

Original Article

*Joint senior authors.

Cite this article: Thomson KC *et al* (2023). Continuities in maternal substance use from early adolescence to parenthood: findings from the intergenerational cohort consortium. *Psychological Medicine* **53**, 2136–2145. <https://doi.org/10.1017/S0033291721003925>

Received: 8 March 2021

Revised: 7 July 2021

Accepted: 7 September 2021

First published online: 8 October 2021











Key words:

Adolescence; cohort studies; intergenerational; longitudinal data analysis; substance use

Author for correspondence:

Kimberly C. Thomson,
E-mail: kimberly.thomson@ubc.ca

Continuities in maternal substance use from early adolescence to parenthood: findings from the intergenerational cohort consortium

Kimberly C. Thomson^{1,2,3} , Christopher J. Greenwood^{1,4},
Primrose Letcher^{1,4,5} , Elizabeth A. Spry^{1,4} , Jacqui A. Macdonald^{1,4,5} ,
Helena M. McAnally⁶ , Lindsey A. Hines^{7,8} , George J. Youssef^{1,4},
Jennifer E. McIntosh^{1,4,5,9}, Delyse Hutchinson^{1,4,5,10} , Robert J. Hancox⁶ ,
George C. Patton^{4,5,*}  and Craig A. Olsson^{1,4,5,*} 

¹Faculty of Health, Deakin University, Centre for Social and Early Emotional Development, School of Psychology, Geelong, Victoria, Australia; ²University of British Columbia, Human Early Learning Partnership, School of Population and Public Health, Vancouver, British Columbia, Canada; ³Centre for Health Evaluation and Outcome Sciences, Providence Health Care Research Institute, Vancouver, British Columbia, Canada; ⁴Murdoch Children's Research Institute, Centre for Adolescent Health, The Royal Children's Hospital Campus, Parkville, Victoria, Australia; ⁵Department of Paediatrics, Faculty of Medicine, Dentistry and Health Sciences, University of Melbourne, The Royal Children's Hospital Campus, Parkville, Victoria, Australia; ⁶Department of Preventive and Social Medicine, University of Otago, Dunedin, New Zealand; ⁷Centre for Academic Mental Health, Population Health Sciences Institute, University of Bristol, Bristol, UK; ⁸Integrative Epidemiology Unit, Population Health Sciences Institute, University of Bristol, Bristol, UK; ⁹Department of Psychology, La Trobe University, The Bouverie Centre, Melbourne, Victoria, Australia and ¹⁰Faculty of Medicine, University of New South Wales, National Drug and Alcohol Research Centre, Sydney, New South Wales, Australia

Abstract

Background. This study assessed the extent to which women's preconception binge drinking, tobacco use and cannabis use, reported prospectively in adolescence and young adulthood, predicted use of these substances during pregnancy and at 1 year postpartum.

Methods. Data were pooled from two intergenerational cohort studies: the Australian Temperament Project Generation 3 Study (395 mothers, 691 pregnancies) and the Victorian Intergenerational Health Cohort Study (398 mothers, 609 pregnancies). Alcohol, tobacco and cannabis use were assessed in adolescence (13–18 years), young adulthood (19–29 years) and at ages 29–35 years for those transitioning to parenthood. Exposures were weekly or more frequent preconception binge drinking (5+ drinks in one session), tobacco use and cannabis use. Outcomes were any alcohol, tobacco and cannabis use prior to awareness of the pregnancy, after awareness of pregnancy (up to and including the third trimester pregnancy) and at 1 year postpartum.

Results. Frequent preconception binge drinking, tobacco use and cannabis use across both adolescence and young adulthood were strong predictors of continued use post-conception, before and after awareness of the pregnancy and at 1 year postpartum. Substance use limited to young adulthood also predicted continued use post-conception.

Conclusions. Persistent alcohol, tobacco use and cannabis use that starts in adolescence has a strong continuity into parenthood. Reducing substance use in the perinatal period requires action well before pregnancy, commencing in adolescence and continuing into the years before conception and throughout the perinatal period.

High rates of substance use (alcohol, tobacco and cannabis) in the perinatal period, in pregnancy and in the first year following childbirth, are of significant clinical and public health concern globally (Louw, 2018; Rodriguez & Smith, 2019). It is well established that high maternal perinatal substance use poses significant risks to offspring health and development (Conner, Carter, Tuuli, MacOnes, & Cahill, 2015; Crume, 2019; El Marroun *et al.*, 2009; Floyd, Decoufflé, & Hungerford, 1999; Philips *et al.*, 2020). In utero exposure to alcohol, tobacco and cannabis are associated with restricted foetal growth and preterm birth and can cause harms in early pregnancy even prior to pregnancy recognition (Conner *et al.*, 2015; Crume, 2019; El Marroun *et al.*, 2009; Floyd *et al.*, 1999; Philips *et al.*, 2020). Substance use in the first year postpartum is further associated with depressive symptoms in mothers, infant exposure through breastfeeding and second hand smoke and other disruptions to parental care (Chapman & Wu, 2013; Forray, 2016; Herrmann, King, & Weitzman, 2008; Ko *et al.*, 2018; Polcaro & Vettrano, 2020). In the longer term, parent substance use also increases risks of future substance use in offspring (Crume, 2019; De Genna, Goldschmidt, Richardson, Cornelius, & Day, 2018; Kerr, Capaldi,

Pears, & Owen, 2012). For these reasons, guidelines in Australia and other countries recommend abstinence of substance use in pregnancy (Australian Government Department of Health, 2019; O’Keeffe et al., 2015).

However, in high-income countries including Australia, prevalence of perinatal substance use is high. Within general population samples, it is estimated that 30–60% of mothers drink alcohol during pregnancy (McCormack et al., 2017; Muggli et al., 2016), 11–14% smoke tobacco cigarettes (Crume, 2019; Kurti et al., 2017) and approximately 4% use cannabis (el Marroun et al., 2008; Ko et al., 2018), with cannabis use likely to rise with recent policy changes to decriminalisation in many countries (Metz & Stickrath, 2019; Young-Wolff et al., 2019). Furthermore, while most women decrease or cease substance use upon pregnancy recognition (typically after the fourth week of gestation) (Floyd et al., 1999), a high proportion continue use after pregnancy recognition (e.g. approximately 30% continue to drink alcohol at low levels) (Hutchinson, Moore, Breen, Burns, & Mattick, 2013; Muggli et al., 2016). Following childbirth, many women recommence use in the postpartum period (Borschmann et al., 2019; De Genna et al., 2018; Hutchinson et al., 2013). These trends make it pertinent to more precisely define who is most at risk of substance use in the perinatal period and when it is most effective to intervene.

From a life course perspective, most substance use problems have their origins in adolescence and young adulthood, with earlier onset, as well as heavier and more frequent use, associated with worse outcomes (Kessler et al., 2005; Luciana & Feldstein Ewing, 2015; McGorry, Purcell, Goldstone, & Amminger, 2011; Palmer et al., 2009). Consistent with this, there is emerging evidence from retrospective studies that preconception substance use may be an important determinant of substance use in pregnancy (Skagerström, Chang, & Nilsen, 2011; Young-Wolff et al., 2019). This has potentially significant public health implications; however, prospective multigenerational cohort studies remain rare, which means that much remains unknown about when and for whom, preconception interventions to prevent perinatal substance use might be most effective.

Here we bring together data from two long-running Australian intergenerational cohort studies to examine the extent to which maternal binge drinking, tobacco use and cannabis use in adolescence and young adulthood predict use of these substances in pregnancy and 1 year postpartum for women of the peak reproductive age in Australia (ages 29–35 years). Specifically, we sought to address three objectives: (1) to describe the natural history of substance use from adolescence to young adulthood and into pregnancy and motherhood; (2) to examine the extent to which maternal preconception use predicts continued use in pregnancy; and (3) to examine the extent to which maternal preconception use predicts use by the end of the first year of life.

Method

Sample and procedure

Data were pooled from two Australian intergenerational cohort studies within the Australia and New Zealand Intergenerational Cohort Consortium (Olsson et al., 2020). The Australian Temperament Project (ATP), established in 1983, began as a representative sample of 2443 infants and their families recruited from maternal and child health centres within the state of Victoria, Australia. Sociodemographic and child development

data were collected from parents (Generation 1) and self-reported by children after age 11 (Generation 2) via mail surveys. Data were collected approximately every 2 years across childhood and adolescence, then again at ages 21, 24 and 28 years of age (Vassallo & Sanson, 2013). From 2012 to 2018, ATP participants were followed up via email and telephone to identify pregnancies from 29 to 35 years of age. Women who reported a pregnancy were eligible to participate in the ATP Generation 3 Study (ATPG3). Telephone or web-based surveys, including questions on substance use, were administered to prospective mothers in trimester 3 of pregnancy and 1 year postpartum.

The Victorian Adolescent Health Cohort Study (VAHCS), established in 1992, was based on a representative sampling framework with a high initial response of 1943 mid-secondary school students recruited via a two-stage cluster sampling design from schools also in Victoria, Australia. Data were collected every 6 months in adolescence until a mean age of 17.4 years-old and again at ages 21, 24, 29, 35 and 42 years-old, via telephone-based structured interviews. From 2006 to 2013, VAHCS participants were followed up via email and telephone to identify pregnancies between ages 29 and 35 years. Women who reported a pregnancy were eligible to participate in the Victorian Intergenerational Health Cohort Study (VIHCS) (Spry et al., 2020). Telephone and web-based surveys were administered to prospective mothers in trimester 3 of pregnancy and 1 year postpartum.

In both ATPG3 and VIHCS, multiple pregnancies during the study period were included in the analytic sample and accounted for using clustered analyses. Miscarried and terminated pregnancies were not included. Ethics approval for VAHCS and VIHCS and perinatal data collection for the ATP were obtained from the Royal Children’s Hospital Human Research Ethics Committee. Prior ATP waves were approved by human research ethics committees at the University of Melbourne, the Australian Institute of Family Studies and/or the Royal Children’s Hospital, Melbourne.

Measures

Preconception substance use exposures

In the ATP, preconception alcohol and cannabis use were measured at two waves in adolescence (15–16 years; 17–18 years) and three waves in young adulthood (ages 19–20 years; 23–24 years; and 27–28 years). Preconception tobacco use was measured at one additional time point from ages 13–14 years. At each wave, participants were asked how many times they had used substances in the past 30 days. For alcohol and tobacco, participants were also asked how much they consumed per occasion. Binge drinking was indicated by having consumed at least five drinks in quick succession (in adolescence) and by having consumed at least five drinks in 1 day (in young adulthood). In VAHCS, alcohol, tobacco and cannabis use were measured at six waves in adolescence (Waves 1–6; mean age 14.9–17.4 years) and three waves in young adulthood (Waves 7–9; mean ages 21, 24 and 29 years). At each wave, participants reported on frequency of cannabis use (adolescence: within the past 6 months; young adulthood: past 12 months). Alcohol and tobacco use were assessed at each wave using a retrospective diary. For tobacco use, this was each of the past 7 days prior to the survey. For alcohol use, this was each of the past 7 days prior to the survey in adolescence and four of the past 7 days (Friday, Saturday, Sunday and the most recent weekday when drinking occurred) in young adulthood.

Problematic Preconception Substance Use. We classified problematic levels of substance use in the preconception period as

binge-drinking alcohol weekly or more frequently (5 or more drinks in a drinking session) (Patton, 2004), smoking tobacco cigarettes weekly or more frequently, and using cannabis weekly or more frequently. This was derived in the ATP data as reporting any binge drinking, tobacco use and cannabis use on 4 or more days in the past month and in the VAHCS data as substance use at least 1 day in the past week (binge drinking and tobacco use) and cannabis use weekly or more frequently in the past 6 months (adolescence) or 12 months (young adulthood).

Persistent Problematic Preconception Substance Use. We then created a combined preconception substance use continuity variable for each substance based on the presence of frequent binge drinking, tobacco, or cannabis use at ≥ 1 adolescent wave and frequent binge drinking, tobacco, or cannabis use at ≥ 1 young adult wave. These dichotomised variables at each preconception period were then grouped into four levels of problematic substance use continuity: 'none,' 'adolescent only,' 'young adult only,' and 'both adolescent and young adult.'

Maternal perinatal substance use outcomes

ATPG3 and VIHCS mothers reported on their perinatal substance use once in trimester three of pregnancy and once at 1 year post-partum. In trimester three of pregnancy, mothers reported how often they drank any alcohol, smoked cigarettes and smoked or used marijuana or any other cannabis product immediately prior to pregnancy awareness (i.e. 'Just before finding out you were pregnant'), during pregnancy after pregnancy awareness ('Shortly after finding out you were pregnant') and currently ('Now, [in 3rd trimester]'). Responses to 'Shortly after finding out you were pregnant' and 'Now (in third trimester)' were averaged to estimate substance use post-awareness of pregnancy. At 1 year postpartum, mothers reported their substance use 'In the past month [30 days].' In total, three perinatal periods were examined: (1) Pregnancy pre-awareness, (2) pregnancy post-awareness and (3) 1 year postpartum.

Potential confounders

We controlled for potential preconception confounders associated with both preconception substance use problems and perinatal substance use. Dichotomised variables were parental education [completed post-secondary school qualifications (ATP) or secondary school (VAHCS) prior to participant age 18 years *v.* did not complete post-secondary qualifications or secondary school), parental separation (not separated/divorced/widowed prior to participant age 18 years *v.* separated/divorced/widowed) and parent ethnicity (not from an ethnic minority group *v.* ethnic minority). Adolescent antisocial behaviours were defined as three or more problem behaviours in the past month between the ages of 13 and 18 years. Adolescent mental health problems were assessed as anxious or depressive symptoms before age 18 years. More detail on these adolescent measures are provided in the study protocol (Olsson *et al.*, 2020). Post-conception, we also controlled for whether or not mothers were expecting their first child, to adjust for any differences in participants' perinatal substance use associated with first parenthood experience. We also controlled for study cohort (ATPG3 or VIHCS).

Analyses

Data from the two cohorts were pooled by harmonising measures across studies, comparing frequencies in each sample (Table 1), and then combining samples to be able to analyse low prevalence

outcomes (Hutchinson *et al.*, 2015; Olsson *et al.*, 2020). Models were run separately for each exposure–outcome relationship (e.g. alcohol to alcohol) adjusting for the other substance use histories, potential confounding factors, and an indicator of study cohort. Each substance was modelled as a multivariable outcome defined across three discrete time periods: just prior to pregnancy awareness, pregnancy post-awareness, and 1 year postpartum.

Generalised estimating equations (GEE), with logit links, were used to estimate associations between preconception substance use and perinatal substance use to account for clustering of pregnancies and for repeated outcome measures in mothers. To examine associations between preconception substance use history and maternal substance use at each perinatal time period, simple slopes were calculated based on an interaction between substance use history and a variable denoting maternal substance use at the three time periods (pregnancy pre-awareness, pregnancy post-awareness, 1 year postpartum).

Missing data ranged from 0% to 37% in ATPG3 (mean = 18%; pregnancy pre-awareness = 36%, pregnancy post-awareness = 37%, 1 year postpartum = 8%) and from 0% to 32% in VIHCS (mean = 14%; pregnancy pre-awareness = 32%, pregnancy post-awareness = 32%, 1 year postpartum = 7%). To handle missing data, we imputed 50 complete datasets, separately by cohort based on a multivariate normal model (Bodner, 2008). All analytic variables were included in the imputation models. This included binary preconception problematic substance use variables defined as weekly or more frequent binge drinking/tobacco/cannabis use, in adolescence and young adulthood. Persistence variables were derived post-imputation. We additionally included low education (< year 12) and divorce/separation by young adulthood as auxiliary variables. Binary variables were imputed as continuous variables and then back transformed with adaptive rounding following imputation. Estimates were obtained by averaging results across the 50 imputed datasets with inferences under multiple imputation obtained using Rubin's rules (Rubin, 2004). In the analyses, varying omitted terms across imputations due to low cell sizes were handled by removing problematic imputations (i.e. those which had reduced samples in regression models due to omitted terms) as recommended by Stata (Stata Corp., 2019). Due to low cell sizes, 18% and 22% of imputed samples were dropped for the tobacco and cannabis models, respectively. Sensitivity analyses were conducted using all imputations by (1) collapsing none and adolescent only users (online Supplementary Material A), and (2) removing adolescent only tobacco users from all analyses (online Supplementary Material B). The interpretation of findings and strength of findings was consistent with sensitivity analyses using all imputations. All analyses were conducted in Stata release 16 (Stata Corp., 2019).

Results

In 1983, 1168 of 2443 recruited ATP participants were female. In 2012, on commencement of ATPG3 (age 29, 2012), 851 women remained in the study. During the pregnancy identification period (ages 29–35), 460 women reported pregnancies and were eligible for the study. Of those eligible, 400 women participated. Baseline demographic characteristics of those screened for ATPG3 broadly matched those of the original cohort (ATP), except that women screened for the study were less likely to have parents born outside of Australia (online Supplementary Material C). There were no demographic differences between women eligible and

Table 1. Frequency of preconception substance use and potential confounders, by study cohort

	ATPG3 (n = 393)			VIHCS (n = 398)			Combined (n = 791)		
	n	%	(95% CI)	n	%	(95% CI)	n	%	(95% CI)
<i>Preconception exposures</i>									
Continuity of weekly binge drinking									
None	167	42%	(37–48%)	129	32%	(27–37%)	296	37%	(34–41%)
Adolescence only	23	6%	(3–9%)	40	10%	(7–13%)	63	8%	(6–10%)
Young adulthood only	134	34%	(9–40%)	112	28%	(23–33%)	246	31%	(27–35%)
Adolescence and young adulthood	69	17%	(13–22%)	118	30%	(25–34%)	187	24%	(20–27%)
Continuity of weekly tobacco use									
None	199	51%	(45–56%)	226	57%	(52–62%)	425	54%	(50–57%)
Adolescence only	34	9%	(5–12%)	12	3%	(1–5%)	46	6%	(4–8%)
Young adulthood only	42	11%	(7–14%)	55	14%	(10–17%)	97	12%	(10–15%)
Adolescence and young adulthood	118	30%	(25–35%)	105	26%	(22–31%)	223	28%	(25–32%)
Continuity of weekly cannabis use									
None	331	84%	(80–88%)	327	82%	(78–86%)	658	83%	(80–86%)
Adolescence only	17	4%	(2–7%)	24	6%	(3–9%)	41	5%	(3–7%)
Young adulthood only	28	7%	(4–10%)	26	7%	(4–9%)	54	7%	(5–9%)
Adolescence and young adulthood	16	4%	(2–6%)	22	5%	(3–8%)	38	5%	(3–6%)
<i>Potential confounders</i>									
Family socio-demographics									
Childhood parental separation	99	25%	(21–29%)	79	20%	(16–24%)	178	22%	(20–25%)
Childhood parental low education	92	23%	(19–28%)	154	39%	(34–44%)	246	31%	(28–34%)
Parent from ethnic minority group	11	3%	(1–4%)	28	7%	(4–10%)	39	5%	(3–7%)
Adolescent behaviour									
Adolescent mental health problems	189	48%	(43–53%)	192	48%	(43–53%)	381	48%	(45–52%)
Adolescent antisocial behaviour	140	36%	(31–40%)	196	49%	(44–54%)	336	42%	(39–46%)

ATPG3, Australian Temperament Project Generation 3; VIHCS, Victorian Intergenerational Health Cohort Study.

Frequency estimates were calculated from imputed percentage estimates and total number of participants. Parental low education was measured in ATPG3 as non-completion of post-secondary school qualifications and in VIHCS as non-completion of secondary school.

participating in ATPG3. An additional seven mothers had not participated in at least two of three data collection periods (i.e. adolescence, young adulthood, or the perinatal period) and were excluded from the analysis. The final analytic ATPG3 sample included 689 pregnancies to 393 women.

In 1992 1000 of 1943 recruited VAHCS participants were female. In 2006, at commencement of VIHCS (age 29, 2006), 885 women remained in the study. During the pregnancy identification period (ages 29–35) 465 women reported pregnancies were eligible for the study. Of those eligible, 398 participated. The final analytic VIHCS sample included 609 pregnancies to 398 women. Baseline substance use and demographic characteristics of those screened for, identified as eligible for, and participating in VIHCS, broadly matched those of the original adolescent cohort (VAHCS) (Spry et al., 2020) (online Supplementary Material D). A sampling flow diagram of both studies is provided in online Supplementary Material E.

Frequency of preconception substance use and potential confounders in ATPG3 and VIHCS are presented in Table 1.

Demographics and substance use rates between the two cohorts were similar and were combined into one sample to be able to examine associations with low frequency perinatal outcomes (see Table 1). Sixty-three per cent [95% confidence interval (CI) 59–66] of the combined sample reported weekly or more frequent binge drinking at one or more preconception waves in adolescence or young adulthood. Forty-six per cent (95% CI 43–50) reported weekly or more frequent tobacco use, and 17% (95% CI 14–20) reported a preconception history of weekly or more frequent cannabis use, at one or more preconception waves in adolescence or young adulthood.

The proportion of the sample reporting substance use for any pregnancies at each perinatal assessment period is shown in Table 2. In the combined sample, during pregnancy just before finding out they were pregnant, 76% of mothers reported any alcohol use, 14% reported tobacco use, and 4% reported cannabis use. Subsequent analysis found that the majority of mothers reporting perinatal alcohol use (78%) stopped drinking after pregnancy awareness. Forty-six per cent and 63% of mothers stopped

Table 2. Perinatal substance use outcomes, by study cohort

Measures	ATPG3 689 infants to 393 mothers			VIHCS 609 infants to 398 mothers			Combined 1300 infants to 793 mothers		
	<i>n</i>	%	(95% CI)	<i>n</i>	%	(95% CI)	<i>n</i>	%	(95% CI)
Any alcohol use									
Pregnancy pre-awareness	528	77%	(73–80%)	460	76%	(71–80%)	989	76%	(73–79%)
Pregnancy post-awareness	83	12%	(9–15%)	148	24%	(20–28%)	230	18%	(15–20%)
One year postpartum	604	88%	(85–90%)	396	65%	(61–69%)	1000	77%	(75–79%)
Any tobacco use									
Pregnancy pre-awareness	75	11%	(8–14%)	111	18%	(15–22%)	186	14%	(12–17%)
Pregnancy post-awareness	65	9%	(7–12%)	52	8%	(6–11%)	116	9%	(7–11%)
One year postpartum	92	13%	(11–16%)	55	9%	(7–11%)	147	11%	(10–13%)
Any cannabis use									
Pregnancy pre-awareness	34	5%	(3–7%)	21	3%	(2–5%)	54	4%	(3–5%)
Pregnancy post-awareness	17	2%	(1–4%)	7	1%	(0–2%)	24	2%	(1–3%)
One year postpartum	22	3%	(2–5%)	4	1%	(0–1%)	26	2%	(1–3%)

ATPG3, Australian Temperament Project Generation 3; VIHCS, Victorian Intergenerational Health Cohort Study. Frequency estimates were calculated from imputed percentage estimates and total number of participants.

smoking tobacco and using cannabis (respectively) after pregnancy awareness.

The frequencies of perinatal substance use outcomes by preconception substance use history are presented in online Supplementary Material F. Of pregnancies in which mothers reported perinatal alcohol use, 65% (95% CI 61–68) were preceded by any history of weekly binge drinking [persistent use across adolescence and young adulthood: 24% (95% CI 21–26); use in young adulthood only: 34% (95% CI 31–37); use in adolescence only: 7% (95% CI 5–9)]. Of pregnancies in which mothers reported perinatal tobacco use, 90% (95% CI 85–95) were preceded by any history of weekly tobacco use [persistent: 69% (95% CI 62–76); young adulthood only: 17% (95% CI 12–23); adolescence only: 4% (95% CI 1–6)]. Of pregnancies in which mothers reported perinatal cannabis use 59% (95% CI 45–74) were preceded by any history of weekly cannabis use [persistent: 32% (95% CI 20–45); young adulthood only: 21% (95% CI 9–32); adolescence only: 7% (95% CI –1 to 14)]. [Table 3](#) presents the odds ratios of preconception binge drinking, tobacco, and cannabis use histories and perinatal substance use outcomes adjusted for family demographics and adolescent risk factors. Estimated marginal probabilities of perinatal substance use for each preconception history and substance type are presented in [Fig. 1](#).

Adolescent limited substance use

The odds of any alcohol use during pregnancy, post-awareness, were doubled for mothers with histories of frequent binge drinking limited to adolescence, compared to those without histories of frequent binge drinking in adolescence or young adulthood. The odds of tobacco use at 1 year postpartum were also higher for mothers with histories of frequent tobacco use limited to adolescence, compared to those without histories of frequent preconception tobacco use. Despite combining data from two cohorts, it was difficult to precisely estimate the association between adolescent

limited preconception cannabis use and perinatal cannabis use due to low sample size resulting in wide confidence intervals.

Young adult limited substance use

Preconception substance use limited to young adulthood was associated with heightened use of every substance type at each perinatal assessment period. Specifically, the odds of reporting any alcohol use prior to pregnancy awareness, during pregnancy post-awareness, and at 1 year postpartum were doubled for mothers with histories of frequent binge drinking in young adulthood compared to those without histories of frequent preconception binge drinking. The odds of reporting any tobacco use across the three perinatal assessment periods were much higher for mothers with histories of frequent tobacco use in young adulthood compared to those without histories of frequent preconception tobacco use. The odds of reporting any cannabis use were again higher across the three perinatal assessment periods for mothers with histories of frequent cannabis use in young adulthood compared to those without histories of frequent preconception cannabis use.

Persistent adolescent and young adult substance use

There was a suggestion that persistent frequent substance use across both adolescence and young adulthood was associated with the highest odds of perinatal substance use for nearly all substance types and perinatal assessment periods, although confidence intervals were wide and overlapping for these estimates. Specifically, the odds of reporting any alcohol use just prior to pregnancy awareness and 1 year postpartum were doubled in those with persisting preconception binge drinking compared to those with no such histories. This increased to tripled post-pregnancy-awareness. The odds of perinatal tobacco use across the three perinatal assessment periods were higher again in those with persistent histories of tobacco use compared to

Table 3. Odds ratios of mothers' preconception substance use and substance use pregnancy pre-awareness, pregnancy post-awareness and 1 year postpartum

	Substance use in pregnancy pre-awareness		Substance use in pregnancy post-awareness		Substance use one year postpartum	
	OR	95% CI	OR	95% CI	OR	95% CI
<i>Any maternal perinatal alcohol use</i>						
Preconception binge drinking						
None						
Adolescence only	0.99	(0.52–1.88)	2.49	(1.14–5.41)	0.90	(0.49–1.64)
Young adulthood only	1.98	(1.23–3.18)	1.97	(1.13–3.44)	2.21	(1.44–3.40)
Adolescence and young adult	1.97	(1.15–3.38)	3.16	(1.74–5.74)	2.08	(1.30–3.32)
<i>Any maternal perinatal tobacco use</i>						
Preconception tobacco use						
None						
Adolescence only	1.22	(0.19–7.84)	2.84	(0.22–35.89)	7.07	(2.00–24.98)
Young adulthood only	10.32	(4.38–24.31)	18.59	(4.14–83.50)	13.40	(5.41–33.21)
Adolescence and young adult	17.03	(7.79–37.24)	31.21	(7.58–128.51)	25.25	(10.68–59.72)
<i>Any maternal perinatal cannabis use</i>						
Preconception cannabis use						
None						
Adolescence only	1.80	(0.21–15.50)	3.61	(0.29–44.27)	3.50	(0.32–37.63)
Young adulthood only	5.51	(1.77–17.14)	10.56	(2.85–39.15)	17.89	(4.41–72.60)
Adolescence and young adult	24.27	(9.07–64.94)	24.16	(7.03–83.06)	27.98	(6.55–119.58)

Note. Adjusted for study cohort, childhood parental separation, childhood parental low education, parent ethnicity, adolescent mental health problems, adolescent delinquency, first child. Tobacco model required dropping nine imputed samples (18%) and the cannabis model required dropping 11 imputed samples (22%).

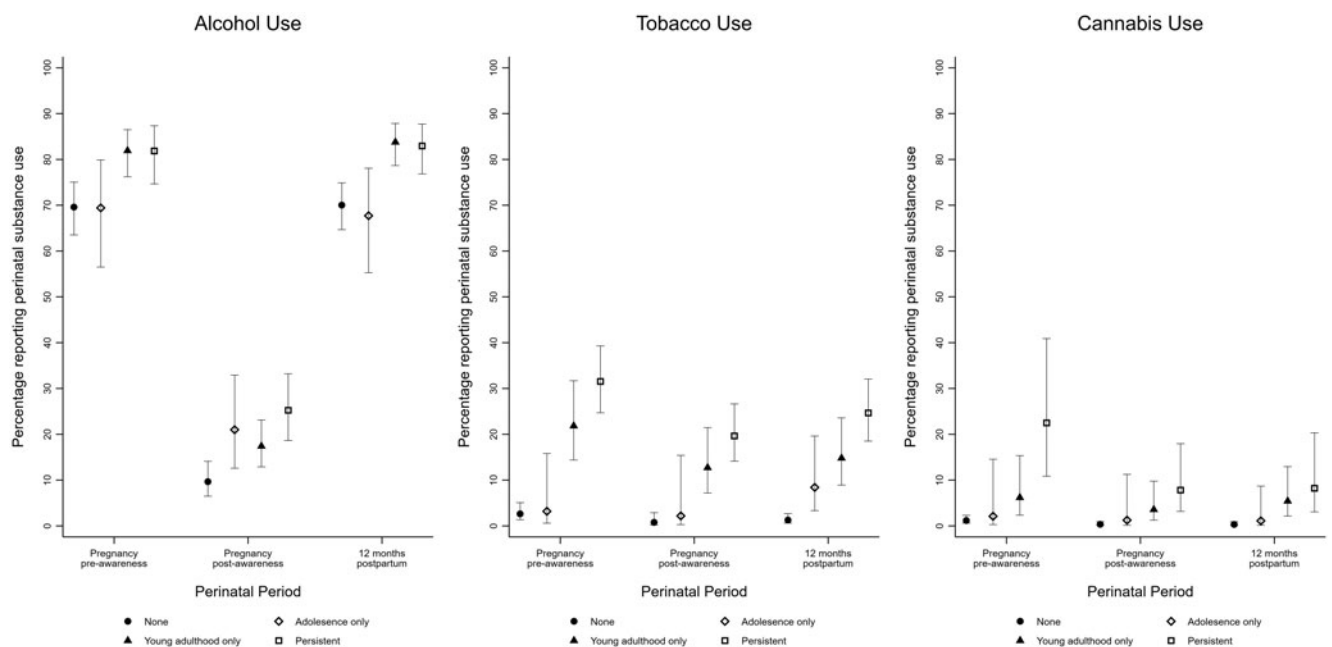


Fig. 1. Estimated marginal proportions of perinatal alcohol, tobacco, and cannabis use by preconception substance use history. Preconception history groups: (1) None: No binge drinking/tobacco/cannabis use in adolescence or young adulthood; (2) Adolescence only: Weekly or more frequent binge drinking/tobacco/cannabis use limited to adolescence (ages 13–18 years); (3) Young adulthood only: Weekly or more frequent binge drinking/tobacco/cannabis use limited to young adulthood (ages 19–29 years); (4) Persistent: Weekly or more frequent binge drinking/tobacco/cannabis use across adolescence and young adulthood.

those without. The odds of perinatal cannabis use were higher yet again across the three perinatal assessment periods for those with persistent histories of cannabis use compared to those without.

Discussion

Using rare intergenerational data from two Australian cohort studies, these analyses suggest that maternal alcohol, tobacco, and cannabis use during pregnancy, both prior to and following pregnancy awareness, as well as at 1 year postpartum, are likely to have their origins well prior to becoming a parent. This clarifies findings from prior reviews and retrospective research (Skagerström *et al.*, 2011; Young-Wolff *et al.*, 2019), by showing that preconception risks extend back to adolescence. There was a suggestion that early frequent substance use beginning in adolescence and persisting into young adulthood was the strongest predictor of perinatal alcohol, tobacco, and cannabis use, although confidence intervals were wide for tobacco and cannabis use outcomes. Frequent substance use limited to young adulthood was also consistently associated with higher odds of perinatal substance use. Women with these two preconception substance use histories also accounted for the largest proportion of subsequent substance use in the perinatal period. Of pregnancies in which women reported any alcohol, tobacco, or cannabis use, 58%, 86%, and 53% of pregnancies, respectively, were preceded by a preconception history of weekly or more frequent binge drinking or tobacco/cannabis use across both adolescence and young adulthood, or in young adulthood only. Additionally, whilst mothers generally reduced their substance use following pregnancy recognition, mothers with a history of persistent and young-adult-limited frequent substance use had consistently higher odds of substance use during pregnancy post-awareness compared to mothers without these histories, indicating a high-risk group for early intervention prior to pregnancy. Frequent preconception substance use limited to adolescence had small associations with future substance use in the case of adolescent binge drinking, which was associated with higher odds of drinking during pregnancy post-awareness, and adolescent tobacco use, which was associated with higher odds of tobacco use at 1 year postpartum. Having controlled for adolescent behaviour and sociodemographic background, this may reflect to some extent that substance use that starts and stops in adolescence represents experimentation (Wells, McGee, Baxter, Agnew, & Kokaua, 2009). That said, early experimentation often increases alcohol use and other risks from adolescence to young adulthood (Yuen *et al.*, 2020). Overall, our findings suggest that interventions to prevent longer-term patterns of frequent substance use may be well positioned to begin in adolescence, before potential sustained problem use starts.

In this study we also found that patterns of perinatal substance use varied considerably by substance type. In close to eight in 10 pregnancies (76%), mothers reported some alcohol use before pregnancy awareness. Drinking during pregnancy substantially reduced after pregnancy recognition (18%), but then rebounded to pre-pregnancy levels (77%) 1 year postpartum. This reduction in drinking after becoming aware of the pregnancy and dramatic resurgence postpartum is consistent with other prospective studies (Borschmann *et al.*, 2019; Hutchinson *et al.*, 2013). Although women with preconception histories of persistent or young-adult-limited frequent binge drinking had higher odds of perinatal alcohol use, 35% of pregnancies in which any drinking occurred were not preceded by earlier frequent use, suggesting

that alcohol use in early pregnancy and postpartum are common regardless of a woman's preconception drinking history.

Although perinatal tobacco and cannabis use were lower than alcohol use, it was nonetheless concerning that in over one in ten pregnancies (14%) mothers reported smoking tobacco cigarettes before pregnancy awareness. The continuity between preconception use and perinatal use was also strong, with 90% of pregnancies in which mothers reported tobacco use preceded by a preconception history of weekly or more frequent smoking. Smoking during pregnancy somewhat reduced after pregnancy recognition (9%), but increased again at 1 year postpartum (11%). This pattern of quitting smoking and relapsing across the perinatal period is similar to that reported by other perinatal substance use studies, and shows that patterns of perinatal smoking have not changed substantially in the last decade despite prevention efforts (Crume, 2019; Kurti *et al.*, 2017). This is especially so for mothers who spontaneously quit smoking during pregnancy (Crume, 2019), and points to the addictive nature of tobacco smoking. This finding is of significant clinical and public health concern because of the well documented adverse effects of passive smoking on child development (Herrmann *et al.*, 2008).

A somewhat different story was evident for cannabis use. Prevalence was lower than for tobacco, with mothers reporting cannabis use in approximately one in 20 pregnancies (4%) before pregnancy awareness, reducing to one in 50 (2%) after pregnancy awareness and remaining stable (2%) at 1 year postpartum. Lack of postpartum relapse is contrary to trends reported in prior perinatal studies of cannabis use (el Marroun *et al.*, 2008; Ko *et al.*, 2018). However, differences in study design may account for this. For example, previous studies have focused on younger mothers (<24 years) who, based on population trends, are more likely to use cannabis (Ko *et al.*, 2018), whereas our data are from mothers in the normative range for births in Australia (29–35 years). Postpartum rebound in tobacco, but not cannabis use, suggests differences in the addictive potential of the two substances and a need for more intensive intervention around smoking to reduce risk for postpartum use.

Strengths and limitations

A strength of this study was the integration of rare multigenerational data from two longitudinal population-based cohorts. In doing so we were able to maximise sample size and power for outcomes with a relatively low prevalence. Our multi-wave, prospective design also minimised recall bias of adolescent and young adulthood substance use and included a broad range of relevant potential confounding variables. Limitations of our study included the use of self-reported substance use, which could have underestimated prevalence rates and attenuated associations. In the third trimester pregnancy, mothers retrospectively reported their substance use just before finding out they were pregnant and shortly thereafter, which also may have introduced inaccurate reporting. Previous research has shown up to 97% concordance between women's self-reported substance use during pregnancy and biological samples (Hutchinson *et al.*, 2018), although most research and clinical practice supports the use of self-report screening in conjunction with biological measures for optimal substance use identification during pregnancy (Burns, Gray, & Smith, 2010; Polak, Kelpin, & Terplan, 2019). Perinatal data were collected for pregnancies identified in women aged between 29 and 35 years, the peak period for births in high-income countries such as Australia. Because pregnancies at younger ages were

excluded, generalisability of the findings may be reduced and associations attenuated between adolescent-limited substance use and perinatal use. Excluding miscarried or terminated pregnancies also may have introduced bias.

Data from the ATP/ATPG3 and VAHCS/VICHCS study cohorts were collected over close to four and three decades, respectively, resulting in sample attrition and non-response. Notably, a higher proportion of participants were missing at the third trimester assessment in both study cohorts, due to the logistical challenges of identifying all pregnancies to cohort participants before birth. We addressed missing data with multiple imputation. Although we found minimal differences in demographics between participants who remained in the studies compared to those initially recruited (women in ATPG3 were less likely to have parents born outside of Australia), it is possible that those retained in the studies differed on unmeasured characteristics, as well as in their levels of perinatal substance use. Furthermore, measures of preconception and perinatal substance use were not identical across the ATP/ATPG3 and VAHCS/VICHCS studies. Variable derivations (e.g. weekly binge drinking) were created based on the closest possible alignment between studies, which in some cases involved long assessment periods. These derivations could have introduced misclassification in some cases, if patterns of substance use changed dramatically throughout the assessment period (e.g. up to 1 year). There were some differences between cohorts in demographic and substance use rates, although findings were similar across the two cohorts. Further, even within the pooled sample, the low prevalence rates of perinatal substance use outcomes resulted in low precision of odds ratio estimates. Wide confidence intervals limited interpretations of effect sizes, however the results consistently indicated elevated risk associated with preconception substance use. Finally, our study did not include measures of substance use for participants' partners (e.g. fathers of the infants), which has been identified as an important predictor of maternal substance use in pregnancy as well as a risk factor for infant offspring behaviour and future substance use (el Marroun et al., 2008; Kerr et al., 2012). Future research should investigate the extent to which fathers' substance use histories persist into parenthood and how these are related to offspring outcomes.

Implications and conclusions

From a population health perspective, this study suggests that persistent frequent preconception substance use from adolescence to young adulthood plays a significant role in influencing substance use in pregnancy and across the first year of offspring life. This highlights the significance of the preconception years as a key period for investment in early intervention. Specifically, identifying and addressing common patterns that predict potential substance use harms through universal monitoring systems may have profound benefits. Universal approaches may be particularly beneficial for alcohol where use is highly prevalent in the population; even small reductions in alcohol use across many cases could result in significant population health improvements (Rose, 1985; Stockwell et al., 2004). Similar principles apply to smoking prevention, where use is less prevalent but highly addictive. Furthermore, targeted interventions may be warranted for sustained patterns of frequent alcohol, tobacco, or cannabis use throughout adolescence and young adulthood, both to reduce harm to the health of the individual as well as to the health of potential future offspring. Importantly, interventions should

prioritise the wellbeing of individuals irrespective of their health behaviours to avoid stigmatising individuals and encourage engagement with family planning and prenatal care (Roberts, Thompson, & Taylor, 2021). Supports should also be extended to partners of pregnant mothers who influence substance use habits and, in the case of tobacco and cannabis smoke, increase the risk of passive exposure within the household (el Marroun et al., 2008; Schneider, Huy, Schütz, & Diehl, 2010).

Effective public health responses are likely to be multifaceted, focusing both on the reduction of substance use and greater planning around pregnancies. There is much opportunity to invest in school-based programmes, pre-emptively addressing substance misuse at the point of initiation at a population-level, in addition to addressing current substance misuse through targeted school-based programmes (Conrod et al., 2013). Public health campaigns focusing on substance use in the family planning context are also examples of (late) preconception intervention. These could complement existing prenatal screening and intervention programmes which often miss a critical period before pregnancy recognition when in utero exposures may have already occurred (Louw, 2018). The pause in substance use during pregnancy may offer a further point of post conception intervention to maintain reduced substance use patterns during the childrearing years (Chapman & Wu, 2013; Crume, 2019; Skagerström et al., 2011). Research examining predictors of substance use continuity and discontinuity (e.g. mental health, delinquency, social support) would likewise help inform prevention and intervention efforts. Inclusion of indicators of young adulthood and early-onset persistent substance use into population monitoring activities would also provide valuable information on when and where increased supports and services may benefit populations and ultimately reduce the prevalence of substance use in adulthood including parenthood. Studies comparing the natural history of preconception substance use in different policy settings (e.g. where cannabis is decriminalised) may also provide further insights into effective population-level strategies to address problematic drinking, tobacco, and cannabis use from an early age.

Supplementary material. The supplementary material for this article can be found at <https://doi.org/10.1017/S0033291721003925>

Acknowledgements. The ATP, Australian Temperament Project Generation 3 (ATPG3), Victorian Adolescent Health Cohort Study (VAHCS), and Victorian Intergenerational Health Cohort Study (VIHCS) are located at The Royal Children's Hospital Melbourne. ATP and ATPG3 are a collaboration between Deakin University, The University of Melbourne, The Murdoch Children's Research Institute, The Australian Institute of Family Studies, The University of New South Wales, The University of Otago (NZ), and the Royal Children's Hospital. We acknowledge all collaborators who have contributed to the ATP, especially Professors Ann Sanson, Frank Oberklaid, Dr Diana Smart, and the late Professor Margot Prior. We would also like to sincerely thank the participating families in all studies for their time and invaluable contributions, as well as all collaborators and the study teams involved in the data collection and management. Further information on these studies is available at <https://www.melbournechildrens.com/atp/> and <https://lifecourse.melbournechildrens.com/cohorts/2000-stories/>.

Financial support. Funding for this work was supported by grants for CAO from the Australian Research Council [DP130101459; DP160103160; DP180102447] and the National Health and Medical Research Council of Australia (NHMRC) [APP1082406]. GCP was supported by the NHMRC [APP1117873]. KCT was supported by funding from the Canadian Institutes of Health Research [MFE158141] and Michael Smith Foundation

for Health Research [RT-2020-0550]. Additionally, this work was supported by the NHMRC (APP1008273, APP1063091, APP437015), Australian Rotary Health, Colonial Foundation, Perpetual Trustees, Financial Markets Foundation for Children (Australia), Royal Children's Hospital Foundation and the Murdoch Children's Research Institute. Research at the Murdoch Children's Research Institute is supported by the Victorian Government's Operational Infrastructure Program.

Conflict of interest. The authors have no conflicts of interest to declare.

Ethical standards. The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

References

- Australian Government Department of Health. (2019). *Pregnancy Care Guidelines: Substance Use*. <https://www.health.gov.au/resources/pregnancy-care-guidelines/part-c-lifestyle-considerations/substance-use>.
- Bodner, T. E. (2008). What improves with increased missing data imputations? *Structural Equation Modeling: A Multidisciplinary Journal*, 5511(4), 651–675. <https://doi.org/10.1080/10705510802339072>.
- Borschmann, R., Becker, D., Spry, E., Youssef, G. J., Olsson, C. A., Hutchinson, D. M., ... Patton, G. C. (2019). Alcohol and parenthood: An integrative analysis of the effects of transition to parenthood in three Australasian cohorts. *Drug and Alcohol Dependence*, 197(February), 326–334. <https://doi.org/10.1016/j.drugalcdep.2019.02.004>.
- Burns, E., Gray, R., & Smith, L. A. (2010). Brief screening questionnaires to identify problem drinking during pregnancy: A systematic review. *Addiction*, 105(4), 601–614. <https://doi.org/10.1111/j.1360-0443.2009.02842.x>.
- Chapman, S. L. C., & Wu, L. T. (2013). Postpartum substance use and depressive symptoms: A review. *Women and Health*, 53(5), 479–503. <https://doi.org/10.1080/03630242.2013.804025>.
- Conner, S. N., Carter, E. B., Tuuli, M. G., MacOnes, G. A., & Cahill, A. G. (2015). Maternal marijuana use and neonatal morbidity. *American Journal of Obstetrics and Gynecology*, 213(3), 422.e1–422.e4. <https://doi.org/10.1016/j.ajog.2015.05.050>.
- Conrod, P. J., O'Leary-Barrett, M., Newton, N., Topper, L., Castellanos-Ryan, N., MacKie, C., & Girard, A. (2013). Effectiveness of a selective, personality-targeted prevention program for adolescent alcohol use and misuse: A cluster randomized controlled trial. *JAMA Psychiatry*, 70(3), 334–342. <https://doi.org/10.1001/jamapsychiatry.2013.651>.
- Crume, T. (2019). Tobacco use during pregnancy. *Clinical Obstetrics and Gynecology*, 62(1), 128–141. <https://doi.org/10.1097/GRF.0000000000000413>.
- De Genna, N. M., Goldschmidt, L., Richardson, G. A., Cornelius, M. D., & Day, N. L. (2018). Trajectories of pre- and postnatal co-use of cannabis and tobacco predict co-use and drug use disorders in adult offspring. *Neurotoxicology and Teratology*, 70(September), 10–17. <https://doi.org/10.1016/j.ntt.2018.09.002>.
- el Marroun, H., Tiemeier, H., Jaddoe, V. W. V., Hofman, A., Mackenbach, J. P., Steegers, E. A. P., ... Huizink, A. C. (2008). Demographic, emotional and social determinants of cannabis use in early pregnancy: The generation R study. *Drug and Alcohol Dependence*, 98(3), 218–226. <https://doi.org/10.1016/j.drugalcdep.2008.05.010>.
- El Marroun, H., Tiemeier, H., Steegers, E. A. P., Jaddoe, V. W. V., Hofman, A., Verhulst, F. C., ... Huizink, A. C. (2009). Intrauterine cannabis exposure affects fetal growth trajectories: The generation R study. *Journal of the American Academy of Child and Adolescent Psychiatry*, 48(12), 1173–1181. <https://doi.org/10.1097/CHI.0b013e3181bfa8ee>.
- Floyd, R. L., Decoufle, P., & Hungerford, D. W. (1999). Alcohol use prior to pregnancy recognition. *American Journal of Preventive Medicine*, 17(2), 101–107. [https://doi.org/10.1016/S0749-3797\(99\)00059-8](https://doi.org/10.1016/S0749-3797(99)00059-8).
- Forray, A. (2016). Substance use during pregnancy. *F1000Research*, 5(May), 1–9. <https://doi.org/10.12688/F1000RESEARCH.7645.1>.
- Herrmann, M., King, K., & Weitzman, M. (2008). Prenatal tobacco smoke and postnatal secondhand smoke exposure and child neurodevelopment. *Current Opinion in Pediatrics*, 20(2), 184–190. <https://doi.org/10.1097/MOP.0b013e3282f56165>.
- Hutchinson, D., Moore, E. A., Breen, C., Burns, L., & Mattick, R. P. (2013). Alcohol use in pregnancy: Prevalence and predictors in the longitudinal study of Australian children. *Drug and Alcohol Review*, 32(5), 475–482. <https://doi.org/10.1111/dar.12027>.
- Hutchinson, D., Wilson, J., Allsop, S., Elliott, E., Najman, J., Burns, L., ... Ward, M. (2018). Cohort profile: The triple B pregnancy cohort study: A longitudinal study of the relationship between alcohol, tobacco and other substance use during pregnancy and the health and well-being of Australian children and families. *International Journal of Epidemiology*, 47(1), 26–27m. <https://doi.org/10.1093/ije/dyx126>.
- Hutchinson, D. M., Silins, E., Mattick, R. P., Patton, G. C., Fergusson, D. M., Hayatbakhsh, R., ... Horwood, L. J. (2015). How can data harmonisation benefit mental health research? An example of the cannabis cohorts research consortium. *Australian and New Zealand Journal of Psychiatry*, 49(4), 317–323. <https://doi.org/10.1177/0004867415571169>.
- Kerr, D. C. R., Capaldi, D. M., Pears, K. C., & Owen, L. D. (2012). Intergenerational influences on early alcohol use: Independence from the problem behavior pathway. *Development and Psychopathology*, 24(3), 889–906. <https://doi.org/10.1017/S0954579412000430>.
- Kessler, R. C., Berglund, P., Demler, O., Jin, R., Merikangas, K. R., & Walters, E. E. (2005). Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the national comorbidity survey replication. *Archives of General Psychiatry*, 62, 593–602. <https://doi.org/10.1001/archpsyc.62.6.593>.
- Ko, J. Y., Tong, V. T., Bombard, J. M., Hayes, D. K., Davy, J., & Perham-Hester, K. A. (2018). Marijuana use during and after pregnancy and association of prenatal use on birth outcomes: A population-based study. *Drug and Alcohol Dependence*, 187(November 2017), 72–78. <https://doi.org/10.1016/j.drugalcdep.2018.02.017>.
- Kurti, A. N., Redner, R., Lopez, A. A., Keith, D. R., Villanti, A. C., Stanton, C. A., ... Higgins, S. T. (2017). Tobacco and nicotine delivery product use in a national sample of pregnant women. *Preventive Medicine*, 104, 50–56. <https://doi.org/10.1016/j.ypmed.2017.07.030>.
- Louw, K. A. (2018). Substance use in pregnancy: The medical challenge. *Obstetric Medicine*, 11(2), 54–66. <https://doi.org/10.1177/1753495X17750299>.
- Luciana, M., & Feldstein Ewing, S. W. (2015). Introduction to the special issue: Substance use and the adolescent brain: Developmental impacts, interventions, and longitudinal outcomes. *Developmental Cognitive Neuroscience*, 16, 1–4. <https://doi.org/10.1016/j.dcn.2015.10.005>.
- McCormack, C., Hutchinson, D., Burns, L., Wilson, J., Elliott, E., Allsop, S., ... Mattick, R. (2017). Prenatal alcohol consumption between conception and recognition of pregnancy. *Alcoholism: Clinical and Experimental Research*, 41(2), 369–378. <https://doi.org/10.1111/acer.13305>.
- McGorry, P. D., Purcell, R., Goldstone, S., & Amminger, G. P. (2011). Age of onset and timing of treatment for mental and substance use disorders: Implications for preventive intervention strategies and models of care. *Current Opinion in Psychiatry*, 24, 301–306. <https://doi.org/10.1097/YCO.0b013e3283477a09>.
- Metz, T. D., & Stickrath, E. H. (2019). Is increasing frequency of marijuana use among women of reproductive age a cause for alarm? *JAMA Network Open*, 2(7), e196464. <https://doi.org/10.1016/j.ntt.2004.11.002>.
- Muggli, E., O'Leary, C., Donath, S., Orsini, F., Forster, D., Anderson, P. J., ... Halliday, J. (2016). Did you ever drink more? A detailed description of pregnant women's drinking patterns. *BMC Public Health*, 16(1), 1–13. <https://doi.org/10.1186/s12889-016-3354-9>.
- O'Keeffe, L. M., Kearney, P. M., McCarthy, F. P., Khashan, A. S., Greene, R. A., North, R. A., ... Kenny, L. C. (2015). Prevalence and predictors of alcohol use during pregnancy: Findings from international multicentre cohort studies. *BMJ Open*, 5(7), 1–11. <https://doi.org/10.1136/bmjopen-2014-006323>.
- Olsson, C. A., Spry, E., Letcher, P., McAnally, H., Thomson, K., Macdonald, J., ... Patton, G. C. (2020). The Australian and New Zealand intergenerational cohort consortium: A study protocol for investigating mental health and well-being across generations. *Longitudinal and Life Course Studies*, 11(2), 267–281. <https://doi.org/10.1332/175795920X15792720930280>.
- Palmer, R. H. C., Young, S. E., Hopfer, C. J., Corley, R. P., Stallings, M. C., Crowley, T. J., & Hewitt, J. K. (2009). Developmental epidemiology of drug use and abuse in adolescence and young adulthood: Evidence of

- generalized risk. *Drug and Alcohol Dependence*, 102(1–3), 78–87. <https://doi.org/10.1016/j.drugalcdep.2009.01.012>.
- Patton, G. C. (2004). Puberty and the onset of substance use and abuse. *Pediatrics*, 114(3), e300–e306. <https://doi.org/10.1542/peds.2003-0626-F>.
- Philips, E. M., Santos, S., Trasande, L., Aurrekoetxea, J., Barros, H., von Berg, A., ... Jaddoe, V. W. V. (2020). Changes in parental smoking during pregnancy and risks of adverse birth outcomes and childhood overweight in Europe and North America: An individual participant data meta-analysis of 229,000 singleton births. *PLoS Medicine*, e1003182. <https://doi.org/10.1371/journal.pmed.1003182>.
- Polak, K., Kelpin, S., & Terplan, M. (2019). Screening for substance use in pregnancy and the newborn. *Seminars in Fetal and Neonatal Medicine*, 24(2), 90–94. <https://doi.org/10.1016/j.siny.2019.01.007>.
- Polcaro, J., & Vettrano, I. (2020). Cannabis in pregnancy and lactation – A review. *Missouri Medicine*, 117(5), 400–405.
- Roberts, S. C. M., Thompson, T. A., & Taylor, K. J. (2021). Dismantling the legacy of failed policy approaches to pregnant people's use of alcohol and drugs. *International Review of Psychiatry*, 0(0), 1–12. <https://doi.org/10.1080/09540261.2021.1905616>.
- Rodriguez, J. J., & Smith, V. C. (2019). Epidemiology of perinatal substance use: Exploring trends in maternal substance use. *Seminars in Fetal and Neonatal Medicine*, 24(2), 86–89. <https://doi.org/10.1016/j.siny.2019.01.006>.
- Rose, G. (1985). Sick individuals and sick populations. *International Journal of Epidemiology*, 14(1), 32–38.
- Rubin, D. B. (2004). *Multiple imputation for non-response in surveys*. Wiley.
- Schneider, S., Huy, C., Schütz, J., & Diehl, K. (2010). Smoking cessation during pregnancy: A systematic literature review. *Drug and Alcohol Review*, 29(1), 81–90. <https://doi.org/10.1111/j.1465-3362.2009.00098.x>.
- Skagerström, J., Chang, G., & Nilsen, P. (2011). Predictors of drinking during pregnancy: A systematic review. *Journal of Women's Health*, 20(6), 901–913. <https://doi.org/10.1089/jwh.2010.2216>.
- Spry, E., Olsson, C. A., Hearps, S. J. C., Aarsman, S., Carlin, J. B., Howard, L. M., ... Patton, G. C. (2020). The Victorian Intergenerational Health Cohort Study (VIHCS): Study design of a preconception cohort from parent adolescence to offspring childhood. *Paediatric and Perinatal Epidemiology*, 34(1), 86–98. <https://doi.org/10.1111/ppe.12602>.
- Stata Corp. (2019). *Stata: Release 16. Statistical software*. StataCorp LLC.
- Stockwell, T., Toumbourou, J. W., Letcher, P., Smart, D., Sanson, A., & Bond, L. (2004). Risk and protection factors for different intensities of adolescent substance use: When does the prevention paradox apply? *Drug and Alcohol Review*, 23(1), 67–77. <https://doi.org/10.1080/09595230410001645565>.
- Vassallo, S., & Sanson, A. (2013). *The Australian temperament project: The first 30 Years*. Australian Institute of Family Studies.
- Wells, J. E., McGee, M. A., Baxter, J., Agnew, F., & Kokaua, J. (2009). Onset and lifetime use of drugs in New Zealand: Results from Te Rau hinengaro: The New Zealand mental health survey 2003–2004. *Drug and Alcohol Review*, 28(2), 166–174. <https://doi.org/10.1111/j.1465-3362.2008.00043.x>.
- Young-Wolff, K. C., Sarovar, V., Tucker, L.-Y., Conway, A., Alexeeff, S., Weisner, C., ... Goler, N. (2019). Self-reported daily, weekly, and monthly cannabis use among women before and during pregnancy. *JAMA Network Open*, 2(7), e196471. <https://doi.org/10.1001/jamanetworkopen.2019.6471>.
- Yuen, W. S., Chan, G., Bruno, R., Clare, P., Mattick, R., Aiken, A., ... Peacock, A. (2020). Adolescent alcohol use trajectories: Risk factors and adult outcomes. *Pediatrics*, 146(4), e20200440. <https://doi.org/10.1542/peds.2020-0440>.