58	1.30	1.92
Marital status	Married	Ref		
	Never married	1.33	1.22	1.45
	Separated, widowed, divorced	1.52	1.24	1.88
Socioeconomic status	Most Advantaged > 10%	Ref		
	Second Group 10% to <25%	1.18	0.91	1.53
	Third Group 25% to <50%	1.36	1.07	1.72
	Fourth Group 50% to <75%	1.48	1.17	1.87
	Fifth Group 75% to <90%	1.68	1.32	2.13
	Most Disadvantaged Bottom 10%	1.79	1.41	2.28
	Unknown	1.30	1.01	1.68
Mental health diagnosis	No	Ref		
	Yes	1.20	1.11	1.30
Maternal age at child's birth	20 < 25 years	Ref		
	<20 years	1.42	1.29	1.58
	25 < 30 years	0.87	0.79	0.95
	30 < 35 years	0.78	0.70	0.86
	35 < 40 years	0.76	0.66	0.88
	40+ years	0.91	0.69	1.21
Parity	0	Ref		
	1	1.26	1.16	1.37

	2	1.73	1.56	1.92
	3+	2.47	2.19	2.78
Number of schools	1 school	Ref		
	2 schools	2.41	2.20	2.64
	3 or more schools	3.48	2.49	4.87
School type	Primary	Ref		
	Combined	1.11	0.94	1.31
	Secondary	1.36	1.19	1.56
	Other	0.97	0.81	1.18
School area	Metropolitan	Ref		
	Provincial	0.99	0.92	1.07
	Remote, very remote, closed	1.25	1.12	1.40
Year level	1	Ref		
	2	0.82	0.73	0.92
	3	0.81	0.71	0.92
	4	0.80	0.70	0.92
	5	0.84	0.72	0.97
	6	0.88	0.75	1.03
	7	1.01	0.86	1.20
	8	1.45	1.18	1.78
	9	2.54	2.06	3.14
	10	3.75	3.02	4.66
Ever suspended	No	Ref		
	Yes	2.36	2.19	2.54

OR = adjusted for all other variables in the table and baby year of birth (matching variable)

Table 7. Adjusted odds ratios for alcohol use disorder exposure, demographic and school factors significantly associated with <60% attendance, Indigenous mothers

		OR	95% confidence interval	
Alcohol diagnosis	No Alcohol diagnosis	Ref		
	During pregnancy	1.58	1.34	1.87
	>1 years post-pregnancy	1.60	1.45	1.76
	>1 year pre-pregnancy	1.60	1.41	1.81
	Up to 1 year post-pregnancy	1.26	1.00	1.57
	Up to 1 year pre-pregnancy	1.57	1.30	1.89
Maternal age at child's birth	20 < 25 years			
	<20 years	1.36	1.23	1.51
	25 < 30 years	0.83	0.75	0.92
	30 < 35 years	0.78	0.70	0.88
	35 < 40 years	0.79	0.67	0.94
	40+ years	1.06	0.67	1.68
Marital status	Married			
	Never married	1.15	1.07	1.25
	Separated, widowed, divorced	0.95	0.75	1.21
Socioeconomic status	>50% - most advantaged			
	50% to <75%	1.06	0.90	1.24
	75% to <90%	1.23	1.06	1.43
	Most disadvantaged 10%	1.36	1.17	1.57
	Unknown	1.71	1.46	1.99
Health region	Metropolitan			
	Rural	1.26	1.15	1.38
Parity	0			
	1	1.18	1.06	1.31
	2	1.25	1.11	1.41

	3+	1.80	1.60	2.03
Record of Illicit drugs use	No			
	Yes	0.88	0.79	0.98
Number of schools	1 school			
	2 schools	2.25	2.10	2.40
	3 or more schools	3.28	2.80	3.85
School type	Primary			
	Combined	1.65	1.50	1.82
	Secondary	1.66	1.52	1.81
	Other	1.06	0.77	1.46
School area	Metropolitan			
	Provincial	0.84	0.76	0.93
	Remote	1.32	1.18	1.47
	School Closed	1.78	1.26	2.51
	Very Remote	1.62	1.45	1.80
Year level	1			
	2	0.81	0.73	0.90
	3	0.81	0.72	0.90
	4	0.67	0.59	0.76
	5	0.73	0.64	0.83
	6	0.77	0.67	0.89
	7	0.91	0.78	1.05
	8	1.10	0.93	1.30
	9	1.73	1.46	2.06
	10	2.29	1.91	2.75
Suspension record	No			
	Yes	1.42	1.33	1.52

OR = adjusted for all other variables in the model and baby year of birth (matching variable)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Page 1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Page 2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page 4
Objectives	3	State specific objectives, including any prespecified hypotheses	Page 5
Methods			
Study design	4	Present key elements of study design early in the paper	Page 6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Page 6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	Page 6
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	Page 6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Page 7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Page 7
Bias	9	Describe any efforts to address potential sources of bias	Page 7 and 9
Study size	10	Explain how the study size was arrived at	Page 6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Pages 7-9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Page 9
		(*b*) Describe any methods used to examine subgroups and interactions	n/a
		(*c*) Explain how missing data were addressed	n/a
		(*d*) If applicable, explain how loss to follow-up was addressed	n/a
		(*e*) Describe any sensitivity analyses	Page 9
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Page 7
		(b) Give reasons for non-participation at each stage	n/a
		(c) Consider use of a flow diagram	n/a
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Page 11, and page 20 (table 1)
		(b) Indicate number of participants with missing data for each variable of interest	Page 22 (table 2)
		(c) Summarise follow-up time (eg, average and total amount)	Page 22 (table 2)
Outcome data	15*	Report numbers of outcome events or summary measures over time	Page 22 (table 2)
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Page 11
		(*b*) Report category boundaries when continuous variables were categorized	Page 20 (table 1), page 22 (table 2)
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Page 13
Discussion			
Key results	18	Summarise key results with reference to study objectives	Page 14
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page 14-16
Generalisability	21	Discuss the generalisability (external validity) of the study results	Page 15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page 17

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

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

BMJ Open

Maternal alcohol use disorder and child school attendance outcomes for non-Indigenous and Indigenous children in Western Australia: a population cohort record linkage study

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Maternal alcohol use disorder and child school attendance outcomes for non-Indigenous and Indigenous children in Western Australia: a population cohort record linkage study

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Abstract

Objectives: Examine the relationship between maternal alcohol-use disorder and child school attendance outcomes for non-Indigenous and Indigenous children in Western Australia.

Design: Population cohort study.

Setting: Routinely collected linked administrative health, education and child protection data.

Participants: Those in-scope for the study were women with a birth recorded on the Western Australian Midwives Notification System (1989-2007). Women who had an alcohol related diagnosis (ICD 9/10) recorded on the Hospital Morbidity, Mental Health Outpatients and Drug and Alcohol Office datasets formed the exposed group. The comparison cohort were frequency matched to the exposed cohort based on maternal age within Indigenous status, and child's year of birth.

Primary outcome measure: Child's school attendance was obtained from the Department of Education (2008-2012). Poor attendance was defined as <80% attendance for non-Indigenous children, and <60% attendance for Indigenous children.

Results: 11,430 exposed children and 26,850 unexposed children had a linked attendance record. Maternal alcohol-use disorder was significantly associated with increased odds of poor attendance (non-Indigenous: OR = 1.61, 95% CI = 1.50-1.74, Indigenous: OR = 1.66, 95% CI = 1.54-1.79). With adjustment for maternal and child factors, there was no significant difference between the timing of alcohol diagnosis relative to pregnancy, and attendance outcomes. The population attributable fraction was higher in the Indigenous cohort than the non-Indigenous cohort (6.0% vs 1.3%).

Conclusions: Maternal alcohol-use disorder was associated with a significantly increased odds of poor school attendance for non-Indigenous and Indigenous children. There was no significant difference between the timing of diagnoses and odds of poor school attendance. This suggests that the effect of maternal alcohol-use disorder may not be driven by the neurodevelopmental effects of alcohol exposure in-utero, but may be mediated through family or social factors for which we were unable to adjust.

Strengths and limitations of this study

- A key strength of this analysis is the use of administrative linked data to obtain a large population cohort, which negates the use of retrospective recall of past behaviours, and removes participation bias.

- In addition, due to the frequency matching of the comparison group to the exposed cohort, both Indigenous and non-Indigenous estimates could be calculated.
- A limitation of the study is that there are women in the comparison group who may have drunk heavily during the same time period, without receiving an alcohol related diagnosis, and this would bias estimates towards the null.
- In addition, we lacked information regarding ongoing alcohol use by mothers, and were unable to access paternal information which may have affected outcomes.

Background

It is well recognised that, in order to gain the skills necessary for academic and social success, children need to attend school regularly [1 2]. Previous research has identified that absences from school are linked with negative outcomes such as greater risk of poor academic performance, risk taking behaviours, delinquency and early school dropout [3 4]. Of note, children from disadvantaged backgrounds have been identified as more likely to have poor attendance patterns, and are disproportionately affected by absences compared with other children [1 5]. As poor school attendance in the early years is highly predictive of future absences [1], there has been substantial interest in identifying risk factors for absences in the early years of schooling with the aim of providing additional support and interventions to vulnerable children and families.

A number of factors have been associated with poor school attendance, including low socioeconomic status, and low levels of parental education[1 3].In Australia, Indigenous young people have been identified to have significantly worse attendance and school retention when compared to non-Indigenous children, and it has been suggested that this is a key driver of the gap in academic outcomes between non-Indigenous and Indigenous young people [6-8]. In addition Moore and McArthur identified that maternal and family risks such as family instability, mental illness and drug and alcohol issues, are associated with reduced child participation in school [9]. Poor school attendance can also indicate lack of engagement in schooling, on the part of both the child and their parents or carers.

One group who may be at risk of poor attendance are children of mothers with alcohol-use disorders. The teratogenic effects of prenatal alcohol exposure on the developing brain can lead to neurodevelopmental deficits in the child [10]. At high levels of exposure, and during vulnerable time points during pregnancy, prenatal alcohol exposure has cognitive and behavioural impacts which may affect a child's academic performance and behaviour [11 12]. In addition to in-utero effects of alcohol, children exposed to heavy parental alcohol use postnatally have been identified as having abnormal developmental and social trajectories. This has been attributed to greater family instability, poor family functioning and communication, and greater levels of family stress. In addition, it has been identified that there is a higher risk of child abuse periods out of home care, and mental health problems in the offspring of parents who have heavy alcohol use [13-16]. Further, co-morbidities associated with heavy alcohol use, such as use of other substances, parental mental and physical health problems, may add to an unstable home environment in which school attendance is not prioritised [15 17 18]. Previous research has identified that parental alcoholism is a risk factor for poor school performance, and school absenteeism [19]. Heavy maternal alcohol consumption is one of

a range of factors that is negatively associated with parents' involvement in their children's education [20-22]. However, little research has examined whether heavy maternal alcohol use specifically, and the timing of alcohol use relative to pregnancy, impacts on a child's school attendance.

Therefore, the primary aim of this project was to determine whether maternal alcohol exposure contributed to poor school attendance, and to quantify the impact on school absenteeism for Indigenous and non-Indigenous young people. In addition, this project sought to determine whether the timing of a maternal alcohol related diagnosis in relation to pregnancy differentially affected a child's school attendance patterns, with the aim of determining whether this relationship was driven by biological effects of alcohol exposure in-utero. In order to investigate these relationships, we made use of routinely collected administrative education, health, and child protection data. It was hypothesised that children whose mother had a diagnosis of an alcohol-use disorder, which provided a proxy for heavy drinking, would be at greater risk of poor attendance than other children.

Methods

Cohort

This analysis made use of routinely collected Western Australian administrative linked data. All women who had a birth recorded on the Western Australian Midwives Notification System (MNS) between 1983 and 2007 were in-scope for the study (n =253,714 women, non-Indigenous: n = 242,956 and Indigenous: n=10,758)[23]. Cohort selection has been described previously [24].

Mothers with an alcohol related diagnosis, based on the International Classification of Diseases Revisions 9/10, were considered to have an alcohol-use disorder and constituted the exposed group. An alcohol related diagnosis provided a proxy for heavy maternal alcohol use. Diagnoses were obtained from the following administrative datasets: Hospital Morbidity data system; Mental Health inpatients and Outpatients; and the Drug and Alcohol office. Diagnoses recorded at any time prior to the birth, during pregnancy or postnatally, during the follow up period, were considered in-scope. Included diagnoses are included in Supplementary material, table 1.

The comparison cohort included a random selection of mothers, identified on the Western Australian MNS, who had no records of an alcohol related diagnosis. This cohort was frequency matched to the cohort of exposed mothers based on maternal age within Indigenous status, and year of child's birth. The ratio of exposed to comparison mothers was 1:3 and 1:2 for non-Indigenous and Indigenous mothers respectively. It is important to note that, while maternal alcohol-use disorder is a proxy for heavy alcohol use, mothers in the comparison group may have consumed alcohol during the same time period, and some of these mothers may have consumed alcohol at high and at-risk levels without receiving an alcohol related diagnosis during a hospital or mental health service admission. The final population cohort included 85,205 births between 1983 and 2007.

Records were linked by the Western Australian Data Linkage Branch using probabilistic matching [25]. Ethics approval for the conduct of the study was granted by the Princess Margaret Hospital Human Research Ethics Committee (no. 1244/EP), the WA Department of Health Human Research Ethics Committee (no. 2011/34) and the WA Aboriginal Health Ethics Committee (no. 134-04/06).

Data treatment

Alcohol exposure

Both the presence of an alcohol-use disorder and the timing of diagnosis relative to pregnancy were of interest. The presence of alcohol-use disorder was treated as a binary variable (yes/no). The timing of exposure was categorised hierarchically, and prioritised diagnoses during pregnancy. Categories included: (a) any alcohol related diagnosis during pregnancy. This may include women who also have a diagnosis before and/or after pregnancy. For women who did not have an alcohol diagnosis recorded during pregnancy the categories included (b) A diagnosis within the year before pregnancy. As the coding was hierarchical, this group may include women with an additional exposure recorded more than one year before pregnancy or any exposure post-pregnancy; (c) A diagnosis up to one year after pregnancy. This may include women who had a recorded exposure for more than one year before or after pregnancy; (d) more than one year before pregnancy, and this could include exposure greater than one year post pregnancy; and (e) more than 1 year after pregnancy. This hierarchical coding, and the treatment of women with multiple diagnoses throughout the study period, is illustrated in the supplementary material Table 2. This has previously been described [24].

School attendance

Routinely collected attendance records were obtained from the Western Australian Department of Education. Records were available for the years 2008 through 2012 for children who attended public schools in Western Australia. Attendance data were linked to MNS records for 11,430 exposed children and 26,850 children in the comparison cohort. Of children with a birth recorded between 1991 and 2006 on the MNS, 16,829 (31%) were not linked to an attendance record. Children without a linked record include those who attended independent or catholic schools during this period, and those who had left the Western Australian school system. The linkage rate closely matches the proportion of children attending government schools in Australia in 2012 (71%)[26].

Absence from school is classified by the Department of Education as either authorised, where the reason provided by the caregiver is considered adequate or legitimate by the principal, or unauthorised. Unauthorised absences refer to those where a student is absent without a reasonable explanation (e.g. truancy). Attendance is recorded as the number of half days attended in the first semester of the school year.

Attendance was calculated as the number of half days in attendance as a percentage of the total number of possible half-days within the first semester of the school year. In the case where children attended multiple schools, available days and absences were summed. Therefore, there was one

attendance record per student per semester, and if children had a record for all in-scope years (2008-2012 inclusive), they would have a total of five attendance records.

It has previously been identified that attendance records are less consistent for Years 11 and 12 due to exams and work placements [1]. Therefore, in an attempt to reduce reporting error, the analysis was restricted to records for children in Year 10 (approximately 15 years of age) and below. In addition, records of less than 30 percent attendance were removed from the analysis. Removing records of less than 30 percent attendance was viewed as a conservative approach to estimating the impact of maternal alcohol use diagnosis on attendance outcomes, and completed with the aim of reducing the impact of children who have left the Western Australian school system, or changed schools but continued to be marked absent. This has been identified to be a problem which disproportionately affects Indigenous young people who have very high levels of mobility, including across state borders, often due to cultural reasons[6]. Of the 917 children who were completely excluded from the analysis, based on an attendance rate of less than 30 percent, 81 percent were Indigenous and 45 percent had a mother with a maternal alcohol use diagnosis.

In the reported models, 68,173 non-Indigenous semester records and 39,815 Indigenous semester records were included. The average number of semesters of data per child was three, with a maximum of five semesters of data per child (i.e. one semester record per year for 2008-2012 inclusive).

The Department of Education provide the following categories for attendance: Regular (90-100% attendance), Indicated (80-89% attendance), Moderate (60-79% attendance) and Severe (less than 60% attendance). For the purpose of this analysis, poor attendance was defined differently for non-Indigenous and Indigenous cohorts, due to the vastly different attendance distributions in these cohorts. In non-Indigenous children poor attendance equated to an attendance rate less than 80% (i.e. severe or moderate attendance). This was approximately 10 per cent of the final, non-Indigenous sample. In Indigenous students, the overall attendance rate was substantially lower. As a result, poor attendance was defined as less than 60% attendance (i.e. severe attendance). This was approximately 18 percent of the final sample of Indigenous students. As absence from school impacts on a child's learning and academic outcomes, whether authorised or unauthorised, total absence represented the primary outcome.

School information

Available school information included school type (primary, secondary, combined), child's grade, and school area. School area refers to the school's location and categorised based on the Standing

Council on School Education and Early Childhood Schools Geographic Location Classification System. These categories include metropolitan, provincial (large urban areas outside of the metropolitan area such as Kalgoorlie Boulder or Geraldton), remote and very remote locations. Further, the number of schools attended within the semester, and any history of school suspension was determined. Where multiple schools were attended within a single semester, school information was obtained from the school with most days attended.

Mother's socio-demographic information

Maternal demographic, mental health, and drug use information was obtained from the MNS, Hospital Morbidity Data System (hospital inpatients) and Mental Health Inpatient and Outpatients datasets. Demographic information included in this analysis was predominately from the time of the child's birth and included socioeconomic status, maternal age at child's birth, parity, Indigenous status, health service region (rural or metropolitan), and maternal marital status. In addition, record of any mental health problem or illicit drug use (ICD 9/10 codes), excluding those related to alcohol use, was available.

Child variables

In addition to school information, child gender, preterm status (<37 weeks gestation), and presence of Fetal Alcohol Spectrum Disorder and/or an intellectual disability were obtained from the MNS, Western Australian Register of Developmental Anomalies, and Intellectual Disability database respectively [23]. Further, proportion of optimal birth weight was calculated by comparing observed to optimal birth weight. This measure, which provides an indication of fetal growth, takes into account sex, gestational age, maternal height and parity [27]. Low proportion of optimal birth weight was defined as below the 10th percentile. Finally, a record of contact with child protective services, which was defined as a substantiated maltreatment allegation or period of out of home care, was obtained from the Department of Child Protection and Family Support.

Statistical analysis

All analysis was carried out using SAS 9.3 (SAS Institute, Inc., Cary, NC).

Comparisons between exposed and comparison cohorts were assessed for significance using chi-square tests.

As attendance distributions were highly skewed, and with the aim of reducing the impact of children with very low attendance records who were not attending school, poor attendance was treated as a binary outcome (non-Indigenous: < 80% days attended, Indigenous: <60% days attended).

Hierarchical generalized linear mixed models with a logit link were used to analyse the relationship between poor attendance and maternal alcohol use, socio-demographic and school characteristics, with models nested at the child and family level. Possible maternal, child and school covariates were tested in a univariate model and those which were significant ($\alpha < 0.05$) were tested for significance in multivariate models. The most parsimonious model was reported. Indigenous and non-Indigenous data were modelled separately to align with the aims of the study. All models included the frequency matching variables (i.e. maternal age and baby year of birth).

In addition, generalised linear models were used to estimate the impact of maternal alcohol use on the number of days absent (total, authorised and unauthorised) within the exposed cohort. In order to estimate this, model parameters were used to score the data. This was completed twice, once with the data in its original form, and once with alcohol exposure set to zero. The difference between the estimated number of days absent was calculated. The difference between these two estimates was used to calculate the percentage of total absences which could be attributed to maternal alcohol use exposure.

The population attributable risk fraction, which is the difference in the rate of non-attendance between the exposed and comparison cohorts, was calculated. The population attributable risk fraction was calculated by adjusting for the matching ratio, and multiplying up to the Western Australian population.

Sensitivity analysis

The minimum threshold for attendance (i.e. 30%) was not based on a pre-defined cut-point and, therefore, in order to test the stability of results, we re-ran the final models using different minimum cut-offs for attendance. We examined two alternative models, one with a sample of children who attended a minimum of 20 per cent of days during the semester, and a second model which included children who attended a minimum of 40 per cent of available days during the semester. We assessed the change in the strength and direction of results compared to the final models.

Results

Within the non-Indigenous cohort, a higher proportion of mothers in the comparison cohort were married (84.2% vs 72.2%) and were in the highest 25% of socioeconomic status (15.2% vs 9.5%) at the time of the child's birth compared with those mothers in the exposed cohort. A substantially greater proportion of non-Indigenous mothers in the exposed cohort had a mental health diagnosis compared with comparison mothers (53.5% vs 11.0%) and/or a record of illicit drug use (40.7% vs 2.2%).

Within the Indigenous cohort, there was little difference between the socio-economic status, health service region, and maternal age at child's birth of exposed and comparison cohort mothers. A greater proportion of exposed mothers had a mental health record (32.4% vs 12.9%), or a record of illicit drug use (27.0% vs 6.0%) than the comparison cohort. While numbers were low, fetal alcohol spectrum disorder and intellectual disability were higher in the exposed group when compared to those whose mother did not have an alcohol use disorder diagnosis for both Indigenous and non-Indigenous cohorts (Table 1).

When comparing the exposed and comparison children within Indigenous status, there were similar proportions of students in schools in metropolitan, provincial and remote schools (Table 2). However, there were differences between Indigenous and non-Indigenous cohorts with a higher proportion of Indigenous students in remote and very remote locations compared to non-Indigenous students (44% vs 9%). A greater proportion of exposed than comparison children attended multiple schools and had a history of a school suspension. This was consistent between non-Indigenous (more than one school: 6.8% exposed vs 3.9% comparison, suspension: 10.8% vs 5.6%) and Indigenous cohorts (more than one school: 16.1% exposed vs 13.1% comparison, suspension: 20.7% vs 15.3%). It is important to note that school level data reported in Table 2 includes multiple records per child.

Attendance profiles by Indigenous status and maternal alcohol use exposure

Table 3 provides the distribution of students across attendance categories by Indigenous status and presence of a maternal alcohol-use disorder. Within Indigenous status, those children exposed to a maternal alcohol use disorder were significantly more likely to be classified as being in the 'severe' attendance category when compared to those in the comparison cohort (non-Indigenous: 1.9 vs 4.8, $p < 0.001$, Indigenous: 19.7% vs 30.5%, $p < 0.001$).

Indigenous students had substantially worse attendance than non-Indigenous students (regular attendance: 30% vs 69%, $p<0.001$). The median number of authorised absences was 4 days in both non-Indigenous (comparison: 4, Q1-Q3 = 1.3-8.0, exposed: 4.3, Q1-Q3 = 1.5-9.5) and Indigenous cohorts (comparison: 4.1, Q1-Q3 = 1.0-10.1, exposed: 3.7, Q1-Q3 = 1.0-10.1). Median number of

days classified as unauthorised absences were substantially higher in the Indigenous cohort (comparison: 9.0 Q1-Q3 = 2.1-24.2, exposed: 14.7, Q1-Q3 = 4.0-35.9) compared to the non-Indigenous cohort (comparison: 0.0, Q1-Q3 = 0.0-2.6, exposed: 1.1, Q1-Q3 = 0.0-5.3). Again, these data are reported at the semester level and, as a result, there are multiple records per child.

Predictors of poor attendance

The unadjusted odds of poor attendance associated with maternal alcohol use disorder were higher in the non-Indigenous cohort (OR = 2.11, 95% CI = 1.98 – 2.26) than in the Indigenous cohort (OR = 1.70, 95% CI = 1.58 – 1.82). When maternal and child factors were accounted for, children whose mother had an alcohol-use disorder were more likely to be classified as having poor attendance compared with other children (non-Indigenous: OR = 1.61, 95% CI = 1.50 – 1.74, Indigenous: OR = 1.66, 95% CI = 1.54-1.79). When the model was adjusted for maternal and child factors, the odds of poor attendance did not significantly differ with the timing of alcohol diagnosis relative to pregnancy in non-Indigenous and Indigenous cohorts. However, a diagnoses at any time point was associated with a significantly elevated odds of poor attendance.

A number of socio-demographic factors were significantly associated with poor school attendance (tables 4 and 5). In the non-Indigenous cohort, there was increasing odds of poor attendance with increasing socioeconomic disadvantage. Mothers under the age of 20 at the time of the child's birth were at greater risk of having a child with poor attendance compared with those in the 20 to 25-year-old age group (< 20 years: OR = 1.47 95% CI = 1.33-1.63). In contrast, having a mother over the age of 25 appeared protective. Higher parity was significantly associated with poor attendance outcomes (3 or more siblings: OR =2.65, 95% CI = 2.36-2.98), as was being unmarried at the time of the child's birth (never married: OR = 1.38, 95% CI = 1.27-1.50, Separated, widowed or divorced: OR = 1.53, 95% CI = 1.25-1.88). A maternal mental health diagnosis (OR = 1.20, 95% CI = 1.11-1.30), or a record of contact with the child protection system (OR = 1.12, 95% CI = 1.00-1.24) were also associated with elevated risk.

In the Indigenous cohort, maternal age at birth (<20 years: OR = 1.45, 95% CI = 1.30– 1.60), socio-economic status (most disadvantaged 10%: OR = 1.44, 95% CI = 1.24– 1.67) and parity (3 or more siblings: OR = 1.85, 95% CI = 1.64 – 2.08) were associated with increased odds of poor attendance. In addition, Indigenous children born in rural health service regions were at greater odds of being classified as having poor attendance compared with Indigenous children born in metropolitan regions (rural: OR = 1.52, 95% CI = 1.40 – 1.64). A maternal mental health diagnosis, or a record of illicit drug use appeared protective in this cohort (mental health diagnosis: OR = 0.91, 95% CI =0.83-0.99, illicit drug record: OR = 0.85, 95% CI =0.76-0.95).

There were a number of school factors which were significantly associated with poor attendance in both the non-Indigenous and Indigenous cohorts (Tables 6 and 7). Children in secondary school were at greater odds of poor attendance than children in primary school (non-Indigenous OR = 1.36, 95% CI = 1.19-1.56, Indigenous: OR = 1.66, 95% CI = 1.51-1.81). In addition, those attending a school in remote areas had a greater risk of poor attendance compared with other children in both non-Indigenous (remote/ very remote: OR =1.25, 95% CI =1.12 – 1.40) and Indigenous cohorts (remote: OR =1.32, 95% CI =1.18-1.47, very remote: OR =1.62, 95% CI =1.45-1.80). A higher number of schools attended within the semester, and a suspension record (non-Indigenous: OR = 2.36 95% CI =2.19-2.54, Indigenous: OR = 1.43 95% CI = 1.33 – 1.52), were also positively associated with likelihood of poor attendance.

Impact of maternal alcohol use on attendance rates

The population attributable fraction for poor attendance with any maternal alcohol diagnosis was estimated to be 1.3% (1.2-1.5) in the non-Indigenous population and 6.0% (95% CI = 5.0– 6.7) in the Indigenous population. It is important to note that poor attendance was defined as less than 80 percent attendance for non-Indigenous students, and less than 60 percent attendance for Indigenous students.

When the impact was estimated within the exposed cohort, maternal alcohol use disorder accounted for approximately 15 percent of total days absent in both Indigenous and non-Indigenous children (16% and 14% respectively). Further, maternal alcohol use accounted for 30 per cent of unauthorised absences in non-Indigenous children and 21 per cent in Indigenous children. Maternal alcohol-use disorder accounted for 9 and 2 per cent of the authorised absences in exposed non-Indigenous and Indigenous children respectively.

Sensitivity analysis

Sensitivity analysis, which made use of alternative minimum attendance thresholds for inclusion in modelling, suggested that the final models were relatively stable. The average difference between the results of these models was less than 10 percent, and the use of different minimum attendance thresholds did not change the direction or interpretation of the final models.

Discussion

As hypothesised, children whose mother had received a diagnosis of an alcohol-use disorder were significantly more likely to be classified as having poor attendance compared with children whose mother did not have a diagnosis. This finding was consistent in both Indigenous and non-Indigenous cohorts. While any diagnosis of an alcohol-use disorder was associated with poor school attendance, in the final models there was little difference between the timing of diagnosis relative to pregnancy, and the strength of association with attendance outcomes. Of note, this finding differs from the result of previously published results for other types of adverse outcomes, which make use of this cohort and the hierarchical classification of timing of alcohol diagnosis. O'Leary and colleagues identified that the there was a significantly increased risk of birth defects and intellectual disability in children whose mother received an alcohol related diagnosis during pregnancy, compared to children whose mother received a diagnosis at other time points [23 28]. However, the results of the current study suggest, that the relationship between exposure and attendance may not be driven by the biological effects of in-utero alcohol exposure alone. This relationship may be mediated through family, social and environmental factors, during pregnancy and/or pre and post pregnancy, for which we were unable to adjust. Whilst the data do not provide detailed information about the family or household circumstances pre or post birth, previous research demonstrates that households with heavy parental alcohol use are at risk of instability, as well as concomitant risks such as abuse, poor family functioning, mental health problems and illicit substance use [13 17 29]. This is likely to be an environment in which school attendance is not prioritised. While results should be interpreted with caution, as an alcohol related diagnosis does not capture all women who drink during pregnancy, these findings suggest that providing social support for vulnerable families may be effective in reducing child non-attendance.

In addition to maternal alcohol use, there were a number of socio-demographic factors which were associated with poor attendance. Indigenous children had substantially worse attendance than non-Indigenous students. This attendance gap is well recognised in the literature, and exists in spite of targeted interventions which span a number of decades [30]. This significant gap has been attributed to several factors including greater family mobility, social and cultural reasons for absence, the higher rate of emotional and behavioural problems in Aboriginal children, the intergenerational legacy of past practices of exclusion of Aboriginal children from schools, and its impact on shaping family and community values regarding the importance of attending school in Indigenous families compared with non-Indigenous families [6 7 31]. Additional socioeconomic and school factors differed slightly between the Indigenous and non-Indigenous cohorts. However, low maternal age at child's birth, high parity and greater school mobility were consistently found to be associated with poor

attendance. Further, it was evident that there was a strong relationship between type of school and attendance, with children in secondary school at greater odds of poor attendance compared with children attending primary school. This in part may be due to children leaving school to attend workplace training, alternative education pathways, or greater autonomy in older age groups leading to increased truancy. However, it suggests that interventions to support children throughout their school career are needed to encourage higher rates of attendance, and student retention, through to school completion. Of note, in the Indigenous cohort, a diagnosis of a maternal mental health disorder or maternal record of illicit drug use in the administrative datasets was protective of poor attendance in the Indigenous cohort. While we are unable to investigate this further due to the nature of administrative data, this may reflect greater service use, increased likelihood of intervention, or increased support for families with a mother who has been identified to have a mental health or history of illicit drug use.

The population attributable fraction provides an estimate of reduction in the poor attendance that would occur if maternal alcohol use disorder were eliminated. This was estimated to be 1.3 percent in the non-Indigenous population and 6 percent in the Indigenous population. While the population attributable fraction was substantially higher in the Indigenous population compared with the non-Indigenous, this was due to the higher prevalence of maternal alcohol use disorder in Indigenous mothers within the community. Therefore, we also aimed to quantify the impact of maternal alcohol use disorder within the relatively small exposed population by estimating the percentage of days absent associated with maternal alcohol use disorder. We estimated the impact of maternal alcohol-use disorder on total, unauthorised and authorised absences in the exposed populations. These results suggest that maternal alcohol use disorder predominantly impacts unauthorised absences and the impact, when measured as the percentage of days absent, was greater in non-Indigenous children than Indigenous children. While the greatest effect appeared to be on unauthorised absences, eight percent of authorised absences in the non-Indigenous cohort could be attributed to maternal alcohol use disorder. Of note, while the population attributable fraction is higher in Indigenous cohorts, the impact is greater in non-Indigenous children. This finding supports the intervention programs which target both parent and child school engagement to reduce child non-attendance.

Strengths and limitations

A key strength of the project is the use of administrative data which avoids the use of self-reports of drinking behaviours which may be biased due to retrospective recall and social desirability. Further, we can be confident that mothers who received an alcohol related diagnosis were consuming alcohol at very high levels. However, we have no information about level of dependency, periods of

sobriety, or ongoing maternal alcohol use following a diagnosis. Further, it is important to note that it is likely that there are a number of children who were exposed to significant amounts of maternal alcohol use (as evidenced by the presence of cases of Fetal Alcohol Spectrum Disorder in the comparison cohort), and the associated social and environmental effects, which were not identified in the dataset. This dilution of the comparison group is likely to bias the findings towards the null. In addition, paternal factors, detailed maternal poly-drug use, comorbidities, the family environment, and additional unmeasured confounders not captured by administrative datasets cannot be included in the analysis. Therefore, it is difficult to ascertain all the underlying reasons for school non-attendance. Additional work is required to determine the reasons for non-attendance in families where there is maternal alcohol use problems, in order to develop and target effective interventions.

Conclusions

The causes of non-attendance are complex. However, this study indicates that a child whose mother has an alcohol related diagnosis is significantly more likely to have poor attendance problems than children whose mother does not have a diagnosis. The strength of the association of poor school attendance was similar at each of the diagnostic time periods. This differs from previous studies which use this cohort, where exposure in pregnancy had a significantly greater effect on other types of adverse child outcomes [23 28]. These findings may indicate that the relationship between school attendance and maternal alcohol use disorders is not primarily driven by the neurobehavioral effects of alcohol during pregnancy, but rather a complex family and social environment in which school attendance is not a priority or not well monitored. Ongoing pre-pregnancy counselling regarding the impact of alcohol use on the offspring, as well as ongoing education, treatment and support regarding problematic or risky drinking behaviours throughout pregnancy and parenthood is imperative. In addition, further research regarding why women continue to consume significant amounts of alcohol in these time periods despite health recommendations, as well as more effective methods to target, educate and support these women is needed. Finally, detailed and mandatory data collection regarding alcohol use during pregnancy, would not only improve the ability to intervene during pregnancy or post-pregnancy, but would also improve the quality of research and understanding regarding alcohol use and child outcomes.

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References

1. Hancock KJ, Shepherd CC, Lawrence D, et al. Student attendance and educational outcomes: Every day counts: Report for the Department of Education, Employment and Workplace Relations, Canberra., 2013.
2. Dube SR, Orpinas P. Understanding Excessive School Absenteeism as School Refusal Behavior. *Children and Schools* 2009;31(2):87-95.
3. Daraganova G, Mullan K, Edwards B. Occasional Paper No. 51: Attendance in primary school: factors and consequences Canberra: Australian Government Department of Social Services, 2014.
4. Kearney CA. School absenteeism and school refusal behavior in youth: A contemporary review. *Clinical Psychology Review* 2008;28:451-71.
5. Romero M, Lee Y. A National Portrait of Chronic Absenteeism in the Early Grades. New York National Center for Children in Poverty, Columbia University, 2007.
6. Zubrick SR, Silburn SR, De Maio JA, et al. Western Australian Aboriginal Child Health Survey: Improving the educational experiences of Aboriginal children and young people. Perth: Curtin University of Technology and Telethon Institute for Child Health Research, , 2006.
7. Purdie N, Buckley S. School Attendance and Retention of Indigenous Australian Students. Issues Paper No. 1: ERIC 2010.
8. Helme S, Lamb S. Closing the School Completion Gap for Indigenous Students. Resource Sheet No. 6. *Australian Institute of Health and Welfare* 2011
9. Moore T, McArthur M. If only I, they, we had done things differently: Young people talk about school difficulties and crime. *Children and youth services review* 2014;44:249-55.
10. Vall O, Salat-Batlle J, Garcia-Algar O. Alcohol consumption during pregnancy and adverse neurodevelopmental outcomes. *Journal of epidemiology and community health* 2015:jech-2014-203938.
11. Goldschmidt L, Richardson GA, Stoffer DS, et al. Prenatal alcohol exposure and academic achievement at age six: a nonlinear fit. *Alcoholism: Clinical and Experimental Research* 1996;20(4):763-70.
12. Mattson SN, Riley EP. A review of the neurobehavioral deficits in children with fetal alcohol syndrome or prenatal exposure to alcohol. *Alcoholism: Clinical and Experimental Research* 1998;22(2):279-94.
13. Hutchinson DM, Mattick RP, Danya B, et al. The impact of alcohol use disorders on family life: a review of the empirical literature: National Drug and Alcohol Research Centre, University of New South Wales, 2014.
14. Burke S, Schmied V, Montrose M. Parental alcohol misuse and the impact on children - A literature review: Research, Funding & Business Analysis Division, Centre for Parenting & Research, 2006.
15. Dawe S, Harnett P, Frye S. Improving outcomes for children living in families with parental substance misuse: What do we know and what should we do. *National Child Protection Clearinghouse* 2008(29)
16. Sarkola T, Kahila H, Gissler M, et al. Risk factors for out-of-home custody child care among families with alcohol and substance abuse problems. *Acta Paediatrica* 2007;96(11):1571-76.
17. Burns L, Teesson M, Lynskey M. The epidemiology of comorbidity between alcohol use disorders and mental disorders in Australia: National Drug and Alcohol Research Centre.
18. Kahila H, Gissler M, Sarkola T, et al. Maternal welfare, morbidity and mortality 6–15 years after a pregnancy complicated by alcohol and substance abuse: a register-based case-control follow-up study of 524 women. *Drug and alcohol dependence* 2010;111(3):215-21.
19. Casas-Gil MJ, Navarro-Guzman JI. School characteristics among children of alcoholic parents *Psychological Reports* 2002(90):341-48.
20. Hill NE, Taylor LC. Parental school involvement and children's academic achievement pragmatics and issues. *Current directions in psychological science* 2004;13(4):161-64.

21. Barton AC, Drake C, Perez JG, et al. Ecologies of parental engagement in urban education. *Educational Researcher* 2004;33(4):3-12.
22. Peters M, Ken Seeds K, Goldstein A, et al. Parental involvement in children's education 2007: BMRB Social Research, Department for children, schools and families, 2008.
23. O'Leary C, Leonard H, Bourke J, et al. Intellectual disability: population-based estimates of the proportion attributable to maternal alcohol use disorder during pregnancy. *Developmental Medicine & Child Neurology* 2013;55(3):271-77. doi: 10.1111/dmcn.12029
24. O'Leary CM, Watson L, D'Antoine H, et al. Heavy maternal alcohol consumption and cerebral palsy in the offspring. *Developmental Medicine & Child Neurology* 2012;54(3):224-30. doi: 10.1111/j.1469-8749.2011.04201.x
25. Holman CDAJ, Bass AJ, Rouse IL, et al. Population-based linkage of health records in Western Australia: development of a health services research linked database. *Australian and New Zealand Journal of Public Health* 1999;23(5):453-59. doi: 10.1111/j.1467-842X.1999.tb01297.x
26. Australian Bureau of Statistics. 4221.0 - Schools Australia2012 [Available from: http://www.abs.gov.au/AUSSTATS/abs@.nsf/Previousproducts/4221.0Main%20Features2012012?opendocument&tabname=Summary&prodno=4221.0&issue=2012&num=&view= accessed March 2017.
27. Blair EM, Liu Y, de Klerk NH, et al. Optimal fetal growth for the Caucasian singleton and assessment of appropriateness of fetal growth: an analysis of a total population perinatal database. *BMC pediatrics* 2005;5(1):1.
28. O'Leary CM, Elliott EJ, Nassar N, et al. Exploring the potential to use data linkage for investigating the relationship between birth defects and prenatal alcohol exposure. *Birth Defects Research Part A: Clinical and Molecular Teratology* 2013;97(7):497-504. doi: 10.1002/bdra.23142
29. Jacobson SW, Chiodo LM, Sokol RJ, et al. Validity of maternal report of prenatal alcohol, cocaine, and smoking in relation to neurobehavioral outcome. *Pediatrics* 2002;109(5):815-25.
30. Gray J, Beresford Q. A 'formidable challenge': Australia's quest for equity in Indigenous education. *Australian Journal of Education* 2008;52(2):197-223.
31. Bourke CJ, Rigby K, Burden J. Better practise in school attendance: Improving the school attendance of Indigenous students: Monash University for Commonwealth Department of Education Training and Youth Affairs, 2000.

Table 1. Characteristics of mothers at the time of their child's birth, by Indigenous status and maternal alcohol-use disorder exposure

	Non-Indigenous					Indigenous				
	Comparison		Exposed		x^2 P	Comparison		Exposed		x^2 P
	n	percent	n	percent		n	percent	n	percent	
*Maternal age**					<0.001					0.021
<20	2,364	14.3	854	12.4		2,515	24.5	1,004	22.1	
20 < 25	5,123	30.9	2,054	29.8		3,306	32.2	1,475	32.5	
25 < 30	4,502	27.1	1,950	28.3		2,495	24.3	1,129	24.8	
30 < 35	3,017	18.2	1,354	19.7		1,361	13.3	668	14.7	
35 < 40	1,320	8	576	8.4		535	5.2	246	5.4	
40+	257	1.5	98	1.4		55	0.5	22	0.5	
Marital status					<0.001					<0.001
Married	13,971	84.2	4,969	72.2		6,770	65.9	2,782	61.2	
Never married	2,447	14.8	1,637	23.8		3,215	31.3	1,609	35.4	
Separated/divorced/widowed	146	0.9	236	3.4		209	2	101	2.2	
Missing	19	0.1	44	0.6		73	0.7	52	1.1	
Socioeconomic Status					<0.001					<0.001
Highest > 10%	780	4.7	192	2.8		34	0.3	5	0.1	
10-<25%	1,742	10.5	527	7.7		157	1.5	47	1	
25-<50%	3,432	20.7	1,239	18		714	7	229	5	
50-<75%	4,313	26	1,772	25.7		1,784	17.4	638	14	
75-<90%	3,014	18.2	1,426	20.7		2,386	23.2	912	20.1	
Lowest 10%	1,842	11.1	1,170	17		3,247	31.6	1,452	32	
Missing / unknown	1,460	8.8	560	8.1		1,945	18.9	1,261	27.8	
Health service region										0.025
Perth metropolitan area	11,773	71	4,862	70.6	0.552	3,628	35.3	1,519	33.4	
Rural / remote	4,810	29	2,024	29.4		6,639	64.7	3,025	66.6	
Any maternal mental health diagnosis					<0.001					<0.001

No	14,761	89	3,205	46.5		8,947	87.1	3,071	67.6	
Yes	1,822	11	3,681	53.5		1,320	12.9	1,473	32.4	
Any maternal illicit drugs record					<0.001					<0.001
No	16,224	97.8	4,085	59.3		9,554	93.1	3,315	73	
Yes	359	2.2	2,801	40.7		613	6	1,229	27	
Fetal Alcohol Spectrum Disorder					0.007**					<0.001
No	16,583	100	6,882	99.9		10,256	99.9	4,487	98.8	
Yes	0	0	4	0.1		11	0.1	57	1.3	
Child Intellectual disability					<0.001					<0.001
No	16,260	98.1	6,695	97.2		10,007	97.5	4,349	95.7	
Yes	323	2	191	2.8		260	2.5	195	4.3	
Total	16,583	100	6,886	100		10,267	100	4,544	100	

*frequency matching variable
** Fischer's exact test

Table 2. School factors for all linked records, year 10 or below, by Indigenous status and maternal alcohol-use disorder exposure

	Non-Indigenous					Indigenous				
	Comparison		Exposed		x^2 P	Comparison		Exposed		x^2 P
	n	percent	n	percent		n	percent	n	percent	
Number of years per child					0.058					0.014
1	2,699	18.2	1,083	17.6		1,710	18.7	821	20.3	
2	2,570	17.3	979	15.9		1,558	17.0	704	17.4	
3	2,418	16.3	1,037	16.8		1,447	15.8	658	16.3	
4	2,268	15.3	974	15.8		1,452	15.8	660	16.3	
5	4,878	32.9	2,090	33.9		2,998	32.7	1,205	29.8	
School type					<0.001					<0.001
Combined	1,797	3.7	961	4.7		3,254	10.9	1,475	11.5	
Primary	33,145	68.3	13,391	65.3		18,316	61.1	7,839	60.9	
Secondary	12,466	25.7	5,499	26.8		7,000	23.4	2,819	21.9	
Other	1,147	2.4	647	3.2		1,395	4.7	735	5.7	
School area					<0.001					<0.001
Metropolitan	31,540	65.0	12,675	61.8		9,978	33.3	3,701	28.8	
Provincial	46	26.4	5,892	28.8		7,265	24.2	2,916	22.7	
Remote, very remote, school closed	4,181	8.6	1,913	9.3		12,722	42.5	6,251	48.6	
Number of schools attended					<0.001					<0.001
1 school	46,700	96.2	19,099	93.2		26,066	87	10,801	83.9	
2 schools	1,771	3.7	1,312	6.4		3,461	11.6	1,823	14.2	
3 or more schools	84	0.2	87	0.4		438	1.5	244	1.9	
Suspension Record					<0.001					<0.001
No	45,810	94.4	18,277	89.2		25,376	84.7	10,203	79.3	
Yes	2,745	5.6	2,221	10.8		4,589	15.3	2,665	20.7	

Note: 1 semester record per child for each year attended within follow up period

Table 3. Attendance categories for all linked records year 10 and below, by Indigenous status and maternal alcohol-use disorder exposure

	Non-Indigenous				Indigenous			
	Comparison		Exposed		Comparison		Exposed	
	n	percent	n	percent	n	percent	n	percent
Regular (90-100% attendance)	35,163	72.4	12,459	60.8	9,769	32.6	3,254	25.3
Indicated (80-89% attendance)	9,295	19.1	4,697	22.9	6,915	23.1	2,382	18.5
Moderate (60-79% attendance)	3,199	6.6	2,354	11.5	7,366	24.6	3,309	25.7
Severe (<60% attendance)	898	1.9	988	4.8	5,915	19.7	3,923	30.5
Total	48,555	100.0	20,498	100.0	29,965	100.0	12,868	100.0

Note: 1 semester per child per year of school attended within follow up period

Table 4. Adjusted odds ratios for alcohol use disorder exposure and demographic factors significantly associated with <80% attendance, Non-Indigenous

		OR*	95% confidence interval	
Alcohol diagnosis	No Alcohol diagnosis	Ref		
	During pregnancy	1.45	1.11	1.88
	>1 years post-pregnancy	1.59	1.45	1.74
	>1 year pre-pregnancy	1.65	1.49	1.83
	Up to 1 year post-pregnancy	1.39	1.06	1.81
	Up to 1 year pre-pregnancy	1.54	1.27	1.87
Maternal age at child's birth	20 < 25 years	Ref		
	<20 years	1.47	1.33	1.63
	25 < 30 years	0.83	0.76	0.91
	30 < 35 years	0.73	0.66	0.81
	35 < 40 years	0.68	0.59	0.79
	40+ years	0.80	0.60	1.05
Marital status	Married	Ref		
	Never married	1.38	1.27	1.50
	Separated, widowed, divorced	1.53	1.25	1.88
Socioeconomic status	Most Advantaged > 10%	Ref		
	Second Group 10% to <25%	1.21	0.94	1.57
	Third Group 25% to <50%	1.42	1.12	1.80
	Fourth Group 50% to <75%	1.57	1.24	1.99
	Fifth Group 75% to <90%	1.78	1.41	2.26
	Most Disadvantaged Bottom 10%	1.90	1.50	2.42
	Unknown	1.37	1.06	1.77
Parity	0	Ref		
	1	1.29	1.19	1.41
	2	1.81	1.63	2.00
	3+	2.65	2.36	2.98
Percentage of optimal birth weight	Greater or equal to 10th percentile	Ref		
	less than 10th percentile	1.24	1.13	1.36

Any maternal mental health record	No	Ref		
	Yes	1.20	1.11	1.30
Child protection contact	No	Ref		
	Yes	1.12	1.00	1.24

*Adjusted for all other variables and baby year of birth (matching variable)

Table 5. Adjusted odds ratios for alcohol use disorder exposure and demographic factors significantly associated with <60% attendance, Indigenous

		OR*	95% confidence interval	
Alcohol diagnosis	No Alcohol diagnosis	Ref		
	During pregnancy	1.76	1.48	2.08
	>1 years post-pregnancy	1.70	1.54	1.87
	>1 year pre-pregnancy	1.62	1.43	1.83
	Up to 1 year post-pregnancy	1.42	1.12	1.78
	Up to 1 year pre-pregnancy	1.66	1.38	2.00
Maternal age at child's birth	20 < 25 years	Ref		
	<20 years	1.45	1.30	1.60
	25 < 30 years	0.81	0.74	0.90
	30 < 35 years	0.77	0.69	0.87
	35 < 40 years	0.79	0.67	0.94
	40+ years	1.03	0.65	1.61
Marital status	Married	Ref		
	Never married	1.16	1.07	1.25
	Separated, widowed, divorced	0.96	0.75	1.22
Any maternal illicit drug record	No	Ref		
	Yes	0.85	0.76	0.95
Any maternal mental health record	No	Ref		
	Yes	0.91	0.83	0.99
Health region	Metro	Ref		
	Rural	1.52	1.40	1.64
Socioeconomic status	>50% - most advantaged	Ref		
	50% to <75%	1.09	0.93	1.28
	75% to <90%	1.25	1.07	1.45
	Most disadvantaged 10%	1.44	1.24	1.67
	Unknown	1.95	1.68	2.27
Parity	0	Ref		
	1	1.17	1.05	1.30

2	1.25	1.11	1.41
3+	1.85	1.64	2.08

*Adjusted for all other variables and baby year of birth (matching variable)

Table 6. Adjusted odds ratios for alcohol use disorder exposure, demographic and school factors significantly associated with <80% attendance, non-Indigenous mothers

		OR*	95% confidence interval	
Alcohol diagnosis	No Alcohol diagnosis	Ref		
	During pregnancy	1.52	1.17	1.98
	>1 years post-pregnancy	1.55	1.41	1.70
	>1 year pre-pregnancy	1.62	1.46	1.80
	Up to 1 year post-pregnancy	1.36	1.04	1.78
	Up to 1 year pre-pregnancy	1.58	1.30	1.92
Marital status	Married	Ref		
	Never married	1.33	1.22	1.45
	Separated, widowed, divorced	1.52	1.24	1.88
Socioeconomic status	Most Advantaged > 10%	Ref		
	Second Group 10% to <25%	1.18	0.91	1.53
	Third Group 25% to <50%	1.36	1.07	1.72
	Fourth Group 50% to <75%	1.48	1.17	1.87
	Fifth Group 75% to <90%	1.68	1.32	2.13
	Most Disadvantaged Bottom 10%	1.79	1.41	2.28
	Unknown	1.30	1.01	1.68
Any maternal mental health record	No	Ref		
	Yes	1.20	1.11	1.30
Maternal age at child's birth	20 < 25 years	Ref		
	<20 years	1.42	1.29	1.58
	25 < 30 years	0.87	0.79	0.95
	30 < 35 years	0.78	0.70	0.86
	35 < 40 years	0.76	0.66	0.88
	40+ years	0.91	0.69	1.21
Parity	0	Ref		
	1	1.26	1.16	1.37

	2	1.73	1.56	1.92
	3+	2.47	2.19	2.78
Number of schools	1 school	Ref		
	2 schools	2.41	2.20	2.64
	3 or more schools	3.48	2.49	4.87
School type	Primary	Ref		
	Combined	1.11	0.94	1.31
	Secondary	1.36	1.19	1.56
	Other	0.97	0.81	1.18
School area	Metropolitan	Ref		
	Provincial	0.99	0.92	1.07
	Remote, very remote, closed	1.25	1.12	1.40
Year level	1	Ref		
	2	0.82	0.73	0.92
	3	0.81	0.71	0.92
	4	0.80	0.70	0.92
	5	0.84	0.72	0.97
	6	0.88	0.75	1.03
	7	1.01	0.86	1.20
	8	1.45	1.18	1.78
	9	2.54	2.06	3.14
	10	3.75	3.02	4.66
Ever suspended	No	Ref		
	Yes	2.36	2.19	2.54

*Adjusted for all other variables in the table and baby year of birth (matching variable)

Table 7. Adjusted odds ratios for alcohol use disorder exposure, demographic and school factors significantly associated with <60% attendance, Indigenous mothers

		OR*	95% confidence interval	
Alcohol diagnosis	No Alcohol diagnosis	Ref		
	During pregnancy	1.63	1.38	1.94
	>1 years post-pregnancy	1.63	1.48	1.79
	>1 year pre-pregnancy	1.63	1.44	1.84
	Up to 1 year post-pregnancy	1.30	1.04	1.63
	Up to 1 year pre-pregnancy	1.61	1.33	1.94
Maternal age at child's birth	20 < 25 years	Ref		
	<20 years	1.37	1.24	1.51
	25 < 30 years	0.83	0.75	0.91
	30 < 35 years	0.78	0.69	0.88
	35 < 40 years	0.79	0.67	0.93
	40+ years	1.06	0.67	1.67
Marital status	Married	Ref		
	Never married	1.16	1.07	1.25
	Separated, widowed, divorced	0.96	0.76	1.22
Socioeconomic status	>50% - most advantaged	Ref		
	50% to <75%	1.06	0.90	1.24
	75% to <90%	1.23	1.06	1.43
	Most disadvantaged 10%	1.36	1.17	1.58
	Unknown	1.71	1.47	2.00
Health region	Metropolitan	Ref		
	Rural	1.25	1.14	1.37
Parity	0	Ref		
	1	1.18	1.06	1.31
	2	1.26	1.12	1.42

	3+	1.81	1.61	2.04
Any maternal illicit drug record	No	Ref		
	Yes	0.90	0.80	1.00
Child protection contact	No	Ref		
	Yes	0.89	0.81	0.98
Number of schools	1 school	Ref		
	2 schools	2.25	2.11	2.41
	3 or more schools	3.30	2.81	3.86
School type	Primary	Ref		
	Combined	1.65	1.50	1.81
	Secondary	1.66	1.51	1.81
	Other	1.08	0.78	1.48
School area	Metropolitan	Ref		
	Provincial	0.84	0.76	0.93
	Remote	1.32	1.18	1.47
	Very Remote	1.62	1.45	1.80
	School Closed	1.76	1.25	2.48
Year level	1	Ref		
	2	0.81	0.73	0.90
	3	0.81	0.72	0.90
	4	0.67	0.59	0.76
	5	0.73	0.64	0.83
	6	0.77	0.67	0.89
	7	0.91	0.78	1.05
	8	1.10	0.93	1.29
	9	1.73	1.46	2.06
	10	2.28	1.90	2.74
Suspension record	No	Ref		
	Yes	1.43	1.33	1.52

*Adjusted for all other variables in the model and baby year of birth (matching variable)

Supplementary material

Table 1. In-scope ICD9/10 alcohol related diagnoses

Alcohol diagnoses [a]	**ICD10 codes**	**ICD9 codes**
Mental and behavioural disorders		
Acute alcohol intoxication	F10.0; F10.1	303.0–303.03; 305.0–305.03
Alcohol dependence syndrome	F10.2	303.9–303.93
Alcohol withdrawal	F10.3; F10.4	291.0; 291.81
Alcohol psychotic disorder	F10.5	291.3; 291.5
Alcohol amnesic syndrome	F10.6	291.1
Residual and late-onset alcohol psychiatric disorder	F10.7	291.2; 291.4
Other	F10.8; F10.9	291.82; 291.89; 291.9
Alcohol-related diseases		
Alcoholic pseudo-Cushing syndrome	E24.4	255.0
Alcoholic nervous system degeneration	G31.2	331.7
Alcoholic polyneuropathy	G62.1	357.5
Alcoholic myopathy	G72.1	359.4
Alcoholic cardiomyopathy	I42.6	425.5
Alcoholic gastritis	K29.2	535.30; 535.31
Alcoholic liver disease	K70–K70.9	571.0–571.3
Alcoholic pancreatitis	K86.0	577.1
'Other' alcohol disorders		
Infant damage due to alcohol [b]	O35.4; P04.3; Q86.0	655.43; 760.71
Other	R78.0; T51; T51.0; T51.8; T51.9; Y90–Y90.9	790.3; 980.0; 980.8; 980.9; E860.00
Poisoning	X45; X65; Y15	E86.09; E950.09; E98.05

Rehabilitation/history of alcohol use disorder	Z50.2; Z71.4; Z86.41	V57.89, V65.42, V11.3
Encountering health services due to alcohol problems	Z72.1	–

[a] Some women may have more than one diagnosis.
[b] Recorded on maternal record.

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Table 1. Coding of timing of maternal alcohol-related diagnosis in relation to pregnancy

	Timing of maternal alcohol related diagnosis in relation to pregnancy				
	During	≤1 yr pre-pregnancy	≤1 yr after pregnancy	> yr before pregnancy	>1 yr after pregnancy
During pregnancy	**Yes**	Possible	Possible	Possible	Possible
≤ 1 yr pre pregnancy	No	**Yes**	Possible	Possible	Possible
≤ 1 yr after pregnancy	No	No	**Yes**	Possible	Possible
>1 yr before pregnancy	No	No	No	**Yes**	Possible
>1 yr after pregnancy	No	No	No	No	**Yes**

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STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Page 1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Page 2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page 4
Objectives	3	State specific objectives, including any prespecified hypotheses	Page 5
Methods			
Study design	4	Present key elements of study design early in the paper	Page 6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Page 6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	Page 6
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	Page 6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Page 7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Page 7
Bias	9	Describe any efforts to address potential sources of bias	Page 7 and 9
Study size	10	Explain how the study size was arrived at	Page 6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Pages 7-9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Page 9
		(*b*) Describe any methods used to examine subgroups and interactions	n/a
		(*c*) Explain how missing data were addressed	n/a
		(*d*) If applicable, explain how loss to follow-up was addressed	n/a
		(*e*) Describe any sensitivity analyses	Page 9
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Page 7
		(b) Give reasons for non-participation at each stage	n/a
		(c) Consider use of a flow diagram	n/a
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Page 11, and page 20 (table 1)
		(b) Indicate number of participants with missing data for each variable of interest	Page 22 (table 2)
		(c) Summarise follow-up time (eg, average and total amount)	Page 22 (table 2)
Outcome data	15*	Report numbers of outcome events or summary measures over time	Page 22 (table 2)
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Page 11
		(*b*) Report category boundaries when continuous variables were categorized	Page 20 (table 1), page 22 (table 2)
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Page 13
Discussion			
Key results	18	Summarise key results with reference to study objectives	Page 14
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page 14-16
Generalisability	21	Discuss the generalisability (external validity) of the study results	Page 15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page 17

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

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