Received: 26 July 2021 | Revised: 30 January 2022 | Accepted: 16 March 2022

DOI: 10.1111/birt.12638

ORIGINAL ARTICLE

BIRTH ISSUES IN PERINATAL CARE WILEY

Maternal factors associated with interbirth intervals in Australia: Results from a population-based longitudinal study

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Funding information
This work was supported by the Australian Government Department of Health, which funds the ALSWH. GDM is supported by a National Health and Medical Research Council of Australia Principal Research Fellowship (App1121844). The funding source had no role in the data collection, analyses, interpretation, and decision to publish the manuscript

Abstract

Background and objective: Short and long intervals between successive births are associated with adverse birth outcomes, especially in low-income and middle-income countries, yet the birth intervals in high-income countries remain relatively understudied. The aim was to examine maternal factors associated with birth intervals in Australia.

Methods: The sample comprised 6130 participants in the Australian Longitudinal Study on Women's Health who were born in 1973-1978, had two or more births, and responded to regular surveys between 1996 and 2018. Interbirth interval (IBI) was defined as the time between successive live births. Maternal factors were examined using accelerated failure time models.

Results: For women with only two births (n = 3802), the median time to the second birth was 34.0 months (IQR 23.1, 46.2) with shorter IBI associated with higher socioeconomic status (eg, university education (31.9 months), less income stress (31.1)), and longer IBI associated with age over 35 (39.7), fair/poor health (43.0), untreated fertility problems (45.5), miscarriage (39.4), or abortion (41.0). For women with three or more births (n = 2328), the median times to the second and third births were 31.2 months (19.9, 42.1) and 36.5 months (25.3, 50.1), respectively; some factors were consistent between the first IBI and second IBI (eg, university education and being married were associated with shorter IBI), whereas income stress was associated with longer first IBI but not with second IBI.

Conclusions: Understanding maternal factors associated with birth intervals in a high-income country like Australia may enable more nuanced tailoring of guidelines for prepregnancy care.

KEYWORDS
birth intervals, high-income country, maternal factors, reproductive, socioeconomic

1 | BACKGROUND

The length of birth spacing is considered as an important modifiable factor linked with adverse perinatal and maternal outcomes. Evidence is often presented in terms of interpregnancy interval (IPI)—the time between one birth and the next conception. A short IPI of <18 months, particularly <12 months, has been associated with increased risk of preterm birth, low birthweight, small for gestational age, and infant mortality, whereas an IPI of >60 months has been linked with pregnancy complications such as preeclampsia.[1]

Yet, there currently remains a lack of consensus in guidelines on the optimal birth spacing to reduce the risk of adverse outcomes.[2–4] In 2006, the World Health Organization (WHO) defined a short birth-to-pregnancy interval as ≤6-18 months, whereas a long birth to pregnancy interval was >60 to 75 months.[5] The WHO recommended that women wait at least 24 months after a successful birth before trying for the next pregnancy.[5] Evidence-based guides for clinicians conclude that the optimal IPI after a live birth should be 18 to 24 months.[2,4] Clinical guidelines in Australia take a different approach and are aligned with those in the UK, where the risks associated with an IPI of <12 months are included in advice to women on contraception options after childbirth.[6]

There is ongoing debate as to whether IPI is *causally* related to adverse outcomes.[3,7–9] Researchers have argued that the observed associations of IPI with pregnancy and newborn complications may simply reflect unmeasured confounding by maternal factors, including the mother's socioeconomic status, health behaviors, preexisting health conditions, and the outcome of the previous pregnancy.[10,11] This hypothesis is supported by the smaller effect sizes evident for IPI outcomes for the same mother compared with the associations of IPIs across different mothers. For example, using linked data on over 5 million births in Australia, Finland, Norway, and the United States (1991-2012), Tessema et al found that in a within-mother analysis, in which each mother had two IPIs and acted as her own control, there was a substantial attenuation of the effect of short IPI on the risk of adverse perinatal outcomes, except for spontaneous preterm birth.[12] This suggests that short IPI may be a marker of unmeasured maternal characteristics rather than reflecting a biological effect of IPI on adverse perinatal outcomes.

Many studies on birth spacing are from low- to middle-income settings,[13–15] where having a girl, short breastfeeding duration, less maternal education, younger maternal age, and not using modern contraceptives have been associated with short IPI and hence short birth spacing. Most of the evidence contributing to the WHO guidelines comes from these settings.[16] There is more limited evidence on maternal factors associated with birth spacing in high-income countries like Australia with a low fertility rate.[10,17–19] Although these studies account for maternal sociodemographic factors, few include reproductive factors or health behaviors. This may be because of the limited availability of longitudinal data on detailed maternal characteristics.[5,16]

If data on time of conception are not available, for example if the data source is administrative records, an alternative measure that is often used is the spacing between consecutive live births, or the interbirth interval (IBI). Although IBI is likely to be more accurately measured than IPI, it is affected by gestational length and ignores any intervening pregnancy losses.

The aim of this study was to clarify the associations between maternal characteristics (demographic, socioeconomic, reproductive, mental, and physical health) and IBI. IBI was chosen as a proxy for IPI[5] as data on pregnancy dates were not available. Using detailed data on maternal characteristics from a large national cohort of Australian women born in 1973-1978, we investigated variations in IBI across women who had two births only (one IBI) or three or more births (permitting analysis of two successive IBIs).

2 | METHODS

The Australian Longitudinal Study on Women's Health (ALSWH) is a longitudinal population-based survey examining health and health service use of over 57 000 women. ALSWH follows women in four age cohorts, with a detailed description previously published.[20] We used data from the 14 247 women in the cohort born in 1973-1978 and who were first surveyed in 1996, when they were aged 18 to 23. The women have been resurveyed since then about every 3 years. The ALSWH was approved by the University of Queensland and The University of Newcastle Human Research Ethics Committees, and all women gave informed consent.

The criteria for the study sample and the birth spacing duration were based on dates the women completed Surveys 1 to 8 (in 2018) and the birth dates of each woman's first, second, and third child (as applicable). Out of 14 247 women initially recruited, 6130 were included in this paper. Figure 1 shows the inclusion and exclusion criteria. Briefly, the 6130 women were those who had two or more singleton births, had completed at least two consecutive surveys since 1996, reported plausible IBI values, and had no more than one child before survey 1. The 6130 women comprised 3802 with two births only and 2328 with three or more births.

FIGURE 1 Study flow diagram

2.1 | Outcomes

Birth spacing was calculated as the interval between the first and second live births (first IBI) or the interval between the second and third live birth (second IBI).

2.2 | Explanatory variables

Maternal age was recorded at the start of the relevant IBI (ie, mother's age at time of the birth). Other maternal factors (marital status, area of residence,[21] level of education, occupation, and managing on available income) were those reported at the survey before the second or third births depending on the IBI of interest. Health behavior variables (smoking status, alcohol intake,[22] level of physical activity,[23] and body mass index[24]) and self-rated measures of general health and mental health[25] were those reported at the survey before the IBI of interest.

Reproductive factors included a history of miscarriage and abortion (asked by "How many times have you had each of the following: miscarriage, termination"), current contraception use, fertility problems (asked by "Have you and your partner (current or previous) ever had problems with infertility, that is tried unsuccessfully for 12 months or more to get pregnant?"), and how many months they breastfed each child (see Table 1 for variable categories).

2.3 | Statistical analysis

Not all women participated in all eight surveys. To deal with incomplete data for the explanatory variables, the "Last Observation Carried Forward" method was applied. For variables not measured in survey 1 (physical activity, fertility problems, and contraceptive use), a missing data category was used. For women with exactly two children, the cumulative probability of having a second birth over

TABLE 1 Characteristics of women born in 1973-1978 participating in the Australian Longitudinal Study on Women's Health

Variables[a,b]	Two children only (N = 3802)	Three or more children (N = 2328)	
	IBI[c] N (%)	First IBI[c] N (%)	Second IBI[c] N (%)
Age at birth (mean (SD[d])), in years	32.5 (4.4)	29.4 (4.3)	32.7 (4.3)
Age at birth group, in years			
≤25	204 (5.4)	425 (18.3)	101 (4.3)
>25-30	885 (23.3)	820 (35.2)	560 (24.1)
>30-35	1561 (41.1)	854 (36.7)	897 (38.5)
>35	1152 (30.3)	229 (9.8)	770 (33.1)
Highest educational qualification			
≤12 years	1029 (27.1)	823 (35.4)	754 (32.4)
Trade/certificate/diploma	1006 (26.5)	547 (23.5)	579 (24.9)
University/higher degree	1767 (46.5)	958 (41.2)	995 (42.7)
Occupation			
Manager/professional	1707 (44.9)	973 (41.8)	856 (36.8)
Trade/associate professional/ intermediate	561 (14.8)	367 (15.8)	277 (11.9)
Elementary/laborer	774 (20.4)	521 (22.4)	471 (20.2)
No paid job	760 (20.0)	467 (20.1)	724 (31.1)
Marital status			
Married	2847 (74.9)	1605 (68.9)	1821 (78.2)
De facto	678 (17.8)	453 (19.5)	340 (14.6)
Separated/divorced/widowed	58 (1.5)	58 (2.5)	91 (3.9)
Single	219 (5.8)	212 (9.1)	76 (3.3)
Area of residence			
Major cities	2171 (57.1)	1129 (48.6)	1082 (46.5)
Inner regional	1008 (26.5)	701 (30.1)	738 (31.7)
Outer regional	520 (13.7)	398 (17.1)	410 (17.6)
Remote/very remote	103 (2.7)	100 (4.3)	98 (4.2)
Manage on income			
Impossible/difficult always	405 (10.7)	304 (13.1)	352 (15.1)
Sometimes difficult	1112 (29.2)	708 (30.4)	770 (33.1)
Not bad	1560 (41.0)	930 (39.9)	893 (38.4)
Easy	725 (19.1)	386 (16.6)	313 (13.4)
Body Mass Index			
Underweight <18.5 kg/m^2	131 (3.4)	120 (5.2)	100 (4.3)
Healthy 18.5- < 25 kg/m^2	2204 (58.0)	1747 (63.3)	1321 (56.7)
Overweight 25-30 kg/m^2	903 (23.8)	482 (20.7)	558 (24.0)
Obese >30 kg/m^2	564 (14.8)	252 (10.8)	349 (15.0)
Smoking status			
Current smoker	549 (14.4)	407 (17.5)	357 (15.3)
Former smoker	1058 (27.8)	608 (26.1)	644 (27.7)
Never smoker	2195 (57.7)	1313 (56.4)	1327 (57.0)
Alcohol intake			
Low-risk drinker	2028 (53.3)	1150 (49.4)	1141 (49.0)

(Continues)

TABLE 1 (Continued)

Variables[a,b]	Two children only (N = 3802) IBI[c] N (%)	Three or more children (N = 2328) First IBI[c] N (%)	Second IBI[c] N (%)
Nondrinker	526 (13.8)	330 (14.2)	371 (15.9)
Rarely drinks	1172 (30.8)	801 (34.4)	773 (33.2)
Risky and high-risk drinker	76 (2.0)	47 (2.0)	43 (1.8)
Physical activity level			
Nil/sedentary	381 (10.0)	191 (8.2)	277 (11.9)
Low	1251 (32.9)	682 (29.3)	795 (31.4)
Moderate	727 (19.1)	398 (17.1)	429 (18.4)
High	669 (17.6)	366 (15.7)	333 (14.3)
SF-36[e]: Self-rated health			
Excellent	583 (15.3)	391 (16.8)	322 (13.8)
Very good	1784 (46.9)	1026 (44.1)	1066 (45.8)
Good	1167 (30.7)	759 (32.6)	745 (32.0)
Fair/Poor	268 (7.0)	152 (6.5)	195 (8.4)
SF36: Mental Health Inventory			
<52	447 (11.8)	279 (12.0)	301 (12.9)
≥52	3355 (88.2)	2049 (88.0)	2027 (87.1)
Fertility problems			
No problem	2256 (59.3)	1231 (52.9)	1504 (64.6)
Never tried to become pregnant	190 (5.0)	164 (7.0)	38 (1.6)
Yes, but have not sought help/treatment	138 (3.6)	61 (2.6)	99 (4.3)
Yes, and have sought help/treatment	497 (13.1)	197 (8.5)	239 (10.3)
Use of contraception			
No	1540 (40.5)	803 (34.5)	805 (34.6)
Yes	1538 (40.5)	850 (36.5)	1067 (45.7)
Breastfeeding (first birth of the interval)			
≤6 months	1558 (41.0)	911 (39.1)	818 (35.1)
7-9 months	469 (12.3)	310 (13.3)	325 (14.0)
10-12 months	678 (17.8)	440 (18.9)	469 (20.1)
>12 months	727 (19.1)	457 (19.6)	487 (20.9)
History of miscarriage			
No	2917 (76.7)	1858 (79.8)	1556 (66.8)
Yes	885 (23.3)	470 (20.2)	772 (33.2)
History of abortion			
No	3280 (86.3)	2008 (86.3)	1952 (83.8)
Yes	522 (13.7)	320 (13.7)	376 (16.2)

[a]Variables measured at the survey before the birth that defines the end of each spacing, except age. For mothers with exactly two births, the mean age shown is at the second birth. For women with three or more births, the mean ages shown are at the second and third births.

[b]Average percent missing data across eight surveys were <2% for marital status, area of residence, manage on income, smoking status, alcohol drinking level, SF36, Mental Health Inventory, fertility problems, and contraceptive use; 2 to 5% for education level, occupation, history of miscarriage, history of abortion, and physical activity; 6% for BMI and 11% for breastfeeding (for 1st and 2nd births).

[c]Interbirth interval.

[d]Standard deviation.

[e]Medical Outcomes Study Short Form 36 Health Survey.

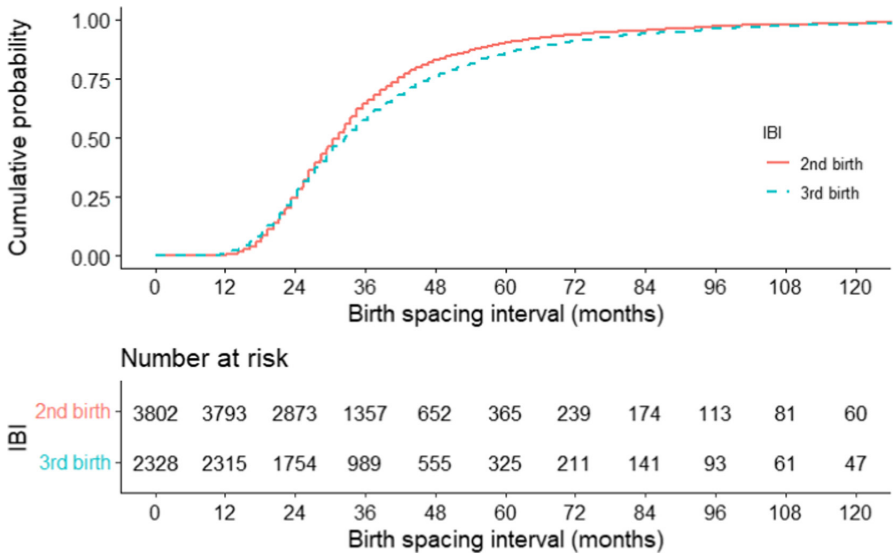

FIGURE 2 Cumulative probability of having a second birth, defining the end of the first interbirth interval (solid line), and a third (dashed line) birth over time [Color figure can be viewed at wileyonlinelibrary.com]

time was plotted. For women with three or more births, the corresponding figure for having a third birth was plotted. The cumulative probability is the complement of the Kaplan–Meier curve, ranging from zero at the start to one at the end of the study period.

For the main analysis, accelerated failure time (AFT) regression based on the Weibull distribution was used with the logarithm of time to event (ie, next birth) as a function of the explanatory variables. The exponentials of the coefficients are the acceleration factors (AFs), which represent proportional changes in time-to-event (ie, time to next birth). For example, AF values above 1 indicate a longer IBI.[26] This interpretation of the coefficients is the reason an AFT model was used in preference to a proportional model[27] where the coefficients represent changes in hazard rates (HR) and longer intervals are associated with smaller HRs. The results are reported as AFs with 95% confidence intervals. The median (IQR) times to the next birth, calculated from the model-based estimates for each woman, were also reported.

Separate models were developed for each IBI. In the initial step, univariate associations with time to next birth were assessed, and those variables with a *P*-value <0.20 were selected for inclusion in the multivariable models. Four multivariable models were developed: first, for women with one IBI (exactly two children); second, for the first IBI for women with three or more children; third, for the second IBI of women with three or more children; and fourth, to determine whether the association of variables varied from the first to second IBI, a joint model was developed with the inclusion of interaction terms between birth order and maternal factors. To account for correlation among characteristics of the same mother for within mother IBIs, robust estimates of variances of regression coefficients were obtained. For variables with no interaction terms, one AF was estimated for the association between the variables and the combined outcome. When interactions for each explanatory variable and the combined outcome were found in the joint model, AFs for the first and second birth intervals were estimated separately.

In supplementary analyses, to show the effect of censoring we included women with one child. For these women, the censoring time was calculated as the difference between dates of childbirth and last survey returned. In addition, to show a comparison between AF and HR, both parametric Weibull regression and the semi-parametric Cox proportional hazard regression models were fitted. Figure S1 has further explanation of the methods and sample R code. Statistical analyses were performed using R software (survival, flexsurv, survminer, rms, and ggplot2 packages).[28]

3 | RESULTS

For the 6130 women, mean age at first birth was 28.4 (SD 4.8) years. Of the 8458 IBIs in the study, 40% (3371) were less than 27 months (corresponding approximately to less than 18 months between one birth and the next conception). Figure 2 shows the cumulative probability for the first and second IBIs and illustrates the typically longer duration of the second IBI compared with the first. For women with only two births (N = 3802), the median time to the second birth was 34.0 months (IQR 23.1, 46.2). For women with three or more births (N = 2328), the median time to the second birth was 31.2 (19.9, 42.1) months and from the second birth to the third birth was 36.5 (25.3, 50.1).

There were marked differences in the characteristics of women with only two births and those with three or more during the first IBI (Table 1). Women with two IBIs were younger before their first IBI (eg,18.3% were aged 25 years

or below vs 5.4% of women with only one IBI), had less education, and fewer were overweight or obese. For women with two IBIs, the prevalence of some factors increased from their first IBI to the second, including the percentage not in paid employment, overweight or obese, and with low or sedentary physical activity levels (for completeness, comparisons with women before each of their births or for women who had not given birth are in Table S1 and Table 2, respectively).

For women with exactly two births, multivariable modeling showed factors associated with the time to second birth (Table 2; univariable results are in Table S3). The estimated median time increased with maternal age, from 33.9 months for those <25 years to 39.7 months for those >35 years. Median time to second birth was generally shorter for women with a university education vs grade 12 level education (31.9 vs 39.7) who were married vs other arrangements (eg, 32.9 vs 48.1 for single women), found it easier to manage on their income vs finding it impossible/always difficult (31.1 vs 43.7), and were in a managerial or professional occupation vs being in a less skilled occupation (33.5 vs 42.4 for the laborer category). The median time to the second birth tended to be longer for women who were underweight vs a healthy weight (40.7 vs 34.2), had fair/poor vs excellent self-rated health (43.0 vs 30.8), rarely drank alcohol vs being a low-risk drinker (37.2 vs 34.9), reported fertility problems but did not seek treatment vs having no problems (45.5 vs 33.6), and had a history of miscarriage (39.4 vs 34.5) or abortion (41.0 vs 34.8).

Some similar patterns were found for women with three or more live births (Table 3). The length of IBI increased with maternal age for both second and third births. Shorter IBI was associated with higher levels of education and with being married (especially compared with women who were separated/divorced/widowed). There were, however, some differences from the first to the second IBI revealed in the joint modeling. For the first IBI, the ease of managing on income (not bad, easy) was associated with a shorter median time to second birth, but this was not the case for the time to the third birth. Similarly, having fertility problems and seeking help, experiencing abortion, and no or rarely drinking alcohol were associated with longer first IBI but not the second IBI. Women who reported fertility problems at their first IBI but who sought treatment had a similar second IBI as those who reported no fertility problems. This contrasted with the longer IBI for women who had fertility problems but did not seek treatment. For the second IBI, however, there was no evidence of differences in IBI related to fertility. Both IBIs tended to be longer for women who reported fair/poor self-rated health or had a history of miscarriage.

The effect of including women who did not have a second (or subsequent) birth and censoring them at the time of their last survey response was to increase the AF estimates (Table S4). This is expected as these women may have completed their preferred family size and not be intending further births. The relationship between AF and HR is also illustrated in Table S4. For example, for abortion history, the AF estimate of 1.16 indicates the time to the second birth for women who experienced abortion was 1.16 times higher than other women. The corresponding HR estimate of 0.77 indicates that the instantaneous hazard, at any time, of experiencing having the second child was 23% lower for women who experienced abortion.

4 | DISCUSSION

4.1 | Principal findings and interpretation

This national study has provided new information on how maternal characteristics relate to birth spacing for a large cohort of Australian women. To compare with WHO guidelines, which are based on birth to pregnancy timelines, we can convert birth to birth intervals to birth to pregnancy intervals by subtracting 9 months,[5] while acknowledging the limitation we had of not knowing exact pregnancy dates. In terms of WHO guidelines,[5] 40% of second or third births were less than the recommended 18 months between birth and conception (ie, equivalent to 27 months IBI). However, the relevance of the WHO guidelines and other country-specific guidelines[6] in high-income countries is unclear.[16] Birth spacing varied substantially according to a range of factors: from socioeconomic factors (such as education level, marital status, and ability to manage on income) to biological and health-related (eg, maternal age, poor self-rated health, fertility problems, history of abortion, and miscarriage), and health behaviors and bodyweight (smoking status, alcohol intake, and BMI category).

In Australian national statistics, the mean age at first birth increased from 28.1 years in 2005 to 28.9 years in 2015.[29] This is consistent with women in the 1973-1978 ALSWH cohort who were a mean 29.0 (SD 1.2) years at their first birth (Table S1), and with the age at first birth of the analysis sample of women with two or more births (28.4 years). The finding that 40% of IBIs were less than the WHO recommendations of 18 months between pregnancies is similar to the figures of 44% from a previous Australian study[10] and 45% found in a large study from Manitoba, Canada.[19] The latter study also showed longer birth spacing with older maternal age, which is consistent with findings in our study for both the first and second IBI. The findings suggest that women who have three or more births have their first birth at a younger age than

TABLE 2 Maternal characteristics, acceleration factors (95% confidence interval), and median interbirth interval estimated from multivariable Weibull accelerated failure time models for interbirth interval duration

	Women with two births only (N = 3802)		
	N	AF	Median estimated from Weibull regression
Age at birth group			
25-30	885	REF	33.4
<25	204	0.84 (0.77, 0.90)	33.9
30-35	1561	1.19 (1.14, 1.23)	34.9
>35	1152	1.42 (1.36, 1.48)	39.7
Highest educational qualification			
≤12 years	1029	REF	39.7
Trade/apprenticeship	1006	0.98 (0.94, 1.02)	38.0
University/higher degree	1767	0.87 (0.83, 0.91)	31.9
Occupation			
Manager/professional	1707	REF	33.5
Trade/associate professional/intermediate	561	0.99 (0.93, 1.05)	35.8
Elementary/laborer	774	1.11 (1.05, 1.16)	42.4
No paid job	760	0.91 (0.88, 0.95)	33.2
Marital status			
Married	2847	REF	32.9
De facto	678	1.13 (1.08, 1.17)	39.3
Separated/divorced/widowed	58	2.01 (1.79, 2.27)	79.9
Single	219	1.32 (1.22, 1.43)	48.1
Area of residence			
Major cities	2171	REF	34.6
Inner regional	1008	1.05 (1.02, 1.08)	37.4
Outer regional	520	1.06 (1.02, 1.10)	36.9
Remote/very remote	103	1.01 (0.93, 1.09)	32.7
Manage on income			
Impossible/difficult always	405	REF	43.7
Sometimes difficult	1112	0.89 (0.84, 0.94)	37.9
Not bad	1560	0.86 (0.82, 0.91)	34.0
Easy	725	0.80 (0.76, 0.85)	31.1
Body Mass Index			
Healthy 18.5- < 25 kg/m^2	2204	REF	34.2
Underweight <18.5 kg/m^2	131	1.19 (1.10, 1.28)	40.7
Overweight 25-30 kg/m^2	903	1.02 (0.98, 1.06)	36.3
Obese >30 kg/m^2	564	1.04 (1.00, 1.08)	38.9
Smoking status			
Never	2195	REF	33.3
Former	1058	1.00 (0.96, 1.03)	35.5
Current	549	1.15 (1.11, 1.20)	45.0
Alcohol intake			
Low-risk drinker	2028	REF	34.9
Nondrinker	526	0.96 (0.92, 1.01)	33.3

(Continues)

TABLE 2 (Continued)

	Women with two births only (N = 3802)		
	N	AF	Median estimated from Weibull regression
Rarely drinks	1172	1.04 (1.01, 1.08)	37.2
Risky and high-risk drinker	76	1.07 (0.95, 1.21)	47.0
Physical activity level			
Moderate	727	REF	34.2
Nil/sedentary	381	1.01 (0.95, 1.07)	37.2
Low	1251	0.94 (0.91, 0.98)	32.8
High	669	1.07 (1.02, 1.13)	37.6
Self-rated health			
Excellent	583	REF	30.8
Very good	1784	1.07 (1.03, 1.12)	34.4
Good	1167	1.15 (1.10, 1.21)	38.3
Fair/poor	268	1.17 (1.09, 1.26)	43.0
SF36: Mental Health Subscale score			
≥52	3355	REF	35.0
<52	447	1.05 (1.00, 1.10)	41.9
Fertility problems			
No problem	2256	REF	33.6
Never tried to become pregnant	190	0.98 (0.91, 1.05)	35.4
Yes, and did not seek help/treatment	138	1.27 (1.18, 1.37)	45.5
Yes, but sought help/treatment	497	1.05 (1.01, 1.09)	37.0
Use of contraception			
Yes	1538	REF	35.8
No	1540	0.94 (0.91, 0.98)	33.9
History of miscarriage			
No	2917	REF	34.5
Yes	885	1.07 (1.04, 1.11)	39.4
History of abortion			
No	3280	REF	34.8
Yes	522	1.07 (1.03, 1.12)	41.0

women who only have two births (29.4 and 32.5 years, respectively). These women also have a shorter median time to second birth (31.2 and 34.0 months, respectively). Women with three or more births have their third birth when they were only slightly older than women with two births were at their second birth (32.7 years and 32.5 years, respectively).

Previous reviews have concluded that although fertility rates are related to socioeconomic factors these relationships are not straightforward, with mixed evidence on their direction and the potential causal pathways at work.[30] In the Manitoba study, women with a very short spacing between birth and next conception (<6 months) tended to be from low socioeconomic neighborhoods, had not graduated from high school, and had received income assistance.[19] Evidence from the present study, however, points towards the role of favorable socioeconomic factors such as university qualifications, being married, and finding it easier to manage on their income being associated with shorter first IBI. By the second IBI, however, these associated factors had shifted with the duration of birth spacing no longer associated with the ability to manage on income. The same pattern of associations was evident for most factors associated with the first IBI for women with three or more births, with women who had relatively better socioeconomic circumstances and resources tending to have shorter intervals between their first and second births.

TABLE 3 Maternal characteristics, acceleration factors (95% confidence interval), and median times to second or third birth estimated from multivariable Weibull accelerated failure time models for interbirth interval duration, including joint modeling of successive interbirth intervals—among women with three births or more (N = 2328)

	1st birth spacing		2nd birth spacing		Joint Model		
	Acceleration factor	M[a]	Acceleration factor	M[a]	Acceleration factor[b]	M[a]	*P*-value[c]
Age (years) group							
25-30	REF	31.2	REF	32.0	REF	33.3	
<25	0.76 (0.70, 0.82)	28.9	0.64 (0.58, 0.70)	23.9	0.73 (0.68, 0.79)	33.1	0.48
30-35	1.15 (1.09, 1.21)	30.9	1.38 (1.27, 1.41)	37.8	1.23 (1.17, 1.30)	36.3	0.69
>35	1.45 (1.34, 1.57)	39.8	1.68 (1.59, 1.78)	44.9	1.58 (1.49, 1.68)	42.1	0.75
Highest educational qualification							
≤12 years	REF	34.6	REF	39.3	REF	36.4	
Trade/apprenticeship	0.95 (0.90, 1.01)	34.2	0.95 (0.90, 1.00)	41.9	0.96 (0.91, 1.02)	37.5	0.98
University degree	0.80 (0.75, 0.86)	27.3	0.79 (0.74, 0.83)	35.1	0.80 (0.76, 0.85)	31.2	0.82
Occupation							
Manager/professional	REF	29.2	REF	37.4	REF	32.5	
Trade/associate professional/ intermediate	0.97 (0.90, 1.05)	31.2	0.98 (0.92, 1.04)	39.0	0.98 (0.91, 1.05)	34.9	0.83
Elementary/laborer	1.05 (0.98, 1.12)	35.5	1.04 (0.97, 1.11)	41.9	1.05 (0.99, 1.11)	37.4	0.94
No paid job	0.98 (0.92, 1.04)	32.4	0.92 (0.88, 0.97)	36.1	0.95 (0.90, 0.99)	35.9	0.30
Marital status							
Married	REF	28.6	REF	36.0	REF	33.1	
De facto	1.19 (1.12, 1.26)	36.0	1.14 (1.07, 1.21)	42.6	1.17 (1.11, 1.24)	36.5	0.51
Separated/divorced/widowed	1.58 (1.38, 1.82)	51.3	1.54 (1.39, 1.70)	60.9	1.55 (1.42, 1.70)	45.1	0.84
Single	1.27 (1.18, 1.37)	39.2	1.16 (1.03, 1.31)	43.5	1.23 (1.14, 1.33)	38.9	0.31
Area of residence							
Major cities	REF	31.1	REF	37.6	REF	34.2	
Inner regional	0.98 (0.93, 1.03)	31.9	0.99 (0.95, 1.03)	38.6	0.99 (0.94, 1.04)	35.0	0.77
Outer regional	1.01 (0.95, 1.07)	32.5	1.06 (1.00, 1.12)	39.1	1.03 (0.97, 1.09)	35.3	0.41
Remote/very remote	1.27 (1.18, 1.37)	29.5	1.03 (0.93, 1.13)	36.6	0.97 (0.90, 1.05)	33.9	0.21
Manage on income							
Impossible/difficult always	REF	39.8	REF	39.6	REF	36.3 41.8	
Sometimes difficult	0.93 (0.87, 1.00)	34.4	1.09 (1.03, 1.16)	39.9	0.98 (0.91, 1.05) 1.08 (1.03, 1.14)	34.0 38.2	0.02
Not bad	0.83 (0.77, 0.89)	28.7	1.07 (1.01, 1.14)	37.2	0.86 (0.81, 0.91) 1.07 (1.02, 1.13)	30.2 36.4	0.001
Easy	0.78 (0.72, 0.84)	26.6	1.04 (0.97, 1.13)	35.1	0.81 (0.74, 0.89) 1.06 (0.98, 1.14)	28.7 35.4	0.001
Body Mass Index							
Healthy 18.5- < 25 kg/m^2	REF	30.7	REF	36.6	REF	33.7	
Underweight <18.5 kg/m^2	0.92 (0.84, 1.02)	31.3	0.93 (0.85, 1.03)	33.0	0.94 (0.89, 1.00)	32.5	0.85
Overweight 25-30 kg/m^2	0.99 (0.94, 1.05)	32.1	1.04 (0.99, 1.09)	39.6	1.02 (0.97, 1.07)	35.9	0.37
Obese >30 kg/m^2	1.02 (0.95, 1.09)	35.9	1.08 (1.02, 1.14)	43.4	1.05 (0.99, 1.11)	39.7	0.33
Smoking status							
Never	REF	29.1	REF	36.5	REF	32.5	
Former	1.02 (0.97, 1.07)	32.1	0.98 (0.94, 1.02)	38.5	1.01 (0.96, 1.06)	35.6	0.37
Current	1.15 (1.08, 1.23)	38.8	1.13 (1.06, 1.20)	43.7	1.14 (1.07, 1.21)	39.0	0.72
Alcohol intake							
Low-risk drinker	REF	29.9	REF	39.2	REF	30.7 37.2	

(Continues)

TABLE 3 (Continued)

	1st birth spacing		2nd birth spacing		Joint Model		
	Acceleration factor	M[a]	Acceleration factor	M[a]	Acceleration factor[b]	M[a]	*P*-value[c]
Nondrinker	1.09 (1.03, 1.16)	32.7	0.94 (0.89, 1.00)	35.2	1.13 (1.02, 1.24) 0.92 (0.87, 0.98)	32.3 36.7	0.02
Rarely drinks	1.08 (1.03, 1.14)	32.7	0.98 (0.94, 1.02)	37.3	1.11 (1.03, 1.18) 0.94 (0.89, 0.99)	32.6 37.7	0.02
Risky and high-risk drinker	1.11 (0.94, 1.29)	42.5	1.17 (1.02, 1.35)	54.4	1.15 (1.02, 1.29)	37.2 46.4	0.59
Physical activity level							
Moderate	REF	29.3	REF	38.3	REF	33.8	
Nil/sedentary	1.05 (0.96, 1.15)	33.2	0.99 (0.92, 1.07)	37.8	1.03 (0.94, 1.24)	36.4	0.47
Low	0.99 (0.93, 1.05)	30.5	0.99 (0.93, 1.05)	36.5	0.99 (0.93, 1.05)	35.0	0.97
High	1.07 (1.00, 1.16)	32.5	1.03 (0.97, 1.09)	38.4	1.05 (0.98, 1.13)	34.3	0.53
Self-rated health							
Excellent	REF	28.5	REF	33.2	REF	32.1	
Very good	1.01 (0.95, 1.07)	29.3	1.11 (1.04, 1.17)	38.5	1.06 (1.00, 1.13)	33.6	0.13
Good	1.07 (1.01, 1.14)	34.3	1.07 (1.01, 1.14)	37.9	1.09 (1.03, 1.15)	35.9	0.98
Fair/poor	1.16 (1.04, 1.29)	40.9	1.15 (1.05, 1.26)	45.4	1.15 (1.05, 1.26)	40.5	0.98
SF36: Mental Health Subscale score							
≥52	REF	30.9	REF	37.5	REF	34.1	
<52	1.00 (0.95, 1.06)	36.2	1.07 (1.01, 1.14)	42.7	1.03 (0.98, 1.09)	37.7	0.23
Fertility problems							
No problem	REF	29.9	REF	36.9	REF	29.8 37.2	
Never tried to become pregnant	1.05 (0.95, 1.16)	32.6	1.11 (0.94, 1.29)	48.9	1.08 (0.94, 1.19)	30.8 36.6	0.75
Yes, and did not seek help/ treatment	1.16 (1.01, 1.33)	41.0	1.09 (0.99, 1.21)	42.8	1.12 (0.99, 1.26)	40.4 43.9	0.65
Yes, but sought help/ treatment	1.11 (1.02, 1.20)	36.3	0.94 (0.88, 1.01)	36.8	1.12 (1.01, 1.23) 0.92 (0.86, 1.00)	35.7 38.2	0.02
Use of contraception							
Yes	REF	31.1	REF	38.6	REF	34.2	
No	1.01 (0.96, 1.06)	31.5	0.93 (0.90, 0.97)	36.2	0.95 (0.91, 0.99)	35.5	0.20
History of miscarriage							
No	REF	30.6	REF	37.1	REF	33.9	
Yes	1.07 (1.02, 1.13)	35.2	1.06 (1.01, 1.10)	40.3	1.05 (1.01, 1.09)	38.3	0.66
History of abortion							
No	REF	30.7	REF	37.7	REF	34.0	
Yes	1.07 (1.01, 1.13)	36.6	0.97 (0.92, 1.03)	40.7	1.02 (0.96, 1.08)	38.3	0.07

[a]Estimated median (months).

[b]When two acceleration factors or medians are reported, the top and bottom figures correspond to the 1st and 2nd birth intervals, respectively.

[c]The *P* value represents the comparison of acceleration factors (AFs) in all categories to explore all possible differences.

Detailed information on health behaviors is lacking from previous studies, for instance with data limited to smoking or alcohol consumption during pregnancy for the Manitoba study.[19] In the present study, having fair or poor self-rated health was linked with longer first and second IBIs.

4.2 | Strengths and limitations of the study

The ALSWH is a long-running national cohort study, where the data are for the most part prospective, or short-term recall of events that occurred between the surveys conducted

every 3 years. Relying on self-reported survey data, rather than objectively measured or clinically reported data, has the potential to introduce issues of bias and measurement error, particularly for some factors such as physical activity levels and body weight. Previous ALSWH research that has compared measured and self-reported body weight and height has found self-report to be reasonably valid.[31] Although the present study collected data on live birth spacing, enabling calculation of IBI, it was not designed to collect dates of all unsuccessful pregnancy events including miscarriages, stillbirths, and terminations, or on other potentially relevant variables such as whether the births were the result of intended pregnancies, the gestational length of births that followed an IBI, and adverse birth outcomes for births that preceded an IBI. Although women who gave birth once before the baseline survey were included, as information was available about the subsequent IBI, those who had two or more births before Survey 1 were omitted (N = 196). Furthermore, 408 women gave birth twice within the 3-year survey spacing (with one birth shortly after completing a survey and the second less than 3 years later, IBI <36 months). For these women, variable values were taken from the survey before the first birth as there were no additional survey data collected during the IBI. This could have led to dilution of effects and misclassification. A sensitivity analysis with these women excluded showed no change to the results (data by request). The study also only included singleton births, so women with multiple births at the first or second successful pregnancy were omitted.

The main reason for exclusion of potentially eligible women (those with two or more births) was loss to follow-up, and the number of live births of these women could not be determined (N = 4975 [35%], Figure 1). For the remaining potentially eligible women, further exclusions (N = 1297 [9%]) were because of having no births, having only one birth, having twins, having >1 birth before Survey 1, having implausible IBI data, or not completing two consecutive surveys between births. The exclusion of the 4975 women with unknown number of live births could be a source of bias. A comparison of the excluded and included women on their baseline characteristics shows that women lost to follow-up were generally of lower socioeconomic status, single, reported fair/poor health, and currently smoked (Table S2).

4.3 | Conclusions

This study shows that a wide array of maternal factors is associated with variations in birth spacing. Some of these possibly reflect a woman's assessment of her overall socioeconomic conditions that are favorable for having a baby. The study provides insights on factors affecting women's reproductive choices in Australia, that, as in many high-income nations, has a below replacement fertility rate and a delayed age at first birth. Understanding the factors related to birth spacing may be useful from the point of improving prediction of women's risk of adverse birth outcomes. For example, if we know that women with more educational qualifications and who are married are more likely to have shorter birth spacing (and hence may be at risk of adverse pregnancy outcomes from this), guidelines for prepregnancy care could be even more tailored than they already are (see, eg, Shachar and Lyell[2] and the current international cohort study of over 18 million pregnancies by Marinovich et al[16]). Furthermore, research and replication are needed on the interplay of socioeconomic and health behaviors affecting birth spacing in high-income countries including factors not measured in the current study.

ACKNOWLEDGMENTS

The research on which this paper is based was conducted as part of the Australian Longitudinal Study on Women's Health by The University of Newcastle and the University of Queensland. We are grateful to the Australian Government Department of Health for funding and to the women who provided the survey data. Open access publishing facilitated by The University of Queensland, as part of the Wiley - The University of Queensland agreement via the Council of Australian University Librarians. [correction added on May 13, 2022, after first online publication: CAUL funding statement was added.]

ETHICAL APPROVAL

The ALSWH was approved by the University of Queensland and University of Newcastle Human Research Ethics Committees, and all women gave informed consent.

DATA AVAILABILITY STATEMENT

The ALSWH data are available free of charge on request to bona fide researchers. The process is documented on the website [http://www.alswh.org.au/], which includes all the survey questionnaires, data books of frequency tables for all surveys, meta-data, conditions of data access and request forms. Restrictions are imposed by some of the human research ethics committees (both national and state-based) and some data custodians on where some of the linked data may be analysed.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

How to cite this article: Mishra GD, Baneshi MR, Dobson AJ, Tooth LR. Maternal factors associated with interbirth intervals in Australia: Results from a population-based longitudinal study. *Birth*. 2022;49:728–740. doi: 10.1111/birt.12638