Received: 16 January 2023 | Revised: 27 September 2023 | Accepted: 2 October 2023

DOI: 10.1002/ajs4.296

ORIGINAL ARTICLE

WILEY

Neonatal abstinence syndrome and other neonatal outcomes for the infants of women experiencing incarceration: A retrospective cohort study

Megan F. Bell[1] | **Erin Kelty**[1] | **Leonie Segal**[2] | **Susan Dennison**[3,4] | **Stuart A. Kinner**[4,5,6,7,8] | **Sharon Dawe**[9] | **Matthew J. Spittal**[5] | **David B. Preen**[1]

[1]School of Population & Global Health, The University of Western Australia, Western Australia, Crawley, Australia

[2]Health Economics and Social Policy, University of South Australia, South Australia, Adelaide, Australia

[3]School of Criminology and Criminal Justice, Griffith University, Queensland, Mt Gravatt, Australia

[4]Griffith Criminology Institute, Griffith University, Queensland, Mt Gravatt, Australia

[5]Melbourne School of Population and Global Health, University of Melbourne, Victoria, Parkville, Australia

[6]Justice Health Group, Murdoch Children's Research Institute, Royal Children's Hospital, New South Wales, Parkville, Australia

[7]School of Population Health, Curtin University, Western Australia, Perth, Australia

[8]Justice Health Group, enAble Institute, Curtin University, Bentley, Western Australia, Australia

[9]School of Applied Psychology, Griffith University, Queensland, Mt Gravatt, Australia

Abstract

Substance use during pregnancy is associated with poor neonatal outcomes. Women incarcerated during pregnancy may have a history of substance use, and their babies may be at risk of neonatal abstinence syndrome (NAS). This study examines the incidence of NAS and other outcomes in infants born to currently or formerly incarcerated women. Infants born between 1985 and 2011 in Western Australia were divided into three mutually exclusive groups: born to women incarcerated during pregnancy ($n = 708$); born within 9–24 months of the mother's release from prison ($n = 651$); and born to women who were never incarcerated ($n = 17{,}712$). The impact of the timing of incarceration during pregnancy was also examined. Neonatal outcomes (NAS, preterm birth, low birthweight, infant mortality and admission to special care nursery) were compared using logistic regression. Infants born to currently or recently incarcerated women had higher odds of all adverse outcomes than infants in the nonexposed group. Infants born to women incarcerated during the second or third trimester (but not the month of birth) had poorer outcomes than infants born to women incarcerated during the month of birth. The findings show that babies born to currently

Megan F. Bell and Erin Kelty are joint first authors.

Correspondence
Megan F. Bell, School of Population and Global Health, The University Western Australia, 35 Stirling Highway, Crawley, WA 6009, Australia.
Email: megan.bell@uwa.edu.au

Funding information
Australian Research Council

or formerly incarcerated women are equally likely to experience adverse neonatal outcomes. Enhanced maternal healthcare must be provided during incarceration and after release.

KEYWORDS
incarceration, maternal health, neonatal health, Pregnancy, substance misuse

1 | INTRODUCTION

Women experiencing incarceration often have different physical and mental health needs to those of the general population (Colbert et al., 2013; Harris et al., 2007). Health issues such as chronic disease, mental illness, substance misuse, head injury, disability and communicable diseases are prevalent in prison populations (Abbott et al., 2016; Australian Institute of Health and Welfare, 2013; Indig et al., 2010). The health status of women in prison may be complicated by socioeconomic factors, such as poverty, homelessness, unemployment and victimisation (Ahmed et al., 2016). Upwards of 50% of women prisoners are mothers (Dowell et al., 2017), and the children born to these women can also have significant health needs. Evidence indicates that, compared with children from the general population, children born to currently or recently incarcerated mothers have an increased risk of infant mortality (Dowell et al., 2018a, 2018b; Wildeman et al., 2014), low birthweight and preterm birth (Bell et al., 2004; Dowell et al., 2019; Knight & Plugge, 2005; Testa et al., 2020; Walker et al., 2014). Complicating these findings, however, is the high prevalence of drug use amongst incarcerated women.

Across studies, the prevalence of substance use disorders in women prisoners has been reported as between 30 and 69 per cent (Fazel et al., 2017). This compares to a worldwide lifetime prevalence of 0.9–8.4 per cent (Degenhardt et al., 2019). Although the prevalence of substance use disorders amongst *pregnant* incarcerated women is unknown, one study reported opioid use disorder in 14–26 per cent of pregnant prisoners (Sufrin et al., 2020). Illicit drug use during pregnancy is associated with low birth weight and preterm birth (Kennare et al., 2005; Ludlow et al., 2004; Schempf, 2007), as well as with neonatal abstinence syndrome (NAS). Neonatal abstinence syndrome is a withdrawal syndrome that occurs in infants following the discontinuation of in-utero exposure to a drug or drugs following birth. Neonatal abstinence syndrome is typically an acute condition that presents in the days following birth, with symptoms including hyperirritability, high-pitched crying, poor feeding, vomiting and increased muscle tone (Pomar et al., 2017). Neonatal abstinence syndrome is most commonly associated with the use of illicit and prescription opioids late in pregnancy (McQueen & Murphy-Oikonen, 2016) but has been also observed following exposure to benzodiazepines (Rementeria & Bhatt, 1977), selective serotonin reuptake inhibitors (Rementeria & Bhatt, 1977) and stimulants such as methylphenidate (Bolea-Alamanac et al., 2014), methamphetamines (Smith et al., 2003) and cocaine (Ogunyemi & Hernandez-Loera, 2004). In addition to being a potentially preventable condition, NAS is associated with high healthcare costs, with the average cost of treatment per neonate estimated to be US$22,552 in the United States (2016) (Strahan et al., 2020).

In most cases, the use of illicit substances ceases or at least reduces markedly upon incarceration. At prison entry, women with an opioid use disorder (including pregnant women) may be inducted into an opioid agonist therapy (OAT) programme, most commonly methadone or buprenorphine. Although the maternal use of OAT has also been associated with high rates of NAS (Jones et al., 2010; Kelty et al., 2022), the additional benefits to both mother and infant

are well-documented, and thus, OAT is strongly recommended. Despite high rates of pre-incarceration illicit drug use and OAT in incarcerated women compared with women who have never been incarcerated (Burns & Mattick, 2007; Colbert et al., 2013; O'Donnell et al., 2009), we found only one study examining the risk of NAS in infants born to incarcerated women. This Canadian study found increased odds of NAS in babies born to women incarcerated during pregnancy and those born out of prison to women who had previously been incarcerated, compared with babies born to women in the general population (Carter Ramirez et al., 2020). However, the risk of NAS was not compared between the two prison groups, nor was the impact of the timing of the incarceration during pregnancy examined. Given the potentially preventable nature of NAS and the high associated costs, additional research in this area is warranted.

This study investigates the risk of NAS and other neonatal outcomes (preterm birth, low birthweight, infant mortality and admission to special care nursery) in infants born to incarcerated women. Previous research has established that outcomes of infants born to incarcerated women can be equivalent or better than outcomes of infants born to similarly socioeconomically disadvantaged women who are not incarcerated (Carter Ramirez et al., 2020; Knight & Plugge, 2005; Mertens, 2000; Testa et al., 2020; Testa & Jackson, 2020). We therefore compare the risk of NAS and other neonatal outcomes across three groups: (1) infants born to women incarcerated during pregnancy; (2) infants born within 9–24 months after their mother's release from prison; and (3) infants born to never incarcerated women. We also examine differences in NAS risk *amongst* incarcerated women. From the literature, we assumed that the association between incarceration and NAS is time-dependent, with NAS most common in infants exposed to substances late in pregnancy, and incarceration affecting access to illicit drugs and OAT. Thus, the impact of changes in illicit drug use and OAT, imposed by incarceration, on the incidence and nature of NAS, may differ for infants depending on the period of maternal incarceration. We therefore examine NAS risk for infants born to women incarcerated at different points during pregnancy.

2 | METHODS

2.1 | Study design

The study was a retrospective cohort study utilising linked administrative data. Details of the overarching study have been previously published (Dowell et al., 2017, 2018b).

2.2 | Study cohort

The original retrospective cohort study on which this study was based comprised all children ($N = 9471$) born in Western Australia (WA) from 1985 to 2011 whose biological mother was incarcerated before the child's eighteenth birthday (or before the child's death) and a matched (up to 3:1 sampling based on Aboriginal and/or Torres Strait Islander status, year of birth and sex) comparison group of children whose mothers had no incarceration record within the WA Department of Justice ($N = 22,716$). Data for children and their mothers were linked through the WA Data Linkage System (WADLS) via the Family Connections System (Glasson et al., 2008), based on details recorded on the WA Registry of Birth, Deaths and Marriages. For this study, we selected a subsample of the original cohort, comprising all cohort singleton infants born to women aged 16 to 42 years. The exposed group included infants born to women who had been incarcerated in the 9 months prior to the child's month of birth (prison pregnancies; $n = 708$). Two comparison groups included the following: (1) infants born within 9–24 months after the mother's release from prison (prison controls; $n = 651$) and (2) infants

born to non-incarcerated women (non-exposed group; $n = 17{,}712$). The oversampling of non-exposed comparison group women was performed to account for the low prevalence of NAS in the general community. For women with multiple eligible pregnancies during the study period, only the first was included.

2.3 | Data sources

This study used routinely collected administrative data linked by the WADLS. Records from distinct datasets were linked by matching identifiers (e.g. name and address) common to the sets of records, using a best-practice probabilistic matching approach and clerical review (Holman et al., 2008). Identifying information was removed from records and replaced with an encrypted key, unique to each individual, by the WA Data Linkage Branch prior to data being provided to the research team. Researchers used the encrypted keys to merge the datasets.

Women with a custodial record (sentenced or remand/pretrial) were identified from WA Department of Justice data, which includes records of all incarcerations in WA. Department of Justice data were linked with data from the WA Registry of Births, Deaths and Marriages and Midwives Notification System (MNS) to identify women incarcerated in the 9 months prior to their child's birth and/or those who gave birth within 9–24 months after release from prison. The MNS contains information on maternal, neonatal and labor/delivery details for every birth in WA resulting in a live or stillborn neonate of at least 20 weeks' gestation or 400 g birthweight if gestational age is unknown. Any missing information in the MNS was supplemented from equivalent information in the Birth Register.

Neonatal outcomes included NAS, preterm birth, low birth weight, admission to special care nursery after birth and infant mortality. Neonatal abstinence syndrome diagnoses were obtained from the Hospital Morbidity Data Collection (HMDC). The HMDC contains records of all private and public hospitalisations within WA. Each hospital separation contained within the HMDC is assigned a primary diagnosis, a co-diagnosis and up to 20 additional diagnoses, utilising International Statistical Classification of Diseases and Related Health Problems (ICD). For hospitalisations prior to July 1999, ICD version 9 Clinical Modification was used (ICD-9-CM). ICD version 10 Australian Modification (ICD-10-AM) was used for hospitalisations from July 1999 onwards. Hospital records with a primary or additional diagnosis of ICD-9-CM 779.5 or ICD-10-AM P96.1 identified infants with NAS. Gestational age, birth weight and admission to special care nursery were obtained from the MNS, with preterm birth classified as gestational age < 37 weeks and low birthweight classified as <2500 grams. The WA Death Register was used to identify children who had died prior to their first birthday ("infant mortality"). Although the WA Death Register contains data on causes of death, this was not examined due to low numbers and a high percentage of cases with no assigned cause of death.

Midwives Notification System data were also used to identify child and maternal sociodemographic characteristics, including child sex (as assigned at birth; male/female), Aboriginal ethnicity (Aboriginal/non-Aboriginal), geographic area of residence at birth (metropolitan/regional/remote), area-level socioeconomic status (in quintiles, from least disadvantaged to most disadvantaged; measured at Collection District level, or Statistical Local Area if Collection District not available), maternal smoking during pregnancy (self-reported; yes/no) and maternal marital status (married or de facto/unmarried).

2.4 | Incarceration timing

To reduce the probability of infants in the study being identifiable, date of birth was provided as month and year, making it impossible to identify the precise timing of incarceration in relation

to conception, pregnancy trimester and birth. We therefore created four approximate periods for the prison pregnancies group, using a hierarchical allocation: (1) birth (in custody during the month of birth), (2) third trimester (in custody in the 3 months prior to birth, but not the month of birth), (3) second trimester (in custody 3 to 6 months prior to birth, but not later) and (4) first trimester (in custody 6 to 9 months prior to birth, but not at other times during pregnancy). Women who were in custody across multiple periods during the 9 months prior to the child's birth were classified per the latest period in which they were still in custody so that they were only included in a single group. For instance, a woman who was in custody throughout her entire pregnancy would have been classified as being in custody during the month of birth.

2.5 | Statistical analysis

Maternal and neonatal characteristics are presented for infants born to women incarcerated at any time during pregnancy, infants born within 9–24 months after their mother's release from prison and infants born to women who had never been incarcerated. The incidence of NAS and other neonatal outcomes (infant mortality, preterm birth, low birth weight and admission to special care nursery) in each of these three groups was then compared using logistic regression, adjusting for child sex, Aboriginal ethnicity, maternal smoking during pregnancy, maternal age, maternal marital status, area-level socioeconomic index and metropolitan residence. Infants born to never-incarcerated women were used as the reference group. Subsequent analyses were restricted to infants born to women with a history of incarceration, comparing the incidence of NAS and other neonatal outcomes depending on the timing of birth in relation to the mother's incarceration, with infants born to mothers incarcerated during the month of birth as the reference group. Analyses were carried out using SAS Version 8.3.

2.6 | Ethics and ethical considerations

Ethics approval for this study was granted by the WA Department of Health Human Research Ethics Committee (2013/72), the University of Western Australia Human Research Ethics Committee (RA/4/1/8111), the University of South Australia Human Research Ethics Committee (0000032609) and the WA Aboriginal Health Ethics Committee (543).

3 | RESULTS

3.1 | Study cohort

The study included 708 infants born to women incarcerated in the 9 months leading up to and including the month of birth. Of those, 18.9% ($n = 134$) were born to women who were incarcerated during the month of birth, 26.0% ($n = 184$) were born to women incarcerated during the third trimester, but not the month of birth, 27.0% ($n = 191$) were born to women incarcerated during the second trimester, but not at other times, and 28.1% ($n = 199$) were born to women incarcerated during the first trimester, but not later. There were also 651 children born within the period 9–24 months after their mother was released from prison.

Table 1 reports the sociodemographic characteristics of infants born to women who had never been incarcerated and infants born to women incarcerated during pregnancy or born within two years of their mother's release. Compared with infants in the non-exposed group, there was a higher proportion of infants in the prison pregnancy and prison control groups who were Aboriginal, born to mothers aged under 25 years, born to unmarried mothers, had

TABLE 1 Sociodemographic characteristics of infants born to never-incarcerated women and infants born to women with a current or recent history of incarceration.

	Born to never-incarcerated women ($n = 17{,}712$)	Prison pregnancies ($n = 708$)	Prison controls ($n = 651$)	p-Value for comparison of prison controls and prison pregnancies
Aboriginal, *n* (%)	6366 (35.94)	511 (72.18)	470 (72.20)	.993
Male, *n* (%)	8516 (48.08)	364 (51.41)	310 (47.62)	.162
Maternal age at birth ≤24 years, *n* (%)	6567 (37.07)	422 (59.60)	407 (62.52)	.271
Mother unmarried, *n* (%)	2667 (15.10)	290 (41.61)	308 (47.83)	.022
Mother smoked during pregnancy, *n* (%)	2073 (11.70)	317 (44.77)	262 (40.25)	.092
Residing in metropolitan area, *n* (%)	9766 (55.14)	486 (68.64)	401 (61.60)	.006
Residing in area with highest level of socioeconomic disadvantage, *n* (%)	6081 (34.37)	366 (51.99)	399 (61.29)	<.001

Note: Prison pregnancies—babies born to women incarcerated at some point during the 9 months prior to the month of birth; prison controls—babies born within 9–24 months after the mother's release from prison.

a mother who smoked during pregnancy, resided in metropolitan areas and lived in areas with the highest level of socioeconomic disadvantage (Table 1). Chi-squared analyses compared the characteristics of the prison pregnancy and prison control groups. Compared with infants in the prison control group, infants in the prison pregnancy group were significantly more likely to be born to unmarried mothers and to have a home address in a metropolitan area, and significantly less likely to have a home address in an area with the highest level of socioeconomic disadvantage (Table 1). The two groups had similar proportions of Aboriginal children, mothers aged ≤24 years and mothers who smoked during pregnancy.

3.2 | Neonatal abstinence syndrome and other neonatal outcomes

Table 2 presents the frequencies, proportions and adjusted odds ratios of comparisons of neonatal outcomes between infants in the non-exposed group and infants in the prison pregnancy and prison control groups. There were 51 infants born with NAS in the prison pregnancy group, compared with 45 in the prison control group, and 15 in the non-exposed group. Compared with the infants whose mothers were never incarcerated, infants in the prison pregnancy group had 55 times increased odds of NAS (95% CI 28.22, 107.32) and infants in the prison control group had 57 times increased odds of NAS (95% CI 29.66, 113.01). Infants in both prison groups also had approximately two times increased odds of all other adverse neonatal outcomes than infants in the non-exposed group (Table 2).

Compared with infants in the prison control group, infants in the prison pregnancy group had a non-significant decrease in odds of NAS (OR = 0.95, 95% CI = 0.61, 1.48) and low birth weight (OR = 0.87, 95% CI = 0.66, 1.16), and a non-significant increase in odds of admission to special care nursery (OR = 1.23, 95% CI = 0.93, 1.61) and preterm birth (OR = 1.10, 95% CI = 0.82, 1.47). Results for infant mortality demonstrated an increase in odds for infants in the prison pregnancy group than for infants in the prison control group, but results cannot be reported due to data confidentiality.

Table 3 reports the results of the analyses based on timing of maternal incarceration. Results for infant mortality could not be reported due to data confidentiality associated with small cell

TABLE 2 Frequencies, proportions, and adjusted[1] odds ratios of neonatal outcomes for infants born to women who had never been incarcerated compared with infants born to women with a history of incarceration.

	Born to never-incarcerated women[2] (*n* = 17,712)	Prison pregnancies (*n* = 708)		Prison controls (*n* = 651)	
Neonatal outcome	***n* (%)**	***n* (%)**	**aOR (95% CI)**	***n* (%)**	**aOR (95% CI)**
NAS	15 (0.08)	51 (7.20)	55.03 (28.22, 107.32)	45 (6.91)	57.89 (29.66, 113.01)
Special care nursery	1275 (7.20)	156 (22.03)	2.57 (2.10, 3.16)	118 (18.13)	2.10 (1.68, 2.62)
Low birth weight	1044 (5.89)	123 (17.37)	2.16 (1.72, 2.69)	122 (18.74)	2.47 (1.99, 3.08)
Preterm	1126 (6.36)	121 (17.09)	2.02 (1.62, 2.52)	101 (15.51)	1.84 (1.46, 2.33)
Infant mortality	128 (0.72)	19 (2.68)	2.72 (1.60, 4.61)	<5	NR

Note: Prison pregnancies—infants born to women incarcerated at some point during the 9 months prior to the month of birth; prison controls—infants born within 9–24 months after the mother's release from prison.

Abbreviations: 95% CI, 95% confidence interval; aOR, adjusted odds ratio; NAS, neonatal abstinence syndrome; NR, not reported due to data confidentiality.

[1]Adjusted for child Aboriginal ethnicity, child sex, maternal age at birth, maternal marital status at birth, maternal smoking during pregnancy, metropolitan residence, and area-level socioeconomic index.

[2]Reference group for logistic regressions.

TABLE 3 Frequencies, proportions, and adjusted[1] odds ratios of neonatal outcomes for infants born to women incarcerated during the month of birth compared with infants born to women incarcerated at different times during pregnancy and infants born to prison controls.

	Incarceration timing during pregnancy								
	Month of birth[2] ($n=134$)	Third trimester ($n=184$)		Second trimester ($n=191$)		First trimester ($n=199$)		Prison controls ($n=651$)	
Neonatal outcome	*n* (%)	*n* (%)	aOR (95% CI)	*n* (%)	aOR (95% CI)	*n* (%)	aOR (95% CI)	*n* (%)	aOR (95% CI)
NAS	13 (9.70)	11 (5.98)	1.08 (0.44, 2.63)	19 (9.95)	2.28 (1.02, 5.11)	8 (4.02)	0.74 (0.28, 1.93)	45 (6.91)	1.29 (0.63, 2.62)
Special care nursery	26 (19.40)	47 (25.54)	2.17 (1.22, 3.89)	41 (21.47)	1.81 (1.00, 3.28)	42 (21.11)	1.62 (0.89, 2.92)	118 (18.13)	1.44 (0.86, 2.40)
Low birth weight	18 (13.43)	37 (20.11)	1.33 (0.70, 2.53)	34 (17.80)	1.18 (0.62, 2.25)	34 (17.09)	1.10 (0.57, 2.10)	122 (18.74)	1.31 (0.75, 2.31)
Preterm	14 (10.45)	43 (23.37)	2.35 (1.19, 4.64)	30 (15.71)	1.59 (0.79, 3.22)	34 (17.09)	1.65 (0.82, 3.32)	101 (15.51)	1.54 (0.82, 2.88)
Infant mortality	0	5 (2.72)	NR	6 (3.14)	NR	8 (4.02)	NR	<5	NR

Note: Prison controls—infants born within 9–24 months after the mother's release from prison.

Abbreviations: 95% CI, 95% confidence interval; aOR, adjusted odds ratio; NAS, neonatal abstinence syndrome; NR, not reported due to data confidentiality.

[1]Adjusted for child Aboriginal ethnicity, child sex, maternal age at birth, maternal marital status at birth, maternal smoking during pregnancy, metropolitan residence and area-level socioeconomic index.

[2]Reference group for logistic regressions.

sizes. Compared with infants born to women incarcerated during the month of birth, infants born to women incarcerated during the third trimester had a non-significant increase in odds of NAS and low birth weight, and a twofold increase in odds of admission to special care nursery (95% CI = 1.22, 3.89) and preterm birth (95% CI = 1.19, 3.22). Infants born to women incarcerated during the second trimester had two times increased odds of NAS (95% CI = 1.02, 5.11) and 1.8 times increased odds of admission to special care nursery (95% CI = 1.00, 3.28) compared to infants born to women incarcerated during the month of birth, and non-significant increases in odds of low birth weight and preterm birth. For infants born to women incarcerated during the first trimester, all results were non-significant, but indicated decreased odds of NAS and increased odds of admission to special care nursery, low birthweight and preterm birth, compared to infants born to women incarcerated during the month of birth. Finally, infants born within 9–24 months after their mother's release from prison had a non-significant increase in odds of all neonatal outcomes compared with infants born to women incarcerated during the month of birth.

4 | DISCUSSION

In our sample of children born from 1985 to 2011, NAS was diagnosed in 7% of infants born to women incarcerated during pregnancy, compared with 0.8% of the infants in the non-exposed group. The odds of NAS in infants born to women incarcerated during pregnancy were 55 times the odds for infants born to never-incarcerated women. This finding highlights the significant burden of NAS in infants born to women incarcerated during pregnancy, even despite an expected reduction in the use of illicit substances during incarceration. We also found that the odds of NAS in infants born to women incarcerated during pregnancy were approximately equivalent to the odds of NAS in infants born within 9–24 months after their mother's release from prison. These findings are consistent with other research (Carter Ramirez et al., 2020) and suggest a high level of substance use disorders and/or OAT in women incarcerated in the years immediately preceding their child's birth.

In relation to other neonatal outcomes, there was an approximate doubling of odds of preterm birth, low birth weight, and admission to special care nursery in the two prison groups compared with the non-exposed group, with the magnitude of the difference similar for infants born to women incarcerated during pregnancy and those born within 9–24 months after their mother's release. As has been found in other research (Carter Ramirez et al., 2020; Dowell et al., 2018b, 2019; Knight & Plugge, 2005; Testa & Jackson, 2020), these findings suggest that babies born to women who are currently or recently incarcerated are at high risk of a range of adverse outcomes, whether they are born in prison or in the community. This is likely a reflection of the high rates of social and economic disadvantage amongst women with a history of incarceration, rather than the incarceration itself. For previously incarcerated women birthing in the community, other complicating factors, such as barriers to accessing antenatal care and substance use treatment, difficulties obtaining stable housing, and lack of engagement with services due to fear of child protective services involvement, may play a role (King et al., 2021).

We also examined neonatal outcomes amongst incarcerated women to establish whether the timing of incarceration had a differential impact. Babies born to women incarcerated during the second and third trimester (but not during the month of birth) had higher odds of NAS than babies born to women incarcerated during the month of birth. Furthermore, women who were in custody during the month of birth gave birth to infants who were on average heavier and born at older gestations compared with infants born to women incarcerated at other times during pregnancy and infants born within 9–24 months after their mother's release from prison. This suggests improved antenatal care for women incarcerated around the time of birth, potentially including improved access to food, no access to drugs and/or alcohol and higher calorie diets provided to pregnant women while in prison. For pregnant women leaving prison prior to

birth, or those diverted from prison, access to affordable healthy food and nutritional advice may help to address this disparity, as would continuing antenatal care and access to stable housing, allowing for safe food storage and cooking facilities as well as potentially minimising exposure to environments with high levels of drug use, such as boarding houses.

There are three clear implications of these findings for both policy and practice. First, all pregnant women who experience incarceration need access to high-quality maternal healthcare while in prison and after release. Maternal healthcare should be combined with other throughcare services to ensure that women's other needs are met when they return to the community. This includes access to safe, suitable and stable housing; domestic violence victim/survivor support; substance use services; physical and mental healthcare; and connection to other services and supports. Linking mothers to maternal health services in the community prior to release is important so that women are not required to navigate these services themselves during the stressful period of release. Such services should also extend to the provision of nurse home visiting for new mothers and their babies to establish good healthcare practices and support structures for formerly incarcerated mothers. Second, there should be immediate and targeted maternal healthcare for pregnant women entering prison. Such healthcare could include advice and maternal counselling around the risk of NAS and the consequences of this for the mother and her baby, including what a special care unit is and how the mother can best care for an infant who experiences NAS. Women should be prepared for the increased likelihood of their infant being hospitalised for longer periods and the potential for mother–baby separation if women are required to return to prison sooner. Third, and related to the second point, correctional services should consider the potential benefits of women being able to stay longer in hospital to bond with their newborn, establish breastfeeding if desired and obtain support and guidance in understanding their newborns' needs. Strong bonds between mothers and their newborns can have long-term benefits for the rehabilitation of incarcerated mothers and secure attachment of children (Breuer et al., 2021; Goshin et al., 2014).

4.1 | Limitations

This is a naturalistic, observational study. It was not possible to take into account a number of factors that may have contributed to poor neonatal outcomes. For example, we were unable to identify women who were treated with medications such as methadone or buprenorphine. There is evidence that neonatal outcomes differ depending on the method of OAT (Knittel et al., 2023). We also do not know what substances women were using during pregnancy, either in the community or in custody, nor whether there were other factors that may have contributed to less than optimal foetal growth (e.g. malnutrition and stress/trauma). Additionally, with the available data, we were unable to establish when the WA Department of Justice became aware of the pregnancy, and what care was provided to support the pregnancy.

The absence of date of birth was also a significant limitation of the study, which may result in infants being misclassified within the three incarceration timing groups. Although date obfuscation to protect privacy is a common practice in data linkage studies, this must be balanced against the need to ensure scientific merit, particularly in studies where the timing and sequence of events is critical. The study also did not factor in length or type of sentence, which may have impacted neonatal outcomes.

5 | CONCLUSION

Our findings emphasise the high incidence of NAS in babies born to women incarcerated during pregnancy and those recently released from prison, with incarceration during the second

trimester associated with the highest odds of NAS. Babies born to currently and recently incarcerated women also had higher odds of preterm birth, low birth weight, and admission to special care nursery. It is important to ensure that health benefits for mothers and babies achieved in prison are continued through women's release and return to the community, through women's access to and engagement in a variety of services that meet their varied but often complex needs, for as long as they need them. Providing stronger maternal healthcare for women who experience incarceration has the potential to provide long-term benefits to both mothers and their children.

AUTHOR CONTRIBUTIONS

Megan Bell: Conceptualization; formal analysis; methodology; writing – review and editing ; project administration. **Erin Kelty:** Methodology; formal analysis; writing – original draft. **Susan Dennison:** Conceptualization; writing – review and editing; funding acquisition. **Sharon Dawe:** Writing – review and editing; funding acquisition; conceptualization. **Leonie Segal:** Conceptualization; writing – review and editing; project administration; funding acquisition. **Stuart A. Kinner:** Conceptualization; writing – review and editing; funding acquisition. **Matthew J. Spittal:** Conceptualization; funding acquisition; writing – review and editing. **David B. Preen:** Supervision; writing – review and editing; project administration; conceptualization; funding acquisition.

ACKNOWLEDGEMENTS

The findings and views reported in this article are those of the authors and should not be attributed to the governments or departments involved in the research. Any errors of omission or commission are the responsibility of the authors. The authors would like to thank the people of Western Australia for the use of their administrative data in this research. The authors also wish to thank the staff at the Western Australian Data Linkage Branch, the WA Department of Justice, and the data custodians of the Hospital Morbidity Data Collection, Midwives Notification System and Western Australian Registry of Births, Deaths, and Marriages.

FUNDING INFORMATION

This research was supported by an Australian Research Council Discovery Project Grant [grant number DP190101360]. Erin Kelty is funded by a National Health and Medical Research Emerging Leader Fellowship. Matthew Spittal is a recipient of an Australian Research Council Future Fellowship (project number FT180100075) funded by the Australian Government. Funding sources had no role in the collection, analysis and interpretation of data; in the writing of the report; or in the decision to submit the article for publication.

ORCID

Megan F. Bell https://orcid.org/0000-0001-7279-6018
Erin Kelty https://orcid.org/0000-0002-0841-2216
Leonie Segal https://orcid.org/0000-0002-6391-6791
Susan Dennison https://orcid.org/0000-0002-7746-7974
Stuart A. Kinner https://orcid.org/0000-0003-3956-5343
Sharon Dawe https://orcid.org/0000-0003-3533-1101
Matthew J. Spittal https://orcid.org/0000-0002-2841-1536
David B. Preen https://orcid.org/0000-0002-2982-2169

REFERENCES

Abbott, P., Magin, P. & Hu, W. (2016) Healthcare delivery for women in prison: A medical record review. *Australian Journal of Primary Health*, 22(6), 523–529.

Ahmed, R.A., Angel, C., Martell, R., Pyne, D. & Keenan, L. (2016) The impact of homelessness and incarceration on women's health. *Journal of Correctional Health Care*, 22(1), 62–74.

Australian Institute of Health and Welfare. (2013) *The health of Australia's prisoners 2012. Cat.no. PHE 170*. Canberra: AIHW. Available from: https://www.aihw.gov.au/reports/prisoners/health-of-australias-prisoners-2012/contents/table-of-contents

Bell, J.F., Zimmerman, F.J., Cawthon, M.L., Huebner, C.E., Ward, D.H. & Schroeder, C.A. (2004) Jail incarceration and birth outcomes. *Journal of Urban Health*, 81(4), 630–644.

Bolea-Alamanac, B.M., Green, A., Verma, G., Maxwell, P. & Davies, S.J.C. (2014) Methylphenidate use in pregnancy and lactation: A systematic review of evidence. *British Journal of Clinical Pharmacology*, 77(1), 96–101.

Breuer, E., Remond, M., Lighton, S., Passalaqua, J., Galouzis, J., Stewart, K.A. et al. (2021) The needs and experiences of mothers while in prison and post-release: a rapid review and thematic synthesis. *Health and Justice*, 9, 1–19.

Burns, L. & Mattick, R.P. (2007) Using population data to examine the prevalence and correlates of neonatal abstinence syndrome. *Drug and Alcohol Review*, 26(5), 487–492.

Carter Ramirez, A., Liauw, J., Costescu, D., Holder, L., Lu, H. & Kouyoumdjian, F.G. (2020) Infant and Maternal Outcomes for Women Who Experience Imprisonment in Ontario, Canada: A Retrospective Cohort Study. *Journal of Obstetrics and Gynaecology Canada*, 42(4), 462–472.e2.

Colbert, A.M., Sekula, L.K., Zoucha, R. & Cohen, S.M. (2013) Health care needs of women immediately post-incarceration: A mixed methods study. *Public Health Nursing*, 30(5), 409–419.

Degenhardt, L., Bharat, C., Glantz, M.D., Sampson, N.A., Scott, K., Lim, C.C.W. et al. (2019) The epidemiology of drug use disorders cross-nationally: Findings from the WHO's World Mental Health Surveys. *International Journal of Drug Policy*, 71, 103–112.

Dowell, C., Mejia, G.C., Preen, D.B. & Segal, L. (2018a) Maternal incarceration, child protection, and infant mortality: a descriptive study of infant children of women prisoners in Western Australia. *Health and Justice*, 6, 1–12..

Dowell, C., Mejia, G.C., Preen, D.B. & Segal, L. (2018b) Determinants of infant mortality for children of women prisoners: A longitudinal linked data study. *BMC Pregnancy and Childbirth*, 18(1), 1–16.

Dowell, C., Mejia, G.C., Preen, D.B. & Segal, L. (2019) Low birth weight and maternal incarceration in pregnancy: A longitudinal linked data study of Western Australian infants. *SSM – Population Health*, 7, 2018, 100324.

Dowell, C., Preen, D.B. & Segal, L. (2017) Quantifying maternal incarceration: a whole-population linked data study of Western Australian children born 1985-2011. *Australian and New Zealand Journal of Public Health*, 41(2), 151–157. Available from: https://doi.org/10.1111/1753-6405.12613

Fazel, S., Yoon, I.A. & Hayes, A.J. (2017) Substance use disorders in prisoners: an updated systematic review and meta-regression analysis in recently incarcerated men and women. *Addiction*, 112(10), 1725–1739.

Glasson, E.J., de Klerk, N.H., Bass, A.J., Rosman, D.L., Palmer, L.J. & Holman, C.D.J. (2008) Cohort profile: The Western Australian Family Connections Genealogical Project. *International Journal of Epidemiology*, 37(1), 30–35.

Goshin, L.S., Byrne, M.W. & Henninger, A.M. (2014) Recidivism after Release from a Prison Nursery Program. *Public Health Nursing*, 31(2), 109–117.

Harris, F., Hek, G. & Condon, L. (2007) Health needs of prisoners in England and Wales: The implications for prison healthcare of gender, age and ethnicity. *Health & Social Care in the Community*, 15(1), 56–66.

Holman, C.D.J., Bass, J.A., Rosman, D.L., Smith, M.B., Semmens, J.B., Glasson, E.J. et al. (2008) A decade of data linkage in Western Australia: Strategic design, applications and benefits of the WA data linkage system. *Australian Health Review*, 32(4), 766–777.

Indig, D., Topp, L., Ross, B., Mamoon, H., Border, B., Kumar, S. et al. (2010) *2009 NSW inmate health survey: Key findings report*. Sydney: Justice Health.

Jones, H.E., Kaltenbach, K., Heil, S.H., Stine, S.M., Coyle, M.G., Arria, A.M. et al. (2010) Neonatal abstinence syndrome after methadone or buprenorphine exposure. *The New England Journal of Medicine*, 78, 33–38.

Kelty, E.A., Cumming, C.N. & Preen, D.B. (2022) Contribution of pharmaceutical drugs of dependence to the incidence of neonatal abstinence syndrome in Western Australia between 2003 and 2018. *Pharmacotherapy*, 42(5), 405–410.

Kennare, R., Heard, A. & Chan, A. (2005) Substance use during pregnancy: Risk factors and obstetric and perinatal outcomes in South Australia. *Australian and New Zealand Journal of Obstetrics and Gynaecology*, 45(3), 220–225.

King, Z., Kramer, C., Latkin, C. & Sufrin, C. (2021) Access to treatment for pregnant incarcerated people with opioid use disorder: Perspectives from community opioid treatment providers. *Journal of Substance Abuse Treatment*, 126, 108338.

Knight, M. & Plugge, E. (2005) The outcomes of pregnancy among imprisoned women: A systematic review. *BJOG: An International Journal of Obstetrics and Gynaecology*, 112(11), 1467–1474.

Knittel, A.K., Swartzwelder, R.A., Zarnick, S., Tsujimoto, T.M., Horne, T., Lin, F.C. et al. (2023) Neonatal outcomes after medications for opioid use disorder during pregnancy in a state women's prison facility, 2016–2019. *Journal of Addiction Medicine*, 17(5), 587–591. Available from: http://journals.lww.com/journaladdictionmedicine

Ludlow, J.P., Evans, S.F. & Hulse, G. (2004) Obstetrics and perinatal outcomes in pregnancies associated with illicit substance abuse. *Australian and New Zealand Journal of Obstetrics and Gynaecology*, 44(4), 302–306.

McQueen, K. & Murphy-Oikonen, J. (2016) Neonatal Abstinence Syndrome. *New England Journal of Medicine*, 375(25), 2468–2479. Available from: https://doi.org/10.1056/NEJMra1600879

Mertens, D.J. (2000) Pregnancy Outcomes of Inmates in a Large County Jail System: Issues Affecting Quality of Care. *Journal of Correctional Health Care*, 7(1), 105–125 Available from: www.liebertpub.com

O'Donnell, M., Nassar, N., Leonard, H., Hagan, R., Mathews, R., Patterson, Y. et al. (2009) Increasing prevalence of neonatal withdrawal syndrome: Population study of maternal factors and child protection involvement. *Pediatrics*, 123(4), e614–e621.

Ogunyemi, D. & Hernandez-Loera, G.E. (2004) The impact of antenatal cocaine use on maternal characteristics and neonatal outcomes. *The Journal of Maternal-Fetal and Neonatal Medicine*, 2004, 253–259.

Pomar, E.G., Finnegan, L.P., Devlin, L., Bada, H., Concina, V.A., Ibonia, K.T. et al. (2017) Simplification of the Finnegan Neonatal Abstinence Scoring System: Retrospective study of two institutions in the USA. *BMJ Open*, 7(9), e016176.

Rementeria, J.L. & Bhatt, K. (1977) Withdrawal symptoms in neonates from intrauterine exposure to diazepam. *Journal of Pediatrics*, 90(1), 123–126.

Schempf, A.H. (2007) Illicit drug use and neonatal outcomes: A critical review. *Obstetrical & Gynecological Survey*, 62(11), 749–757.

Smith, L., Lynn Yonekura, M., Wallace, T., Berman, N. & Kuo Carol Berkowitz, J. (2003) *Effects of Prenatal Methamphetamine Exposure on Fetal Growth and Drug Withdrawal Symptoms in Infants Born at Term*. Available from: http://journals.lww.com/jrnldbp

Strahan, A.E., Guy, G.P., Bohm, M., Frey, M. & Ko, J.Y. (2020) Neonatal abstinence syndrome incidence and health care costs in the United States, 2016. *JAMA Pediatrics*, 174(2), 199–200.

Sufrin, C., Sutherland, L., Beal, L., Terplan, M., Latkin, C. & Clarke, J.G. (2020) Opioid use disorder incidence and treatment among incarcerated pregnant women in the United States: results from a national surveillance study. *Addiction*, 115(11), 2057–2065.

Testa, A. & Jackson, D.B. (2020) Incarceration Exposure During Pregnancy and Infant Health: Moderation by Public Assistance. *Journal of Pediatrics*, 226, 251–257.e1.

Testa, A., Jackson, D.B., Vaughn, M.G. & Bello, J.K. (2020) Incarceration as a unique social stressor during pregnancy: Implications for maternal and newborn health. *Social Science and Medicine*, 246, 112777.

Walker, J.R., Hilder, L., Levy, M.H. & Sullivan, E.A. (2014) Pregnancy, prison and perinatal outcomes in New South Wales, Australia: A retrospective cohort study using linked health data. *BMC Pregnancy and Childbirth*, 14(1), 1–11.

Wildeman, C., Andersen, S.H., Lee, H. & Karlson, K.B. (2014) Parental incarceration and child mortality in Denmark. *American Journal of Public Health*, 104(3), 428–433.

AUTHOR BIOGRAPHIES

Dr Megan F. Bell Megan Bell is a research fellow at the University of Western Australia School of Population and Global Health. Her PhD (University of Western Australia, 2017) examined the influence of family adversity factors on early child development. Her current research explores the health, developmental, educational and social outcomes of children whose mothers have been incarcerated, using population-level linked administrative data. Dr Bell is also trained as a clinical psychologist and has worked in community mental health.

Dr Erin Kelty Dr Kelty is a National Health and Medical Research Council Emerging Leader and research fellow at the University of Western Australia School of Population and Global Health. She completed her PhD in 2017 (University of Western Australia), examining the safety of pharmacotherapies for the treatment of opioid use disorders. Dr Kelty is additionally trained in biostatistics (Masters of Biostatistics, University of Sydney, 2016) and is highly skilled in the use and analysis of linked health data.

Prof Leonie Segal Leonie Segal holds the Foundation Chair in Health Economics and Social Policy at the University of South Australia and is a leading health economist exploring pathways into and out of social disadvantage, drawing on project and linked administrative data. Professor Segal has been awarded >$20 million in nationally competitive research grants. She is contributing to knowledge creation with >250 publications in high-quality journals such as Pediatrics, Lancet Public Health, BMJ and JAMA Open.

Prof Susan Dennison Susan Dennison is a professor in the School of Criminology and Criminal Justice and the Griffith Criminology Institute at Griffith University. Her research investigates how childhood adversity, particularly parental incarceration, affects young people's outcomes. She is the Director of the Transforming Corrections to Transform Lives Centre, leading a transformative system of practice to better support mothers who experience incarceration, and their children, break down intergenerational cycles of disadvantage and incarceration and generate new knowledge for evidence-based programmes.

Prof Stuart A. Kinner Stuart Kinner is a professor of health equity at Curtin University and Head of the Justice Health Group spanning Curtin University, University of Melbourne and Murdoch Children's Research Institute. His research focusses on health services and health outcomes for people who come into contact with the criminal justice system. Stuart chairs Australia's National Youth Justice Health Advisory Group and serves on the National Prisoner Health Information Committee and the WHO Health in Prisons Programme Steering Group.

Prof Sharon Dawe Sharon Dawe is a professor in clinical psychology at Griffith University, an adjunct professor at the Australian Centre for Child Protection and a visiting fellow at Oxford University. She has over 30-year experience as a researcher and clinician in the field of substance misuse and mental health; is the co-developer of the Parents Under Pressure programme (www.pupprogram.net.au); and leads a large consortium focussing on diagnosis and support of children with prenatal alcohol exposure.

Prof Matthew J. Spittal Matthew Spittal is a professor of epidemiology and biostatistics at the University of Melbourne. He leads the Mental Health Epidemiology Unit—a unit specialising in the design and analysis of studies in suicide prevention, including randomised controlled trials, cohort studies, data linkage studies, case-control studies, sample surveys and meta-analyses.

Prof David B. Preen Professor David Preen is the Chair in Public Health at The University of Western Australia. He has an established international reputation as a leader in the application of epidemiological methods to linked data and has been involved with conducting public health and health services research using whole-population linked administrative data for over 20 years to study areas, including i) cancer service delivery, ii) pharmaco-epidemiology, iii) chronic disease management, iv) health of marginalised populations and v) methodological advances using data linkage.

How to cite this article: Bell, M.F., Kelty, E., Segal, L., Dennison, S., Kinner, S.A., Dawe, S. et al. (2023) Neonatal abstinence syndrome and other neonatal outcomes for the infants of women experiencing incarceration: A retrospective cohort study. *Australian Journal of Social Issues*, 00, 1–14. Available from: https://doi.org/10.1002/ajs4.296