Title: Comparison of stillbirth trends over two decades in Wales and Western Australia using pooled routinely collected health data: International retrospective cohort study

Authors: Helen D Bailey[1*], Sarah J Kotecha[2*], William J Watkins[2], Akilew A Adane[1], Carrington CJ Shepherd[1,3], Sailesh Kotecha[2]

Joint first authorship: *HDB and SJK contributed equally to this paper.

Affiliations:

[1] Telethon Kids Institute, University of Western Australia, Nedlands, Western Australia, Australia

[2] Department of Child Health, Cardiff University School of Medicine, Cardiff, United Kingdom

[3] Ngangk Yira Research Centre for Aboriginal Health & Social Equity, Murdoch University, Murdoch, Western Australia, Australia.

Corresponding Author

Helen D Bailey

Telethon Kids Institute, The University of Western Australia, P.O. Box 855, West Perth 6872, Western Australia, Australia.

Email: Helen.bailey@telethonkids.org.au

Running title: Stillbirth trends in Wales and WA

Synopsis

Study question

This study aimed to compare stillbirth rates and trends in Wales and the State of Western Australia (WA) between 1993 and 2015.

What is already known

Stillbirth is a global public health issue. While relatively low rates are typically observed in high income countries, there are notable disparities between countries. Cross-country comparisons can provide important insights into how reductions can be potentially be achieved.

What this study adds

The stillbirth rate was persistently higher in Wales than WA from 1993 to 2015. While there was a steady decline in the stillbirth rates in WA, there was little change in Wales, resulting in widening disparities, especially among late-term births, even after adjusting for important stillbirth risk factors.

Abstract

Background

Stillbirth is a critical public health issue worldwide. While the rates in high-income countries are relatively low, there are persistent between-country disparities. We aimed to compare stillbirth rates and trends in Wales and the State of Western Australia (WA), Australia and provide insights into any differences.

Methods

In this international retrospective cohort study, we pooled population-based data collections of all births ≥24 weeks' gestation (excluding terminations for congenital anomalies) between 1993 and 2015, divided into six time-periods. The stillbirth rate per 1,000 births was estimated for each cohort in each time-period. Multivariable Poisson regression analyses, adjusted for appropriateness of growth, socio-economic status, maternal age and multiple birth, were performed to evaluate the interaction between cohort and time-period. Relative risks (RRs) and 95% confidence intervals (CIs) for each time-period and cohort were calculated.

Results

There were 767,731 births (3,725 stillbirths) in Wales and 648,373 (2,431 stillbirths) in WA. The overall stillbirth rate declined by 15.9 % over the study period in Wales (from 5.3 in 1993-96 to 4.5 per 1,000 births in 2013-15; *P* trend 0.001) but by 40.4% in WA (from 4.9 to 2.9 per 1,000 births in WA; *P* trend <0.001). Using 1993-1996 in WA as the reference group, the adjusted RRs for late-term stillbirths in the most recent study period (2013-15) were 0.85 (95% CI 0.64 to 1.13) in Wales and 0.51 (95% CI 0.36 to 0.73) in WA.

Conclusions

The stillbirth rates between Wales and WA have widened in the last two decades (especially among late-term births), although the absolute rates for both are distinctly higher than the

best-performing nations. While the differences may be partly explained by timing of birth and maternal lifestyle behaviours such as smoking, it is important to identify and ameliorate the associated risk factors to support a reduction in preventable stillbirths.

Keywords

Stillbirth; trend; Wales; Western Australia;

Tweetable abstract

There was a steady decline in the stillbirth rate in Western Australia between 1993 and 2015, but little change in Wales. This has given rise to widening disparities between these two high-income jurisdictions.

Funding

National Health and Medical Research Council (APP1127265), Public Health Wales

Word count 3689

Background

Stillbirth remains an important health outcome, even in high income settings which have relatively low estimated stillbirth rates (~3.4 per 1000 births compared with global rates of >18%).[1] Despite small rate reductions that have been observed in high income countries (HICs) in recent years, significant differences remain between HICs but the underlying reasons remain largely unknown even when different definitions are taken into account e.g. the inclusion or exclusion of congenital anomalies and late terminations of pregnancy. The vast majority of stillbirths occur or have their origins in the ante-partum period[2] and—despite limitations and difficulties in the investigation and classification of fetal loss (and associated data collection)—many stillbirths in HICs are considered preventable.[3,4] Recommended strategies for prevention include ensuring women are in good health prior to and during pregnancy, appropriate identification and management of women with known risk factors including obesity, smoking, multiple or post-term pregnancy and previous fetal loss,[2] and detection and appropriate management of suspected fetal growth restriction.[5]

Variations in the rates and trends across HICs suggest that further reductions are possible, although identification of the reasons for between-country inequalities is challenging. International comparative studies typically implicate systems of antenatal care and population socio-demographics as explanatory factors for these disparities. However, few studies have directly compared pooled data (in terms of population coverage, time-periods and definitions) to enable direct comparisons.[6] Wales in the UK and Australia are candidate regions for direct comparison given their robust data acquisition and quality (both have population-based birth data for over 20 years), population characteristics (largely a common British ancestry)[7] and health care systems (universal, although in Western Australia (WA), the private health care system is also important with an upward trend in the proportion of births in the private system).[8]

Our aims were to provide a more nuanced examination of the stillbirth rates in defined populations between Wales and WA. Specifically, we aimed (1) to compare stillbirth rates and trends over time in Wales and WA, using routinely collected population-based datasets of all births occurring between 1993 and 2015; and (2) to perform analyses on pooled data from both regions to explore the impact of maternal and other characteristics on the trends in stillbirth risk.

Methods

This study followed the REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) guidelines[9] and the checklist is included in a supplementary file (Table S1).

Data sources and study population

This study included all births occurring from 1993-2015 with a gestational age of at least 24 weeks in Wales and WA, after exclusion of terminations for congenital anomalies (n=479, <0.1%) (Figure 1). The Welsh data for this study were obtained from the All Wales Perinatal Survey (AWPS), which has coordinated the collection of perinatal and infant mortality data (from different sources) in Wales since 1993 and collated and reported perinatal and infant deaths for each calendar year. From 1993-2012, this included notifications from a network of maternity and neonatal unit-based coordinators; from 2013 onwards, data collection for the UK was centralised with MBRRACE-UK (Mothers and Babies: Reducing Risk through Audits and Confidential Enquiries across the UK).[10] AWPS and MBRRACE collaborated closely to ensure that this change did not affect data quality or ascertainment. Welsh data was provided by the National Health Service Wales Informatics Service (NWIS) for the entire study period. NWIS retrieved data from various sources including the Patient Episode Database in Wales[11] and the National Community Child Health Database[12] which contain data for all births at any gestational age, including live births and stillbirths occurring from 24 weeks' gestation (the legal definition of stillbirth in the UK). Data collected by AWPS and MBRRACE-UK included detailed information on individual deaths such as causes of death including lethal congenital anomalies.

The WA data for this study were obtained from population health datasets (Midwives Notification System (MNS), Birth and Death Registers and Western Australian Register of Developmental Anomalies) which are linked by the Data Linkage Branch of the Western Australian Department of Health. The Data Linkage Branch uses probabilistic matching techniques[13] and provides data to third-party researchers with identifying fields removed. The MNS contains information about all livebirths and stillbirths of at least 20 weeks' gestation in WA while the Western Australian Register of Developmental Anomalies contains information based on statutory notification of congenital anomalies including those diagnosed in utero. Apart from information about terminations for congenital anomalies, no information was available about cause of stillbirth for WA.

Data management

In Wales, a termination for congenital anomaly was defined as a termination with a congenital anomaly listed as a cause of death using the Cause Of Death and Associated Condition (CODAC) classification from 2013-2015[14] and the Centre for Maternal and Child Health enquires (CMACE) classification from 1993-2012;[15] in WA, it was any termination diagnosed with a congenital anomaly using the 5-digit British Paediatric Association adaptation of the International Classification of Diseases, Ninth Revision.[16] Ultrasound dating prior to 20 weeks, which is more accurate than last menstrual date,[17] was used to estimate gestational age in WA (71%) and routinely used in Wales since the early 1990s.[18] Appropriateness of growth for gestational age was categorised into three groups (<3rd, 3-<10th and ≥10th centile after adjusting for sex and gestational age (GA)). For the Welsh data, this was calculated using the LMS Growth software (Medical Research Council, UK) which does not account for multiple births,{Cole, 1998 #67;Pan H, 2012 #6} while in the WA data, these were calculated using two methods: 1) using the Australian national birthweight centiles for singletons[19] for all births; and 2) and twin[20] live births' centiles for multiple births (used for sensitivity analyses). Both cohorts had an area-based, composite measure of socio-economic status (SES) of the birth residence that was applied at a small area level, and categorised into quintiles derived from the Welsh population and the State population in WA. For Wales, we applied the most date relevant Welsh Index of Multiple Deprivation (WIMD),[21] the official measure of deprivation in small areas in Wales and for WA the Index of Relative Socio-Economic Disadvantage,[22] which is generated for each Census year. The birth year was used to determine the most appropriate index value for each birth. The other available co-variates were categorised as follows: sex (male/female), year of birth (1993-1996, 1997-2000, 2001-2004, 2005-2008, 2009-2012, 2013-2015), multiple birth (yes/no), maternal age (<20, 20-24, 25-29, 30-34, 35-39, ≥40 years) and GA (24-27, 28-31, 32-36, 37-38, 39-41 and >41 weeks).

Supporting information - WA data only

WA data sources enabled an examination of additional information and explanatory risk factors: hospital or other place of birth category; any maternal smoking in pregnancy (from 1998); body mass index (BMI) at the maternal ante-natal booking appointment (from 2012);

and maternal self-report of Aboriginal and/or Torres Strait Islander (hereafter Aboriginal) status (Indigenous Australian). For the latter, we used an indicator derived from multiple administrative datasets, based on the algorithm developed by the 'Getting our Story Right' collaboration.[23]

Hospital or other place of birth was categorised as tertiary or metropolitan public hospital, metropolitan private hospital, country hospital (public or private) and other (birth centre, planned home delivery), and BMI was categorised into four categories (underweight (BMI<18.5 kg/m^2), normal weight (18.5-24.99 kg/m^2), overweight (25-29.99 kg/m^2) and obese (BMI $\geq$30 kg/m^2)) as per the World Health Organization classifications.[24]

Statistical analyses

The overall stillbirth rate per 1,000 births was estimated for each region for each time-period, using all births for that time-period as the denominator. Gestational age-specific rates were calculated using by two different denominators: 1) the number of ongoing pregnancies at the beginning of the gestational age group (fetuses-at-risk approach)[25,26] and 2) total births in the gestational age group (births-based approach). Time trends were assessed using the Cochrane-Armitage trend test.[27,28] Percentage reductions were calculated as the difference in rates between the first and last time-periods (i.e. stillbirth rate in 2013-2015 minus stillbirth rate in 1993-1996 divided by stillbirth rate in 1993-96 multiplied by 100).

Unconditional multivariable Poisson regression with robust error variance[29] was used to examine the association between stillbirth and available risk factors, including appropriateness of growth group, SES quintile, sex, year of birth group, multiple births and maternal age group, with all but sex included in the final models. We adjusted for the cohort of origin and additional analyses were done for each gestational age group using the fetuses-at-risk approach by using a binary variable (stillbirth/ongoing pregnancy). These analyses generated pooled relative risks (RRs) and 95% confidence intervals (CIs). Additional multivariable Poisson regression analyses were performed using the sample without missing values to evaluate the interaction between study and time-period, using WA and 1993-1996 as the reference group. For WA only, frequency tables were produced for hospital or other place of birth, smoking and maternal BMI for the relevant time-periods.

Missing Data

The overall level of missing data was low for all variables in each study (<3%) (Table 1). However, 5,535 maternal ages (5.5% of livebirths) for the 2013-2015 Welsh data were missing, compared to ~0.5% for the other time-periods—accordingly, the MICE (Multivariate Imputation by Chained Equations) imputation method[30] was used with 50 iterations to impute the missing data (see Supplementary material and Table S2 for further details).

Sensitivity analyses

The analyses were repeated firstly without using the imputed data, then using the Australian twin centiles[20] to define SGA for multiple births and finally excluding births to Aboriginal mothers from the WA data since stillbirth rates are higher in this group than for other groups in WA.[31]

Apart from the multiple imputation which used R version 3.9.0,[32] all other analyses were performed using SAS version 9.4 (SAS Institute Inc, Cary, NC, USA).

Ethics approval

Welsh data were collected after both research ethics committee approval (09/WSE02/54+5) and Confidential Advisory Group approval. Anonymised categorised and encrypted data for Wales was shared with WA after sponsor's approval and formal data sharing agreements between Cardiff University and Telethon Kid's Institute in Perth to permit direct comparisons of both datasets. In WA, ethics approvals were obtained from the Western Australian Department of Health Human Ethics Research Committee (2016/51) and the Western Australian Aboriginal Health Ethics Committee (797).

Results

Between 1993 and 2015, there were a total of 767,731 births including 3,725 stillbirths (4.85/1,000 births) in Wales and 648,373 births including 2,431 stillbirths (3.75/1,000 births) in WA with at least 24 weeks' gestation after exclusion of terminations for congenital anomalies (Table 1). The results highlighted fewer preterm births in Wales and, concurrently, a greater likelihood of being born at 39 weeks' gestation or later. In addition, Welsh mothers were more likely to be younger and to live in a more deprived area. We observed a decrease in the proportion of mothers aged under 20 years over time, and an increase at 40 years of age and over. In WA, there was also a decline in the proportion of births at 39 weeks' gestation or later with only 0.4% of births occurring after 41 weeks by 2013-2015 (Table S3). Birthweights tended to be higher in WA than Wales, except at the extremes of gestation (Table S4).

The overall stillbirth rate declined by 15.9% over the study period in Wales (from 5.3 in 1993-96 to 4.5 per 1,000 births in 2013-15; *P* trend 0.001) and by 40.4% in WA (from 4.9 to 2.9 per 1,000 births in WA; *P* trend <0.001) (Table 2, Figure S1). Using the fetuses-at-risk as the denominator, there were significant decreases in the GA group specific rates in all but the 24-27 week's group in WA, but only for those under 32 weeks in Wales. For the 37-38 and 39-41 weeks' groups, the rates decreased by 14.2% (*P* trend 0.924) and 14.1% (*P* trend 0.315) in Wales and 40.8% and 50.4% (*P* trends both <0.001) in WA, respectively. The overall stillbirth rates among those over 41 weeks were 1.2 and 2.6 per 1,000 births for Wales (51 stillbirths) and WA (15 stillbirths), respectively, but there were insufficient stillbirths to investigate trends. Similar patterns were also seen in the GA group specific rates using total births as a denominator (Table S5).

The multivariable analyses used the 1,409,948 live births and 6,156 stillbirths (Figure 1). These results highlight that SGA was strongly associated with stillbirth—for each GA group, for both Wales and WA—particularly for growth restricted babies below the 3^{rd} but also for those between 3-<10^{th} percentiles (Table 3). Having a multiple birth was also associated with increased risk of stillbirth in each gestational age group while older maternal age, particularly above 40 years of age, was associated with stillbirth among the two term groups.

Multivariable analysis of pooled study data was used to evaluate the interaction between study and time-period, using WA and 1993-1996 as the reference group. The analyses highlighted that the adjusted stillbirth rates in the most recent study period (2013-15) were lower in WA than in Wales, although the differences were only statistically significant at 24-27 weeks' gestation and overall (Figure 2). Further, we observed decreases over time (1993-96 to 2013-15) in WA in the adjusted risk of stillbirth for those born at all gestations, which were statistically significant except for those at 28-31 weeks' gestation. In Wales, the risk declined only among births at 28-31 weeks' gestation (Figure 2).

Sensitivity analyses

There was little change in effect estimates when the analyses were repeated without imputed values (Figure S2), using the Australian Twin centiles to define SGA (Figure S3) and excluding births to Aboriginal mothers (6.3% of births) from the WA data (Figure S4).

Supplementary information – WA only

Overall, 44.6% of births occurred in tertiary or metropolitan public hospitals, 35.0% in metropolitan private hospitals, 19.7% in country hospitals (public or private) and 0.7% at other sites. Between 1993-1995 and 2013-2015, the proportion of births in metropolitan private hospitals increased from 26.8% to 37.8%, with corresponding declines among other hospital categories (results not otherwise shown). Between 1998-2000 and 2013-2015 the proportion of births to mothers who smoked during pregnancy decreased from 22.1% to 10.1%, with the proportions of births to both overweight (from 27.7% to 21.4%) and obese (27.7% to 21.4%) mothers decreased between 2012 and 2015 (results not otherwise shown).

Comment

Principal findings

Using over 20 years of population-based data, we found that the stillbirth rates had decreased between 1993 and 2015 in both Wales and WA. After accounting for differences in known stillbirth risk factors, we observed a steady decline in the rates in WA over time and correspondingly little change in Wales—resulting in widening stillbirth rate disparities which were most evident in births at 39 weeks' gestation or later.

Strengths of the study

The strength of this study is the use of total population birth data from both Wales and WA which was available for a 23-year time-period. Importantly, we adjusted for known stillbirth risk factors (SGA, advanced maternal age, multiple births and higher deprivation level) when comparing stillbirth rates over time and place and the findings of the multivariable analyses confirmed their importance, particularly SGA. Unlike previous comparisons of rates between the UK and Australia,[33] which used a lower limit of 28 weeks, we extended the comparison down to ≥24 weeks' gestation. We also excluded medical terminations for congenital anomalies, albeit with differences in definitions.

Limitations of the data

Our study was limited to factors that were available in both cohorts—as such, were unable to include some known risk factors (e.g. primiparity, antenatal smoking, obesity and maternal ethnicity)[34] and consider potentially important covariates (e.g. whether labour was spontaneous, birth mode). In addition, we acknowledge that there are important socio-demographic differences between the study cohorts (including ethnicity) that could not be adequately accounted for with available data.

The data sharing agreement only allowed gestational age to be shared at the category level, so we could not investigate trends among term births for each week of gestation. In gestational age-specific analyses, we used SGA based on birthweight as a proxy for fetal growth restriction among the fetuses-at-risk. While for term births, this may be a good proxy, it may not be at lower gestations as the fetal growth restriction may have occurred later in the pregnancy. Therefore, we may have over-estimated the prevalence of fetal growth restrictions at lower gestations, resulting in an under-estimation of the true strength of the association between SGA and stillbirth.

Interpretation

The stillbirth rate reductions in WA are similar to trends seen in Australia as a whole.[35] Similar to our findings, MBRRACE-UK reported relatively static findings for Wales between 2003-2013, unlike the declines seen in England and Scotland.[36] Among births of at least 28 weeks' gestation, the stillbirth rates in UK (England and Wales) in 2004 and 2010 were higher than the majority of the European countries in the Euro-Peristat project,[37] while in a global comparison, the UK had higher stillbirth rates than Australia in both 2000 (3.7 and 3.4/1000 births respectively) and 2015 (2.9 and 2.7/1000 births respectively), although rates in Australia were still high compared with Iceland, Denmark, Finland and the Netherlands—which had rates below 2.0/1000 births.[1]

While there is potential for reduction in stillbirth rates in both WA and Wales compared with the best-performing HICs, the growing disparities in stillbirth rates between Wales and WA is concerning. These disparities may, in part, reflect differential changes in primary stillbirth risk factors over time between the two populations. They may also be due to the relatively large downward shift in gestational age at birth among term and post-term births in WA (an Australia-wide trend[35]), given the increase in stillbirth risk with advancing gestation at term.[38] In WA, the proportion of births at 39 weeks or later decreased from 65% to 59% between 1993-2015; while the corresponding proportion remained unchanged in Wales (75%). As early term birth is associated with short and long term adverse outcomes,[39,40] intervention should not be initiated without good reason and considered against the risks of continued pregnancy. The shift to earlier births can lead to maternal complications including caesarean section and instrumental birth, neonatal mortality, and morbidity in early life often requiring admission to neonatal units and medical interventions especially for respiratory disorders.

Our study accounted for the differential distribution of some key variables (maternal age, SGA, SES, multiple births), suggesting that differences in the prevalence of other known risks (e.g. maternal smoking and obesity) and quality of antenatal care may be relevant targets in identifying strategies for reduction. Changes in maternal smoking, for example, may be one driver behind the decline in WA rates. Over the study time-period, antenatal smoking rates more than halved. This parallels the reductions seen in the Australian population as a whole in response to a range of tobacco control measures introduced since the early 1970s[41] and increasing targeting of high-risk populations (e.g. pregnant women).[42] The limited available data suggests that the rate of antenatal maternal smoking in Wales in 2015/2016 was 18%;[43] which is similar to those in WA a decade earlier and among the highest rates in Europe.[44] Since the release of the Tobacco Control Action Plan for Wales in 2012, adult smoking levels have declined to 19% in 2015, which is on track to meet the target of 16% by 2020.[45]

The rates of stillbirth in WA have declined despite the increasing levels of obesity in the Australian population.[46] The levels of maternal obesity in WA in 2015 (18%) were lower than those reported for Wales (26%) but higher than 11 other European countries.[44]

There are significant differences in models of care in Wales and WA. In Wales, the majority of mothers give birth in publicly funded National Health Service hospitals either in consultant obstetrician-led or midwifery-led birth units. An MBBRACE enquiry reported that at least one element of care required improvement in 50% of antepartum normally formed singleton stillbirths at term and raised concerns that the key lessons were similar to those raised in the UK twenty years before.[47] In contrast in WA, the proportion of women giving birth at private hospitals under the care of a private obstetrician increased steadily over the study period. Private obstetrician-led care in Australia is associated with more interventions but reduced risk of perinatal death.[48] However, these findings may not be applicable elsewhere as the common factor between HICs with very low stillbirth rates is the availability of pregnancy care in the public sector,[49] with low rates of interventions[50] and often midwife-led.[49,51] Whether these lower rates in these countries are due to genes, environment or quality of care related issues is uncertain but clearly a subject for continued exploration.

Population-based audits of perinatal deaths such as those in the Welsh and WA systems[10,52] have been associated with declining stillbirth rates,[53] especially when they incorporate thorough autopsy and accurate identification of stillbirth causes for most cases. While an autopsy was requested by clinicians in 96.4% of Welsh stillbirth cases in 2015, parental consent was only given for 43.2%.[54] Post-mortem rates are notionally higher in WA (61% in 2011-13), but a substantial proportion of stillbirths were classified as 'unexplained antepartum death'[52]—further underscoring the need to ensure that systems support bereaved parents in their understanding of post-mortem processes.[55]

This study highlights the need for the collection of high quality data to enable an assessment of the impact of changes in timing of birth, socio-demographic circumstances and quality of care on between-country disparities in all adverse early life outcomes. Euro-Peristat already investigates differences in perinatal health indicators with the aim to learn from best practice[44] so broadening this approach beyond Europe[56] would enable comparisons on a wider scale.

Future research needs to focus on the impact of policy changes and interventions on reducing stillbirth rates. This will provide population-level data on a broader range of factors. For example, although SGA and reduced fetal movements are known risk factors for stillbirth, few data about screening for and management of fetal growth restriction or concerns about fetal movements are routinely collected.

Conclusions

We used robust, population-level data from two HICs, and accounted for important known risk factors, to highlight growing disparities in stillbirth rates over time between Wales and WA—especially among late-term births. Whilst some of these differences may be partially explained by maternity practices or maternal lifestyle behaviours, robust investigation is required to identify factors that have led to the disparity that we have observed.

References

1. Lawn JE, Blencowe H, Waiswa P, Amouzou A, Mathers C, Hogan D, et al. Stillbirths: rates, risk factors, and acceleration towards 2030. *Lancet.* 2016;387(10018):587-603.
2. Flenady V, Middleton P, Smith GC, Duke W, Erwich JJ, Khong TY, et al. Stillbirths: the way forward in high-income countries. *Lancet.* 2011;377(9778):1703-1717.
3. Page JM, Thorsten V, Reddy UM, Dudley DJ, Hogue CJR, Saade GR, et al. Potentially Preventable Stillbirth in a Diverse U.S. Cohort. *Obstet Gynecol.* 2018;131(2):336-343.
4. Flenady V, Wojcieszek AM, Middleton P, Ellwood D, Erwich JJ, Coory M, et al. Stillbirths: recall to action in high-income countries. *Lancet.* 2016;387(10019):691-702.
5. Gardosi J, Madurasinghe V, Williams M, Malik A, Francis A. Maternal and fetal risk factors for stillbirth: population based study. *BMJ.* 2013;346:f108.
6. Australian Institute of Health and Welfare (AIHW). *A working guide to international comparisons of health* Canberra AIHW;2012. Cat. no. PHE 159
7. Australian Bureau of Statistics. 2016 Census QuickStats. 2017; https://quickstats.censusdata.abs.gov.au/census_services/getproduct/census/2016/quickstat/036. Accessed 11 Oct, 2019.
8. Hutchinson M, Joyce A. *Western Australia's Mothers and Babies, 2013: 31st Annual Report of the Western Australian Midwives' Notification System.* Perth, Western Australia.2016
9. Benchimol EI, Smeeth L, Guttmann A, Harron K, Moher D, Petersen I, et al. The REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) statement. *PLoS Med.* 2015;12(10):e1001885.
10. MBRRACE-UK. MBRRACE-UK. Mothers and Babies: Reducing Risk through Audits and Confidential Enquiries across the UK. https://www.npeu.ox.ac.uk/mbrrace-uk.
11. NHS Wales Infomatics Service. Patient Episode Database, PEDW. Secondary Patient Episode Database, PEDW. http://www.infoandstats.wales.nhs.uk/page.cfm?orgid=869&pid=40977. Accessed 21/11/19, 2019.
12. Statistics for Wales Welsh Government. National Community Child Health Database. Secondary National Community Child Health Database. https://gov.wales/births-data-national-community-child-health-database.
13. Holman CDJ, Bass AJ, Rouse IL, Hobbs MST. Population-based linkage of health records in Western Australia: development of a health services research linked database. *Australian and New Zealand Journal of Public Health.* 1999;23(5):453-459.
14. Froen JF, Pinar H, Flenady V, Bahrin S, Charles A, Chauke L, et al. Causes of death and associated conditions (Codac): a utilitarian approach to the classification of perinatal deaths. *BMC Pregnancy Childbirth.* 2009;9:22.
15. Centre for Maternal and Child health Enquiries (CMACE). *Perinatal Mortality 2008.* United Kindgom 2010
16. Bower C, Baynam G, Rudy E, Quick J, Rowley A, Watson L, et al. *Western Australian Regiser of Developmental anomalies 1980-2014.* Subiaco: King Edward Memorial Hospital; 2015 2015
17. Butt K, Lim K, Diagnostic Imaging C. Determination of gestational age by ultrasound. *J Obstet Gynaecol Can.* 2014;36(2):171-181.
18. Knight B, Brereton A, Powell RJ, Liversedge H. Assessing the accuracy of ultrasound estimation of gestational age during routine antenatal care in in vitro fertilization (IVF) pregnancies. *Ultrasound.* 2018;26(1):49-53.
19. Dobbins TA, Sullivan EA, Roberts CL, Simpson JM. Australian national birthweight percentiles by sex and gestational age, 1998-2007. *Medical Journal of Australia* 2012;197(5):291-294.
20. Li Z, Umstad MP, Hilder L, Xu F, Sullivan EA. Australian national birthweight percentiles by sex and gestational age for twins, 2001-2010. *BMC Pediatr.* 2015;15:148.
21. Statistics for Wales. *Welsh Index of Multiple Deprivation 2014 (WIMD 2014); Guidance on use.* 2014.https://gov.wales/sites/default/files/statistics-and-research/2019-01/141112-wimd-2014-guidance-en.pdf

22. Australian Bureau of Statistics. Socio-Economic Indexes for Areas (SEIFA) 2011(Catalogue No 2033.0.55.001).
23. Christensen D, Davis G, Draper G, Mitrou F, McKeown S, Lawrence D, et al. Evidence for the use of an algorithm in resolving inconsistent and missing Indigenous status in administrative data collections. *The Australian Journal of Social Issues.* 2014;49(4):423-443.
24. World Health Organization. Global database on body mass index 2006; http://www.assessmentpsychology.com/icbmi.htm. .
25. Joseph KS. Incidence-based measures of birth, growth restriction, and death can free perinatal epidemiology from erroneous concepts of risk. *J Clin Epidemiol.* 2004;57(9):889-897.
26. Kramer MS, Liu S, Luo Z, Yuan H, Platt RW, Joseph KS, et al. Analysis of perinatal mortality and its components: time for a change? *Am J Epidemiol.* 2002;156(6):493-497.
27. Armitage P. Tests for linear trends in proportions and frequencies. *Biometrics.* 1955;11(3):375-386.
28. Cochran WG. Some methods for strengthening the common χ2 tests. *Biometrics.* 1954;10(4):417-451.
29. Zou G. A modified poisson regression approach to prospective studies with binary data. *American Journal of Epidemiology.* 2004;159(7):702-706.
30. van Buuren S, Groothuis-Oudshoorn K. mice: Multivariate Imputation by Chained Equations in R. *Journal of Statistical Software.* 2011;45(3):1-67.
31. Adane AA, Bailey HD, Marriott R, Farrant BM, White SW, Stanley FJ, et al. Disparities between Aboriginal and non-Aboriginal perinatal mortality rates in Western Australia from 1980 to 2015. *Paediatr Perinat Epidemiol.* 2019.
32. *R: A Language and Environment for Statistical Computing.* [computer program]. Version V4.0.0. Vienna, Austria: R Foundation for Statistical Computing; 2020.
33. Blencowe H, Cousens S, Jassir FB, Say L, Chou D, Mathers C, et al. National, regional, and worldwide estimates of stillbirth rates in 2015, with trends from 2000: a systematic analysis. *Lancet Glob Health.* 2016;4(2):e98-e108.
34. Flenady V, Koopmans L, Middleton P, Froen JF, Smith GC, Gibbons K, et al. Major risk factors for stillbirth in high-income countries: a systematic review and meta-analysis. *Lancet.* 2011;377(9774):1331-1340.
35. Hilder L, Flenady V, Ellwood D, Donnolley N, Chambers GM. Improving, but could do better: Trends in gestation-specific stillbirth in Australia, 1994-2015. *Paediatr Perinat Epidemiol.* 2018.
36. Manktelow BN, Smith LK, Evans TA, Hyman-Taylor P, Kurinczuk JJ, Field DJ, et al. *Perinatal Mortality Surveillance Report UK Perinatal Deaths for births from January to December 2013* Leicester: The Infant Mortality and Morbidity Studies, Department of Health Sciences, University of Leicester;2015
37. Zeitlin J, Mortensen L, Cuttini M, Lack N, Nijhuis J, Haidinger G, et al. Declines in stillbirth and neonatal mortality rates in Europe between 2004 and 2010: results from the Euro-Peristat project. *J Epidemiol Community Health.* 2016;70(6):609-615.
38. Muglu J, Rather H, Arroyo-Manzano D, Bhattacharya S, Balchin I, Khalil A, et al. Risks of stillbirth and neonatal death with advancing gestation at term: A systematic review and meta-analysis of cohort studies of 15 million pregnancies. *PLoS Med.* 2019;16(7):e1002838.
39. Kotecha SJ, Watkins WJ, Lowe J, Henderson AJ, Kotecha S. Effect of early-term birth on respiratory symptoms and lung function in childhood and adolescence. *Pediatr Pulmonol.* 2016;51(11):1212-1221.
40. Bentley JP, Roberts CL, Bowen JR, Martin AJ, Morris JM, Nassar N. Planned Birth Before 39 Weeks and Child Development: A Population-Based Study. *Pediatrics.* 2016;138(6).
41. Department of Health. Australian Government. Tobacco control — key facts and figures. 2017; https://www.health.gov.au/sites/default/files/tobacco-control-key-facts-and-figures.pdf. Accessed, accessed 22/11/19.
42. Australian Government Department of Health. *Clinical Practice Guidelines: Pregnancy Care.* Canberra: Australian Government Department of Health; 2018.

43. Statistics for Wales. *Maternity Statistics, Wales, 2015-2016 (Experimental Statistics).* 2017. SFR 58/2017.https://gov.wales/sites/default/files/statistics-and-research/2019-01/maternity-statistics-financial-year-2015-to-2016-experimental-statistics.pdf. 27/11/19
44. Euro-Peristat Project. *European Perinatal Health Report. Core indicators of the health and care of pregnant women and babies in Europe in 2015.* 2018.https://www.europeristat.com/images/EPHR2015_web_hyperlinked_Euro-Peristat.pdf. 30/10/19
45. NHS Wales. *Tobacco control delivery plan for Wales 2017-20.* 2017.https://gov.wales/sites/default/files/publications/2017-11/tobacco-control-delivery-plan-for-wales-2017-to-2020.pdf. 25/11/19
46. Australian Institute of Health and Welfare. *A picture of overweight and obesity in Australia.* Canberra2017.https://www.aihw.gov.au/reports/overweight-obesity/overweight-obesity-australia-birth-cohort-analysis/contents/table-of-contents. 25/11/19
47. Draper ES, Kurinczuk JJ, Kenyon SE, Enquiry. oboM-UM-UPC. MBRRACE-UK perinatal confidential enquiry: term, singleton, normally formed, antepartum stillbirth. In: , Leicester, UK: The Infant Mortality and Morbidity Studies, Department of Health Sciences, University of Leicester, ; 2015: https://www.npeu.ox.ac. uk/downloads/files/mbrrace-uk/reports/MBRRACE-UK%20Perinatal% 20Report%202015.pdf. Accessed 2017 Nov 24.
48. Adams N, Tudehope D, Gibbons KS, Flenady V. Perinatal mortality disparities between public care and private obstetrician-led care: a propensity score analysis. *BJOG.* 2018;125(2):149-158.
49. Hemminki E, Blondel B, Study Group on B, Incentives to Prenatal Care in E. Antenatal care in Europe: varying ways of providing high-coverage services. *Eur J Obstet Gynecol Reprod Biol.* 2001;94(1):145-148.
50. Swift EM, Tomasson G, Gottfreethsdottir H, Einarsdottir K, Zoega H. Obstetric interventions, trends, and drivers of change: A 20-year population-based study from Iceland. *Birth.* 2018;45(4):368-376.
51. Cronie D, Rijnders M, Jans S, Verhoeven CJ, de Vries R. How good is collaboration between maternity service providers in the Netherlands? *J Multidiscip Healthc.* 2019;12:21-30.
52. Ballestas T., on behalf of the Perinatal and Infant Mortality Committee of Western Australia. *The 15th Report of the Perinatal and Infant Mortality Committee of Western Australia for deaths, 2011-2013. .* Perth, Western Australia2017
53. Norris T, Manktelow BN, Smith LK, Draper ES. Causes and temporal changes in nationally collected stillbirth audit data in high-resource settings. *Semin Fetal Neonatal Med.* 2017;22(3):118-128.
54. Perinatal Survey Office. *All Wales Perinatal Survey Annual Report 2015.* Cardiff: Department of Child Health, School of Medicine, Cardiff University;2015.http://awpsonline.uk. 16/12/19
55. Heazell AE, McLaughlin MJ, Schmidt EB, Cox P, Flenady V, Khong TY, et al. A difficult conversation? The views and experiences of parents and professionals on the consent process for perinatal postmortem after stillbirth. *BJOG.* 2012;119(8):987-997.
56. Zylbersztejn A, Gilbert R, Hjern A, Hardelid P. How can we make international comparisons of infant mortality in high income countries based on aggregate data more relevant to policy? *BMC Pregnancy Childbirth.* 2017;17(1):430.

Acknowledgements

WA: We would like to acknowledge the Data Linkage Branch (Western Australian Government Department of Health), the custodians of the Midwives' Notification System, Birth and Death Registries, and Western Australian Register of Developmental Anomalies for providing data for this project, as well as Paul Stevenson and Matt Cooper, from the Telethon Kids Institute's Biometrics team who performed the imputation for the WA data

Funding

The Western Australian part of this study was supported by funding from an Australian National Health and Medical Research Council (NHMRC) Project Grant (GNT1127265) which funded AAA, HDB, and CCJS.

The AWPS (SK and SJK) was funded by Public Health Wales. The funding sources did not participate in the design or conduct of the study; collection, data management analysis or interpretation, or any part of the manuscript preparation.

Data Sharing

No additional data are available.

Figure legends

Figure 1: Study flow chart for Western Australia and Wales

Figure 2. Comparison of the adjusted relative risks and 95% confidence intervals for stillbirth in Wales and Western Australia (1993-2015) (excluding terminations of pregnancy for congenital anomalies), stratified by gestational age at stillbirth (using the Western Australia rate for 1993-1996 as the reference).

Table 1. Characteristics of all births ≥24 weeks' gestation in Wales and Western Australia, excluding terminations for congenital anomalies (1993-2015)

	Wales	Western Australia
	n = 767,731	n = 648,373
	n (%)	n (%)
Characteristic		
Birth status		
Live birth	764,006 (99.5)	645,942 (99.6)
Stillbirth	3,725 (0.5)	2,431 (0.4)
Sex		
Female	373,784 (48.7)	316,279 (48.8)
Male	393,865 (51.3)	332,094 (51.2)
Missing	82 (0.0)	0 (0.0)
Gestational age (weeks)		
24-27	3,551 (0.5)	2,469 (0.4)
28-31	7,257 (0.9)	5,247 (0.8)
32-36	47,611 (6.2)	47,507 (7.3)
37-38	137,895 (18.0)	200,765 (31.0)
39-41	529,467 (69.0)	386,694 (59.6)
>41	41,950 (5.5)	5,691 (0.9)
Plurality		
Singleton	746,038 (97.2)	629,526 (97.1)
Multiple birth	21,662 (2.8)	18,847 (2.9)
Missing	31 (0.0)	
Small for gestational age (centiles)[a]		
<3	20,902 (2.7)	16,928 (2.6)
3-<10	46,245 (6.0)	41,654 (6.4)
≥10	700,266 (91.2)	589,785 (91.0)
Missing	318 (0.0)	7 (0.0)
Maternal age (years)		
<20	64,583 (8.4)	32,505 (5.0)
20-24	169,259 (22.0)	104,780 (16.2)
25-29	223,531 (29.1)	190,472 (29.4)
30-34	194,746 (25.4)	203,001 (31.3)
35-39	89,834 (11.7)	98,490 (15.2)
≥ 40	18,420 (2.4)	19,125 (3.0)
Missing	7,358 (1.0)	0 (0.0)
Quintile of area-based deprivation[b]		
Most deprived	193,652 (25.2)	137,352 (21.2)
2	166,671 (21.7)	134,296 (20.7)
3	147,057 (19.2)	125,745 (19.4)
4	132,903 (17.3)	124,066 (19.1)
Least deprived	121,829 (15.9)	109,111 (16.8)
Missing	5,619 (0.7)	17,803 (2.7)
Year of birth groups		
1993-1996	142,242 (18.5)	101,373 (15.6)
1997-2000	131,934 (17.2)	101,477 (15.7)
2001-2004	115,993 (15.1)	99,457 (15.3)
2005-2008	135,883 (17.7)	115,815 (17.9)
2009-2012	141,468 (18.4)	127,885 (19.7)
2013-2015	100,211 (13.0)	102,366 (15.8)

[a] For the Welsh data, SGA cut points were calculated using the LMS Growth software (Medical Research Council, UK),[19,20] while in the WA data, the cut points were based on the Australian national birthweight centiles for singleton[21] live births since the UK calculation did not account for plurality.

[b] These are the quintiles of the relevant area-based measure of deprivation based on the Welsh population and the State population for Western Australia. For Wales, this was the Welsh Index of Multiple Deprivation (WIMD), the official measure of deprivation in small areas in Wales. For Western Australia, it was the Western Australian distribution of the smallest geographical area of Index of Social Disadvantage at the Census closest to the birth year. .[24]

Table 2. Stillbirths rates (excluding terminations for congenital anomalies) in Wales and Western Australia (1993-2015), stratified by gestational age group.

Gestational age (weeks)			Birth year							
			1993-1996	1997-2000	2001-2004	2005-2008	2009-2012	2013-2015	Overall	P trend[a]
24-27	Stillbirths per 1,000 fetuses at risk[b] (n)	Wales	1.3 (178)	1.1 (141)	1.4 (164)	1.1 (156)	1.0 (136)	1.1 (106)	1.1 (881)	0.050
		Western Australia	0.9 (96)	0.7 (69)	0.8 (79)	0.7 (86)	0.9 (110)	0.6 (58)	0.8 (498)	0.068
28-31	Stillbirths per 1,000 fetuses at risk[b] (n)	Wales	0.9 (126)	0.9 (124)	0.8 (92)	0.6 (82)	0.7 (105)	0.7 (66)	0.7 (595	0.003
		Western Australia	0.8 (79)	0.7 (74)	0.7 (66)	0.6 (68)	0.6 (74)	0.5 (56)	0.6 (417)	0.010
32-36	Stillbirths per 1,000 fetuses at risk[b] (n)	Wales	1.4 (196)	1.1 (148)	1.4 (165)	1.2 (162)	1.1 (160)	1.3 (126)	1.3 (957)	0.262
		Western Australia	1.5 (148)	1.1 (111)	0.8 (82)	0.9 (98)	0.9 (118)	0.9 (95)	1.0 (652)	<0.001
37-38	Stillbirths per 1,000 fetuses at risk[b] (n)	Wales	0.7 (91)	0.6 (77)	0.8 (84)	0.7 (91)	0.7 (98)	0.6 (55)	0.7 (496)	0.924
		Western Australia	0.7 (69)	0.7 (61)	0.8 (70)	0.7 (72)	0.7 (80)	0.4 (41)	0.7 (393)	0.037
39-41	Stillbirths per 1,000 fetuses at risk[b] (n)	Wales	1.4 (152)	1.3 (121)	1.3 (113)	1.3 (133)	1.3 (135)	1.2 (91)	1.3 (745)	0.315
		Western Australia	1.5 (99)	1.3 (82)	1.2 (71)	1.2 (78)	1.1 (81)	0.7 (45)	1.2 (456)	<0.001
All births (≥24)	Stillbirths per 1,000 births (n)	Wales	5.3 (753)	4.7 (620)	5.4 (629)	4.7 (634)	4.5 (643)	4.5 (446)	4.9 (3,725)	0.001
		Western Australia	4.9 (495)	4.0 (401)	3.7 (396)	3.5 (404)	3.6 (464)	2.9 (298)	3.7 (2,431)	<0.001

[a]Time trends were assessed using the Cochran-Armitage test for linear trend.

[b]Gestational age-specific rates were calculated as the number of stillbirths in each gestational age window divided by the number of ongoing pregnancies (fetuses at risk) at the beginning of the gestational age window multiplied by 1,000.

Table 3. The association between maternal and other factors and stillbirth in Wales and Western Australia (excluding terminations for congenital anomalies) (1993-2015), stratified by gestational age group

	Wales			Western Australia		
	Stillbirths n (%)	Ongoing pregnancies n (%)	Adjusted RR (95% CI)[a]	Stillbirths n (%)	Ongoing pregnancies n (%)	Adjusted RR (95% CI)[a]
24-27 weeks' gestation	n = 881	n = 766,850		n = 498	n = 647,875	
Maternal age (years)						
<20	99 (11.2)	65,056 (8.5)	1.24 (1.00, 1.54)	41 (8.2)	32,464 (5.0)	1.43 (1.03, 1.98)
20-34	627 (71.2)	592,523 (77.3)	1.00 (Reference)	350 (70.3)	497,903 (76.9)	1.00 (Reference)
35-39	119 (13.5)	90,695 (11.8)	1.25 (1.03, 1.53)	90 (18.1)	8,400 (15.2)	1.34 (1.06, 1.69)
≥40	36 (4.1)	18,576 (2.4)	1.70 (1.20, 2.41)	17 (3.4)	19,108 (2.9)	1.24 (0.76, 2.02)
Values imputed	2 (0.2)	7,385 (1.0)		0	0	
SGA (centiles)[b]						
<3	311 (35.3)	20,614 (2.7)	21.45 (18.36, 25.06)	169 (33.9)	16,759 (2.6)	20.79 (16.81, 25.71)
3-<10	125 (14.2)	46,144 (6.0)	4.07 (3.32, 4.97)	83 (16.7)	41,571 (6.2)	4.37 (3.40, 5.62)
≥10	445 (50.5)	700,092 (91.3)	1.00 (Reference)	246 (49.4)	589,539 (91.0)	1.00 (Reference)
Values imputed	11 (1.2)	307 (0.0)		0	0	
Multiple birth[c]	89 (10.1)	21,574 (2.8)	1.99 (1.57, 2.52)	72 (14.5)	1,875 (2.9)	3.30 (2.53, 4.32)
Quintile of area-based deprivation[d]						
Most deprived	282 (32.0)	194,679 (25.4)	1.09 (0.88,1.34)	132 (26.5)	141,192 (21.8)	1.32 (0.97, 1.79)
2	175 (19.9)	167,664 (21.9)	0.85 (0.68, 1.07)	101 (20.3)	137,886 (21.3)	1.17 (0.85, 1.61)
3	160 (18.2)	148,071 (19.3)	0.93 (0.74, 1.18)	117 (23.5)	129,037 (19.9)	1.54 (1.13, 2.10)
4	130 (14.8)	133,776 (17.4)	0.88 (0.69, 1.11)	85 (17.1)	127,604 (19.7)	1.16 (0.84, 1.61)
Least deprived	134 (15.2)	122,660 (16.0)	1.00 (Reference)	63 (12.7)	112,150 (17.3)	1.00 (Reference)
Values imputed	3 (0.3)	5,616 (0.7)		13 (2.6)	17,784 (2.7)	

28-31 weeks' gestation	n = 595	n = 763,585		n = 416	n = 645,488	
Maternal age (years)						
<20	65 (10.9)	64,689 (8.4)	1.20 (0.93, 1.56)	36 (8.7)	32,283 (5.0)	1.38 (0.98, 1.96)
20-34	450 (75.6)	590,114 (77.1)	1.00 (Reference)	310 (74.5)	496,193 (76.9)	1.00 (Reference)
35-39	59 (9.9)	90,303 (11.8)	0.85 (0.65, 1.12)	57 (13.7)	98,004 (15.2)	1.01 (0.76, 1.34)
≥40	21 (3.5)	18,479 (2.9)	1.45 (0.93, 2.25)	13 (3.1)	19,008 (2.9)	1.15 (0.66, 2.00)
Values imputed	1 (0.2)	7,358 (1.0)		0	0	
SGA (centiles)[b]						
<3	207 (34.8)	20,253 (2.7)	18.10 (15.01, 21.83)	106 (25.5)	16,584 (2.6)	12.95 (10.23, 16.39)
3-<10	64 (10.8)	45,902 (6.0)	2.71 (2.07, 3.56)	59 (14.2)	41,412 (6.4)	3.06 (2.28, 4.09)
≥10	324 (54.5)	697,430 (91.3)	1.00 (Reference)	250 (60.1)	587,487 (91.0)	1.00 (Reference)
Values imputed	4 (0.7)	299 (0.0)		0	0	
Multiple birth[c]	91 (15.3)	20,845 (2.7)	3.56 (2.81, 4.51)	41 (9.9)	18,265 (2.8)	2.53 (1.81, 3.53)
Quintile of area-based deprivation[d]						
Most deprived	174 (29.2)	193,721 (25.4)	1.22 (0.92, 1.61)	128 (30.8)	140,491 (21.8)	1.65 (1.18, 2.32)
2	143 (23.9)	166,932 (21.9)	1.25 (0.94, 1.66)	89 (21.4)	137,344 (21.4)	1.32 (0.93, 1.88)
3	113 (18.8)	147,445 (19.3)	1.19 (0.89, 1.59)	87 (20.9)	128,589 (19.4)	1.45 (1.02, 2.07)
4	91 (15.3)	133,265 (17.5)	1.10 (0.81, 1.49)	63 (15.1)	127,204 (19.1)	1.10 (0.76, 1.60)
Least deprived	74 (12.4)	122,222 (16.0)	1.00 (Reference)	49 (11.8)	111,854 (17.3)	1.00 (Reference)
Values imputed	2 (0.3)	5,597 (0.7)		16 (3.8)	17,711 (2.7)	
32-36 weeks' gestation	n = 957	n = 755,966		n = 653	n = 640,004	
Maternal age (years)						
<20	103 (10.8)	63,928 (8.4)	1.21 (0.98,1.49)	47 (7.2)	31,893 (5.0)	1.28 (0.95, 1.74)
20-34	704 (73.6)	584,456 (77.3)	1.00 (Reference)	490 (75.0)	492,209 (76.9)	1.00 (Reference)
35-39	113 (11.8)	89,333 (11.8)	1.06 (0.87, 1.30)	93 (14.2)	97,141 (15.2)	0.99 (0.79, 1.24)
≥40	37 (3.9)	18,249 (2.4)	1.70 (1.22, 2.37)	23 (3.5)	18,761 (2.9)	1.23 (0.81, 1.88)

Values imputed	2 (0.2)	7,301 (1.0)		0	0	
SGA (centiles)[b]						
<3	99 (10.2)	19,512 (2.6)	10.57 (9.06, 12.34)	72 (11.0)	16,315 (2.5)	9.69 (8.00, 11.73)
3-<10	226 (23.6)	45,265 (6.0)	2.17 (1.75, 2.69)	142 (21.7)	41,020 (6.4)	2.08 (1.62, 2.68)
≥10	632 (66.0)	691,189 (91.4)	1.00 (Reference)	439 (67.2)	582,664 (91.0)	1.00 (Reference)
Values imputed	4 (0.4)	280 (0.0)				
Multiple birth[c]	107 (11.2)	19,027 (2.5)	3.12 (2.55, 3.82)	79 (12.1)	16,775 (2.6)	3.62 (2.86, 4.59)
Quintile of area-based deprivation[d]						
Most deprived	316 (33.0)	191,505 (25.3)	1.51 (1.22, 1.87)	171 (26.2)	139,008 (21.7)	1.14 (0.89, 1.47)
2	216 (22.6)	165,214 (21.9)	1.26 (1.01, 1.58)	149 (22.8)	136,124 (21.3)	1.11 (0.86, 1.43)
3	157 (16.4)	146,089 (19.3)	1.07 (0.84, 1.36)	112 (17.2)	127,613 (19.9)	0.92 (0.70, 1.20)
4	150 (15.7)	131,978 (17.5)	1.16 (0.91, 1.48)	120 (18.4)	126,218 (19.7)	1.02 (0.79, 1.33)
Least deprived	118 (12.3)	121,180(16.0)	1.00 (Reference)	101 (15.5)	111,035 (17.3)	1.00 (Reference)
Values imputed	1 (0.1)	5,536 (0.7)		12 (1.8)	17,550 (2.7)	
37-38 weeks' gestation	n = 496	n = 708,816		n = 393	n = 592,757	
Maternal age (years)						
<20	42 (8.5)	59,682 (8.4)	1.02 (0.74, 1.41)	22 (5.6)	29,17 (4.9)	0.98 (0.63, 1.52)
20-34	358 (72.2)	549,338 (77.5)	1.00 (Reference)	285 (72.5)	457,640 (77.2)	1.00 (Reference)
35-39	70 (14.1)	83,050 (11.7)	1.27 (0.98, 1.65)	59 (15.0)	89,154(15.0)	1.12 (0.84,1.29)
≥40	26 (5.2)	16,746 (2.4)	2.34 (1.57, 3.48)	27 (6.9)	16,826 (2.8)	2.65 (1.79, 3.93)
Values imputed	0 (0)	6,818 (1.0)		0	0	
SGA (centiles)[b]						
<3	88 (17.7)	17,295 (2.4)	7.49 (5.88, 9.54)	93 (23.7)	14,948 (2.5)	11.71 (9.26, 14.81)
3-<10	41 (8.3)	42,227 (6.0)	1.57 (1.13, 2.17)	49 (12.5)	37,641 (6.4)	2.63 (1.93, 3.59)
≥10	367 (74.0)	649,294 (91.6)	1.00 (Reference)	250 (63.8)	540,166 (91.9)	1.00 (Reference)

Values imputed	5 (1)	234 (0.0)		0	0	
Multiple birth[c]	46 (9.3)	10,006 (1.4)	4.57 (3.37, 6.21)	29 (7.4)	7,316 (1.2)	3.32 (2.30, 4.80)
Quintile of area-based deprivation[d]						
Most deprived	140 (28.2)	178,423 (25.2)	1.26 (0.94, 1.69)	103 (26.2)	127,509 (21.5)	1.28 (0.91, 1.79)
2	115 (23.2)	154,527 (21.8)	1.23 (0.91, 1.66)	93 (23.7)	126,099 (21.3)	1.28 (092, 1.79)
3	77 (15.5)	137,148 (19.3)	0.94 (0.68, 1.29)	622 (15.8)	118,742 (20.0)	0.93 (0.65, 1.34)
4	94 (19.0)	124,312 (17.5)	1.27 (0.93, 1.72)	78 (19.8)	117,149 (19.8)	1.21 (0.86, 1.70)
Least deprived	70 (14.1)	114,406 (16.1)	1.00 (Reference)	57 (14.5)	103,252 (17.4)	1.00 (Reference)
Values imputed	2 (0.4)	5,254 (0.7)		11 (2.8)	16,232 (2.7)	
39-41 weeks' gestation	n = 745	n = 570,672		n = 456	n = 391,929	
Maternal age (years)						
<20	56 (7.5)	49,206 (8.6)	0.83 (0.63, 1.10)	29 (6.4)	1,218 (5.4)	1.04 (0.71, 1.52)
20-34	554 (74.4)	444,947 (78.0)	1.00 (Reference)	327 (77.7)	309,333 (78.9)	1.00 (Reference)
35-39	103 (13.8)	64,118 (11.2)	1.35 (1.10, 1.68)	78 (17.1)	52,541(13.4)	1.51 (1.18, 1.94)
≥40	32 (4.3)	12,401 (2.2)	2.15 (1.50, 3.09)	22 (0.8)	8,837 (2.3)	2.53 (1.64, 3.89)
Values imputed	2 (0.3)	5,436 (1.0)		0	0	
SGA (centiles)[b]						
<3	97 (12.0)	13,662 (2.4)	6.17 (4.93, 7.71)	169 (19.9)	10,097 (2.6)	7.59 (5.88, 9.80)
3-<10	108 (14.5)	35,422 (6.2)	2.84 (2.31, 3.50)	112 (13.2)	24,917 (6.4)	2.75 (2.10, 3.61)
≥10	540 (72.5)	521,588 (91.4)	1.00 (Reference)	567 (66.8)	85,688 (91.1)	1.00 (Reference)
Values imputed	8 (1.1)	175 (0.0)		0	0	
Multiple birth[c]	24 (3.2)	1,946 (0.3)	4.82 (3.22, 7.21)	8 (1.8)	590 (0.2)	3.90 (1.94, 7.85)
Quintile of area-based deprivation[d]						
Most deprived	201 (27.0)	141,849 (24.9)	1.18 (0.93, 1.50)	120 (26.3)	85,688 (21.9)	1.26 (0.92, 1.71)

2	183 (24.0)	124,243 (21.8)	1.26 (0.99, 1.59)	208 (24.5)	85,293 (21.3)	1.28 (0.94, 1.73)
3	140 (17.4)	110,758 (19.4)	1.09 (0.84, 1.40)	152 (17.9)	79,704 (20.0)	1.09 (0.79, 1.51)
4	112 (16.5)	100,814 (17.7)	0.96 (0.74, 1.25)	142 (16.7)	76,802 (19.6)	0.82 (0.58, 1.15)
Least deprived	109 (14.2)	93,008 (16.3)	1.00 (Reference)	124 (14.6)	64,436 (16.4)	1.00 (Reference)
Values imputed	4 (0.5)	4,314 (0.8)		15 (3.3)	10,944 (2.8)	

CI Confidence Interval; RR Relative Risk; SGA Small-for-gestational age

[a] Mutually adjusted for maternal age, multiple birth, quintile of area-based measure of deprivation of birth residence, SGA group, year of birth group.

[b] For the Welsh data, SGA cut points were calculated using the LMS Growth software (Medical Research Council, UK),[19,20] while in the WA data, the cut points were based on the Australian national birthweight centiles for singleton[21] live births since the UK calculation did not account for plurality.

[c] Reference group was singleton births.

[d] These are the quintiles of the relevant area-based measure of deprivation based on the Welsh population and the State population for Western Australia. For Wales, this was the Welsh Index of Multiple Deprivation (WIMD), the official measure of deprivation in small areas in Wales. For Western Australia, it was the Western Australian distribution of the smallest geographical area of Index of Social Disadvantage at the Census closest to the birth year.[24]

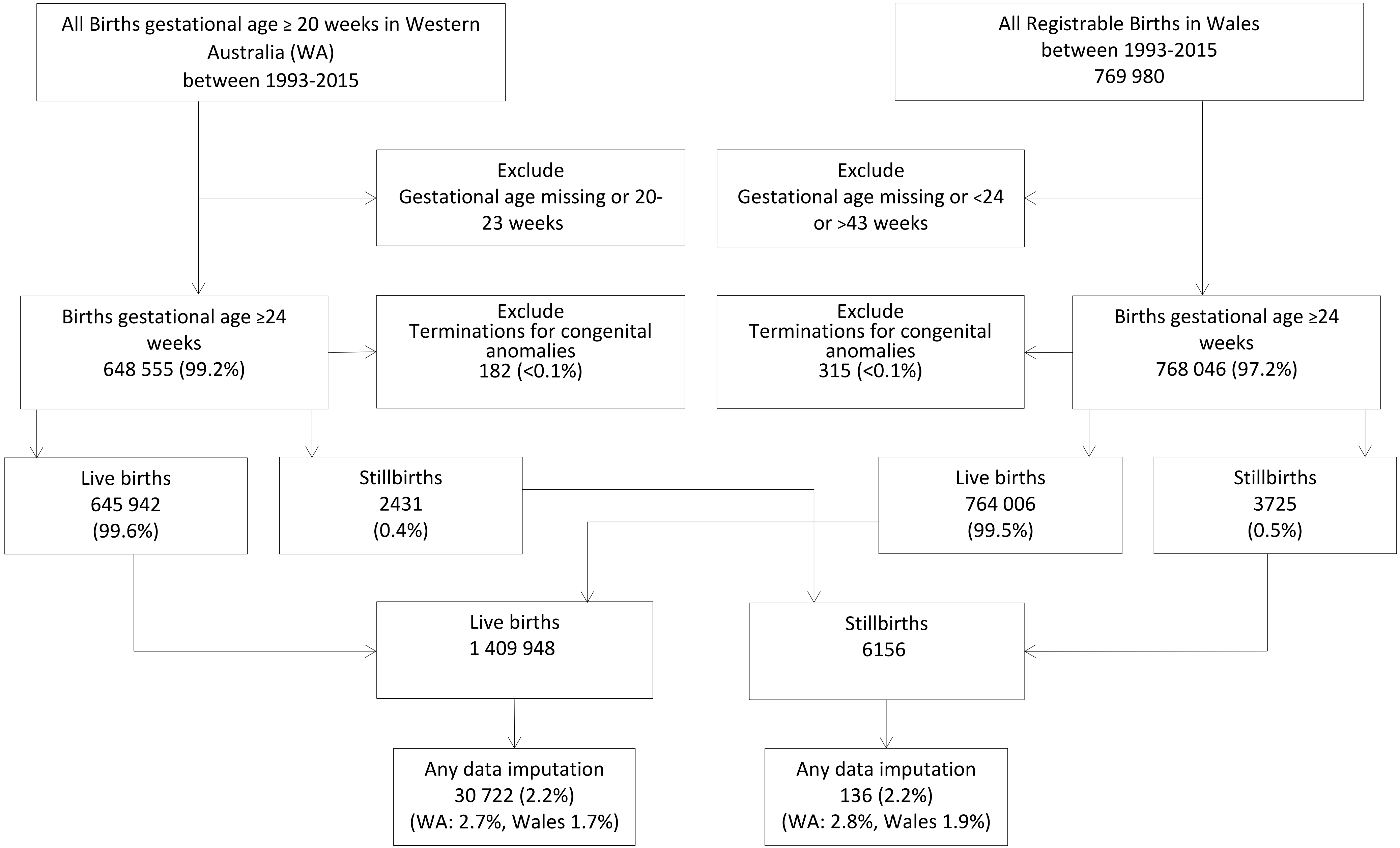
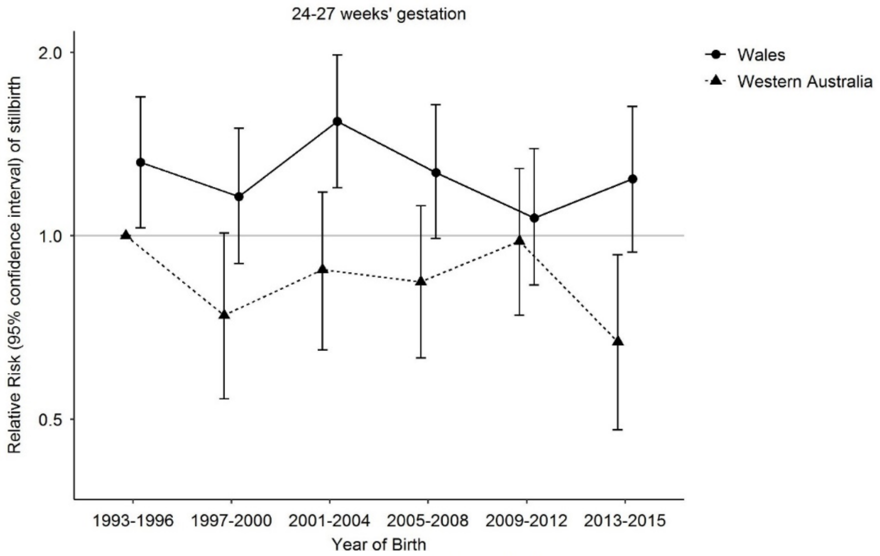
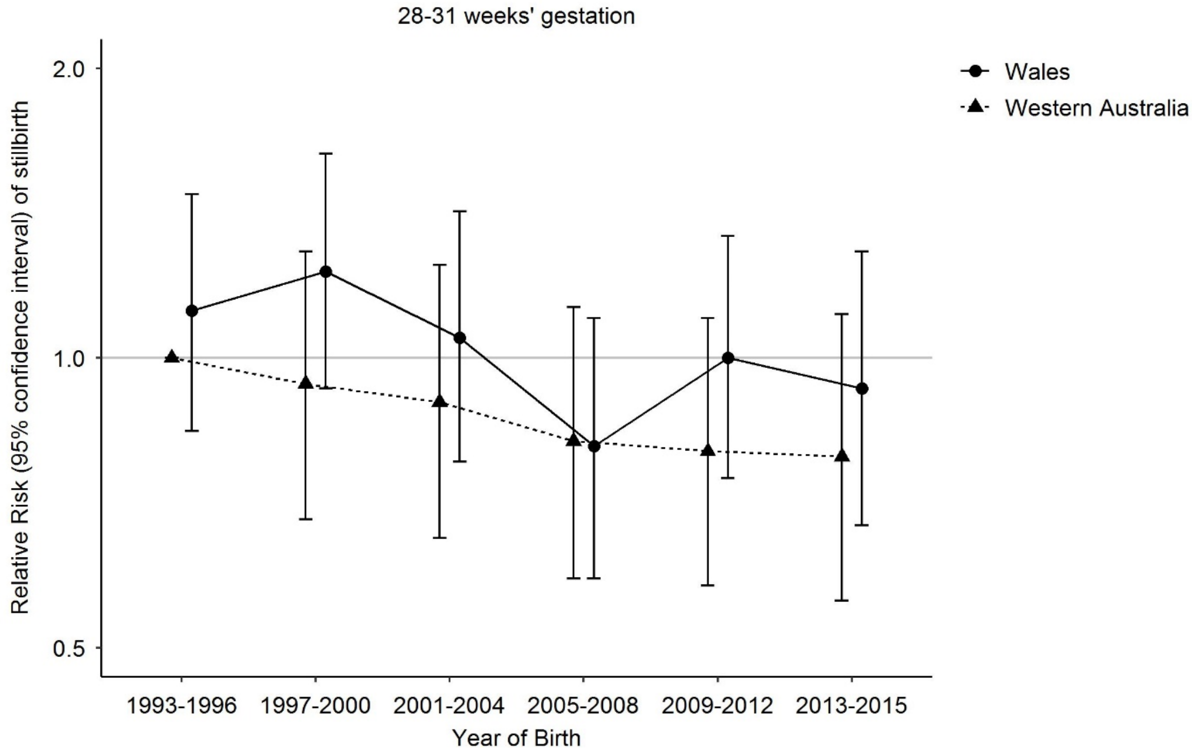
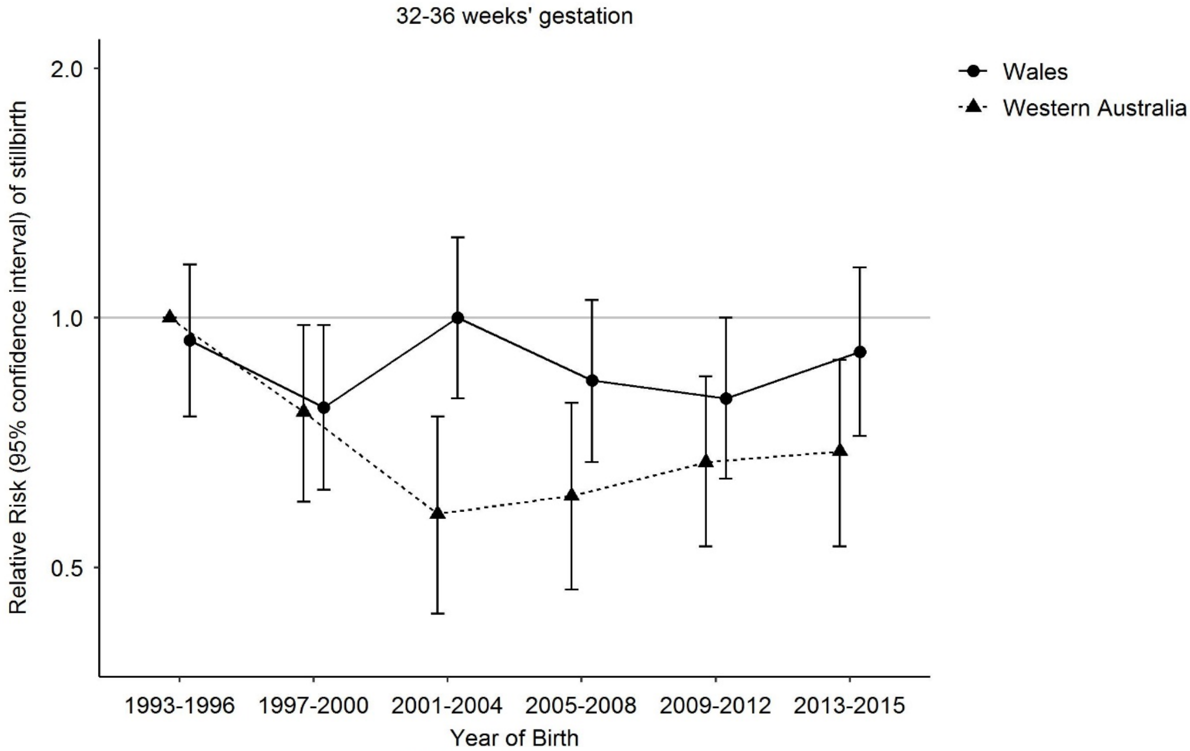


Figure 1: Study flow chart for Western Australia and Wales

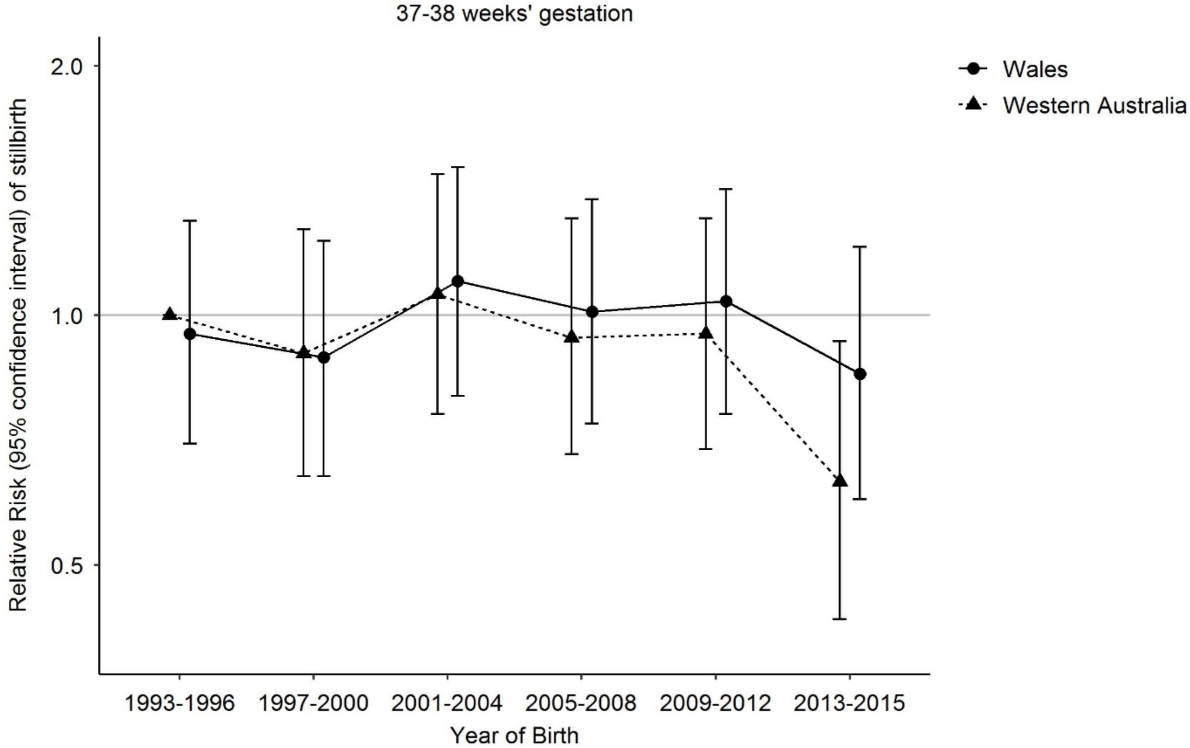
Figure 2: Comparison of the adjusted relative risks and 95% confidence intervals for stillbirth in Wales and Western Australia (1993-2015) (excluding terminations of pregnancy for congenital anomalies), stratified by gestational age at stillbirth (using the Western Australia rate for 1993-1996 as the reference).



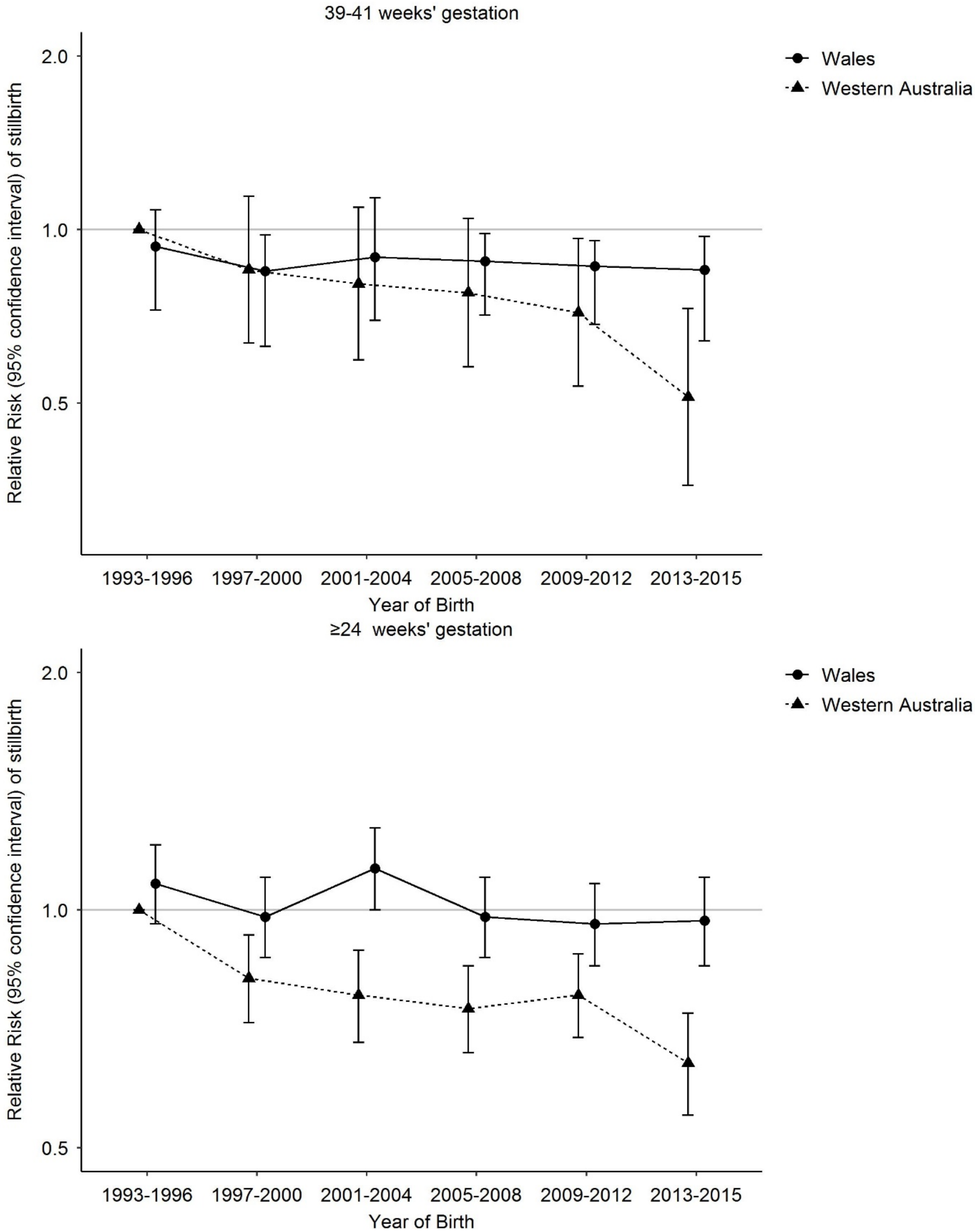




32-36 weeks' gestation
Relative Risk (95% confidence interval) of stillbirth
2.0
1.0
0.5
1993-1996
1997-2000
2001-2004
2005-2008
2009-2012
2013-2015
Year of Birth
Wales
Western Australia



37-38 weeks' gestation
Relative Risk (95% confidence interval) of stillbirth
2.0
1.0
0.5
1993-1996
1997-2000
2001-2004
2005-2008
2009-2012
2013-2015
Year of Birth
Wales
Western Australia



Adjusted for maternal age, multiple birth, quintile of area-based measure of deprivation of birth residence, small-for-gestational-age group, year of birth group, using the WA rate in 1993-1996 as the reference group.

Supplementary appendix:

Comparison of stillbirth trends in Wales and Western Australia 1993-2015 using pooled routinely collected health data.

Authors: Helen D Bailey[1*], Sarah J Kotecha[2*], William J Watkins[2], Akilew A Adane[1], Carrington CJ Shepherd[1, 3], Sailesh Kotecha[2]

Table of contents

Table S1: **The RECORD statement – checklist of items, extended from the STROBE statement, that should be reported in observational studies using routinely collected health data.**[1]

	Item No.	STROBE items	Location in manuscript where items are reported	RECORD items	Location in manuscript where items are reported
Title and abstract					
	1	(a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found	Page 1: Title Page 3: Abstract	RECORD 1.1: The type of data used should be specified in the title or abstract. When possible, the name of the databases used should be included. RECORD 1.2: If applicable, the geographic region and timeframe within which the study took place should be reported in the title or abstract. RECORD 1.3: If linkage between databases was conducted for the study, this should be clearly stated in the title or abstract.	Page 1: Title Page 3: Abstract Page 1: Title (region) Page 3: Abstract (region and timeframe)
Introduction					
Background rationale	2	Explain the scientific background and rationale for the investigation being reported	Page 6		
Objectives	3	State specific objectives, including any prespecified hypotheses	Page 7		
Methods					
Study Design	4	Present key elements of study design early in the paper	Page 7		
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Page 7		
Participants	6	*(a) Cohort study* - Give the	Page 7	RECORD 6.1: The methods of study	Pages 7

		eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study* - Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study* - Give the eligibility criteria, and the sources and methods of selection of participants *(b) Cohort study* - For matched studies, give matching criteria and number of exposed and unexposed *Case-control study* - For matched studies, give matching criteria and the number of controls per case		population selection (such as codes or algorithms used to identify subjects) should be listed in detail. If this is not possible, an explanation should be provided. RECORD 6.2: Any validation studies of the codes or algorithms used to select the population should be referenced. If validation was conducted for this study and not published elsewhere, detailed methods and results should be provided. RECORD 6.3: If the study involved linkage of databases, consider use of a flow diagram or other graphical display to demonstrate the data linkage process, including the number of individuals with linked data at each stage.	Figure 1
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable.	Page 8-9	RECORD 7.1: A complete list of codes and algorithms used to classify exposures, outcomes, confounders, and effect modifiers should be provided. If these cannot be reported, an explanation should be provided.	Page 8-9
Data sources/ measurement	8	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Page 7-9		
Bias	9	Describe any efforts to address potential sources of bias			
Study size	10	Explain how the study size was arrived at	Page 7, Figure 1		
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	Pages 8-9		

Statis tical meth ods	12	(a) Describe all statistical methods, including those used to control for confounding (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed (d) *Cohort study* - If applicable, explain how loss to follow-up was addressed *Case-control study* - If applicable, explain how matching of cases and controls was addressed *Cross-sectional study* - If applicable, describe analytical methods taking account of sampling strategy (e) Describe any sensitivity analyses	a) Pages 10-12 b) Page 11 c) Page 11, Supplementary material, Page 8 e) Page 11		
Data access and cleaning methods		..		RECORD 12.1: Authors should describe the extent to which the investigators had access to the database population used to create the study population. RECORD 12.2: Authors should provide information on the data cleaning methods used in the study.	Page 7
Linkage		..		RECORD 12.3: State whether the study included person-level, institutional-level, or other data linkage across two or more databases. The methods of linkage and methods of linkage quality evaluation should be provided.	Page 7
Results					

Participants	13	(a) Report the numbers of individuals at each stage of the study (*e.g.*, numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed) (b) Give reasons for non- participation at each stage. (c) Consider use of a flow diagram	a) Page 12 b) Page 7, Figure 1 c) Figure 1	RECORD 13.1: Describe in detail the selection of the persons included in the study (*i.e.,* study population selection) including filtering based on data quality, data availability and linkage. The selection of included persons can be described in the text and/or by means of the study flow diagram.	Page 12 Figure 1
Descriptive data	14	(a) Give characteristics of study participants (*e.g.*, demographic, clinical, social) and information on exposures and potential confounders (b) Indicate the number of participants with missing data for each variable of interest (c) *Cohort study* - summarise follow-up time (*e.g.*, average and total amount)	Table 1		
Outcome data	15	*Cohort study* - Report numbers of outcome events or summary measures over time *Case-control study* - Report numbers in each exposure category, or summary measures of exposure *Cross-sectional study* - Report numbers of outcome events or	Page 12-13 Table 2 Page 3: Abstract		
		summary measures			
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder- adjusted estimates and their precision (e.g., 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk	Pages 12-13, Table 3, Figure 2 Page 3: Abstract		

		for a meaningful time period			
Other analyses	17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	Page 13-14, Supplementary material: Tables S3-S4 Figures S3-S4.		
Discussion					
Key results	18	Summarise key results with reference to study objectives	Page 15		
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Pages 15-16	RECORD 19.1: Discuss the implications of using data that were not created or collected to answer the specific research question(s). Include discussion of misclassification bias, unmeasured confounding, missing data, and changing eligibility over time, as they pertain to the study being reported.	Pages 15-16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page 15-19		
Generalisability	21	Discuss the generalisability (external validity) of the study results			
Other Information					
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page 24		

Accessibility of protocol, raw data, and programmin g code		..	Data sharing Page 24	RECORD 22.1: Authors should provide information on how to access any supplemental information such as the study protocol, raw data, or programming code.	Data sharing Page 24

[1]Reference: Benchimol EI, Smeeth L, Guttmann A, Harron K, Moher D, Petersen I, Sørensen HT, von Elm E, Langan SM, the RECORD Working Committee. The REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) Statement. *PLoS Medicine* 2015; in press.

Imputation Methods

While the overall level of missing data was low for all variables in each study (<3%), in the 2013-2015 period in Wales 5.7% (n=5,728) of births were missing data on maternal age. All of the births missing maternal ages were live births so the rates of stillbirth would be artificially elevated for this period in the models adjusted for maternal age. Therefore, MICE (Multivariate Imputation by Chained Equations)[1] was used to impute missing data on maternal age and other variables using the mice package in R version (3.9.0),[2] with a maximum of 50 iterations. The method utilises data from all the available variables and produces plausible values for the missing data across all the variables. The software diagnostics showed that the values produced were plausible and this is further supported by the comparison of the data within each variable at each gestation band (Table S2) as the proportions in each category were similar.

Reference list.

1. Li Z, Umstad MP, Hilder L, Xu F, Sullivan EA. Australian national birthweight percentiles by sex and gestational age for twins, 2001-2010. *BMC Pediatr.* 2015;15:148.

.

Table S2: Comparison of data before and after multiple imputation.

Wales	Missing Data Imputed					With Missing Data				
	Live birth		Stillbirth		Total	Live birth		Stillbirth		Total
	n	%	n	%	N	n	%	n	%	N
24-27 weeks' gestation										
Maternal age (years)										
<20	302	75.3	99	24.7	401	301	75.3	99	24.8	400
20-34	1,959	75.8	627	24.2	2,586	1,939	75.6	626	24.4	2,565
35-39	333	73.7	119	26.3	452	329	73.4	119	26.6	448
≥40	76	67.9	36	32.1	112	75	67.6	36	32.4	111
Missing	0		0		0	26	96.3	1	3.7	27
SGA (centiles)										
<3	154	33.1	311	66.9	465	154	33.2	310	66.8	464
3-<10	178	58.7	125	41.3	303	178	59.1	123	40.9	301
≥10	2,338	84.0	445	16.0	2,783	2,334	84.2	437	15.8	2,771
Missing	0		0		0	4	26.7	11	73.3	15
Plurality										
Singleton	2,032	72.0	792	28.0	2,824	2,031	71.9	792	28.1	2,823
Multiple birth	638	87.8	89	12.2	727	638	87.8	89	12.2	727
Missing	0		0		0	1	100.0	0	0.0	1
Quintile of area-based deprivation										
Most deprived	784	73.5	282	26.5	1,066	778	73.5	281	26.5	1,059
2	589	77.1	175	22.9	764	586	77.1	174	22.9	760
3	513	76.2	160	23.8	673	509	76.1	160	23.9	669
4	420	76.4	130	23.6	550	418	76.4	129	23.6	547
Least deprived	364	73.1	134	26.9	498	362	73.0	134	27.0	496
Sex										
Male	1,478	76.2	461	23.8	1,939	1,478	76.3	460	23.7	1,938
Female	1,192	73.9	420	26.1	1612	1,192	74.2	414	25.8	1,606
Missing	0		0		0	0		7	100.0	7
28-31 weeks' gestation										
Maternal age (years)										
<20	658	91.0	65	9.0	723	655	91.0	65	9.0	720
20-34	4,954	91.7	450	8.3	5,404	4,912	91.6	449	8.4	5,361
35-39	857	93.6	59	6.4	916	850	93.5	59	6.5	909
≥40	193	90.2	21	9.8	214	191	90.1	21	9.9	212
Missing	0		0		0	54	98.2	1	1.8	55
SGA (centiles)										

<3	515	71.3	207	28.7	722	510	71.2	206	28.8	716
3-<10	538	89.4	64	10.6	602	538	89.4	64	10.6	602
≥10	5,609	94.5	324	5.5	5,933	5,599	94.6	321	5.4	5,920
Missing	0	0.0	0	0.0	0	15	78.9	4	21.1	19
Plurality										
Singleton	4,951	90.8	504	9.2	5,455	4,949	90.8	504	9.2	5,453
Multiple birth	1,711	95.0	91	5.0	1,802	1,711	95.0	91	5.0	1,802
Missing	0		0		0	1	100.0	0	0.0	1
Quintile of area-based deprivation										
Most deprived	1,900	91.6	174	8.4	2,074	1,888	91.6	174	8.4	2,062
2	1,502	91.3	143	8.7	1,645	1,484	91.3	142	8.7	1,626
3	1,199	91.4	113	8.6	1,312	1,182	91.3	112	8.7	1,294
4	1,137	92.6	91	7.4	1,228	1,129	92.5	91	7.5	1,220
Least deprived	924	92.6	74	7.4	998	920	92.6	74	7.4	994
Sex										
Male	3,737	91.9	329	8.1	4,066	3,737	92.0	326	8.0	4,063
Female	2,925	91.7	266	8.3	3,191	2,925	91.8	263	8.2	3,188
Missing	0		0		0	0	0.0	6	100.0	6
32-36 weeks' gestation										
Maternal age (years)										
<20	4,204	97.6	103	2.4	4,307	4,178	97.6	103	2.4	4,281
20-34	34,760	98.0	704	2.0	35,464	34,395	98.0	703	2.0	35,098
35-39	6,213	98.2	113	1.8	6,326	6,134	98.2	112	1.8	6,246
≥40	1,477	97.6	37	2.4	1,514	1,469	97.5	37	2.5	1,506
Missing	0		0		0	478	99.6	2	0.4	480
SGA (centiles)										
<3	2,129	90.4	226	9.6	2,355	2,125	90.4	226	9.6	2,351
3-<10	2,997	96.8	99	3.2	3,096	2,992	96.8	98	3.2	3,090
≥10	41,528	98.5	632	1.5	42,160	41,496	98.5	629	1.5	42,125
Missing	0		0		0	41	91.1	4	8.9	45
Plurality										
Singleton	37,679	97.8	850	2.2	38529	37,677	97.8	849	2.2	38,526
Multiple birth	8,975	98.8	107	1.2	9,082	8,974	98.8	107	1.2	9,081
Missing	0		0		0	3	75.0	1	25.0	4
Quintile of area-based deprivation										
Most deprived	12,942	97.6	316	2.4	13,258	12,879	97.6	316	2.4	13,195
2	10,572	98.0	216	2.0	10,788	10,506	98.0	216	2.0	10,722
3	8,864	98.3	157	1.7	9,021	8,805	98.3	156	1.7	8,961
4	7,572	98.1	150	1.9	7,722	7,520	98.0	150	2.0	7,670

Least deprived	6,704	98.3	118	1.7	6,822	6,665	98.3	117	1.7	6,782
Sex										
Male	25,245	98.0	513	2.0	25,758	25,242	98.0	513	2.0	25,755
Female	21,409	98.0	444	2.0	21,853	21,407	98.0	441	2.0	21,848
Missing	0		0		0	5	62.5	3	37.5	8
37-38 weeks' gestation										
Maternal age (years)										
<20	10,420	99.6	42	0.4	10,462	10,327	99.6	42	0.4	10,369
20-34	103,837	99.7	358	0.3	104,195	102,791	99.7	358	0.3	103,149
35-39	18,829	99.6	70	0.4	18,899	18,633	99.6	70	0.4	18,703
≥40	4,313	99.4	26	0.6	4,339	4,276	99.4	26	0.6	4,302
Missing	0		0		0	1,372	100.0	0	0.0	1,372
SGA (centiles)										
<3	3,536	97.6	88	2.4	3,624	3,535	97.6	88	2.4	3,623
3-<10	6,697	99.4	41	0.6	6,738	6,694	99.4	40	0.6	6,734
≥10	127,166	99.7	367	0.3	127,533	127,119	99.7	363	0.3	127,482
Missing	0		0		0	51	91.1	5	8.9	56
Plurality										
Singleton	129,363	99.7	450	0.3	129,813	129,357	99.7	450	0.3	129,807
Multiple birth	8,036	99.4	46	0.6	8,082	8,036	99.4	46	0.6	8,082
Missing	0		0		0	1	100.0	0	0.0	1
Quintile of area-based deprivation										
Most deprived	36,373	99.6	140	0.4	36,513	36,144	99.6	140	0.4	36,284
2	30,101	99.6	115	0.4	30,216	29,914	99.6	114	0.4	30,028
3	26,250	99.7	77	0.3	26,327	26,057	99.7	76	0.3	26,133
4	23,386	99.6	94	0.4	23,480	23,220	99.6	93	0.4	23,313
Least deprived	21,289	99.7	70	0.3	21,359	21,128	99.7	70	0.3	21,198
Sex										
Male	71,916	99.6	257	0.4	72,173	71,909	99.6	253	0.4	72,162
Female	65,483	99.6	239	0.4	65,722	65,481	99.6	239	0.4	65,720
Missing	0	0.0	0	0.0	0	9	69.2	4	30.8	13
39-41 weeks' gestation										
Maternal age (years)										
<20	45,218	99.9	56	0.1	45,274	44,801	99.9	56	0.1	44,857
20-34	411,844	99.9	554	0.1	412,398	407,956	99.9	553	0.1	408,509
35-39	59,983	99.8	103	0.2	60,086	59,326	99.8	102	0.2	59,428
≥40	11,677	99.7	32	0.3	11,709	11,540	99.7	32	0.3	11,572
Missing	0		0		0	5,099	100.0	2	0.0	5,101
SGA (centiles)										

<3	11,025	99.1	97	0.9	11,122	11,015	99.1	96	0.9	11,111
3-<10	30,177	99.6	108	0.4	30,285	30,168	99.6	107	0.4	30,275
≥10	487,520	99.9	540	0.1	488,060	487,377	99.9	534	0.1	487,911
Missing	0		0		0	162	95.3	8	4.7	170
Plurality										
Singleton	52,6807	99.9	721	0.1	527,528	526792	99.9	721	0.1	527513
Multiple birth	1,914	98.8	24	1.2	1,938	1914	98.8	24	1.2	1938
Missing	0		0		0	8	100.0	0	0.0	8
Quintile of area-based deprivation										
Most deprived	131,610	99.8	201	0.2	131,811	130,670	99.8	200	0.2	130,870
2	115,307	99.8	183	0.2	115,490	114,464	99.8	182	0.2	114,646
3	102,569	99.9	140	0.1	102,709	101,736	99.9	140	0.1	101,876
4	93,542	99.9	112	0.1	93,654	92,823	99.9	111	0.1	92,934
Least deprived	85694	99.9	109	0.1	85,803	84,991	99.9	108	0.1	85,099
Sex										
Male	267,869	99.9	366	0.1	268,235	267,858	99.9	360	0.1	268,218
Female	260,853	99.9	379	0.1	261,232	260,829	99.9	374	0.1	261,203
Missing	0		0		0	35	76.1	11	23.9	46

Western Australia

	Missing Data Imputed					With Missing Data				
	Livebirth		Stillbirth		Total	Livebirth		Stillbirth		Total
	n	%	n	%	N	n	%	n	%	N
24-27 weeks' gestation										
Quintile of area-based deprivation										
Most deprived	573	81.3	132	18.7	705	563	81.5	128	18.5	691
2	453	81.8	101	18.2	554	444	81.5	101	18.5	545
3	361	75.5	117	24.5	478	349	75.5	113	24.5	462
4	337	79.9	85	20.1	422	325	79.7	83	20.3	408
Least deprived	247	79.7	63	20.3	310	233	79.5	60	20.5	293
Missing	0		0		0	57	81.4	13	18.6	70
28-31 weeks' gestation										
Quintile of area-based deprivation										
Most deprived	1,312	91.1	128	8.9	1,440	1,273	91.2	123	8.8	1,396
2	1,071	92.3	89	7.7	1,160	1,048	92.5	85	7.5	1,133
3	864	90.9	87	9.1	951	836	90.8	85	9.2	921
4	866	93.2	63	6.8	929	837	93.3	60	6.7	827
Least deprived	718	93.6	49	6.4	767	688	93.6	47	6.4	735
Missing	0		0		0	149	90.3	16	9.7	165

32-36 weeks' gestation										
Quintile of area-based deprivation										
Most deprived	11,396	98.5	171	1.5	11,567	11,097	98.5	169	1.5	11,266
2	9,932	98.5	149	1.5	10,081	9,670	98.5	147	1.5	9,817
3	8,809	98.7	112	1.3	8,921	8,533	98.7	110	1.3	8,643
4	8,991	98.7	120	1.3	9,111	8,742	98.7	118	1.3	8,860
Least deprived	7,726	98.7	101	1.3	7,827	7,507	98.7	97	1.3	7,604
Missing	0		0		0	1,305	99.1	12	0.9	1,317
37-38 weeks' gestation										
Quintile of area-based deprivation										
Most deprived	41,701	99.8	103	0.2	41,804	40,503	99.8	98	0.2	41,804
2	40,691	99.8	93	0.2	40,784	39,663	99.8	92	0.2	40,784
3	38,948	99.8	62	0.2	39,010	37,975	99.8	60	0.2	39,010
4	40,283	99.8	78	0.2	40,361	39,145	99.8	75	0.2	40,361
Least deprived	38,749	99.9	57	0.1	38,806	37,841	99.8	57	0.2	38,806
Missing	0		0		0	5,275	99.8	11	0.2	5286
39-41 weeks' gestation										
Quintile of area-based deprivation										
Most deprived	84,205	99.9	120	0.1	84,325	81,845	99.9	116	0.1	81,961
2	84,013	99.9	115	0.1	84,128	81,735	99.9	108	0.1	81,843
3	78,590	99.9	90	0.1	78,680	76,514	99.9	88	0.1	76,602
4	75,759	99.9	64	0.1	75,832	73,621	99.9	63	0.1	73,684
Least deprived	63,671	99.9	67	0.1	63,731	61,780	99.9	66	0.1	61,846
Missing	0		0		0	10743	99.9	15	0.1	10,758

Table S3: Characteristics of all births ≥24 weeks' gestation by time-period in Wales and Western Australia (1993-2015) (excluding terminations for congenital anomalies)

	1993-1996	1997-2000	2001-2004	2005-2008	2009-2012	2013-2015
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Wales	n=142,242	n=131,934	n=115,993	n=135,883	n=141,468	n=100,211
Gestational age (weeks)						
24-27	602 (0.4)	644 (0.5)	611 (0.5)	614 (0.5)	633 (0.4)	447 (0.4)
28-31	1,346 (0.9)	1,331(1.0)	1,206 (1.0)	1,269 (0.9)	1,279 (0.9)	826 (0.8)
32-36	8,656 (6.1)	8,341(6.3)	7,591 (6.5)	8,358 (6.1)	8,478 (6.0)	6,187 (6.2)
37-38	24,533 (17.2)	25,116 (19.0)	21,731 (18.7)	23,871 (17.6)	24,556 (17.4)	18,088 (18.0)
39-41	95,276 (67.0)	88,352 (67.0)	79,968 (68.9)	95,338 (70.2)	99,891 (70.6)	70,642 (70.5)
>41	11,829(8.3)	8,150 (6.2)	4886 (4.2)	6433 (4.7)	6631 (4.7)	4021 (4.0)
Multiple birth	3,517 (2.5)	3,852 (2.9)	3,296 (2.8)	3,870 (2.8)	4,095 (2.9)	3,032 (3.0)
Missing	12 (0)	2 (0)	2 (0)	0 (0)	0 (0)	0 (0)
SGA (centiles)						
<3	4,446 (3.1)	3,702 (2.8)	3,193 (2.8)	3,558 (2.6)	3,733 (2.6)	2,270 (2.3)
3-<10	9,311(6.5)	8,038 (6.1)	7,026 (6.1)	8,116 (6.0)	8,496 (6.0)	5,285 (5.3)
≥10	128,450 (90.3)	120,172 (91.1)	105,694 (90.5)	124,194 (91.4)	129,219 (91.3)	92,537 (92.3)
Missing	35 (0.0)	22 (0.0)	80 (0.1)	15 (0.0)	47 (0.0)	119 (0.1)
Maternal age (years)						
<20	12,230 (8.6)	13,607 (10.3)	11,316 (9.8)	12,244 (9.0)	10,356 (7.3)	4,830 (4.8)
20-24	33,864 (23.8)	27,325 (20.7)	25,447 (21.9)	30,654 (22.6)	32,434 (22.9)	19,535 (19.5)
25-29	47,836 (33.6)	40,307 (30.6)	30,200 (26.0))	36,081 (26.6)	40,619 (28.7)	28,488 (28.4)
30-34	33,855 (23.8)	33,964 (25.7)	31,417 (27.1)	34,015 (25.0)	35,376 (25.0)	26,119 (26.1)

35-39	11,676 (8.2)	13,800 (10.5)	14,538 (12.5)	19,014 (14.0)	18,312 (12.9)	12,494 (12.5)
≥40	2,060 (1.4)	2,340 (1.8)	2,826 (2.4)	3,824 (2.8)	4,330 (3.1)	3,011 (3.0)
missing	721 (0.5)	591 (0.4)	249 (0.2)	51 (0.0)	41 (0.0)	5,734 (5.7)
Quintile of area-based deprivation[a]						
Most deprived	36,964 (26.0)	32,879 (24.9)	28,307 (24.4)	34,036 (25.0)	35,963 (25.4)	25,503 (25.4)
2	31,181 (21.9)	28,541 (21.6)	24,534 (21.2)	29,197 (21.5)	31,557 (22.3)	21,661 (21.6)
3	26,763 (18.8)	25,320 (19.2)	22,408 (19.3)	25,526 (18.8)	27,215 (19.2)	19,825 (19.8)
4	25,149 (17.7)	23,224 (17.6)	20,328 (17.5)	23,277 (17.1)	23,973 (16.9)	17,002 (17.0)
Least deprived	21,256 (14.9)	21,441 (16.3)	20,122 (17.3)	22,130 (16.3)	21,551 (15.2)	15,359 (15.3)
Missing	929 (0.7)	529 (0.4)	294 (0.3)	1,767 (1.3)	1,209 (0.9)	891 (0.9)
Western Australia	n=101,373	n=101,477	n=99,457	n=115,815	n=127,885	n=102,366
Characteristic						
Gestational age (weeks)						
24-27	383 (0.4)	359 (0.4)	395 (0.4)	469 (0.4)	515 (0.4)	348 (0.3)
28-31	792 (0.8)	871 (0.9)	811 (0.8)	986 (0.9)	992 (0.8)	795 (0.8)
32-36	7,011 (6.9)	7,201 (7.1)	7,402 (7.4)	8,695 (7.5)	9,443 (7.4)	7,755 (7.6)
37-38	27,333(27.0)	29,504 (29.1)	31,806 (32.0)	38,120 (32.9)	40,920 (32.0)	33,082 (32.3)
39-41	63,955 (63.1)	62,491 (61.6)	58,208 (58.5)	66,758 (57.6)	75,274 (58.9)	60,008 (58.6)
>41	1,899 (1.9)	1,051 (1.0)	835 (0.8)	787 (0.7)	741 (0.6)	378 (0.4)
Multiple birth	2,821 (2.8)	3,057 (3.0)	3,208(3.2)	3,394 (2.9)	3,518 (2.8)	2,849 (2.8)
SGA (centiles)						
<3	3,022 (3.0)	2,727 (2.7)	2,505 (2.5)	2,803 (2.4)	2,942 (2.3)	2,195 (2.1)
3-<10	6,775 (6.7)	6,444 (6.4)	6,056 (6.1)	6,939 (6.0)	7,708 (6.0)	6,369 (6.2)

≥10	91,576 (90.3)	92,304 (91.0)	90,895 (91.4)	106,071 (91.6)	117,234 (91.7)	93,801 (91.6)
Missing	0 (0.0)	2 (0.0)	1 (0.0)	2 (0.0)	1 (0.0)	1 (0.0)
Maternal age (years)						
<20	6,128 (6.0)	5,952 (5.9)	5,585(5.6)	6,043 (5.2)	5,538 (4.3)	3,259 (3.2)
20-24	19,737(19.5)	17,441 (17.2)	15,819 (15.9)	18,465 (15.9)	19,380 (15.2)	13,938 (13.6)
25-29	33,598 (33.1)	32,338 (31.9)	28,329 (28.5)	30,901 (26.7)	36,159 (28.3)	29,147 (28.5)
30-34	29,394 (29.0)	30,260 (29.8)	32,251 (32.4)	36,323 (31.4)	40,063 (31.3)	34,710 (33.9)
35-39	10,847 (10.7)	13,300 (13.1)	14,661 (14.7)	20,337 (17.6)	21,912 (17.1)	17,433 (17.0)
≥40	1,669 (1.6)	2,186 (2.2)	2,812 (2.8)	3,746 (3.2)	4,833 (3.8)	3,879 (3.8)
missing	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Quintile of area-based deprivation[a]						
Most deprived	21,930 (21.6)	22,544 (22.2)	21,864(22.0)	23,071 (19.9)	27,316 (21.4)	20,627 (20.2)
2	21,302 (21.0)	21,737 (21.4)	20,764 (20.9)	24,068 (20.8)	26,103 (20.4)	20,322 (19.9)
3	20,661 (20.4)	19,770 (19.5)	17,967 (18.1)	21,342 (18.4)	25,462 (19.9)	20,543 (20.1)
4	18,180 (17.9)	18,502 (18.2)	19,122 (19.2)	22,972 (19.8)	25,284 (19.8)	20,006 (19.5)
Least deprived	15,164 (15.0)	15,695 (15.5)	17,233 (17.3)	21,997 (19.0)	21,675 (16.9)	17,347 (16.9)
Missing	4,136 (4.1)	3,229 (3.2)	2,507 (2.5)	2,365 (2.0)	2,045 (1.6)	3,521 (3.4)

[a] These are the quintiles of the relevant area-based measure of deprivation based on the Welsh population and the State population for Western Australia. For Wales, this was the Welsh Index of Multiple Deprivation (WIMD), the official measure of deprivation in small areas in Wales. For Western Australia, it was the Western Australian distribution of the smallest geographical area of Index of Social Disadvantage at the Census closest to the birth year.[1]

[1]Australian Bureau of Statistics. Socio-Economic Indexes for Areas (SEIFA) 2011(Catalogue No 2033.0.55.001.)

Table S4: Comparison of median birthweights in Wales and Western Australia, excluding terminations for congenital anomalies (1993-2015)

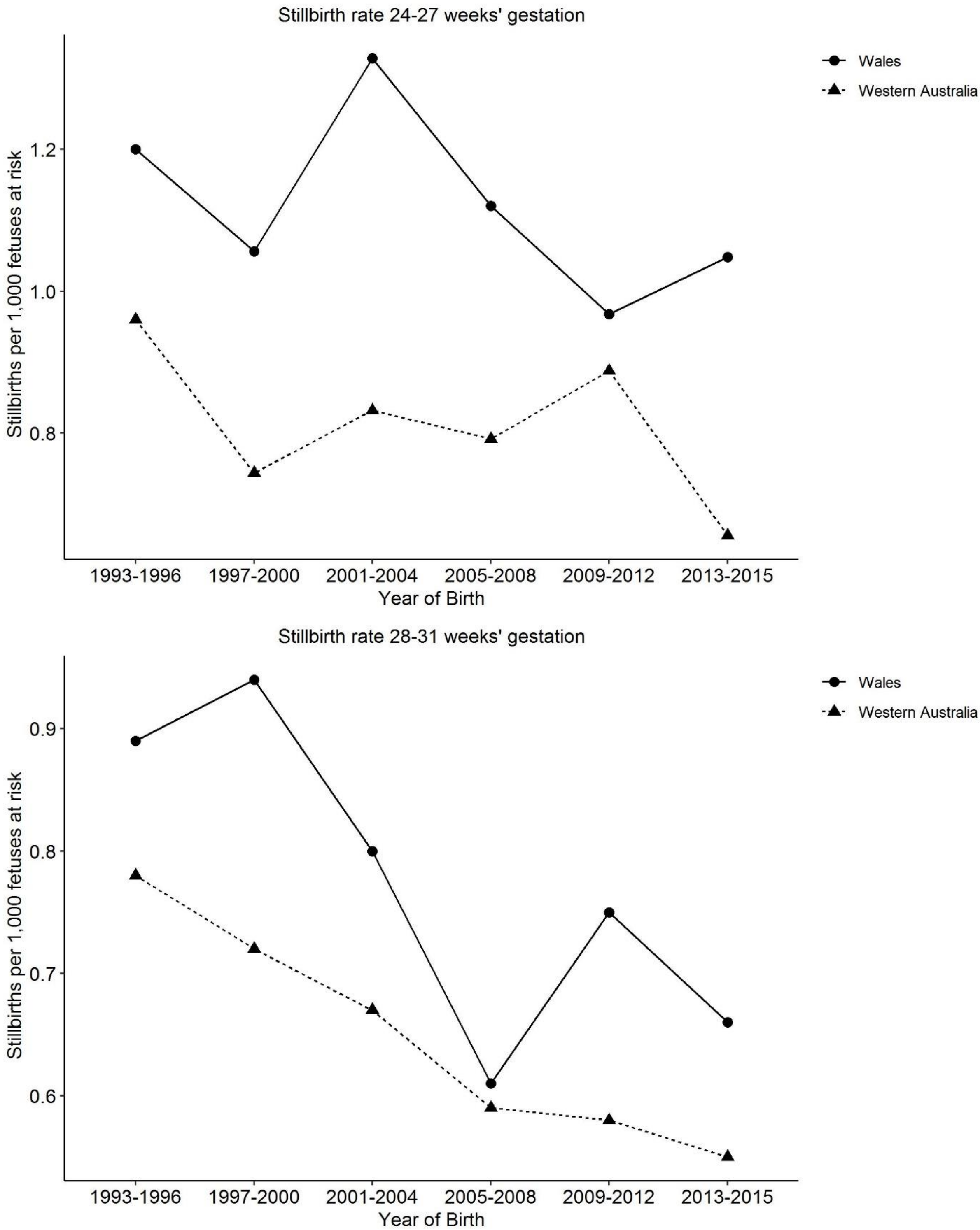
	Wales				Western Australia			
	n	Birth weight percentile			n	Birth weight percentile		
		25	50	75		25	50	75
Overall	767,731	2,915	3,300	3,559	648,367	3,040	3,380	3,710
Sex								
Female	373,784	2,860	3,220	3,480	316,278	2,990	3,320	3,640
Male	393,865	2,980	3,350	3,620	332,089	3,100	3,445	3,780
Gestational age (weeks)								
24-27	3,551	600	810	925	2,469	655	800	965
28-31	7,257	1,037.5	1,360	1,510	5,246	1,170	1,400	1,635
32-36	47,611	1,950	2,352	2,590	47,505	2,200	2,550	2,900
37-38	137,895	2,800	3,100	3,430	200,763	2,935	3,225	3,530
39-41	529,467	3,180	3,480	3,799	386,693	3,240	3,525	3,820
>41	41,950	3,320	3,740	4,060	5,691	3,350	3,360	3,990
Plurality								
Singleton	746,053	2940	3310	3569.99	629,520	3,075	3,400	3,720
Multiple birth	21,662	2220	2550	2690	18,847	2,030	2,450	2,790

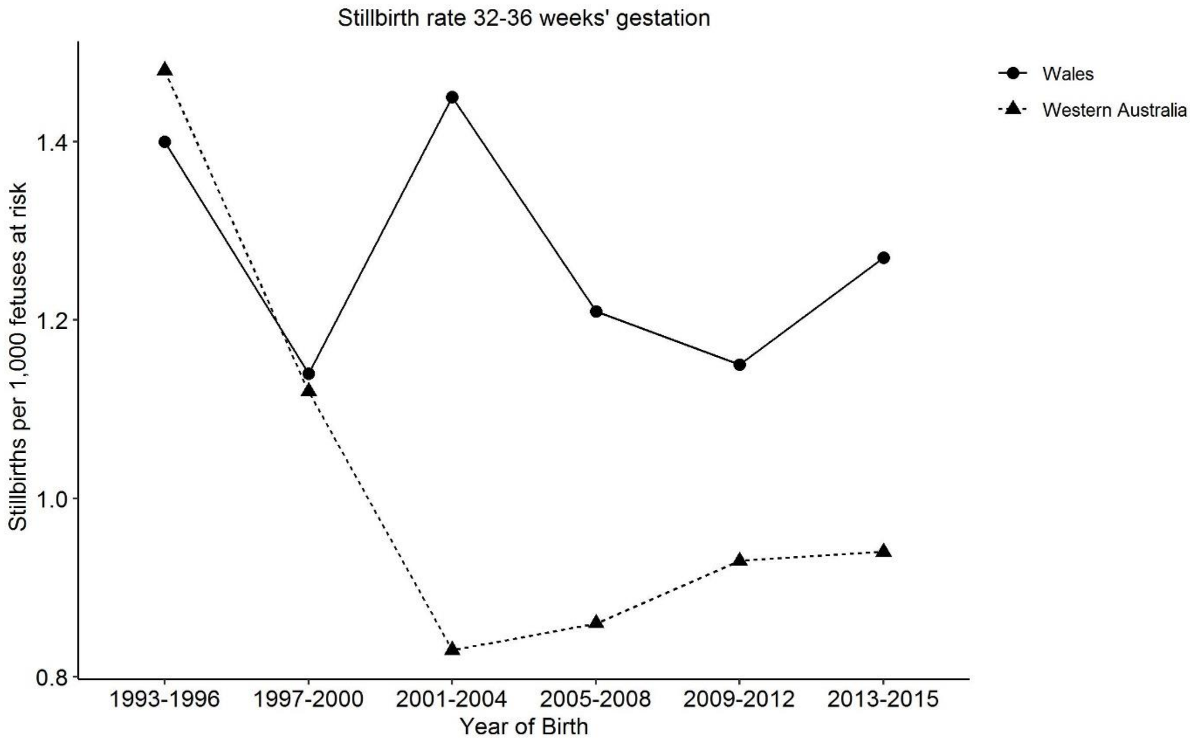
Table S5: Stillbirths (excluding terminations of pregnancy for congenital anomalies) in Wales and Western Australia per 1,000 births between 1993-2015, stratified by gestational age group (births-based approach).[a]

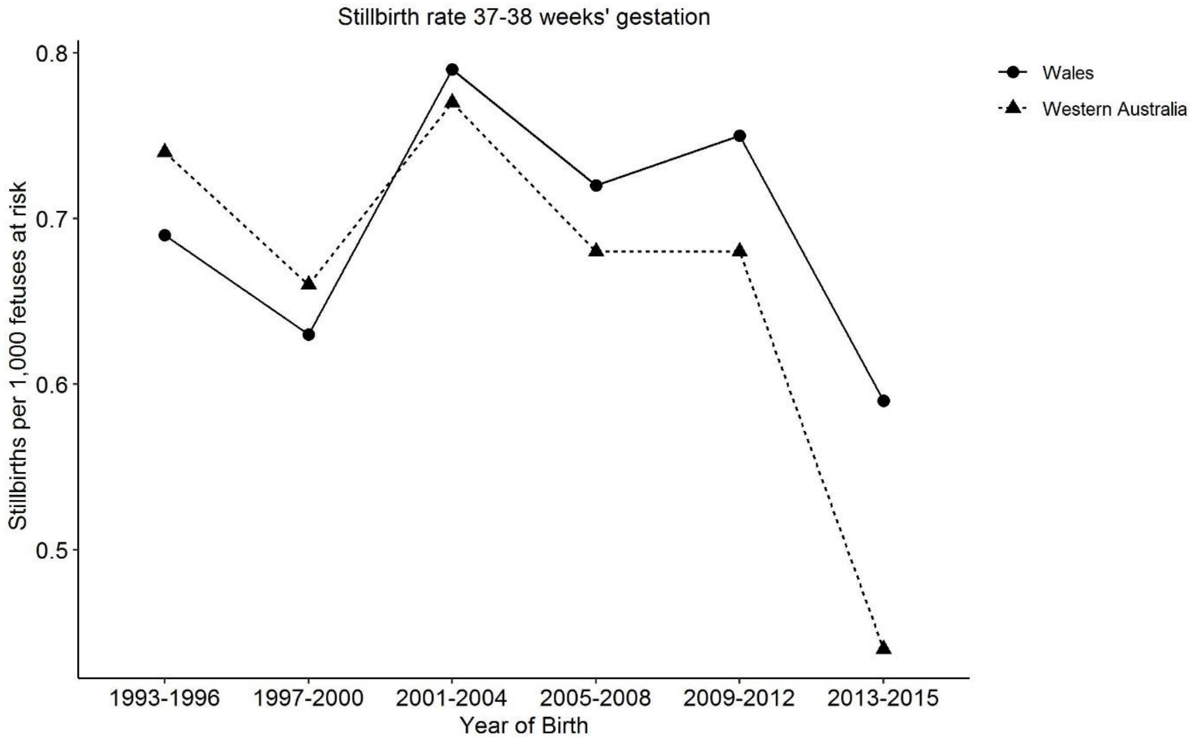
	Gestational age (weeks):											
	24-27		28-31		32-36		37-38		39-41		All births ≥24	
	Stillbirths/1,000 births (n)		Stillbirths /1,000 births (n)		Stillbirths /1,000 births (n)		Stillbirths /1,000 births (n)		Stillbirths /1,000 births (n)		Stillbirths /1,000 births (n)	
Birth year	Wales	Western Australia	Wales	Western Australia	Wales	Western Australia	Wales	Western Australia	Wales	Western Australia	Wales	Western Australia
1993-1996	295.7 (178)	250.7 (96)	93.6 (126)	99.7 (79)	22.6 (196)	21.1 (148)	3.7 (91)	2.5 (69)	1.6 (152)	1.5 (99)	5.3 (753)	4.9 (495)
1997-2000	218.9 (141)	192.2 (69)	93.2 (124)	83.8 (73)	17.7 (148)	15.4 (112)	3.1 (77)	2.1 (61)	1.4 (121)	1.3 (82)	4.7 (620)	4.0 (401)
2001-2004	268.4 (164)	200.0 (79)	76.3 (92)	81.4 (66)	21.7 (165)	11.1 (82)	3.9 (84)	2.2 (70)	1.4 (113)	1.2 (71)	5.4 (629)	3.7 (369)
2005-2008	254.1 (156)	183.4 (86)	64.6 (82)	69.0 (68)	19.4 (162)	11.3 (98)	3.8 (91)	1.9 (72)	1.4 (133)	1.2 (78)	4.7 (634)	3.5 (404)
2009-2012	214.8 (136)	213.6(110)	82.1 (105)	74.6 (74)	18.9 (160)	12.5 (118)	4.0 (98)	2.0 (80)	1.4 (135)	1.1 (81)	4.5 (643)	3.6 (464)
2013-2015	237.1 (106)	166.7 (58)	79.9 (66)	70.4 (56)	20.4 (126)	12.2 (95)	3.0 (55)	1.2 (41)	1.4 (91)	0.7 (45)	4.5 (446)	2.9 (298)
Total	248.1 (881)	201.7 (498)	82.0 (595)	79.3 (416)	20.1 (957)	13.7 (653)	3.6 (496)	2.0 (373)	1.4 (745)	1.2 (456)	4.9 (3725)	3.7 (2431)
P trend[b]	0.031	0.049	0.058	0.018	0.368	<0.001	0.954	<0.001	0.128	<0.001	0.001	<0.001

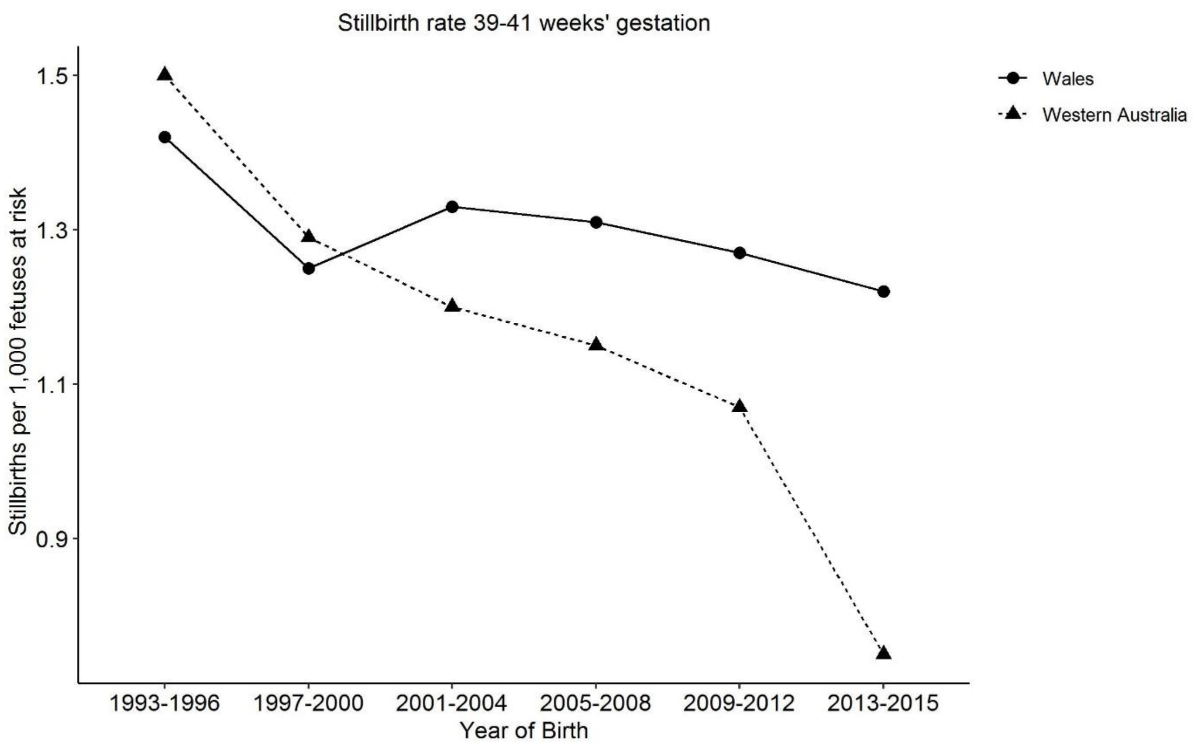
[a]The overall stillbirths rate among births with a gestation of >41 weeks were 1.2 /1,000 births (n= 51) in Wales and 2.6/1,000 lbirths (n= 15) in Western Australia . Due to small numbers, time-period specific rates not shown.
[b]Time trends were assessed using the Cochran-Armitage test for linear trend. .

Figure S1: Comparison of stillbirth rates in Wales and Western Australia (1993-2015) (excluding terminations of pregnancy for congenital anomalies), stratified by gestational age group (using ongoing pregnancies (fetuses-at risk).




Stillbirth rate 32-36 weeks' gestation
Wales
Western Australia
Stillbirths per 1,000 fetuses at risk
1.4
1.2
1.0
0.8
1993-1996
1997-2000
2001-2004
2005-2008
2009-2012
2013-2015
Year of Birth


Stillbirth rate 37-38 weeks' gestation
Wales
Western Australia
Stillbirths per 1,000 fetuses at risk
0.8
0.7
0.6
0.5
1993-1996
1997-2000
2001-2004
2005-2008
2009-2012
2013-2015
Year of Birth


Stillbirth rate 39-41 weeks' gestation
Wales
Western Australia
Stillbirths per 1,000 fetuses at risk
1.5
1.3
1.1
0.9
1993-1996
1997-2000
2001-2004
2005-2008
2009-2012
2013-2015
Year of Birth

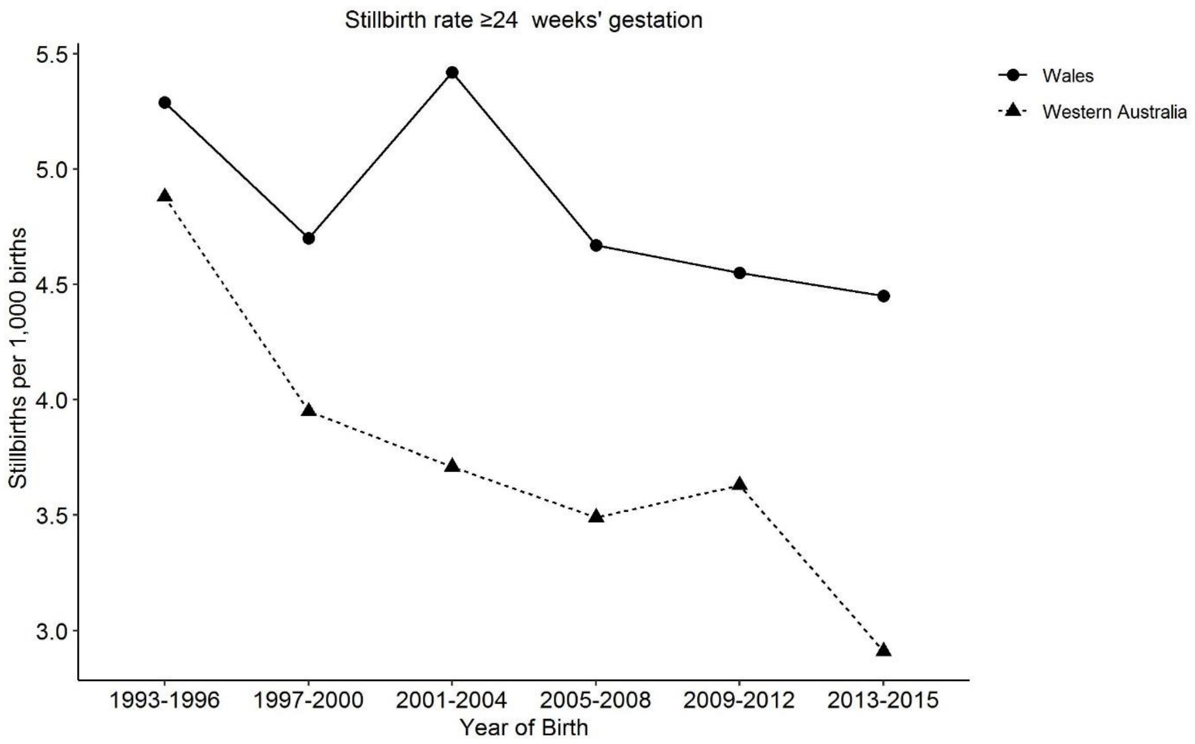
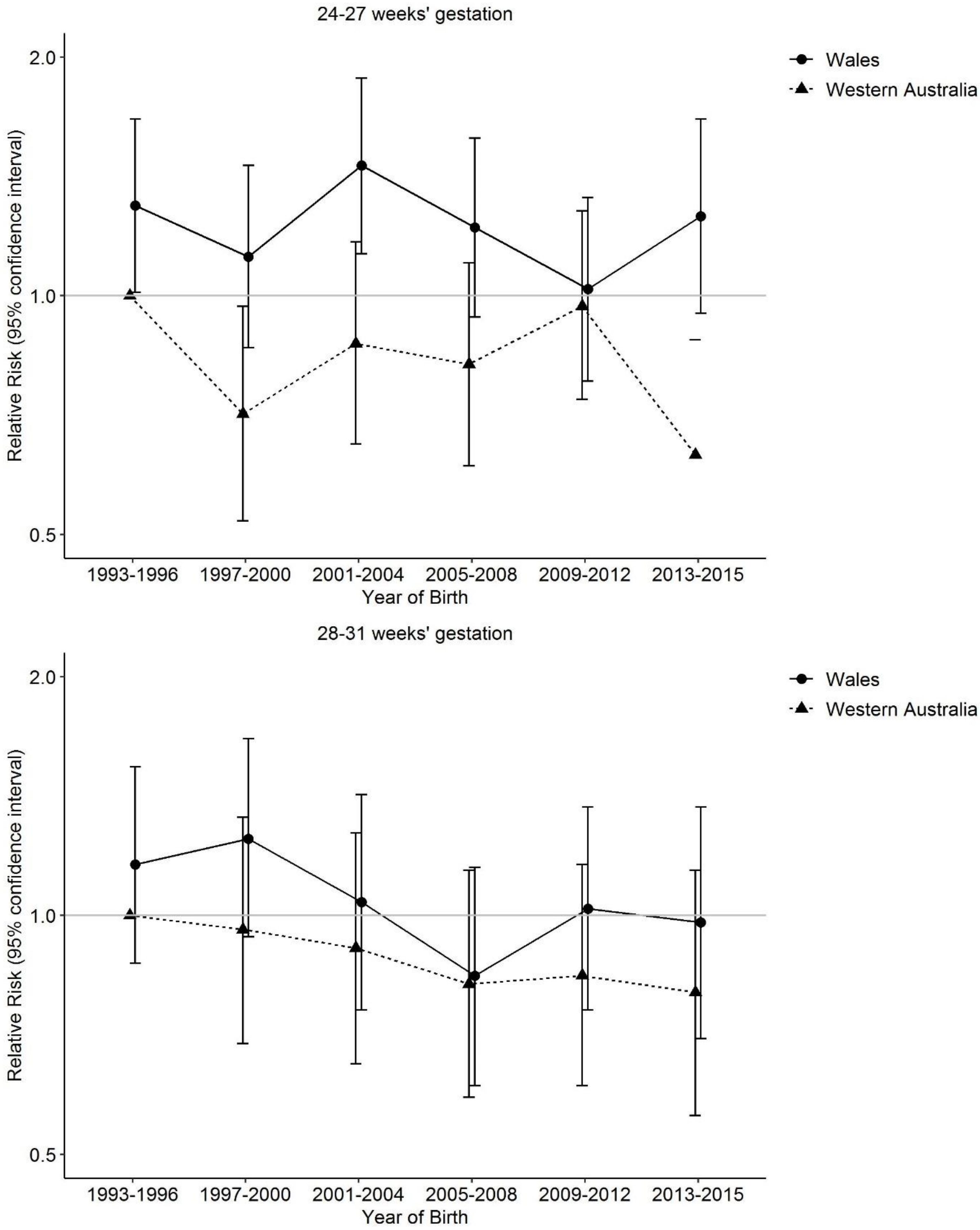
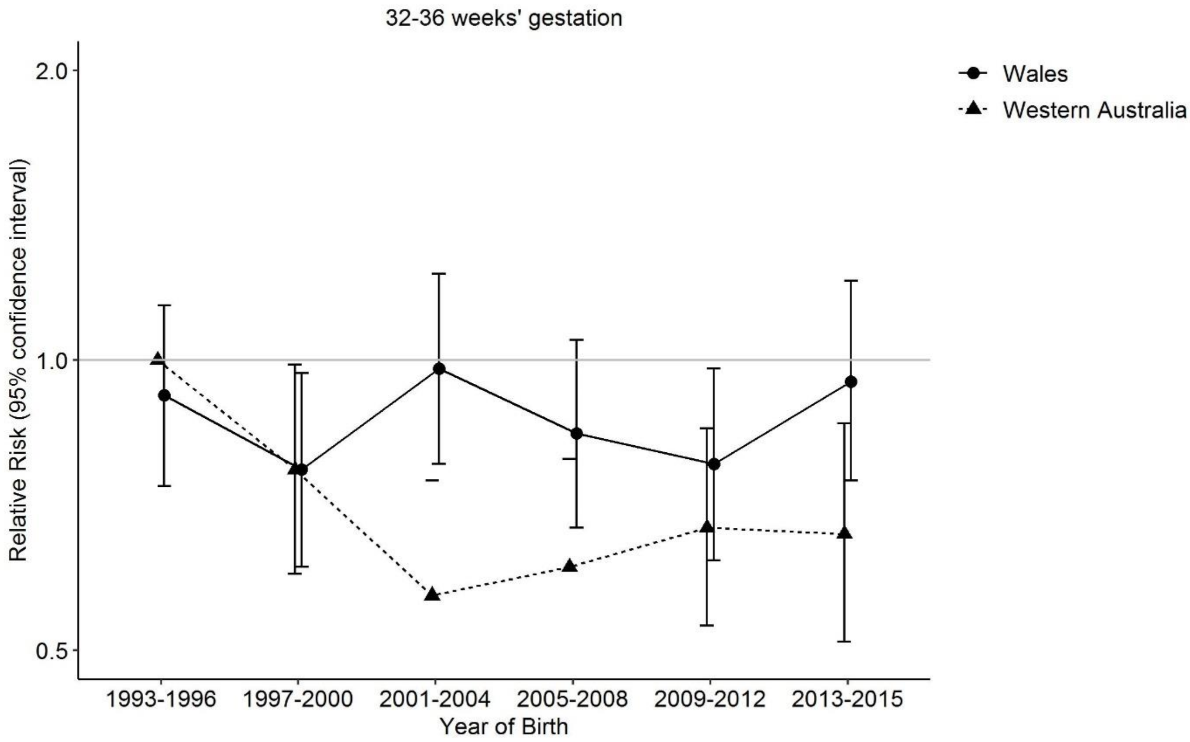
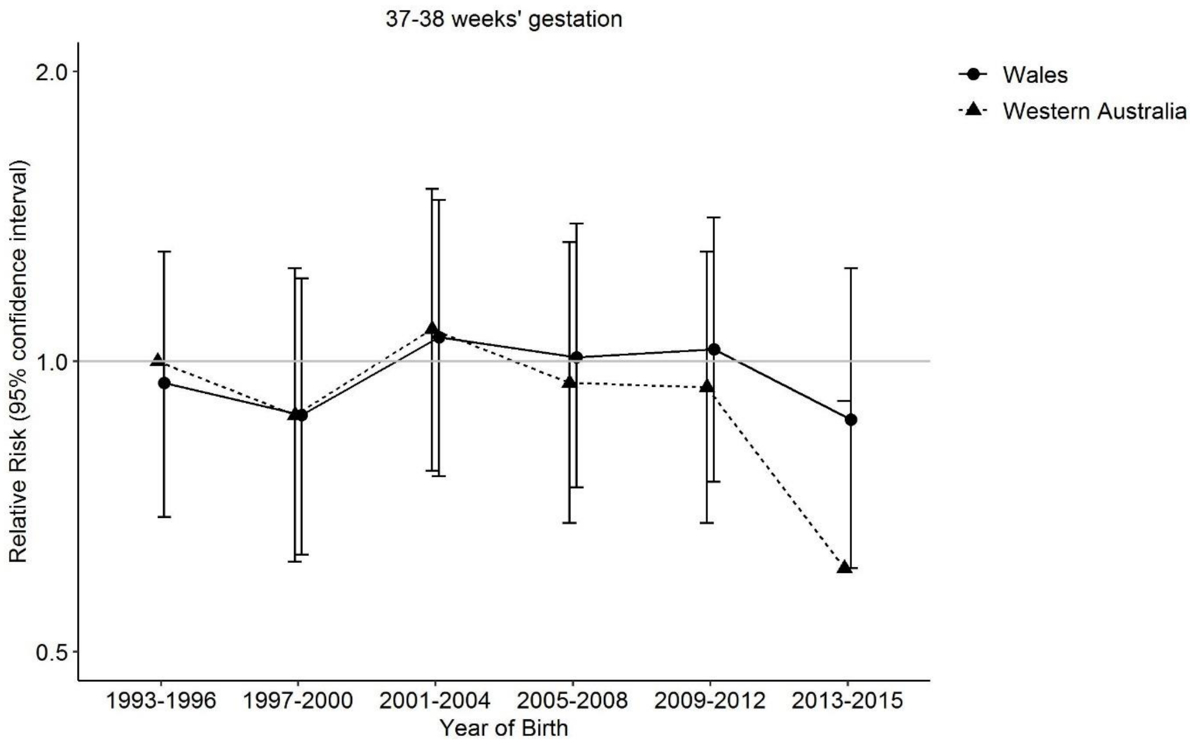
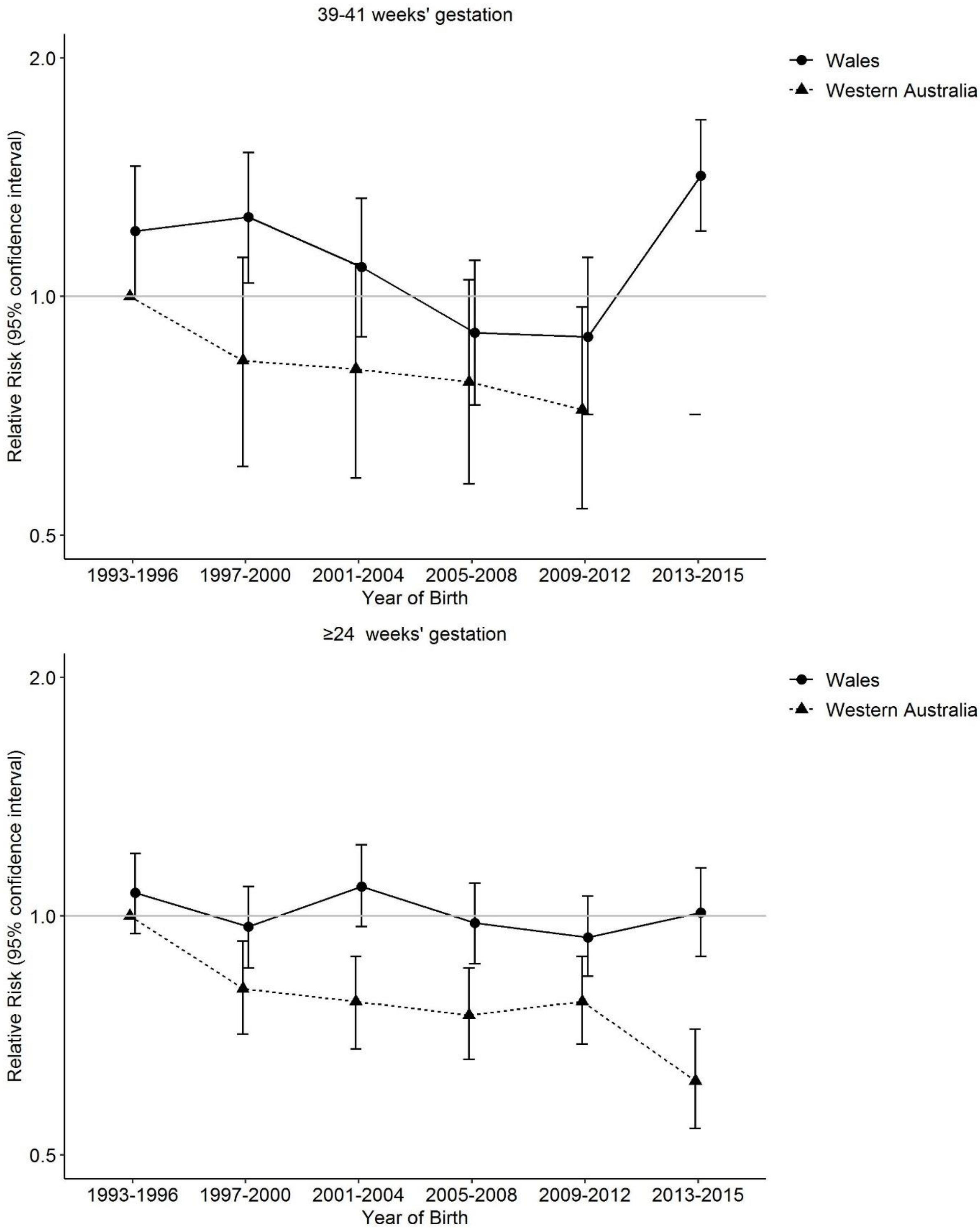

Stillbirth rate ≥24 weeks' gestation
Wales
Western Australia
Stillbirths per 1,000 births
5.5
5.0
4.5
4.0
3.5
3.0
1993-1996
1997-2000
2001-2004
2005-2008
2009-2012
2013-2015
Year of Birth

Figure S2: Sensitivity analysis, excluding all with missing data: Comparison of the adjusted relative risk and 95% confidence interval, for stillbirth in Wales and Western Australia (1993-2015) (excluding terminations of pregnancy for congenital anomalies), stratified by gestational age at stillbirth (using the Western Australia rate for 1993-1996 as the reference).



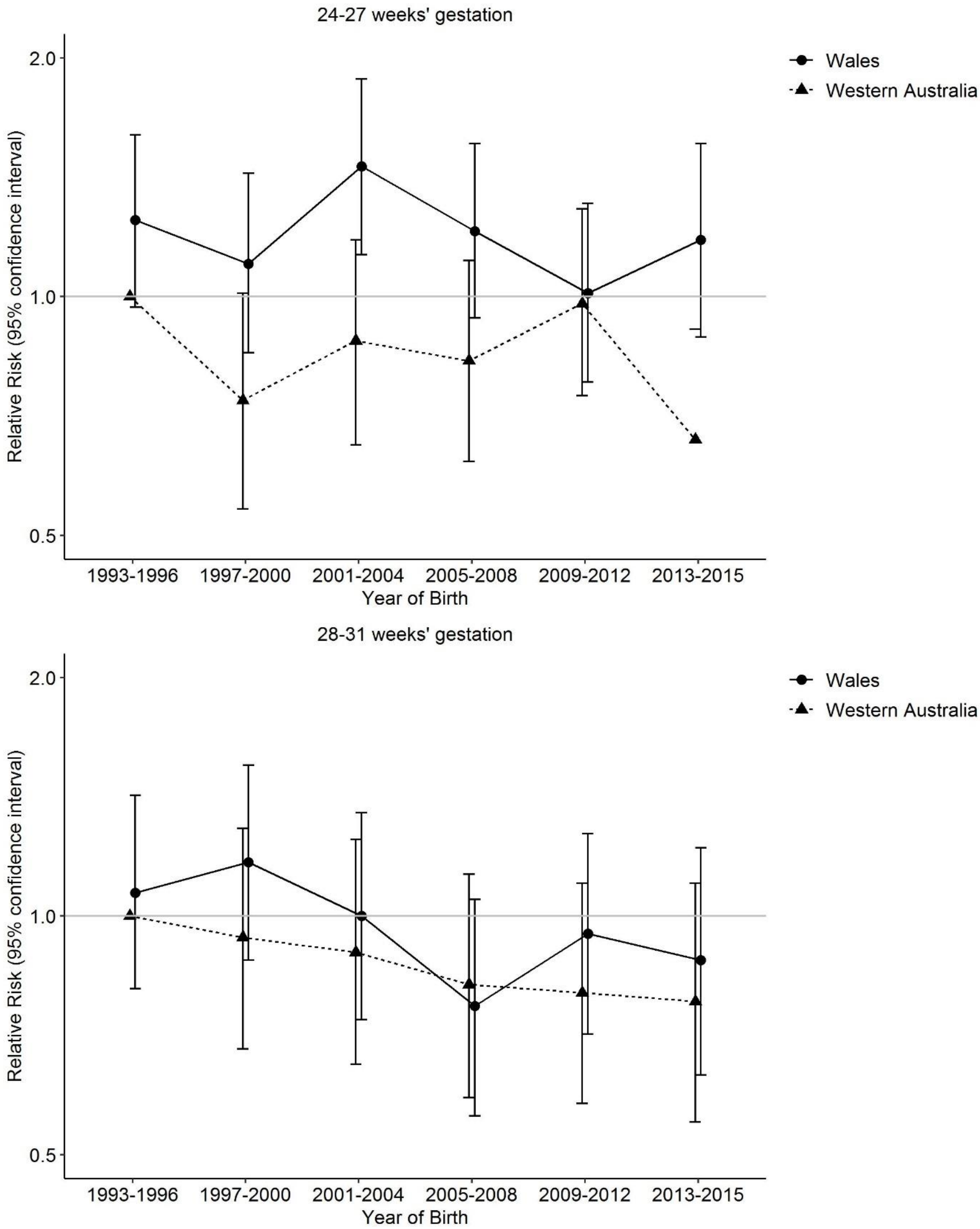

32-36 weeks' gestation
Wales
Western Australia
Relative Risk (95% confidence interval)
2.0
1.0
0.5
1993-1996
1997-2000
2001-2004
2005-2008
2009-2012
2013-2015
Year of Birth

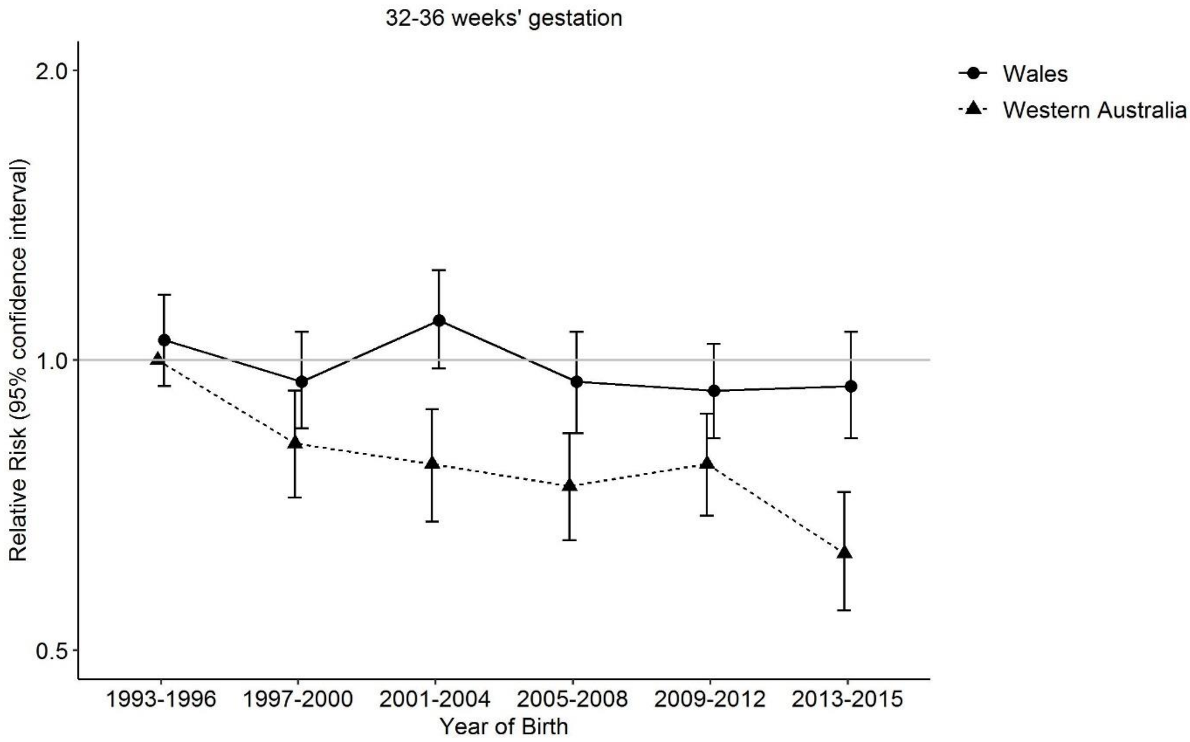

37-38 weeks' gestation
Wales
Western Australia
Relative Risk (95% confidence interval)
2.0
1.0
0.5
1993-1996
1997-2000
2001-2004
2005-2008
2009-2012
2013-2015
Year of Birth

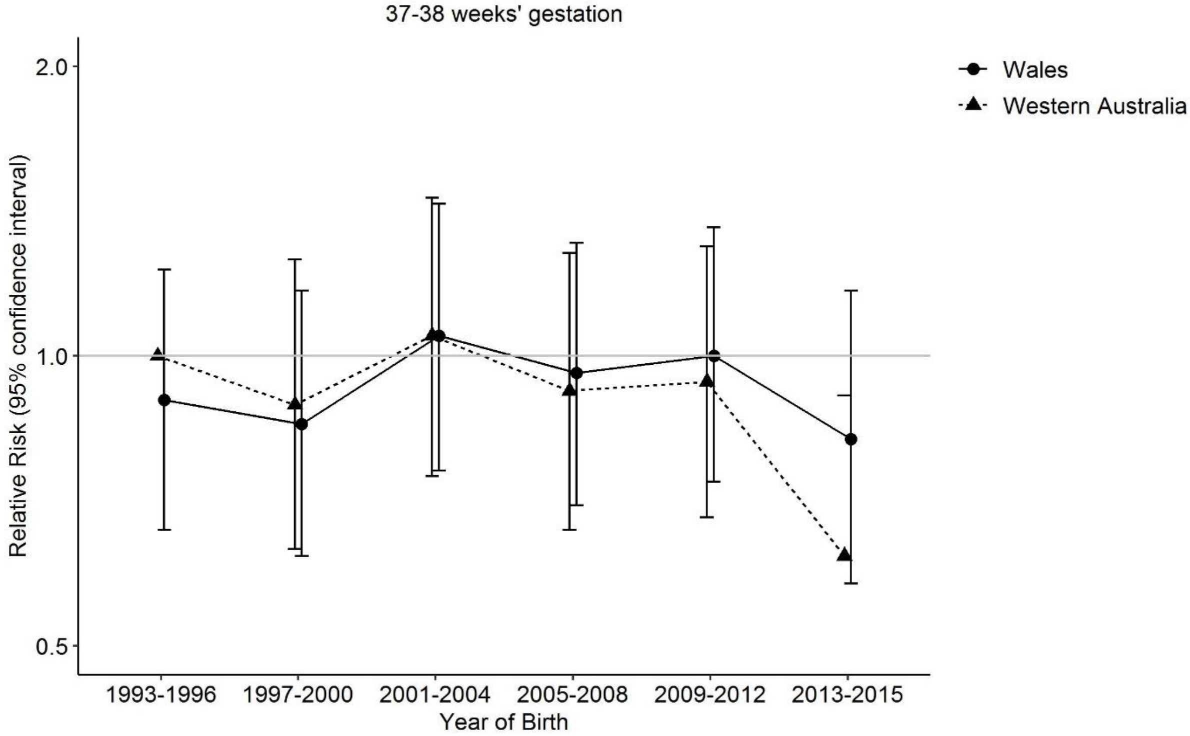


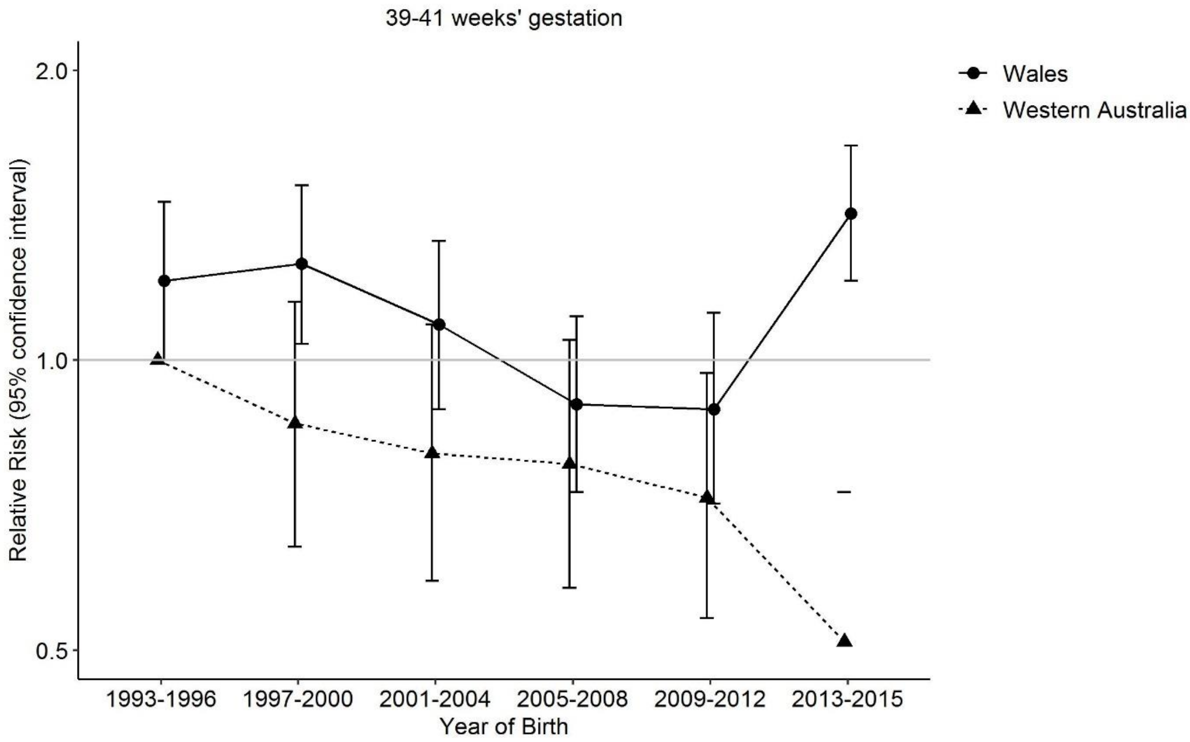
Adjusted for maternal age, multiple birth, quintile of area-based measure of deprivation of birth residence, small-for-gestational-age group, year of birth group, using the WA rate in 1993-1996 as the reference group.

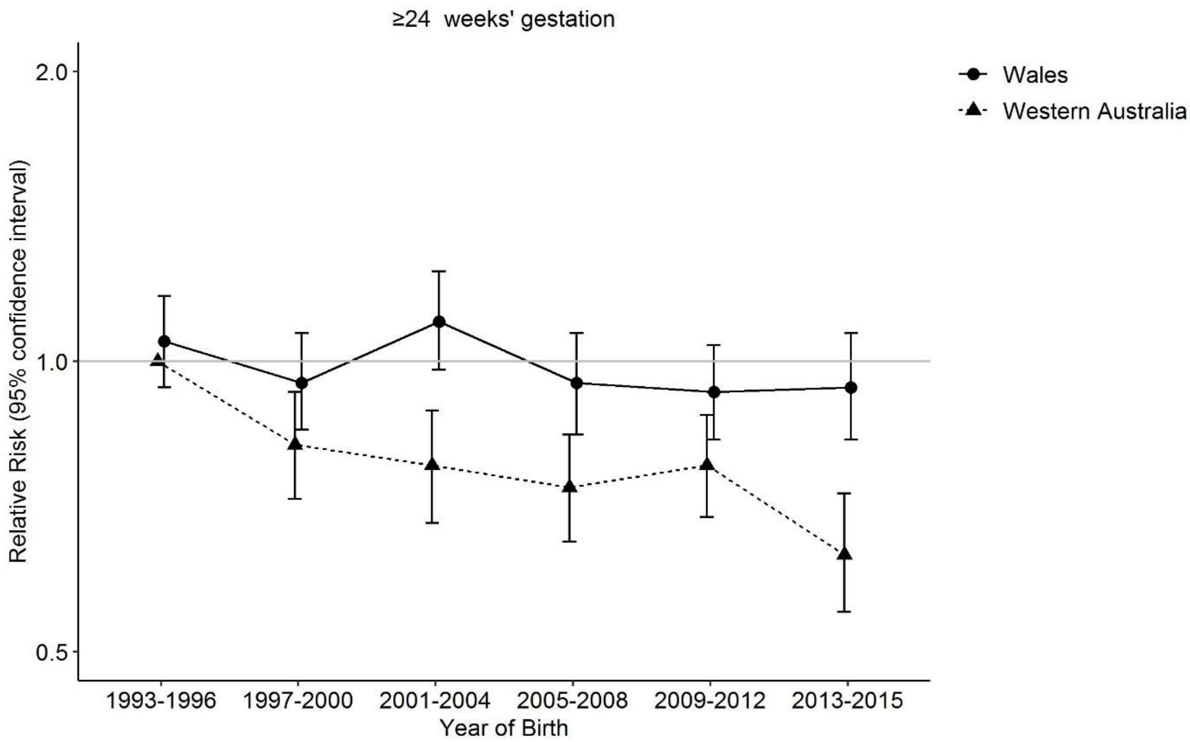
Figure S3: Sensitivity analysis, using the Australian national birthweight centiles for twin[1] live births for all plurals: Comparison of the adjusted relative risk and 95% confidence interval, for stillbirth in Wales and Western Australia (1993-2015) (excluding terminations of pregnancy for congenital anomalies), stratified by gestational age at stillbirth (using the Western Australia rate for 1993-1996 as the reference).




32-36 weeks' gestation
Wales
Western Australia
Relative Risk (95% confidence interval)
2.0
1.0
0.5
1993-1996
1997-2000
2001-2004
2005-2008
2009-2012
2013-2015
Year of Birth

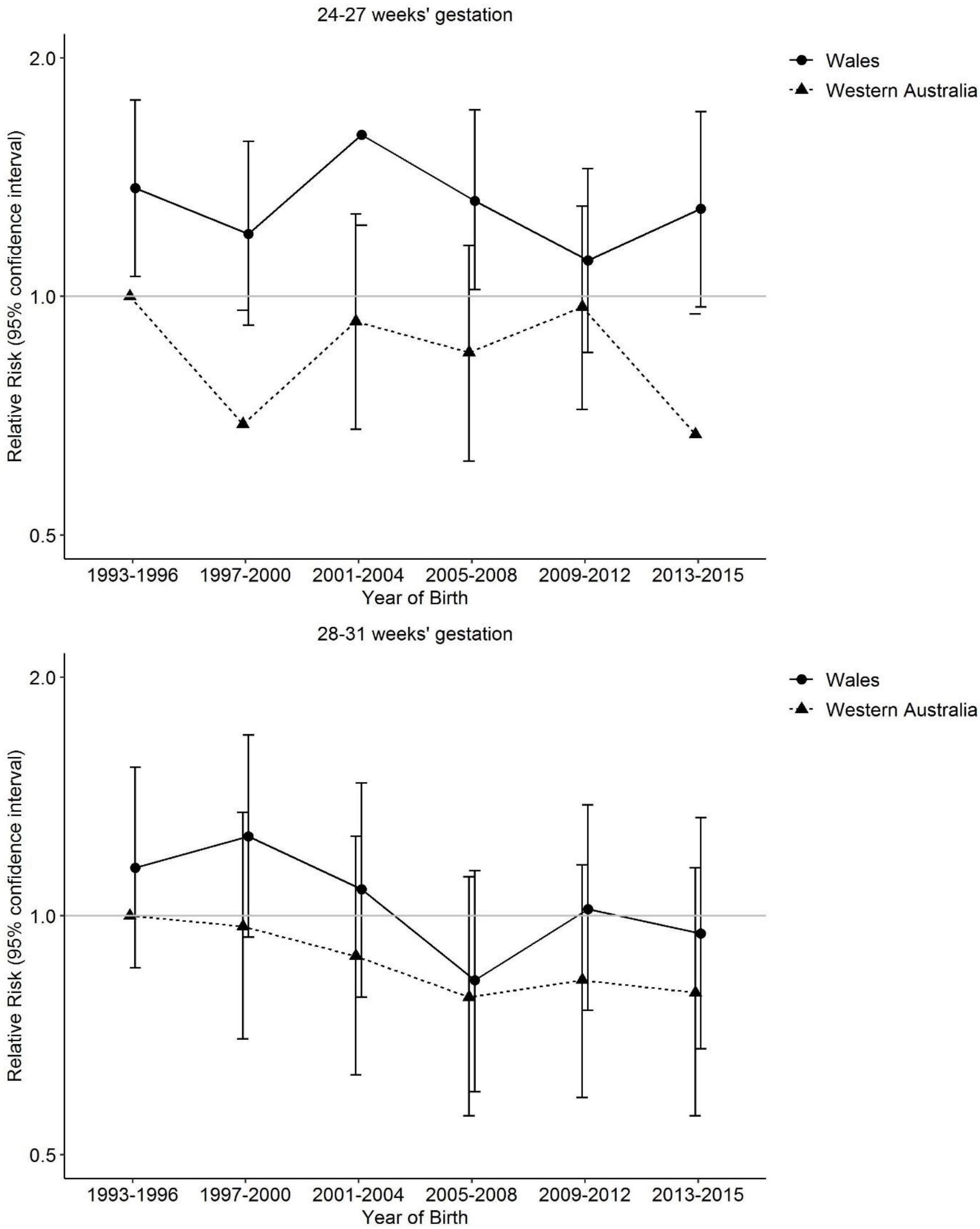

37-38 weeks' gestation
Wales
Western Australia
Relative Risk (95% confidence interval)
2.0
1.0
0.5
1993-1996
1997-2000
2001-2004
2005-2008
2009-2012
2013-2015
Year of Birth

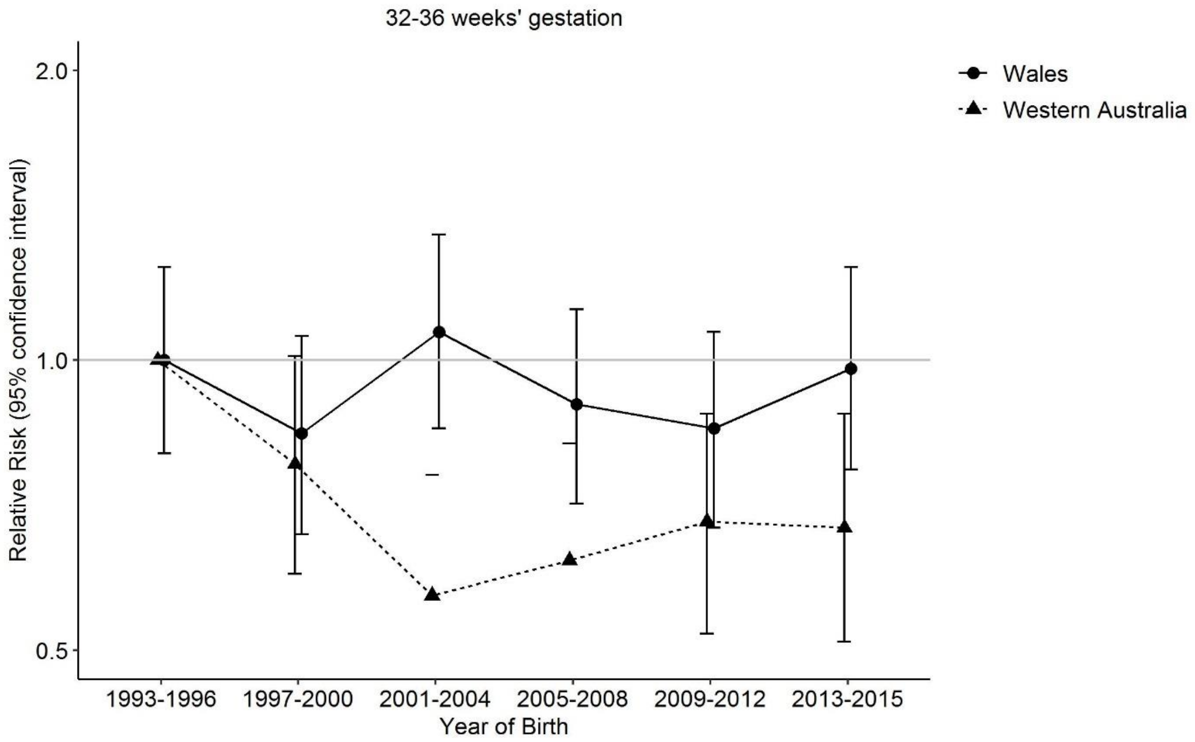


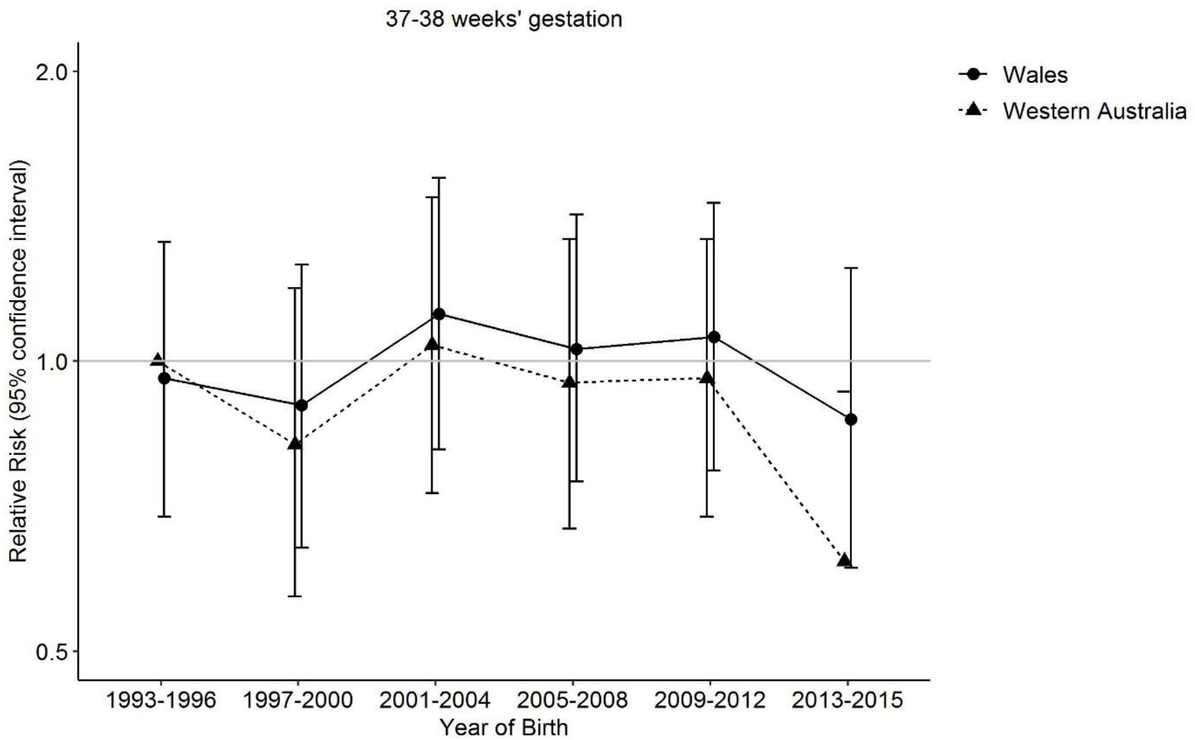


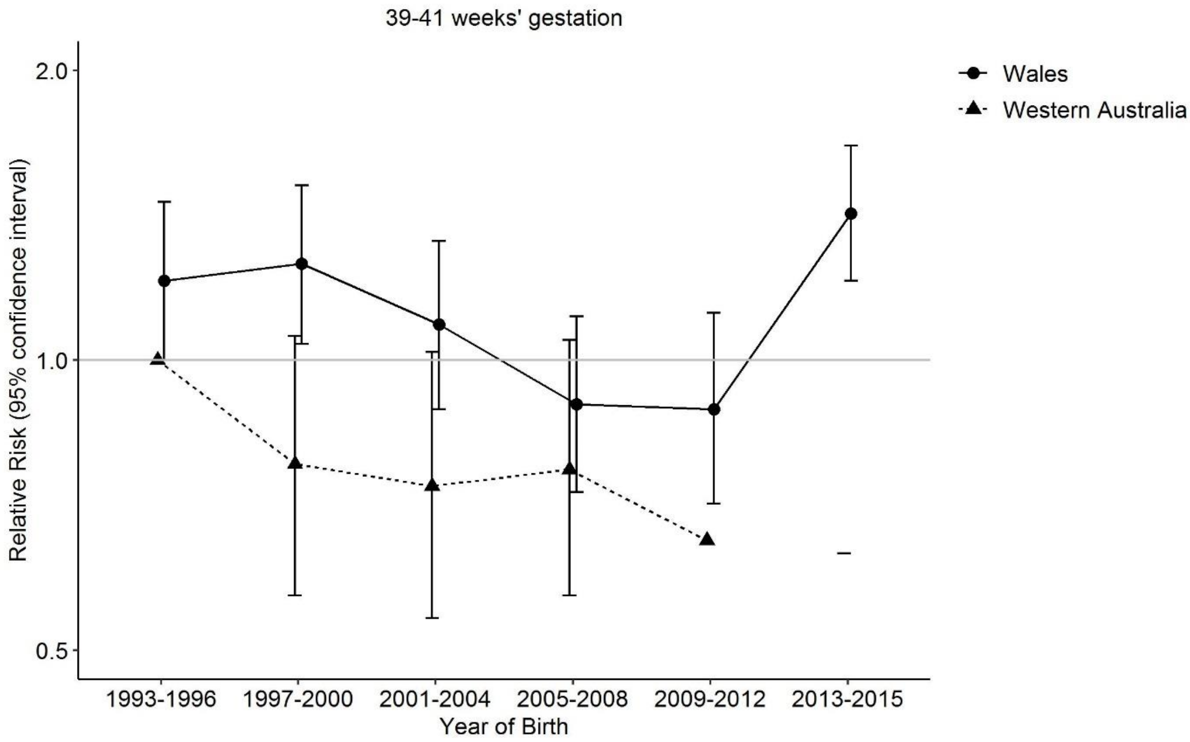
Adjusted for maternal age, multiple birth, quintile of area-based measure of deprivation of birth residence, small-for-gestational-age group, year of birth group, using the WA rate in 1993-1996 as the reference group.
[1] Li Z, Umstad MP, Hilder L, Xu F, Sullivan EA (2015) Australian national birthweight percentiles by sex and gestational age for twins, 2001-2010. BMC Pediatr 15:148. doi:10.1186/s12887-015-0464-y

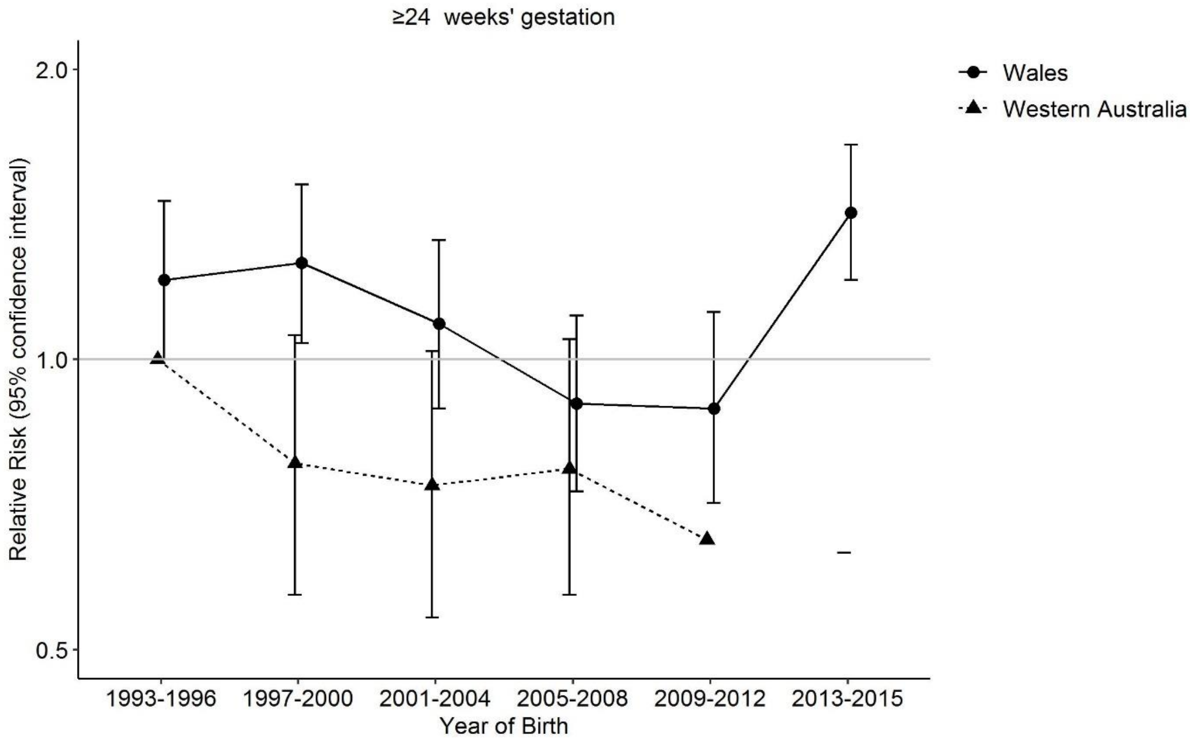
Figure S4: Sensitivity analysis after exclusion of births to Aboriginal mothers in WA (n = 40,911, 6.3%): Comparison of the adjusted relative risk and 95% confidence interval, for stillbirth in Wales and Western Australia (1993-2015) (excluding terminations of pregnancy for congenital anomalies), stratified by gestational age at stillbirth (using the Western Australia rate for 1993-1996 as the reference).




32-36 weeks' gestation
Wales
Western Australia
Relative Risk (95% confidence interval)
2.0
1.0
0.5
1993-1996
1997-2000
2001-2004
2005-2008
2009-2012
2013-2015
Year of Birth


37-38 weeks' gestation
Wales
Western Australia
Relative Risk (95% confidence interval)
2.0
1.0
0.5
1993-1996
1997-2000
2001-2004
2005-2008
2009-2012
2013-2015
Year of Birth





Adjusted for maternal age, multiple birth, quintile of area-based measure of deprivation of birth residence, small-for-gestational-age group, year of birth group, using the WA rate in 1993-1996 as the reference group.