Use of cannabis during pregnancy and birth outcomes in an Aboriginal birth cohort: a cross-sectional, population-based study

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ABSTRACT

Objectives: Indigenous women continue to experience rates of stillbirth, preterm birth and low birth weight, two to three times higher than other women in high-income countries. The reasons for disparities are complex and multifactorial. We aimed to assess the extent to which adverse birth outcomes are associated with maternal cannabis use and exposure to stressful events and social health issues during pregnancy.

Design/setting: Cross-sectional, population-based survey of women giving birth to Aboriginal babies in South Australia, July 2011–June 2013. Data include: maternal cannabis use, exposure to stressful events/social health issues, infant birth weight and gestation.

Participants: 344 eligible women with a mean age of 25 years (range 15–43 years), enrolled in the study. Participants were representative in relation to maternal age, infant birth weight and gestation.

Results: 1 in 5 women (20.5%) used cannabis during pregnancy, and 52% smoked cigarettes. Compared with mothers not using cannabis or cigarettes, mothers using cannabis had babies on average 565 g lighter (95% CI –762 to –367), and were more likely to have infants with a low birth weight (OR=6.5, 95% CI 1.9 to 7.6). Controlling for education and other social characteristics, including stressful events/social health issues did not alter the conclusion that mothers using cannabis experience a higher risk of negative birth outcomes (adjusted OR for odds of low birth weight 3.9, 95% CI 1.4 to 11.2).

Conclusions: The findings provide a compelling case for stronger efforts to address the clustering of risk for adverse outcomes in Aboriginal and Torres Strait Islander communities, and point to the need for antenatal care to address broader social determinants of adverse perinatal outcomes. Integrated responses—collaboratively developed with Aboriginal communities and organisations—that focus on constellations of risk factors, and a holistic approach to addressing social determinants of adverse birth outcomes, are required.

INTRODUCTION

Despite attention brought to maternal and child health by the Millenium Development Goals, disparities in maternal and child health outcomes affecting indigenous populations in high-income countries remain poorly understood and neglected in global priorities.1 2 In Australia, Aboriginal and Torres Strait Islander mothers experience rates of stillbirth, preterm birth, low birth weight, and neonatal death that are two to three times higher than other Australian
women. The causes of these disparities are complex and multifactorial. \(^1\) The continuing high prevalence of tobacco use by Aboriginal women during pregnancy is a major contributor, with 49% of Aboriginal and Torres Strait Islander mothers continuing to smoke during pregnancy, compared with around 11% of other Australian women. \(^7\) Other effects of extreme social disadvantage, such as low education, poor health literacy, drug and alcohol use, undernutrition, unhealthy weight gain, and health system barriers, such as lack of culturally appropriate services, are also implicated in continuing disparities. \(^9\) In addition to high rates of smoking, there is evidence of high rates of cannabis use among Aboriginal women. \(^11\) The implications of this for maternal and child outcomes are unclear. While three recent studies indicate maternal cannabis use is associated with adverse perinatal outcomes, such as fetal growth restriction and preterm birth, \(^12\)–\(^14\) conflicting findings are generating a lack of consensus in the international literature. \(^15\)–\(^17\) Animal studies show that cannabis readily crosses the blood/brain and placental cell barriers, with potential to affect fetal growth and development. \(^15\)–\(^17\) Controversy remains regarding the extent to which observed associations with fetal growth and child development are confounded by factors such as the use of other illicit drugs or other environmental factors. \(^15\)–\(^17\)

This study draws on data collected in the Aboriginal Families Study: a population-based cross-sectional study of 344 women who gave birth to an Aboriginal baby in the state of South Australia between July 2011 and June 2013. The study was designed and conducted in partnership with the Aboriginal Health Council of South Australia Inc (AHCSA), the peak body representing Aboriginal community controlled health organisations in South Australia. The aims of the paper are to investigate the use of cannabis in pregnancy among mothers of Aboriginal babies, and the associated birth outcomes taking into account health and social factors.

**METHODS**

**Participants**

Women were eligible to take part if they gave birth to an Aboriginal and/or Torres Strait Islander baby in the state of South Australia during the study period, and if they were aged 14 years or older at the time their baby was born. South Australia covers a geographic area that is four times the size of the UK. A team of 12 Aboriginal research interviewers recruited women living in urban, regional and remote areas of the state via public hospitals, community-based agencies, community events, and the interviewers’ own community networks.

Planning for the study started in 2007 with the establishment of an Aboriginal Advisory Group, under the auspices of the Aboriginal Heath Council of South Australia. The study protocol was developed after an extensive 18-month period of consultation with Aboriginal communities across South Australia confirming support for the study, and providing guidance regarding the study’s focus and methods. Further details regarding the development of the study protocol are available in a previous paper. \(^19\)

**Data collection**

Informed consent was obtained from participants by Aboriginal research interviewers. Data collection was undertaken using a structured questionnaire administered when the infant was approximately 4–12 months old. Women were invited to participate in a face-to-face interview with an Aboriginal interviewer, or to self-complete the questionnaire. Information was collected on a wide range of topics focusing on women’s views and experiences of antenatal, intrapartum and postnatal care, and on social factors potentially affecting birth outcomes, including tobacco and cannabis use.

Birth outcome data included infant birth weight and gestation. An adverse outcome was defined as an infant of low birth weight (<2500 g), preterm birth (birth before 37 completed weeks’ gestation), or an infant small for gestational age (SGA). Australian birth weight standards were used to define a population of infants who were SGA, that is, less than the tenth centile for Australian birth weight standards. \(^20\)

Questions regarding cigarette smoking and cannabis use were designed based on questions used in a statewide population-based survey of women giving birth in South Australia, \(^21\) and feedback from pretesting the questionnaire. \(^19\) Women were asked: ‘At any time, when you were pregnant, did you smoke any cigarettes or use ‘yarnidi’ (cannabis)?’ The questions were designed to enable women to report separately on use of cigarettes and cannabis, in recognition that cannabis may be used in combination with tobacco, or inhaled or ingested in other ways. No questions were asked regarding the frequency of using cigarettes or cannabis during pregnancy, or regarding the frequency of use before the index pregnancy.

Information was also collected on maternal medical conditions (eg, diabetes and hypertension); reproductive characteristics (eg, parity); stressful events and social health issues (eg, death of a family member, housing problems); and maternal sociodemographic characteristics, including age, education and place of residence. Ascertainment of the extent to which women had experienced stressful events and social health issues during pregnancy was based on a study designed measure drawing on feedback from consultations, and responses from women to pretesting of the questionnaire. \(^19\) The Australian Geographical Classification System was used to classify women as living in urban, regional or remote areas of South Australia. \(^22\)

**Statistical analysis**

Birth outcomes for the cohort as a whole were compared with corresponding reference values for
Australia to contextualise the level of risk for this cohort prior to making within-cohort comparisons. Within the cohort, we compared the social and health characteristics and birth outcomes of women who reported using cannabis, cigarettes or neither of these during pregnancy, using the Wald test from linear regression where the outcome was continuous, and χ² test for categorical outcomes. Birth outcomes were compared for mothers using cannabis, cigarettes, or neither of these, using regression models where these exposures were represented using a factor variable with neither cannabis nor cigarettes as the reference category. Linear regression was used for continuous birth outcomes (gestational age and birth weight) and logistic regression for preterm birth (<37 weeks), low birth weight (<2500 g), and SGA. Univariable regression analyses were initially conducted to estimate unadjusted associations, followed by multivariable regression analyses in which the effects of mothers’ health and social characteristics were additionally accounted for as potential confounding factors. All analyses were conducted in Stata V.13.1 (StataCorp, Stata Statistical Software Release 13. College Station, Texas, USA: StataCorp LP, 2013) using a complete case analyses approach given the cross-sectional nature of the survey, and thus, limited potential for imputation of information not reported.

RESULTS

The study achieved an initial response rate of 83% (348/418) from women who expressed interest and provided their contact details and consent for a member of the research team to contact them. A total of 57 women were subsequently unable to be contacted, either because they had moved address and/or the phone number provided was no longer connected. Thirteen women decided not to take part because they were ‘too busy’ or ‘there was too much happening’ at the time that they were contacted. A total of 348 women completed the questionnaire; one woman was excluded because she had all her pregnancy care outside of South Australia, and three because they had incomplete consent forms, leaving a final sample of 344 mother-infant dyads. Compared with Aboriginal women who gave birth in South Australia during the study period, cohort participants are representative in relation to maternal age, infant birth weight and gestation. However, a larger proportion of mothers had just given birth to their first infant (42.2% vs 34.3% in routinely collected data), and a lower proportion gave birth at metropolitan hospitals (52.2% vs 59% in routinely collected data).

Analyses are presented for 337 mother-infant dyads from the original cohort of 344 women, excluding seven mothers of twins. Mothers included in the sample for analysis were aged between 15 and 43 years at the time of giving birth (mean 25.5, SD 5.6), with infants aged between 1 and 17 months when the questionnaire was completed (mean 6.7, SD 2.9); 51.3% were male, and 48.7% female. Characteristics of the analytic cohort are reported in table 1.

There were few missing data (n=5, 1.5%) regarding use of cannabis and cigarettes during pregnancy. One in six women reported using both cannabis and cigarettes during pregnancy (56/332, 16.9%). A further 12 women (3.6%) reported using cannabis alone, and one-third (106/332, 31.9%) reported that they smoked cigarettes, but did not use cannabis. The remaining 158 women (47.6%) reported that they had not used cannabis or cigarettes during pregnancy. Comparisons were made between the 68 (20.5%) mothers who reported using cannabis (with or without cigarettes), mothers who used cigarettes only, and mothers who had not used cigarettes or cannabis during pregnancy.

Cannabis use and cigarette smoking were higher among mothers who had begun childbearing at a younger age, had lower levels of education and were not employed or studying during pregnancy (see table 1). There was a clear gradient in use of cannabis associated with experiencing stressful events and social health issues during pregnancy with 25.9% of mothers reporting three or more social health issues using cannabis. There was some evidence of lower use of cannabis and cigarettes among mothers who engaged with health services earlier and more frequently during pregnancy. A consistent pattern was evident showing that mothers who experienced different types of social health issues and stressful events during pregnancy were more likely to use cannabis, particularly if they had experienced conflict in their family or community, or physical violence during pregnancy (see table 2).

Overall, women in the study experienced poorer birth outcomes than corresponding reference values for Australia (see table 3). Notably, 13.7% of infants had a low birth weight (compared to 6.2% in the reference data), and 21.6% of infants were SGA (less than 10th centile in reference values). Acutely differential birth outcomes are evident for mothers who used cannabis, in comparison with those who used cigarettes only or neither of these substances. Univariable analyses show that compared with mothers not using cannabis or smoking cigarettes, babies born to mothers using cannabis were, on average, 565 g lighter, and were more likely to have a low birth weight, and be born SGA. There were 38.6% of mothers who used cannabis, who had infants that were SGA, versus 22.6% of mothers who smoked cigarettes only, and 14.3% of mothers who did not smoke or use cannabis (p<0.004). Although less marked, there was some indication of a shorter mean length of gestation, and a higher prevalence of preterm births among mothers who used cannabis. Overall, 51% of mothers using cannabis experienced adverse perinatal outcomes, compared with 30% of mothers smoking cigarettes alone, and 24% of mothers not using either substance during pregnancy.
Table 4 reports associations between mothers’ social and obstetric characteristics and birth outcomes. There is evidence of poorer birth outcomes among mothers with lower levels of education, and starting childbearing at an earlier age. Women experiencing a greater number of social health issues and stressful events in pregnancy had a higher likelihood of having a baby that is SGA. Women who attended their first antenatal visit in the first trimester of pregnancy were less likely to have an infant born SGA. Attending fewer pregnancy visits was associated with shorter gestation, low birth weight, preterm birth and infants born SGA, but fewer visits may be a consequence rather than an antecedent of a shorter gestation period.

The unadjusted mean difference in birth weight between mothers who used cannabis and those who did not is shown in Table 1.
not use either cannabis or cigarettes was −565 g (95% CI −762 to −367 g) (see Table 5). Multivariable analyses were undertaken to account for associated health and social characteristics that may, to some extent, explain the associations between maternal cannabis use and birth outcomes. The unadjusted mean difference in birth weight between mothers who used cannabis and those who did not use either cannabis or cigarettes was attenuated to −431 g (95% CI −675 g to −187 g) on adjustment for maternal education, age at first birth, parity, social health issues and stressful life events in pregnancy, and receiving antenatal care in the first trimester of pregnancy (model 2). These factors were selected as having importance in this community referenced by the study Aboriginal Advisory Group. In further analyses (model 3) which controls for all health and social characteristics included in Table 1 (excluding number of pregnancy check-ups due to associated shorter gestation, diabetes and hypertension), the mean difference was attenuated slightly further to −419 g (95% CI −672 to −165 g). Health and social effects were highly colinear in this model and are not presented. The unadjusted OR for low birth weight of 6.5 (95% CI 3.0 to 14.3) was attenuated to 4.2 (95% CI 1.5 to 11.3) in model 2, and further to 3.9 (95% CI 1.4 to 11.2) in model 3. Multivariable analyses showed a similar pattern for babies born SGA, and more modest associations with preterm birth.

### Table 2 Use of cannabis and cigarettes in the Aboriginal Families Study (AFS) cohort during pregnancy by experiences of stressful events and social health issues

|                           | AFS cohort |          | Cannabis (with or without cigarettes) | Cigarettes only | Neither (31.9%) | p Value |
|---------------------------|------------|----------|---------------------------------------|-----------------|-----------------|---------|
|                           | N          | Percent  | (20.5%)                               | (31.9%)         | (47.6%)         |         |
| Housing problems          |            |          |                                       |                 |                 |         |
| No                        | 186        | 57.1%    | 18.3%                                 | 32.3%           | 49.5%           | 0.487   |
| Yes                       | 140        | 42.9%    | 23.6%                                 | 31.4%           | 45.0%           |         |
| Very sick or badly hurt   |            |          |                                       |                 |                 |         |
| No                        | 246        | 76.6%    | 18.7%                                 | 35.4%           | 45.9%           | 0.066   |
| Yes                       | 75         | 23.4%    | 25.3%                                 | 21.3%           | 53.3%           |         |
| Problems with the police or need to go to court |          |          |                                       |                 |                 |         |
| No                        | 284        | 87.4%    | 18.3%                                 | 32.4%           | 49.3%           | 0.062   |
| Yes                       | 41         | 12.6%    | 34.1%                                 | 26.8%           | 39.0%           |         |
| Problems with drugs or alcohol |          |          |                                       |                 |                 |         |
| No                        | 295        | 90.8%    | 15.3%                                 | 32.2%           | 52.5%           | <0.001  |
| Yes                       | 30         | 9.2%     | 70.0%                                 | 23.3%           | 6.7%            |         |
| Partner has problems with drugs/alcohol |          |          |                                       |                 |                 | <0.001  |
| No                        | 242        | 77.8%    | 13.2%                                 | 31.0%           | 55.8%           |         |
| Yes                       | 69         | 22.2%    | 42.0%                                 | 30.4%           | 27.5%           |         |
| Scared by other people’s behaviour |          |          |                                       |                 |                 | <0.001  |
| No                        | 226        | 69.8%    | 14.2%                                 | 33.6%           | 52.2%           |         |
| Yes                       | 98         | 30.2%    | 33.7%                                 | 26.5%           | 39.8%           |         |
| Pestered for money        |            |          |                                       |                 |                 | <0.001  |
| No                        | 225        | 68.8%    | 14.7%                                 | 29.3%           | 56.0%           |         |
| Yes                       | 102        | 31.2%    | 33.3%                                 | 36.3%           | 30.4%           |         |
| Upset by family arguments |            |          |                                       |                 |                 | 0.007   |
| No                        | 145        | 44.3%    | 13.1%                                 | 33.1%           | 53.8%           |         |
| Yes                       | 182        | 55.7%    | 26.9%                                 | 30.8%           | 42.3%           |         |
| Family member or a friend passed away |          |          |                                       |                 |                 | 0.239   |
| No                        | 189        | 58.5%    | 19.6%                                 | 29.1%           | 51.3%           |         |
| Yes                       | 134        | 41.5%    | 23.1%                                 | 35.1%           | 41.8%           |         |
| Left home because of a family argument or fight |          |          |                                       |                 |                 | 0.021   |
| No                        | 239        | 73.1%    | 16.7%                                 | 33.1%           | 50.2%           |         |
| Yes                       | 88         | 26.9%    | 30.7%                                 | 28.4%           | 40.9%           |         |
| Had to stop working or studying |          |          |                                       |                 |                 | 0.423   |
| No                        | 267        | 83.4%    | 21.3%                                 | 33.0%           | 45.7%           |         |
| Yes                       | 53         | 16.6%    | 15.1%                                 | 30.2%           | 54.7%           |         |
| Ever pushed, shoved or assaulted |          |          |                                       |                 |                 | 0.003   |
| No                        | 270        | 84.1%    | 16.7%                                 | 32.2%           | 51.1%           |         |
| Yes                       | 51         | 15.9%    | 37.3%                                 | 27.5%           | 35.3%           |         |
Table 3  Birth outcomes for the Aboriginal Families Study (AFS) cohort compared to Australian reference data and differentially according to whether cannabis and cigarettes were used in pregnancy

| Birth outcomes for those using | Australian reference data\(^{10}\) | AFS cohort | p Value* |
|-------------------------------|---------------------------------|------------|---------|
|                               | Mean (SD)                       | Mean (SD)  |         |
| Birth outcomes for those using |                                 |            |         |
| Cannabis (with or without cigarettes) (20.5%) | 38.7% 3.8% | 37.8% 2.0% | <0.001 |
| Cigarettes only (31.9%)       | 698 733                       | 3267 579   |         |
| Neither (47.6%)               | 3345 690                      | 3345 690   | <0.001 |
| Gestational age (weeks)       | 38.8%                         | 308 38.7%‡| 2.7%    |
| Birth weight (g)              | 3367                          | 315 3209‡ | 2781 733| <0.001 |
| Gestation at birth            |                                |            |         |
| Preterm (<37 weeks)           | 8.5%                          | 36 11.7%§ | 19.1%   |
| Term (≥37 and <42 weeks)      | 90.9%                         | 268 87.0% | 79.4%   |
| Post-term (≥42 weeks)         | 0.6%                          | 4 1.3%    | 1.6%    |
| Infant birth weight           |                                |            |         |
| Low (<2500 g)                 | 6.2%                          | 43 13.7%¶ | 35.5%   |
| Appropriate (≥2500 and <4000 g) | 82.3%                        | 241 76.5% | 59.7%   |
| High (≥4000 g)                | 11.5%                         | 31 9.8%   | 4.8%    |
| Weight for gestational age    |                                |            |         |
| Small (<10th centile)         | 10.0%                         | 64 21.6%**| 38.6%   |
| Appropriate (≥10th and <90th centile) | 80.0%                    | 210 70.7% | 54.4%   |
| Large (≥90th centile)         | 10.0%                         | 23 7.7%   | 7.0%    |

\(*p\) Value comparing mothers who used cannabis, cigarettes or neither during pregnancy (Wald test from linear regression for continuous birth outcomes, \(\chi^2\) test for categorised birth outcomes).

\(†p\) Value from one sample t test comparing mean gestational age to full cohort to Australian reference data = 0.498.

\(‡p\) Value from one sample t test comparing mean birth weight to Australian reference data < 0.001.

\(§p\) Value from binomial probability test comparing proportion of preterm births to Australian reference data = 0.052.

\(¶p\) Value from binomial probability test comparing proportion of low birth weight to Australian reference data < 0.001.

\(**p\) Value from binomial probability test comparing proportion SGA to Australian reference data < 0.001.
To our knowledge, the Aboriginal Families Study is the first to examine the association between cannabis use and perinatal outcomes in an indigenous population. Two Australian record linkage studies drawing on routinely collected perinatal data, and one cross-sectional study include estimates for cannabis use during pregnancy among Aboriginal and Torres Strait Islander women, with estimates ranging from 7.6% to 15%. None of these studies report analyses comparing birth outcomes for indigenous women identified as using cannabis during pregnancy, with women not using cannabis. The table below presents birth outcomes in the Aboriginal Families Study (AFS) cohort during pregnancy by socioeconomic resources, timing of childbearing, experiencing stressful events and social health issues and engagement with health services.

| Table 4 Birth outcomes in the Aboriginal Families Study (AFS) cohort during pregnancy by socioeconomic resources, timing of childbearing, experiencing stressful events and social health issues and engagement with health services |
|-----------------------------------------------|
| **Educational level attained** | **Gestational age (weeks)** | **Birth weight (g)** | **Preterm birth (<37 weeks) (11.7%)** | **Low birth weight (<2500 g) (13.7%)** | **Small for gestational age (<10th centile) (21.6%)** |
|-----------------------------------------------|-----------------------------|------------------------|---------------------------------|---------------------------------|---------------------------------|
| **Mean** | **p Value** | **Mean** | **p Value** | **Mean** | **p Value** | **Mean** | **p Value** | **Mean** | **p Value** | **Mean** | **p Value** |
| Less than year 12 | 38.7 | 0.811 | 3055 | 0.011 | 14.2% | 0.414 | 16.9% | 0.399 | 27.8% | 0.015 |
| Completed year 12 | 38.3 | 0.266 | 3387 | 0.008 | 12.5% | 0.515 | 17.6% | 0.019 | 27.1% | 0.008 |
| Certificate or traineeship | 38.8 | 0.147 | 3270 | 0.269 | 8.6% | 0.363 | 13.4% | 0.629 | 16.7% | 0.004 |
| Diploma or degree | 38.6 | 0.173 | 3407 | 0.333 | 18.2% | 0.987 | 21.7% | 0.816 |
| In employment or study | **No** | 38.7 | 0.793 | 3160 | 0.173 | 11.6% | 0.874 | 14.6% | 0.492 | 21.7% | 0.816 |
| | **Yes** | 38.7 | 0.793 | 3266 | 0.173 | 12.1% | 0.874 | 12.0% | 0.492 | 20.6% | 0.816 |
| Age of mother at birth of first child (years) | 14–19 | 38.7 | 0.266 | 3147 | 0.008 | 10.3% | 0.515 | 17.6% | 0.019 | 27.1% | 0.008 |
| | 20–24 | 38.5 | 0.147 | 3165 | 0.269 | 14.5% | 0.363 | 13.2% | 0.629 | 20.4% | 0.008 |
| | 25+ | 39.2 | 0.147 | 3480 | 0.269 | 9.8% | 0.363 | 2.0% | 0.629 | 6.1% | 0.008 |
| Age of mother at birth of study child (years) | 15–19 | 39.3 | 0.266 | 3093 | 0.008 | 6.0% | 0.363 | 17.3% | 0.629 | 38.8% | 0.004 |
| | 20–24 | 38.5 | 0.147 | 3188 | 0.269 | 12.3% | 0.363 | 13.4% | 0.629 | 16.7% | 0.004 |
| | 25+ | 38.7 | 0.147 | 3270 | 0.269 | 13.5% | 0.363 | 11.9% | 0.629 | 18.9% | 0.004 |
| Number of children (including child in survey) | 1 | 38.9 | 0.266 | 3243 | 0.535 | 11.3% | 0.967 | 9.6% | 0.192 | 17.7% | 0.192 |
| | 2–3 | 38.6 | 0.266 | 3150 | 0.535 | 12.3% | 0.967 | 17.2% | 0.192 | 26.9% | 0.192 |
| | 4–10 | 38.3 | 0.266 | 3233 | 0.535 | 12.1% | 0.967 | 14.7% | 0.192 | 18.8% | 0.192 |
| Stressful events and social health issues | 0 | 39.3 | 0.278 | 3247 | 0.693 | 8.8% | 0.793 | 8.6% | 0.345 | 14.7% | 0.027 |
| | 1–2 | 38.5 | 0.278 | 3278 | 0.693 | 13.0% | 0.793 | 8.8% | 0.345 | 13.2% | 0.027 |
| | 3+ | 38.8 | 0.278 | 3199 | 0.693 | 10.8% | 0.793 | 14.6% | 0.345 | 27.7% | 0.027 |
| Diabetes in pregnancy | No | 38.9 | 0.004 | 3213 | 0.663 | 10.3% | 0.020 | 12.9% | 0.461 | 21.6% | 0.226 |
| | Yes | 37.4 | 0.004 | 3273 | 0.663 | 25.0% | 0.020 | 17.9% | 0.461 | 11.5% | 0.226 |
| Hypertension in pregnancy | No | 38.9 | 0.004 | 3253 | 0.054 | 7.5% | <0.001 | 10.8% | 0.005 | 19.6% | 0.005 |
| | Yes | 37.7 | 0.004 | 3058 | 0.054 | 30.9% | <0.001 | 25.0% | 0.005 | 25.9% | 0.005 |
| Attended a health service/clinic prior to pregnancy | No | 39.1 | 0.130 | 3245 | 0.729 | 9.4% | 0.482 | 11.6% | 0.607 | 18.8% | 0.607 |
| | Yes | 38.6 | 0.130 | 3214 | 0.729 | 12.3% | 0.482 | 13.8% | 0.607 | 21.5% | 0.607 |
| Timing of first pregnancy check-up | Trimester 1 (1–13 weeks) | 38.9 | 0.038 | 3266 | 0.013 | 9.3% | 0.143 | 12.7% | 0.384 | 17.0% | 0.004 |
| | Trimester 2 (14–26 weeks) | 38.7 | 0.038 | 3096 | 0.013 | 15.4% | 0.143 | 19.6% | 0.384 | 36.0% | 0.004 |
| | Trimester 3 (27 weeks or later)/no check-ups before labour and delivery | 36.4 | 0.038 | 2692 | 0.013 | 28.6% | 0.143 | 20.0% | 0.384 | 42.9% | 0.004 |
| Number of pregnancy check-ups altogether | 0–4 | 37.7 | 0.027 | 2886 | 0.001 | 28.1% | 0.010 | 18.8% | 0.140 | 34.5% | 0.005 |
| | 5–10 | 38.4 | 0.027 | 3100 | 0.001 | 11.8% | 0.010 | 18.6% | 0.140 | 29.9% | 0.005 |
| | 10+ | 39.0 | 0.027 | 3319 | 0.001 | 8.9% | 0.010 | 10.6% | 0.140 | 14.8% | 0.005 |

*p Value from Wald test from linear regression for continuous birth outcomes, \( \chi^2 \) test for categorised birth outcomes.

DISCUSSION
To our knowledge, the Aboriginal Families Study is the first to examine the association between cannabis use and perinatal outcomes in an indigenous population. Two Australian record linkage studies drawing on routinely collected perinatal data, and one cross-sectional study include estimates for cannabis use during pregnancy among Aboriginal and Torres Strait Islander women, with estimates ranging from 7.6% to 15%. None of these studies report analyses comparing birth outcomes for indigenous women identified as using cannabis during pregnancy, with women not using cannabis.
| Birth outcome                        | Gestational age (weeks) | Birth weight (g) | Preterm birth (<37 weeks) | Low birth weight (<2500 g) | Small for gestational age (<10th centile) |
|-------------------------------------|-------------------------|------------------|---------------------------|---------------------------|----------------------------------------|
|                                     | Mean diff               | 95% CI           | p Value                   | OR 95% CI                  | p Value                                |
| Model 1* (N)                        | 308                     | (−1.0 to −0.3)   | 0.009                     | 0.001                     | 0.001                                  |
| Cannabis (vs neither)               |                         | −565 (−762 to −367) | <0.001                    | 2.0 (0.9 to 4.4)          | 0.107                                  |
| Model 1* (N)                        | 236                     | (−0.9 to −0.5)   | 0.097                     | 0.001                     | 0.001                                  |
| Cigarettes (vs neither)             | −0.9                    | (−1.8 to −0.1)   | 0.064                     | 1.9 (0.6 to 5.8)          | 0.273                                  |
| Model 1* (N)                        |                         | −431 (−675 to −187) | 0.001                    | 4.2 (1.5 to 11.3)         | 0.005                                  |
| Vaccination (vs neither)            | −0.4                    | (−0.1 to 1.1)    | 0.319                     | 0.7 (0.2 to 2.0)          | 0.499                                  |
| Model 1* (N)                        |                         | −12 (−202 to 179) | 0.904                     | 1.3 (0.6 to 2.8)          | 0.579                                  |
| Maternal education :                 |                         |                  |                           |                           |                                        |
| Year 12 or further                  | −0.3                    | (−1.0 to 0.4)    | 0.415                     | 0.5 (0.2 to 1.2)          | 0.128                                  |
| Maternal age first birth            |                         | 148 (−40 to 337) | 0.122                     | 1.2 (0.2 to 1.2)          | 0.744                                  |
| 20–24 (vs 15–19)                    |                         |                  |                           |                           |                                        |
| Number of children                  | −0.5                    | (−1.2 to 0.3)    | 0.210                     | 1.1 (0.4 to 2.7)          | 0.920                                  |
| 2 to 3 (vs 1)                       |                         | −107 (−292 to 78) | 0.257                     | 2.1 (0.8 to 5.4)          | 0.111                                  |
| 4 to 5 (vs 1)                       |                         | 93 (−144 to 330) | 0.441                     | 1.2 (0.3 to 4.1)          | 0.774                                  |
| Social health issues                | −0.4                    | (−1.5 to 0.6)    | 0.432                     | 0.9 (0.2 to 3.9)          | 0.938                                  |
| 1 or 2 (vs none)                    |                         | −52 (−228 to 333) | 0.714                     | 0.9 (0.2 to 3.9)          | 0.938                                  |
| 3 or more                           | −0.2                    | (−1.2 to 0.8)    | 0.855                     | 0.9 (0.2 to 3.9)          | 0.938                                  |
| Pregnancy check-up in 1st trimester |                         |                  |                           |                           |                                        |
| Yes                                 | 0.2                     | (−0.6 to 1.0)    | 0.576                     | 0.4 (0.2 to 0.9)          | 0.028                                  |
| Model 1* (N)                        | 233                     | (−1.0 to 1.0)    | 0.576                     | 0.5 (0.2 to 1.5)          | 0.214                                  |
| Cannabis (vs neither)               | −1.1                    | (−2.0 to −0.2)   | 0.021                     | 0.9 (0.3 to 2.2)          | 0.752                                  |
| Cigarettes (vs neither)             | 0.1                     | (−0.6 to 0.9)    | 0.735                     | 0.9 (0.2 to 3.8)          | 0.938                                  |

*Unadjusted model estimating mean difference/OR for mothers who used cannabis or smoked cigarettes in comparison with mothers who used neither.
†Multivariable model giving adjusted effects accounting for maternal education, maternal age at birth of first child, number of children in the family, social health issues, and whether a pregnancy check-up was conducted in the first trimester of pregnancy.
‡Fully adjusted effects of cannabis use or smoking cigarettes taking account of socioeconomic resources, timing of childbearing, experiencing social health issues and engagement with health services (as detailed in table 1, excluding total number of pregnancy check-ups, diabetes and hypertension).
cannabis. No studies reporting data on use of cannabis during pregnancy by indigenous women in other high-income countries were identified.

In our study, one in five mothers reported that they used cannabis during pregnancy, and half the mothers (51%) who used cannabis experienced adverse perinatal outcomes. Cannabis use was associated with lower infant birth weight and higher prevalence of preterm birth, low infant birth weight (<2500 g) and SGA infants. Controlling for the health and social characteristics of the mothers did not alter the conclusion that cannabis use is associated with negative birth outcomes. These findings, while more extreme, are consistent with two recent studies drawing on routinely collected population-level data in Australia and France showing that cannabis use is associated with low birth weight and preterm birth. Other studies conducted in general population samples of pregnant women report conflicting findings.15-17 There are a number of plausible explanations for the outcomes observed in our cohort, and the deviation from the less extreme12 13 and conflicting findings reported in the international literature.15-17 It is likely that designing the study in partnership with the Aboriginal Advisory Group, the extent of community engagement, and the collection of information by Aboriginal researchers well known in their communities may have resulted in a more accurate disclosure of exposure. While we cannot rule out some under-reporting of cannabis use, pretesting of the questionnaire suggested that women were comfortable with the inclusion of questions about cannabis use and social health issues. Only a small proportion of women in the study (<2%) opted not to answer this section of the questionnaire. While some misclassification is likely, under-reporting of cannabis use or smoking is likely to have led to underestimation rather than overestimation of effects.

A second explanation is that the results reflect the impact of the amount and types of cannabis being consumed by women during pregnancy. A recent Australian study found that 15% of indigenous women reported a mean of seven cones, or joints, per day during pregnancy.25 We deliberately chose not to ask how often women used cannabis in pregnancy due to the likelihood of inaccurate recall, but it is plausible that estimates reflect the frequency of high doses and types of cannabis in common use. Other studies have concluded that the potency of cannabis, reflected in the concentration of psychoactive cannabinoids, and amount of cannabis consumed, are increasing, particularly among young adults and minority populations.17 A third potential explanation is susceptibility to the effects of cannabis, reflecting either biological susceptibility or heightened response in the context of the other social and material adversities experienced by Aboriginal communities. Evidence of extreme social disadvantage is very apparent in the cohort, 39% of mothers had completed less than year 12 at secondary school, 58% of women in the study experienced three or more stressful events or social health issues during pregnancy, and one in four experienced 5–12 of these issues. It is likely that our findings reflect high levels of exposure and susceptibility in the context of acute social disadvantage.

While the poor obstetric and birth outcomes experienced by Aboriginal and Torres Strait Islander mothers are described in numerous Australian Government reports, this study is one of the few population-based studies to examine associations with the social disadvantage experienced by Aboriginal mothers. The studies by Eades et al in an urban population in Western Australia, and Comino et al in a major regional centre in New South Wales, are notable exceptions. Being raised on a mission or in an institution, living in a disadvantaged neighbourhood, unemployment, incomplete education, maternal smoking and alcohol use were some of the social risk factors associated with adverse pregnancy outcomes.9 10

Developing the study in partnership with the AHCSA ensured respect for Aboriginal community protocols and priorities. Extensive community consultations in urban, regional and remote areas of South Australia informed the approach that was taken. Members of the Aboriginal Advisory Group worked with the research team to design and pretest the questionnaire, drawing on community feedback about priorities. Consideration of cannabis use was based on feedback from community consultations identifying concern about the impact of cannabis, and other stresses, such as family violence and housing problems, on the health of mothers and babies. As a result, we collected data that enabled us to take a much broader range of health and social factors into account in the analyses compared with previous studies.15-17 Limitations of our study include reliance on self-reported data for infant birth weight and gestation, although studies comparing maternal self-report with hospital records suggest a high level of congruity.27 28 We were unable to control for use of alcohol and other illicit drugs, and cannot rule out the possibility that the observed effects of cannabis use on birth outcomes are due to unmeasured or residual confounding. Further investigation of dose effects and poly drug use, taking into consideration types of cannabis, will be critical to understanding the extent and nature of the effects and routes to minimising harm.

CONCLUSIONS

Disclosure of cannabis use, and therefore, accuracy of ascertainment was enhanced by the use of culturally appropriate research methods and high level of consultation and community engagement preceding and throughout the study. The time taken to work with the Aboriginal Advisory Group to develop study methods acceptable to Aboriginal communities, and to train Aboriginal researchers to undertake fieldwork has produced a unique data set. Although the study design precludes causal inference, the size of effects and prevalence of cannabis use during pregnancy in the population of Aboriginal women signal the need for action at a community, service and policy level. Although the results are extreme in relation to international literature, and may not be broadly generalisable, internationally
there may be congruent risks for many communities, particularly other indigenous communities within other high-income countries.

The findings provide a compelling case for stronger efforts to address the clustering of risks for adverse birth outcomes in Aboriginal and Torres Strait Islander communities. The results also have implications for other socially disadvantaged populations vulnerable to poor maternal and child health. Antenatal care affords a window of opportunity to identify and support women vulnerable to adverse birth outcomes. Going forward, a greater focus on ensuring that women, families and health professionals are aware of the likely adverse consequences of cannabis use during pregnancy is needed, with new approaches to supporting women to stop, or curtail the use of cannabis before, and during pregnancy. Beyond this, our findings also point to the need for antenatal care to address broader social determinants of adverse perinatal outcomes, and for interventions to support women to reduce cannabis use to be situated within the context of women’s life circumstances. This requires rethinking existing (and outdated) frameworks for providing antenatal care, and redesigning services to combine high-quality clinical care with a stronger public health approach to addressing modifiable social risk factors for poor maternal and child health outcomes.29

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