

# BMJ Open 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 3.0 to 14.3), and small for gestational age (OR=3.8, 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.

## Strengths and limitations of this study

- A strength of this study is the development of the study protocol in collaboration with Aboriginal community organisations, based on extensive community consultations over an 18-month period.
- Engagement with Aboriginal communities right from the start, recruitment of a population-based sample, and involvement of Aboriginal research interviewers in data collection is likely to have led to more reliable ascertainment of cannabis use and data on women's life circumstances compared with routinely collected data.
- Reliance on maternal report of infant birth weight and gestation may introduce bias, although studies comparing maternal self-report and hospital records suggest a high degree of congruity.
- Reliance on maternal recall of cannabis use and smoking cigarettes may lead to misclassification of exposure, most likely to be in the direction of under-reporting. Any under-reporting is likely to have resulted in underestimation, rather than overestimation of effects.
- We were unable to assess dose effects, or to control for use of alcohol or polydrug use, and therefore, cannot rule out the possibility that observed effects are due to unmeasured or residual confounding.

## INTRODUCTION

Despite attention brought to maternal and child health by the Millennium Development Goals, disparities in maternal and child health outcomes affecting indigenous populations in high-income countries remain poorly understood and neglected in global priorities.<sup>1 2</sup> 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.<sup>3</sup> The causes of these disparities are complex and multifactorial.<sup>4–6</sup> 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.<sup>7–8</sup> 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.<sup>9–10</sup>

In addition to high rates of smoking, there is evidence of high rates of cannabis use among Aboriginal women.<sup>11</sup> 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,<sup>12–14</sup> conflicting findings are generating a lack of consensus in the international literature.<sup>15–17</sup> Animal studies show that cannabis readily crosses the blood/brain and placental cell barriers, with potential to affect fetal growth and development.<sup>15–17–18</sup> 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.<sup>15–17</sup>

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 Health 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.<sup>19</sup>

### 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.<sup>20</sup>

Questions regarding cigarette smoking and cannabis use were designed based on questions used in a state-wide population-based survey of women giving birth in South Australia,<sup>21</sup> and feedback from pretesting the questionnaire.<sup>19</sup> Women were asked: 'At any time, when you were pregnant, did you smoke any cigarettes or use 'yarndi' (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.<sup>19</sup> The Australian Geographical Classification System was used to classify women as living in urban, regional or remote areas of South Australia.<sup>22</sup>

### Statistical analysis

Birth outcomes for the cohort as a whole were compared with corresponding reference values for

Australia<sup>20</sup> 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  $\chi^2$  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.<sup>23</sup>

## 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 1** Use of cannabis and cigarettes 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

	AFS cohort		Per cent of women reporting using:			p Value
			N	Cannabis (with or without cigarettes) (20.5%)	Cigarettes only (31.9%)	
Educational level attained						
Less than year 12	130	39.2%	28.5%	33.1%	38.5%	<0.001
Completed year 12	32	9.6%	9.4%	21.9%	68.8%	
Certificate or traineeship	148	44.6%	17.6%	36.5%	45.9%	
Diploma or degree	22	6.6%	9.1%	9.1%	81.8%	
In employment or study						
No	187	56.3%	25.7%	39.6%	34.8%	<0.001
Yes	145	43.7%	13.8%	22.1%	64.1%	
Age of mother at birth of first child (years)						
14–19	153	46.1%	26.8%	36.6%	36.6%	0.003
20–24	124	37.3%	15.3%	30.6%	54.0%	
25+	55	16.6%	14.5%	21.8%	63.6%	
Age of mother at birth of study child (years)						
15–19	54	16.3%	31.5%	22.2%	46.3%	0.167
20–24	137	41.3%	19.0%	31.4%	49.6%	
25+	141	42.5%	17.7%	36.2%	46.1%	
Number of children (including child in survey)						
1	140	42.2%	17.1%	25.0%	57.9%	0.014
2–3	123	37.0%	24.4%	33.3%	42.3%	
4–10	69	20.8%	20.3%	43.5%	36.2%	
Stressful events and social health issues						
0	34	12.5%	0.0%	38.2%	61.8%	<0.001
1–2	81	29.7%	9.9%	23.5%	66.7%	
3+	158	57.9%	25.9%	32.3%	41.8%	
Diabetes in pregnancy						
No	295	90.5%	22.0%	31.2%	46.8%	0.121
Yes	31	9.5%	6.5%	35.5%	58.1%	
Hypertension in pregnancy						
No	270	82.8%	22.2%	30.7%	47.0%	0.257
Yes	56	17.2%	12.5%	35.7%	51.8%	
Attended a health service/clinic prior to pregnancy						
No	90	28.1%	23.3%	31.1%	45.6%	0.698
Yes	230	71.9%	19.1%	32.2%	48.7%	
Timing of first pregnancy check-up						
Trimester 1 (1–13 weeks)	233	78.2%	17.2%	29.6%	53.2%	0.017
Trimester 2 (14–26 weeks)	54	18.1%	35.2%	33.3%	31.5%	
Trimester 3 (27 weeks or later)/no check-up before labour and delivery	11	3.7%	27.3%	36.4%	36.4%	
Number of pregnancy check-ups altogether						
0–4	36	11.8%	33.3%	41.7%	25.0%	0.063
5–10	108	35.4%	22.2%	31.5%	46.3%	
More than 10	161	52.8%	18.0%	30.4%	51.6%	

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

**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		Per cent of women reporting using:			p Value
	N	Percent	Cannabis (with or without cigarettes) (20.5%)	Cigarettes only (31.9%)	Neither (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						
No	242	77.8%	13.2%	31.0%	55.8%	<0.001
Yes	69	22.2%	42.0%	30.4%	27.5%	
Scared by other people's behaviour						
No	226	69.8%	14.2%	33.6%	52.2%	<0.001
Yes	98	30.2%	33.7%	26.5%	39.8%	
Pestered for money						
No	225	68.8%	14.7%	29.3%	56.0%	<0.001
Yes	102	31.2%	33.3%	36.3%	30.4%	
Upset by family arguments						
No	145	44.3%	13.1%	33.1%	53.8%	0.007
Yes	182	55.7%	26.9%	30.8%	42.3%	
Family member or a friend passed away						
No	189	58.5%	19.6%	29.1%	51.3%	0.239
Yes	134	41.5%	23.1%	35.1%	41.8%	
Left home because of a family argument or fight						
No	239	73.1%	16.7%	33.1%	50.2%	0.021
Yes	88	26.9%	30.7%	28.4%	40.9%	
Had to stop working or studying						
No	267	83.4%	21.3%	33.0%	45.7%	0.423
Yes	53	16.6%	15.1%	30.2%	54.7%	
Ever pushed, shoved or assaulted						
No	270	84.1%	16.7%	32.2%	51.1%	0.003
Yes	51	15.9%	37.3%	27.5%	35.3%	

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 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

	Australian reference data <sup>10</sup> Mean	AFS cohort		Birth outcomes for those using								p Value*
		Full cohort		Cannabis (with or without cigarettes) (20.5%)		Cigarettes only (31.9%)		Neither (47.6%)				
		N	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)					
Gestational age (weeks)	38.8%	308	38.7%†	2.7%	37.8%	3.8%	39.0%	2.0%	38.9%	2.3%	0.014	
Birth weight (g)	3367	315	3209‡	698	2781	733	3267	579	3345	690	<0.001	
N												
Gestation at birth												
Preterm (<37 weeks)	8.5%	36	11.7%§		19.1%		8.3%		10.7%		0.245	
Term (≥37 and <42 weeks)	90.9%	268	87.0%		79.4%		89.6%		88.6%			
Post-term (≥42 weeks)	0.6%	4	1.3%		1.6%		2.1%		0.7%			
Infant birth weight												
Low (<2500 g)	6.2%	43	13.7%¶		35.5%		9.1%		7.8%		<0.001	
Appropriate (≥2500 and <4000 g)	82.3%	241	76.5%		59.7%		81.8%		79.9%			
High (≥4000 g)	11.5%	31	9.8%		4.8%		9.1%		12.3%			
Weight for gestational age												
Small (<10th centile)	10.0%	64	21.6%**		38.6%		22.6%		14.3%		0.004	
Appropriate (≥10th and <90th centile)	80.0%	210	70.7%		54.4%		72.0%		76.2%			
Large (≥90th centile)	10.0%	23	7.7%		7.0%		5.4%		9.5%			

\*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.

**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

	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*		p Value*		p Value*		p Value*
Educational level attained										
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		3387		12.5%		6.7%		6.7%	
Certificate or traineeship	38.8		3270		8.6%		12.5%		21.5%	
Diploma or degree	38.6		3407		18.2%		9.1%		4.5%	
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		3266		12.1%		12.0%		20.6%	
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		3165		14.5%		13.2%		20.4%	
25+	39.2		3480		9.8%		2.0%		6.1%	
Age of mother at birth of study child (years)										
15–19	39.3	0.147	3093	0.269	6.0%	0.363	17.3%	0.629	38.8%	0.004
20–24	38.5		3188		12.3%		13.4%		16.7%	
25+	38.7		3270		13.5%		11.9%		18.9%	
Number of children (including child in survey)										
11	38.9	0.266	3243	0.535	11.3%	0.967	9.6%	0.192	17.7%	0.197
2–3	38.6		3150		12.3%		17.2%		26.9%	
4–10	38.3		3233		12.1%		14.7%		18.8%	
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		3278		13.0%		8.8%		13.2%	
3+	38.8		3199		10.8%		14.6%		27.7%	
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		3273		25.0%		17.9%		11.5%	
Hypertension in pregnancy										
No	38.9	0.001	3253	0.054	7.5%	<0.001	10.8%	0.005	19.6%	0.299
Yes	37.7		3058		30.9%		25.0%		25.9%	
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%	0.605
Yes	38.6		3214		12.3%		13.8%		21.5%	
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		3096		15.4%		19.6%		36.0%	
Trimester 3 (27 weeks or later)/no check-ups before labour and delivery	36.4		2692		28.6%		20.0%		42.9%	
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		3100		11.8%		18.6%		29.9%	
10+	39.0		3319		8.9%		10.6%		14.8%	

\*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,<sup>13 24</sup> and one cross-

sectional study<sup>25</sup> 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

**Table 5** Multivariable models of birth outcomes for the Aboriginal Families Study (AFS) cohort, according to whether cannabis and cigarettes were used in pregnancy, and health and social characteristics

Birth outcome	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 diff	95% CI	p Value	Mean diff	95% CI	p Value	OR	95% CI	p Value	OR	95% CI	p Value	OR	95% CI	p Value
	Model 1* (N)	308			315			308			315			297	
Cannabis (vs neither)	-1.0	(-1.8 to -0.3)	0.009	-565	(-762 to -367)	<0.001	2.0	(0.9 to 4.4)	0.107	6.5	(3.0 to 14.3)	<0.001	3.8	(1.9 to 7.6)	<0.001
Cigarettes (vs neither)	0.1	(-0.6 to 0.8)	0.723	-79	(-247 to 90)	0.361	0.8	(0.3 to 1.8)	0.537	1.2	(0.5 to 2.9)	0.715	1.8	(0.9 to 3.4)	0.102
Model 2† (N)	236			241			236			241			229		
Cannabis (vs neither)	-0.9	(-1.8 to 0.1)	0.064	-431	(-675 to -187)	0.001	1.9	(0.6 to 5.8)	0.273	4.2	(1.5 to 11.3)	0.005	1.9	(0.8 to 4.6)	0.175
Cigarettes (vs neither)	0.4	(-0.4 to 1.1)	0.319	-12	(-202 to 179)	0.904	0.4	(0.1 to 1.4)	0.135	0.7	(0.2 to 2.0)	0.499	1.3	(0.6 to 2.8)	0.579
Maternal education															
Year 12 or further	-0.3	(-1.0 to 0.4)	0.415	148	(-40 to 337)	0.122	0.5	(0.2 to 1.2)	0.128	1.2	(0.5 to 2.7)	0.744	0.8	(0.4 to 1.6)	0.545
Maternal age first birth															
20–24 (vs 15–19)	-0.2	(-0.9 to 0.5)	0.591	-179	(-374 to 16)	0.071	3.0	(1.1 to 8.8)	0.039	1.0	(0.4 to 2.4)	0.970	0.9	(0.4 to 1.9)	0.791
25+	0.4	(-0.6 to 1.4)	0.430	153	(-101 to 407)	0.236	2.2	(0.5 to 9.7)	0.299	0.1	(0.0 to 1.1)	0.059	0.3	(0.1 to 1.2)	0.084
Number of children															
2 or 3 (vs 1)	-0.5	(-1.2 to 0.3)	0.210	-107	(-292 to 78)	0.257	1.1	(0.4 to 2.7)	0.920	2.1	(0.8 to 5.4)	0.111	1.5	(0.7 to 3.3)	0.258
4 to 10	0.0	(-0.9 to 0.9)	0.955	93	(-144 to 330)	0.441	0.5	(0.1 to 2.4)	0.349	1.2	(0.3 to 4.1)	0.774	0.7	(0.3 to 2.1)	0.567
Social health issues															
1 or 2 (vs none)	-0.4	(-1.5 to 0.6)	0.432	52	(-228 to 333)	0.714	0.9	(0.2 to 4.5)	0.938	0.6	(0.1 to 2.9)	0.523	1.7	(0.4 to 7.2)	0.492
3 or more	-0.2	(-1.2 to 0.8)	0.655	41	(-219 to 301)	0.757	0.9	(0.2 to 3.9)	0.839	0.9	(0.2 to 3.8)	0.938	3.4	(0.9 to 12.9)	0.068
Pregnancy check-up in 1st trimester															
Yes	0.2	(-0.6 to 1.0)	0.576	88	(-126 to 302)	0.416	0.5	(0.2 to 1.5)	0.214	0.9	(0.3 to 2.2)	0.752	0.4	(0.2 to 0.9)	0.028
Model 3‡ (N)	233			237			233			237			226		
Cannabis (vs neither)	-1.1	(-2.0 to -0.2)	0.021	-419	(-672 to -165)	0.001	2.3	(0.6 to 8.3)	0.200	3.9	(1.4 to 11.2)	0.012	1.7	(0.6 to 4.4)	0.281
Cigarettes (vs neither)	0.1	(-0.6 to 0.9)	0.735	-7	(-213 to 198)	0.943	0.3	(0.1 to 1.4)	0.120	0.6	(0.2 to 2.0)	0.446	1.2	(0.5 to 2.9)	0.718

\*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.<sup>12 13</sup> Other studies conducted in general population samples of pregnant women report conflicting findings.<sup>15–17</sup> There are a number of plausible explanations for the outcomes observed in our cohort, and the deviation from the less extreme<sup>12 13</sup> and conflicting findings reported in the international literature.<sup>15–17</sup> 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.<sup>25</sup> 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.<sup>17</sup> 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,<sup>26</sup> 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*<sup>9</sup> in an urban population in Western Australia, and Comino *et al*<sup>10</sup> 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.<sup>9 10</sup>

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.<sup>15–17</sup> 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.<sup>27 28</sup> 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.<sup>29</sup>

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