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TITLE

Association between timing of diagnosis of trisomy 21, 18 and 13 and maternal socioeconomic status in Victoria, Australia: a population-based cohort study from 2015-16

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DISCLOSURES OF POTENTIAL CONFLICT OF INTEREST

Dr Palma-Dias reports a commercial relationship with Roche Diagnostics, personal fees from Philips Ultrasound, outside the submitted work. Dr D Nisbet reports a commercial relationship with Roche Diagnostics, outside the submitted work.

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BULLETED STATEMENTS

What's already known? Sociodemographic factors influence whether pregnant women are offered or utilise prenatal screening and diagnostic tests for fetal chromosome conditions.

What does this study add? Women from socioeconomically disadvantaged regions were less likely to receive a prenatal diagnosis of a major autosomal trisomy before 17 weeks, and more likely to have a livebirth of an infant with trisomy 21 than advantaged women. The majority of trisomy 21 live births were not preceded by any prenatal genetic testing.

DATA AVAILABILITY STATEMENT

The raw datasets are not publicly available due to the conditions of ethics committee approvals.

ABSTRACT

Objectives: To explore the association between timing of diagnosis of common autosomal trisomies, maternal age and socioeconomic status (SES).

Design: Retrospective study of cytogenetic diagnoses of trisomy 21 (T21), trisomy 18 (T18) and trisomy 13 (T13) in Victoria, Australia in 2015-16, stratified by timing (prenatal < 17 weeks (w), prenatal ≥ 17w, postnatal < 12 months), maternal age and SES region. Utilisation of prenatal testing following a liveborn T21 infant was ascertained via record linkage.

Results: Among 160,230 total births were 571 diagnoses of T21 and 246 of T18/T13. The overall and livebirth prevalences of T21 were 3.56 and 0.47 per 1000 births respectively. Compared with women from disadvantaged SES regions, women from high SES regions were more likely to have a prenatal diagnosis of a trisomy <17w than after ($p<0.01$), and less likely to have a liveborn T21 infant than a prenatal diagnosis ($p<0.01$). There was a significant trend to higher livebirth rates of T21 with lower SES ($p=0.004$). The majority (68.5%) of women who gave birth to a live infant with T21 did not utilise prenatal testing.

Conclusion: There is a significant relationship between lower SES, later prenatal diagnosis of trisomy and higher livebirth rate of T21 in Victoria.

INTRODUCTION

The autosomal trisomies, trisomy 21 (T21, Down Syndrome), trisomy 18 (T18, Edward syndrome) and trisomy 13 (T13, Patau syndrome) are among the most common birth defects, and are associated with significant health and developmental consequences including intellectual disability, congenital malformations and high rates of perinatal loss (miscarriage, stillbirth, neonatal death). It is recommended practice in Australia for maternity clinicians to offer all pregnant women prenatal screening for aneuploidy.[1] The three main screening tests in use in Australia are: combined first trimester screening (CFTS) with the 11-13 week ultrasound for nuchal translucency measurement plus serum biochemical markers, maternal plasma cell-free DNA-based screening (also known as non-invasive prenatal testing or NIPT) from 10 weeks gestation, and second trimester serum screening (STSS) with maternal serum biochemical markers at 15-20 weeks ('quad' screening).

In Australia, prenatal care is provided in a variety of public and private settings, Of women giving birth in Victoria in 2015, 73.4% were public patients and 26.3% were private patients.[14] Government rebates are available for CFTS, second trimester serum screening (STSS) and the mid-trimester morphology ultrasound with variable out-of-pocket cost to the patient (typically <AUD 200). CfDNA has been available on a patient funded basis since 2013 at an average cost of AUD500 and is not subsided by the government. Nevertheless, NIPT has been rapidly adopted through individual patient choice and clinician practice and was used by at least 20% of women as a primary screening test in 2015. The two diagnostic tests, CVS and amniocentesis, are fully government-funded if performed in a public hospital, but incur direct patient costs if performed in the private sector.

Major changes in the prenatal screening field have occurred since the commercial availability of NIPT in Australia and elsewhere in 2013, introducing new ethical implications related to access.[2] There have been ongoing concerns regarding the equitable integration of genomic advances into pregnancy care and recent calls for public funding of NIPT.[3] Ideally, women should be offered prenatal screening in the first trimester, as this maximises choice and facilitates subsequent genetic counselling and prenatal diagnosis of an affected pregnancy before 17 weeks gestation. Earlier prenatal diagnosis is not only psychologically preferable for women,[4] but also improves access to surgical termination of pregnancy in Victoria if requested, as services are limited after 17 weeks gestation.[5] Further opportunities for trisomy detection occur at the time of second trimester fetal morphology scan (typically performed at 18-22 weeks), but its sensitivity for T21 is lower. A prenatal diagnostic procedure prior to 17 weeks (typically via chorionic villus sampling (CVS) at 11-14 weeks, or amniocentesis at 15-16 weeks) can therefore be viewed as a marker of best practice for those women who choose to have prenatal testing.

Our prior research has demonstrated significant variation in indications for prenatal diagnosis according to socioeconomic status (SES), finding women in lower socioeconomic regions more likely to undergo invasive testing as a result of false positive screening results than their higher socioeconomic counterparts.[6] In this study, we newly obtained state-wide postnatal cytogenetic data, in order to (1) to analyse the prenatal and postnatal diagnoses of the common autosomal trisomies in Victoria, (2) to explore the association between timing of diagnosis, maternal age and SES, and (3) to assess the utilisation of prenatal screening in women who gave birth to a live infant with T21.

METHODS

Population characteristics

Victoria has approximately 73,000 births annually. During the study period the median maternal age was 31.1 years, the total fertility rate was 1.79, and the mean weekly disposable household income was AUD $1,009.[7-10]

Data sources

All women with a Victorian postcode who received a prenatal or postnatal cytogenetic diagnosis of T21, T18 and T13 in their fetus/infant from January 2015 to December 2016 were included in this analysis. A perinatal record linkage (PeRL) collaboration was formed between the providers of screening and diagnostic services for this study (see acknowledgements for full list of members).

(i) The Victorian Prenatal Diagnosis Database, which includes results of all amniocenteses and CVS performed in Victoria. This dataset has been described in detail elsewhere.[11]

(ii) The postnatal diagnosis dataset included chromosome results from all products of conception, placenta/umbilical cord, cord blood, and infant samples performed in Victoria. Infant samples up to 12 months of age were included.

(iii) State-wide CFTS and STSS results were obtained from the Victorian Clinical Genetics Service.

(iv) NIPT data were obtained from three pathology services and a number of major private obstetric practices providing a range of NIPT assays (including percept™, Generation™, Panorama™ and Harmony™). These data did not include all NIPT referrals in Victoria due to the fragmented and privatised nature of NIPT provision. However, the participating services collectively represent the vast majority of NIPT referrals in our state. On the basis of ongoing monitoring (unpublished), we estimate that our dataset contains over 80% of NIPT performed in Victoria.

Victorian birth data were obtained from the Consultative Council on Obstetric and Paediatric Mortality and Morbidity (CCOPMM) and the Australian Bureau of Statistics (ABS). [7,12,13] CCOPMM data were used to calculate overall prevalence as it incorporates data on terminations of pregnancy, stillbirths and livebirths from ≥ 20 weeks gestation. ABS birth data was used to calculate the livebirth prevalence stratified by maternal SES.

Record linkage

1. Postnatal cases of T21, T18 and T13 that contained infant identifiers were submitted to the Victorian Infant Hearing Screening Program (VIHSP)[14] to obtain the matched maternal identifiers. This newborn screening program collects maternal and infant identifiers on all live infants born in hospital for the purpose of auditory screening. Only abnormal postnatal results were submitted to the VHISP for retrieval of maternal identifiers to allow linkage to the prenatal screening and diagnosis dataset.
2. Duplicate prenatal and postnatal diagnostic tests for the same pregnancy were identified using probabilistic record linkage with LinkageWizTM (Version 5.5.1, Australia) and manual checking.
3. Data sources (iii) and (iv) were combined to generate a total prenatal screening dataset
4. Manual linkage between the postnatal dataset and the total screening dataset was performed to determine whether women with a livebirth of a T21 infant had accessed any prenatal screening.

Maternal socioeconomic status

Socioeconomic status was assigned to each case using the Index of Relative Socio-economic Advantage and Disadvantage (IRSAD) score associated with maternal postcode. The IRSAD

is a comprehensive metric incorporating data on income, occupation, education, employment and housing, and is assigned by the Australian Bureau of Statistics from 2016 Census data.[15] IRSAD scores were grouped into quintiles, with quintile 5 being the most advantaged and quintile 1 being the least advantaged.

Statistical analysis

We performed two analyses of the timing of diagnosis of trisomy: (i) early prenatal versus late prenatal diagnosis, and (ii) prenatal versus livebirth diagnosis. Postnatal diagnoses performed after perinatal loss were not included in these comparisons as these generally represent inevitable losses (miscarriage or stillbirth) or terminations for fetal structural abnormality where cytogenetic investigation was only performed after the termination. The 17 week cut off for defining 'early prenatal' diagnosis was chosen due to its clinical relevance. Diagnostic confirmation after a high risk first trimester screening result (CFTS or NIPT) should ideally be completed by 17 weeks, accounting for the timeline of referral for genetic counselling, scheduling of a diagnostic procedure, and laboratory turn-around time for fetal chromosome analysis.

$\chi 2$ test for trend and logistic regression for unadjusted and adjusted odds ratios was performed. Confounders available for inclusion for analysis were maternal age (not available for the postnatal diagnosis analysis) and IRSAD quintile. Statistical analysis was performed with STATA v14 (Statacorp, LLC, College Station, TX, USA) and Prism 6 (Version 6.0 h 2015; GraphPad Software Inc., San Diego, CA, USA). A P value <0.05 was considered statistically significant.

Definitions

A table of definitions is provided in Table 1.

Ethics approvals

This study was approved by the Royal Children's Hospital Human Research Ethics Committee (reference numbers: 35171B and 31135A) and Monash Health (reference number 12063B).

RESULTS

Over the 24-month study period, there were 160,230 births and 817 confirmed diagnoses of T21, T18, and T13. Among the 571 total cases of T21, 386 (67.6%) were ascertained via prenatal diagnosis, 112 (12.8%) after a perinatal loss and 73 (19.6%) following a livebirth (Table 2). The vast majority of T18 and T13 cases were diagnosed during pregnancy or after perinatal loss, with only 0.7% and 2.8% of diagnoses made in livebirths respectively.

The overall prevalence of T21 was 3.56 per 1000 pregnancies (1 in 284) and 0.47 per 1000 livebirths (1 in 2714) (Table 2).

Early versus late prenatal diagnosis of T21/18/13

518 women received a prenatal diagnosis of T21/T18/T13 via amniocentesis or CVS, of which 513 had a known gestational age at testing. The majority of prenatal diagnoses of T21 cases occurred before 17 weeks gestation (90.4%). Women who had a prenatal diagnosis of T18 or T13 were significantly less likely to receive a prenatal diagnosis before 17 weeks compared to those with a prenatal diagnosis of T21, after adjusting for maternal age and IRSAD quintile (T18 - adjOR 0.41, $p<0.02$ and T13 - adjOR 0.26, $p<0.01$) (Table 3).

Younger women (19-29 years) were significantly less likely to receive an early prenatal diagnosis, than the 40+ age group (adjOR 0.30, $p=0.01$). There was a significant trend

231 towards early prenatal diagnosis with greater maternal socioeconomic advantage ($\chi 2$ trend =
232 6.23, p =0.01) (Table 3).
233
234 ***Prenatal versus livebirth diagnosis of T21***
235 Due to the small number of livebirths with T18 or T13, this analysis was confined to T21.
236 Compared with women in IRSAD 5, the most disadvantaged women in IRSAD 1 were 4.6
237 times more likely to receive a T21 diagnosis in a live infant rather than during pregnancy
238 (unadjOR 4.62, p<0.01) (Table 4 and Figure 1).
239
240 Figure 2 shows the livebirth rate of T21 in Victoria by IRSAD quintile. There was a
241 significant trend to higher livebirth rate of T21 with declining socioeconomic status ($\chi 2$ trend
242 = 15.6, p =0.004).
243
244 ***Utilisation of prenatal testing among women with T21 livebirth***
245 Of the 73 women who had a livebirth with T21, 50 (68.5%) had not utilised any prenatal
246 screening or diagnosis, 13 (17.8%) had a false negative prenatal screening result, and 7
247 (9.6%) had a high-risk screening result without confirmation via prenatal diagnosis. 3 (4.1%)
248 women directly accessed invasive prenatal diagnosis, without undergoing prior prenatal
249 screening.
250
251
252 **DISCUSSION**
253 This study is the first of its kind to link prenatal and postnatal cytogenetic databases in
254 Australia in order to analyse the timing of the diagnosis of common autosomal trisomies by
255 maternal socioeconomic status. We have shown that women residing in socioeconomically
256 disadvantaged regions are more likely to have a prenatal diagnosis of a trisomy after 17

weeks, and to give birth to a live infant with T21, compared with women from socioeconomically advantaged regions.

Australian women have previously indicated that they value early prenatal diagnosis,[4] preferring first trimester over second trimester screening.[16] The significant relationship between higher SES and early prenatal diagnosis before 17 weeks reflects known differences in screening indications for prenatal diagnosis in our population, with disadvantaged women more likely to undergo STSS-indicated invasive prenatal diagnosis, and less likely to have NIPT-indicated prenatal diagnosis than advantaged women.[6] Timely presentation for antenatal care and financial capacity are the most likely socioeconomic influences on a women's choice of first or second trimester screening. The fact that disadvantaged women are more likely to have a prenatal diagnosis of a major trisomy after 17 weeks has important management, as well as ethical implications, as surgical termination of pregnancy is less available and less affordable in Victoria after 17 weeks, and entails higher surgical risks to the woman.[5]

Sociodemographic factors such as income, education, maternal age, rurality and ethnicity significantly influence whether women are offered or utilise prenatal screening tests in the first instance.[17-20] We found that the likelihood of a livebirth with T21 was almost five times as high in the most disadvantaged women compared to the least; and the majority of these women had not utilised any prenatal screening. This was associated with a significant trend towards higher livebirth rates of T21 for women residing in lower SES regions. These could be explained by patient factors such as differences in ethical, cultural or religious beliefs among women of different SES regions. Maternal age may also be a factor, but as these data were not available for the livebirth cases, we were unable to adjust for this potential

confounder. It is also possible that discrepancies in the utilisation of medical services may have contributed to our results as both lower socioeconomic status and younger maternal age are known to influence engagement with healthcare systems.[21]

We also observed that women with a fetal diagnosis of T13 or T18 were less likely to receive an early prenatal diagnosis than women with a fetal diagnosis of T21. This is probably best explained by the fact that all current screening tests have a lower sensitivity for identifying T18 and T13 compared with T21,[22,23] while STSS does not screen for T13 at all.

As expected, there were a higher number of autosomal trisomies in the older maternal age groups, in keeping with their known association with advanced maternal age.[24,25] The greater number of diagnoses of T21 in the higher SES quintiles was because these quintiles have more births overall and more women of a higher maternal age, compared to lower quintiles.[6] Younger women were significantly less likely to receive an early prenatal diagnosis compared to older women, even after adjustment for SES and trisomy type. Maternal age is an intrinsic component of the CFTS risk algorithm, and CFTS is known to have a lower detection rate in younger women. [26] Other possible explanations for this finding include differences in the offer or acceptance of first trimester screening due to varying perceptions of risk in younger women, and differences in post-test counselling by clinicians following a high-risk screening result.[20]

The main strength of this study was the complete case ascertainment of prenatal and postnatal trisomy cases from all pathology providers in Victoria, and the ability to perform individual record linkage of the postnatal T21 cases to prenatal screening data, including NIPT. This allowed us to measure the utilisation of prenatal testing by women with a live infant

diagnosed with T21, and to assess the association between maternal SES and fetal/infant diagnoses of a major autosomal trisomy.

The major limitation was the lack of pregnancy outcome data for women receiving a prenatal diagnosis of a major trisomy. It was noted that even after both probabilistic and manual linkage, very few cases appeared in both the prenatal and postnatal datasets. Those that are unaccounted for in the postnatal dataset may have either ended in a perinatal loss (termination of pregnancy, miscarriage or stillbirth) or a livebirth without postnatal cytogenetic testing. We do, however, expect that a livebirth of an infant with T21 would be documented with a formal postnatal karyotype within the first year of life.

The other major limitation is that we were unable to define the factors contributing to the differences in prenatal diagnosis between advantaged and disadvantaged women in Victoria. Analyses were restricted by the range of data collected, hence confounding factors known to influence choices regarding prenatal testing (such as ethnicity, religion and cultural background) were unable to be accounted for. Equity of access to medical care is an important principle underlying our universal health care model, and the high patient cost for accessing NIPT has been identified as a major ethical issue for Australia practitioners.[27] Whether our observed differences in outcomes are due to patient factors, practitioner-based factors or systemic barriers to access, particularly economic factors, will be important areas of future research.

CONCLUSION

Maternal residence in an area of socioeconomic disadvantage is significantly associated with later prenatal diagnosis of major autosomal trisomies and higher livebirth rates of T21. These

findings are of particular relevance to health policy makers and clinicians when evaluating the performance of population-based prenatal screening programs. Further research into the potential factors contributing to these differences in outcomes, particularly systemic barriers to accessing healthcare and qualitative research to further characterise women's preferences, is urgently needed.

REFERENCES

1. Royal Australian and New Zealand College of Obstetrics and Gynacologists. Prenatal screening and diagnosis of chromosomal and genetic abnormalities in the fetus in pregnancy. https://www.ranzcog.edu.au/RANZCOG_SITE/media/RANZCOG-MEDIA/Women%27s%20Health/Statement%20and%20guidelines/Clinical-Obstetrics/Prenatal-screening-(C-Obs59)-July18.pdf?ext=.pdf. Accessed October 8, 2018.

2. Dickinson J, Costa C. Non-invasive prenatal testing: the new era in reproductive medicine. *Med J Aust* 2015; 203: 57-8.

3. Maxwell S, O'Leary P. Public funding for non-invasive prenatal testing for fetal aneuploidy – It's time. Aust N Z J Obstet Gynaecol 2018; 58: 385-7.

4. Lewis S, Cullinane F, Carlin J, Halliday J. Women's and health professionals' preferences for prenatal testing for Down syndrome in Australia. Aust N Z J Obstet Gynaecol 2006; 46: 205-11.

5. Keogh L, Newton D, Bayly C, et al. Intended and unintended consequences of abortion law reform: perspectives of abortion experts in Victoria, Australia. J Fam Plann Reprod Health Care 2017; 43: 18-24.

6. Hui L, Barclay J, Poulton A, et al. Prenatal diagnosis and socioeconomic status in the non-invasive prenatal testing era: A population-based study. Aust N Z J Obstet Gynaecol 2018; 58: 404-410.

7. Australian Bureau of Statistics. Births, summary, by state. http://stat.data.abs.gov.au/Index.aspx?DatasetCode=BIRTHS_SUMMARY. Accessed October 8, 2018.

8. Australian Bureau of Statistics. Fertility, By Age, By State. http://stat.data.abs.gov.au/Index.aspx?DataSetCode=BIRTHS_MONTH_OCCURRENCE. Accessed Oct 8, 2018.

9. Australian Bureau of Statistics. Household Income and Wealth, Australia, 2015-16. http://abs.gov.au/household-income. Accessed October 8, 2018.

10. Australian Bureau of Statistics. Confinements, by nuptiality, by state. http://stat.data.abs.gov.au/Index.aspx?DataSetCode=BIRTHS_MONTH_OCCURRENCE Accessed October 8, 2018.

11. Hui L, Muggli E, Halliday J. Population-based trends in prenatal screening and diagnosis for aneuploidy: a retrospective analysis of 38 years of state-wide data. BJOG: An International Journal of Obstetrics & Gynaecology 2016; 123: 90-97.

12. The Consultative Council on Obstetric and Paediatric Mortality and Morbidity (CCOPMM). Victoria's Mothers, Babies and Children 2014 and 2015. Victoria Department of Health & Human Services State Government Victoria; 2016

13. The Consultative Council on Obstetric and Paediatric Mortality and Morbidity (CCOPMM). Victoria's Mothers, Babies and Children 2016 Victoria Department of Health & Human Services State Government Victoria; 2017.

14. Royal Children's Hospital. Victorian Infant Hearing Screening Program. https://www.rch.org.au/vihsp. Accessed March 7, 2019.

15. Australian Bureau of Statistics. Census of Population and Housing: Socio-Economic Indexes for Areas (SEIFA). http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/2033.0.55.001main+features100042011. Accessed June 28 2018.

16. Mulvey S, Wallace E. Women's knowledge of and attitudes to first and second trimester screening for Down's syndrome. BJOG: An International Journal of Obstetrics & Gynaecology 2000; 107: 1302-5.

17. Posthumus A, Peters I, Borsboom G, et al. Inequalities in uptake of prenatal screening according to ethnicity and socioeconomic status in the four largest cities of the Netherlands (2011-2013). Prenatal Diagnosis 2017; 37: 959-967.

18. Coory M, Roselli T, Carroll H. Antenatal care implications of population-based trends in Down syndrome birth rates by rurality and antenatal care provider, Queensland, 1990–2004. MJA 2007; 186: 230-4.

19. Maxwell S, Brameld K, Bower C, et al. Socio-demographic disparities in the uptake of prenatal screening and diagnosis in Western Australia. Aust N Z J Obstet Gynaecol 2011; 51: 9-16.

20. Moses R, Brown J, Wright D, et al. Who is and isn't having babies with Down syndrome in western Sydney: a ten year hospital cohort study. Aust N Z J Obstet Gynaecol 2017; 57: 146-51.

21. Downe S, Finlayson K, Walsh D, Lavender T. 'Weighing up and balancing out': a meta-synthesis of barriers to antenatal care for marginalised women in high-income countries. BJOG: An International Journal of Obstetrics & Gynaecology 2009; 116: 518-29.

22. Taylor-Phillips S, Freeman K, Geppert J. Accuracy of non-invasive prenatal testing using cell-free DNA for detection of Down, Edwards and Patau syndromes: a systematic review and meta-analysis. BMJ Open. 2016; 6; 1.

23. Ekelund C, Peterlin B, Skibsted L, et al. First trimester screening for trisomy 21 in Denmark: implications for detection and birth rates of trisomy 18 and trisomy 13. Ultrasound Obstet Gynecol 2011; 38: 140-44.

24. Snijders RJ, Sundberg K, Holzgreve W, et al. Maternal age- and gestation-specific risk for trisomy 21. Ultrasound Obstet Gynecol 1999; 13: 167-70.

25. Carothers A, Hecht C, Hook E. International variation in reported livebirth prevalence rates of Down syndrome, adjusted for maternal age. Journal of Medical Genetics 1999; 36: 386-93.

26. Spencer K. Age related detection and false positive rates when screening for Down's syndrome in the first trimester using fetal nuchal translucency and maternal serum free beta hCG and PAPP-A. BJOG: An International Journal of Obstetrics & Gynaecology 2001; 108: 1043-6.

27. Hui L, Teoh M, Piessens S, Walker SP. Early clinical experience of cell-free DNA-based aneuploidy screening: a survey of obstetric sonologists in Australia and New Zealand. Aust NZ J Obstet Gynaecol 2015; 55:138-143.

418 **TABLES**
419 **Table 1 – Table of definitions**
420

Term	Definition
Prenatal diagnosis	the results of a karyotype or microarray from a chorionic villus sampling or amniocentesis at any gestation
Early prenatal diagnosis	prenatal diagnosis <17 weeks gestation
Late prenatal diagnosis	prenatal diagnosis ≥ 17 weeks gestation
Postnatal diagnosis	karyotype or microarray of any pregnancy tissue (placenta, cord, infant saliva, infant blood, 'products of conception') obtained after any birth (miscarriage, termination of pregnancy, livebirth, stillbirth), without a prior prenatal diagnosis in the same pregnancy
Miscarriage samples	postnatal samples performed on 'products of conception' referred under the maternal identifier with the indication 'miscarriage'
Livebirth samples	infant blood and buccal swab specimens
Perinatal loss	miscarriage, stillbirth or termination of pregnancy at any gestation
Total births	births at 20 weeks gestation or more, including terminations of pregnancy, stillbirths and livebirths
T21 livebirth prevalence	the number of postnatal T21 diagnoses from infant blood or buccal swab sample divided by the total registered livebirths > 20 weeks from the Australian Bureau of Statistics
T21 overall prevalence	the total number of prenatal and postnatal diagnoses, divided by the total births including terminations and stillbirths from the Consultative Council on Obstetric and Paediatric Mortality and Morbidity

421

Table 2 –Number of prenatal and postnatal diagnoses and prevalence rates of T21, T18 and T13 in Victoria, 2015-16

Timing of diagnosis	Trisomy 21		Trisomy 18		Trisomy 13		Total	
	n (%)	n/1000	n (%)	n/1000	n (%)	n/1000	n (%)	n/1000
Prenatal diagnosis	386 (67.6%)	2.40	88 (63.3%)	0.55	44 (41.1%)	0.27	518 (63.4%)	3.23
Diagnosis following perinatal loss	112 (19.6%)	0.70	50 (36.0%)	0.31	60 (56.1%)	0.37	222 (27.3%)	1.39
Livebirth diagnosis	73 (12.8%)	0.46	1 (0.7%)	<0.01	3 (2.8%)	0.19	77 (9.4%)	0.48
Total diagnoses, n (%)	571 (100%)		139 (100%)		107 (100%)		817 (100%)	
Overall prevalence (rate per 1000 pregnancies)	3.56		0.87		0.66		5.10	
Livebirth prevalence (rate per 1000 livebirths)	0.47		<0.01		0.02		0.49	

Perinatal loss includes miscarriage, stillbirth or termination of pregnancy in the absence of a prenatal karyotype at any gestation. Overall prevalence = the total number of diagnoses, divided by the total births (including terminations and stillbirths from CCOPMM reports (n = 160230).[12,13] Livebirth prevalence = the number of postnatal T21 diagnoses from infant blood or buccal swab sample divided by the total registered livebirths > 20 weeks from the ABS (n=156460)[7]

Table 3 – Association between early prenatal vs late prenatal diagnosis of T21, T18 and T13 by diagnosis, maternal age and Index of Relative Socio-economic Advantage and Disadvantage (IRSAD), 2015-16

Variable (n=513)*	Early prenatal diagnosis n (%)	Late prenatal diagnosis n (%)	Unadjusted OR of early prenatal diagnosis (95% CI)	Adjusted OR ‡ (95% CI)
Trisomy (total n=513)				
T21(n=386)	349 (90.4%)	35 (9.1%)	Reference	Reference
T18 (n=88)	70 (79.6%)	15 (17.1%)	0.47 (0.24-0.90)	0.41 (0.20-0.84)
T13 (n=44)	33 (75.0%)	11 (25.0%)	0.30 (0.14-0.65)	0.26 (0.11-0.60)
Maternal age at diagnosis (total n=457) †				
40+ (n=108)	98 (90.7%)	10 (9.3%)	Reference	Reference
35-40 (n=189)	172 (91.0%)	17 (9.0%)	1.03 (0.45-2.34)	0.88 (0.38-2.01)
30-34 (n=113)	99 (87.6%)	14 (12.4%)	0.72 (0.31-1.70)	0.74 (0.30-1.80)
19-29 (n=47)	34 (72.3%)	13 (27.7%)	0.27 (0.11-0.66)	0.30 (0.11-0.77)
	$\chi 2$ trend = 8.30, p = 0.004*			
IRSAD quintile (total n=513)				
5 (n=166)	153 (92.2%)	13 (7.8%)	Reference	Reference
4 (n=183)	163 (89.1%)	20 (10.9%)	0.69 (0.33-1.44)	0.70 (0.31-1.56)
3 (n=65)	55 (84.6%)	10 (15.4%)	0.47 (0.19-1.13)	0.51 (0.20-1.30)
2 (n=59)	47 (79.7%)	12 (20.3%)	0.33 (0.14-0.78)	0.30 (0.12-0.74)
1 (n=40)	34 (85.0%)	6 (15.0%)	0.48 (0.17-1.36)	0.54 (0.16-1.86)
	$\chi 2$ trend = 6.23, p =0.01			

IRSAD = Index of Relative Socio-economic Advantage and Disadvantage, 5 is more advantaged, 1 is less advantaged. *5 gestational ages missing in the prenatal dataset. † 56 maternal ages missing in the prenatal dataset. ‡ covariates in the model: maternal age, IRSAD quintile & diagnosis.

Table 4 – Association between IRSAD quintile and timing of diagnosis of trisomy 21, 2015-16

IRSAD quintile (n=458)	Livebirth diagnosis (n=73) n (%)	Prenatal diagnosis (n=385) n (%)	Unadjusted* Odds Ratio of livebirth diagnosis (95% CI)
5	9 (6.9%)	121 (93.1%)	Reference
4	28 (16.2%)	145 (83.8%)	2.60 (1.18-5.71)
3	11 (19.6%)	45 (80.4%)	3.29 (1.28-8.46)
2	14 (25.0%)	42 (75.0%)	4.48 (1.81-11.11)
1	11 (25.6%)	32 (74.4%)	4.62 (1.76-12.11)

IRSAD = Index of Relative Socio-economic Advantage and Disadvantage, 5 is more advantaged, 1 is less advantaged. * Unable to adjust for maternal age due to missing data on maternal ages for livebirths of trisomy 21

FIGURES (attached)

Figure 1 – Prenatal diagnosis vs livebirth diagnosis of T21 by IRSAD quintile (2015-16)

Figure 2 – Livebirth rate of T21 per 1000 livebirths in Victoria by IRSAD quintile (2015-16)