Aust. J. Rural Health (2019) **27**, 64–69

Original Research

Diabetes screening in pregnancy failing women in rural Western Australia: An audit of oral glucose tolerance test completion rates

Andrew B. Kirke, MBBS,[1] David Atkinson, MBBS, MPH,[1,2] Sarah Moore, MBBS,[1] Kylie Sterry, MBBS,[1] Sally Singleton, MBBS, BMedSc, FACRRM, FRACGP, MPHTM,[1,2] Carly Roxburgh, MBBS,[1] Kate Parrish, BVSc,[3] Cindy Porter, PhD,[4] and Julia V. Marley, PhD[1,2]

[1]*Rural Clinical School of Western Australia, University of Western Australia, Bunbury,* [2]*Kimberley Aboriginal Medical Services Council, Broome,* [4]*Combined Universities Centre for Rural Health, Geraldton, Western Australia, and* [3]*Veterinary Virology, Elizabeth Macarthur Agricultural Institute, Menangle, New South Wales, Australia*

Abstract

Objective: *To quantify screening rate for gestational diabetes mellitus and completion of oral glucose tolerance test in rural and remote Western Australia.*

Design and participants: *Retrospective audit of 551 antenatal records from women of 16 years and older without pre-existing diabetes and with singleton pregnancies delivered in 2013.*

Main outcome measures: *Number of women recorded screened for gestational diabetes mellitus in second or third trimester using oral glucose tolerance test or other tests; gestational diabetes mellitus rate.*

Results: *Only 278 (50.5%) women were screened with oral glucose tolerance test; 113 (20.5%) had no record of any screening related to gestational diabetes mellitus. In a nested mixed-effects logistic regression model, women with a previous gestational diabetes mellitus diagnosis, two or more risk factors (excluding ethnicity) or high-risk gestational diabetes mellitus ethnicity other than Australian Aboriginal were more likely to be screened, while Australian Aboriginal women were less likely to be screened with oral glucose tolerance test. Clinicians reported patient and clinician factors and logistical difficulties as reasons for the oral glucose tolerance test not being completed at their site. Of those screened with oral glucose tolerance test, a high rate of gestational diabetes mellitus was diagnosed (14.7% versus Western Australia state-wide average of 7.4%).*

Conclusion: *Adherence to oral glucose tolerance test screening in rural Western Australia is inadequate for effective screening for gestational diabetes mellitus. Screening was not acceptable or available for a significant proportion of women at risk. Efforts to improve oral glucose tolerance test adherence and exploration of alternative gestational diabetes mellitus screening strategies are required.*

KEY WORDS: *Aboriginal, antenatal care, gestational diabetes, Indigenous, oral glucose tolerance test, rural.*

Introduction

The prevalence of diabetes, including gestational diabetes mellitus (GDM), has risen in recent decades.[1] In Western Australia (WA), GDM has risen from 2.3% of all pregnancies in 1993[2] to 7.4% in 2013.[3] Higher rates of GDM have been reported in Indigenous populations globally.[4] In 2005–2006, age-standardised incidence in Australian Aboriginal and Torres Strait women was 1.5 times that of other Australian women.[5] Gestational diabetes mellitus (GDM) is associated with adverse neonatal and maternal outcomes, including macrosomia, neonatal hypoglycaemia, respiratory distress, higher rates of preterm delivery and delivery by Caesarean.[6] Children of mothers with GDM are at greater risk of impaired glucose tolerance and obesity in later life.[7] The risk of women with GDM developing type 2 diabetes is seven times greater than in women without GDM.[8]

Correspondence: Andrew Kirke, Rural Clinical School of Western Australia, University of Western Australia, PO Box 412, Bunbury, Western Australia, 6230, Australia. Email: andrew.kirke@rcswa.edu.au

Disclosure: This research has not been published in part or full elsewhere.

Accepted for publication 31 July 2018.

doi: 10.1111/ajr.12465

***What is already known on this subject*:**
- *Gestational diabetes incidence is increasing in Australia.*
- *The key to minimising its impact is early screening and active management through pregnancy.*
- *The current recommended screening test has a widely varying completion rate when measured in different settings internationally (30–91%).*

***What this study adds*:**
- *Screening for gestational diabetes mellitus with the recommended oral glucose tolerance test was only recorded in half the population audited.*
- *Gestational diabetes mellitus was diagnosed twice as frequently in those completing the oral glucose tolerance test in this study, compared with the whole of Western Australia for the same year (14.7% versus 7.4%).*
- *The study highlights the need for better processes to ensure oral glucose tolerance test screening occurs and further study into alternative screening strategies that could reduce the number of oral glucose tolerance tests required without compromising diagnosis.*

Following the Hyperglycemia and Adverse Pregnancy Outcomes (HAPO) study,[9] the oral glucose tolerance test (OGTT) is internationally recognised as the gold standard for diagnosing GDM. In the HAPO study, involving 25 505 women who were tested with OGTT and glycated haemoglobin (HbA_{1c}) at 24–28 weeks' gestation, it was found OGTT to be superior to HbA_{1c} in predicting some of the adverse primary (e.g. macrosomia, cord C-peptide levels) and secondary (e.g. primary Caesarean section, sum of neonatal skinfolds) outcomes measured.[10] The impact of HAPO is that recommended screening for GDM has shifted from risk group identification to universal diagnostic testing with OGTT.[11] Prior to this, in Australia, women were screened with a glucose challenge test (GCT) and referred for OGTT if measuring over a predetermined threshold. The transition from screening with GCT to OGTT for all pregnancies has proceeded on a state-by-state basis in Australia, with universal OGTT implemented in WA in April 2012.

Anecdotally, clinicians report a significant number of antenatal patients failing to complete the OGTT. In view of limited published data on screening rates for GDM since universal screening was introduced, this study aimed to document OGTT testing in rural WA and any alternative tests used to screen for GDM.

Methods

Paper and electronic medical records of women receiving antenatal care at 12 clinical sites around regional, rural and remote WA were retrospectively audited between 5 August 2014 and 3 November 2015. Clinical sites were selected based on where members of the research team had access to antenatal records as part of their normal clinical duties (e.g. GP obstetricians or clinical staff working at birthing hospitals, Aboriginal Community Controlled Health Services or private GP obstetric clinics). Clinical sites providing the majority of antenatal care were categorised by the current remoteness index for Australia, the Modified Monash Model (MMM).[12]

Women in this convenience sample were included if: aged 16 years or more at delivery; no documented pre-existing diabetes; singleton pregnancy; and delivered in rural WA in 2013. The GDM was primarily diagnosed using accepted criteria at the time (OGTT: fasting glucose ≥ 5.5 mmol L^{-1} or 2-hour glucose ≥ 8.0 mmol L^{-1}). The GDM had also been diagnosed by treating clinicians based on other criteria. These diagnoses were recorded as indicated in patients' notes. The test used to diagnose GDM was recorded (OGTT, fasting and random blood glucose, HbA_{1c} and GCT). Risk factors recorded included previous GDM, ethnicity, maternal age, family history of diabetes or GDM, obesity, hypertension prior to 20 weeks, previous macrosomia, history of unexplained stillbirth, previous baby with congenital abnormalities and polycystic ovarian syndrome. Clinicians involved in the audit were requested to reflect on screening practice, including review of clinical notes for evidence as to why the OGTT was not completed and other tests were used instead.

Statistical analysis

Data were imported into Stata 13 (StataCorp, College Station, TX, USA). Differences in characteristics between Aboriginal and non-Aboriginal women were compared using χ^2 tests for categorical data and Mann–Whitney tests for continuous non-parametric data. As the first step, logistic regression models were created using a backward step-wise approach to identify factors associated with: (i) OGTT screening; and (ii) those diagnosed with GDM. Following this, a

TABLE 1: *Geographical distribution of audit sampling*

Geographical region†	Patients	Sites
Kimberley	113	Broome, Bidyadanga, Balgo, Mulan, Bililuna, Beagle Bay
Mid West	89	Geraldton
Goldfields	101	Kalgoorlie
Southwest	195	Bunbury, Busselton
Great Southern	53	Albany

†Geographical regions as defined on Western Australian Country Health Service website, http://www.wacountry.health.wa.gov.au/index.php?id=833, accessed 11/2/2018.

nested mixed-effect logistic regression model with antenatal care sites ($n = 29$), included as a random effect, was fitted for the screening outcome. Diagnosis follows directly from the OGTT screening result and is independent of subject or site. For all models, $P < 0.05$ was defined as statistically significant.

Ethics approval

Ethics approval was obtained from the Western Australian Aboriginal Health Ethics Committee and WA Country Health Service (WACHS) Research Ethics Committee. The Kimberley Aboriginal Health Planning Forum Research Subcommittee supported this project.[13]

Results

Five-hundred-and-fifty-one women (39.0% Australian Aboriginal; 8.3% other high-risk ethnicities) were audited, representing 7.7% of 7198 births in rural WA and 12.4% of 1739 births to Australian Aboriginal women in WA in 2013.[3] All women audited reached 24 weeks' gestation between 5 August 2012 and 25 October 2013. The audit sampled 12 clinics from five geographical regions (Table 1).

The Aboriginal women were significantly younger and more had preterm deliveries, compared to non-Aboriginal (Table 2). After excluding high-risk ethnicity as a risk factor, Australian Aboriginal women had significantly more risk factors for GDM than non-Aboriginal women (47.0% versus 34.8%; $P = 0.004$; Table 2). Most (98.6%) Aboriginal women audited received the majority of antenatal care from health services located in MMM3, MMM6 and MMM7. Most non-(92.2%) Aboriginal women audited received their care in MMM2 and MMM3 (Table 2).

Only 278 (50.5%) women were recorded as screened appropriately, according to guidelines at the time, using OGTT. One-hundred-and-thirteen (20.5%) women had no screening for GDM recorded (Table 3). The lowest and highest OGTT screening rates by any health service with at least 20 audited records were 29.2% (7 of 24) and 72.5% (74 of 102; Kalgoorlie), respectively. Alternative tests related to GDM screening were GCT ($n = 101$), random plasma glucose ($n = 87$), HbA_{1c} ($n = 42$) and fasting plasma glucose ($n = 20$).

In the nested mixed-effects logistic regression model, the likelihood of being screened with OGTT was higher in women with a previous GDM diagnosis (odds ratio, OR, 4.2; 95% confidence interval, CI, 1.5–12.3; $P = 0.008$), two or more risk

TABLE 2: *Demographic characteristics of women audited*

	Non-Aboriginal	Australian Aboriginal
No. of women audited	336	215
Median maternal age in years (range)	29.6 (17.2–44.5)	24.0 (16.2–40.6)*
Median gestational age at delivery in weeks (range)	39 (30–41)	39 (28–41)*
No. of women with preterm delivery (%)†	16 (4.8)	21 (9.8)*
Remoteness classification of health service providing majority of antenatal care		
MMM2 (%)	71 (21.1)	2 (0.9)
MMM3 (%)	239 (71.1)	91 (42.3)
MMM4–5 (%)‡	20 (6.0)	1 (0.5)
MMM6 (%)	3 (0.9)	75 (34.9)
MMM7 (%)	3 (0.9)	46 (21.4)
No. of women with risk factors for GDM (excluding high-risk ethnicity) recorded		
None (%)	219 (65.2)	114 (53.0)
One (%)	95 (28.3)	75 (34.9)
Two (%)	18 (5.4)	21 (9.8)
Three (%)	4 (1.2)	4 (1.9)
Four (%)	0 (0)	0 (0)
Five (%)	0 (0)	1 (0.5)

*Significant at $P < 0.05$ compared with the group of non-Aboriginal Aboriginal women. †Gestational age < 37 weeks; ‡while antenatal services in MMM4 and MMM5 were not audited directly, women who received antenatal care from services located in MMM4 and MMM5 were included if they delivered their baby at participating obstetric units. GDM, gestational diabetes mellitus; MMM, Modified Monash Model.

TABLE 3: *Screening for and diagnosis of gestational diabetes mellitus (GDM) in second or third trimester in rural Western Australia in 2013*

Variable	Remoteness classification of health service providing majority of antenatal care					Total
	MMM2	MMM3	MMM4–5†	MMM6	MMM7	
No. of women audited (%)	73 (13.2)	330 (59.9)	21 (3.8)	78 (14.2)	49 (8.9)	551
No. of women with tests potentially related to GDM recorded‡ (%)	53 (72.6)	262 (79.4)	17 (81.0)	62 (79.5)	44 (89.8)	438 (79.5)
No. with completed OGTT recorded (%)	41 (56.1)	174 (52.7)	10 (47.6)	32 (41.0)	21 (42.9)	278 (50.5)
No. with other tests but not completed OGTT recorded (%)	12 (16.4)	88 (26.7)	7 (33.3)	30 (38.5)	23 (46.9)	160 (29.0)
No. of women diagnosed with GDM (%)						
No. of women diagnosed using OGTT (%)	8 (19.5)	21 (12.1)	2 (20)	5 (15.6)	5 (23.8)	41 (14.7)
No. of women diagnosed without OGTT completed (%)	0 (0)	4 (4.6)	0 (0)	1 (3.3)	3 (13.0)	8 (5.0)

†While antenatal services in MMM4 and MMM5 were not audited directly, women who received antenatal care from services located in MMM4 and MMM5 were included if they delivered their baby at participating obstetric units. ‡OGTT, glucose challenge, fasting plasma glucose, random plasma glucose and/or glycated haemoglobin. MMM, Modified Monash Model; OGTT, oral glucose tolerance test.

factors, excluding ethnicity (OR, 2.3; 95% confidence interval, CI, 1.4–3.7; $P = 0.001$), or high-risk GDM ethnicity other than Australian Aboriginal (OR, 3.0; 95% CI, 1.8–5.0; $P < 0.001$). The likelihood of being screened with OGTT was lower in Aboriginal women (OR, 0.45; 95% CI, 0.26–0.79; $P = 0.005$). This was not independently influenced by the time since introduction of universal screening, remoteness classification or any other GDM risk factor recorded. Clinicians at each audit site reported that patient and clinician factors and logistical difficulties were the most likely reasons that the OGTT was not completed at their site (Table 4).

Of 278 women screened with OGTT, 41 (14.7%) were diagnosed with GDM (Table 3). In the logistic regression model, women were more likely to be diagnosed with GDM if they previously had GDM (OR, 7.7; 95% CI, 2.7–22.3; $P < 0.001$) or high-risk GDM ethnicity other than Australian Aboriginal (OR, 2.7; 95% CI, 1.1–6.7; $P = 0.035$). This was not independently influenced by the time since introduction of universal screening, remoteness classification or any other GDM risk factor recorded. There was also no difference in diagnosis rates between Australian Aboriginal women and women who had a low-risk GDM ethnicity (OR, 1.2; 95% CI, 0.52–2.6; $P = 0.7$).

TABLE 4: *Clinician reflections on reasons for oral glucose tolerance test (OGTT) not being completed*

Category	Comment
Patient factors	Do not like the test (e.g. health-conscious patients do not want to drink a large sugar load)
	Nausea and vomiting
	Family demands, other children, no time
Clinician factors	Alternative test, such as GCT or HbA_{1c}, offered as compromise
	Routine use of random BSL confounding need to do OGTT
Logistical difficulties	No transport to the health service if living out of town
	Long distances to travel, especially in small very remote communities
	Moving between care sites and loss of records or failure to follow up
Other	Late presentation for antenatal care
	Incomplete tests, leaving before 2 hours is up
	Poor communication regarding test process to patient

BSL, blood sugar level; GCT, glucose challenge test; HbA1c, glycated haemoglobin.

Discussion

This is the first report of completion rates for OGTT as a universal screening test for GDM in rural Australia. Recommended screening with OGTT failed to occur for half the pregnant women audited. This falls within the lower end of the range of OGTT screening rates reported in Europe (30–91%).[14–16] It also falls between other Australian universal screening programs where the test is not simple, such as cervical cancer (70% of eligible women within 3 years)[17] and bowel cancer screening (37% in 2013–2014).[18] In Northern Australia, Pap smear screening rates were half the national rate and remoteness of community was associated with lower participation rates.[19]

Screening for GDM with OGTT fits some of the requirements for a high-quality screening program[20]: GDM is an important health issue with a well-understood natural history; there is an effective treatment; OGTT has high sensitivity and good specificity; and benefits of screening outweigh risks. Other requirements, such as whether OGTT is a suitable and acceptable test, if detection is early enough and cost-effectiveness compared with alternatives, have not yet been well documented.

In terms of acceptability, the OGTT is difficult for many pregnant women to complete. Side-effects, including nausea, vomiting, bloating, diarrhoea, sweating, dizziness and headache, affect up to 38%.[21,22] Apart from these studies, there is little or no discussion of acceptability of OGTT screening in the literature. While this study was not designed to answer the question of why so few women were screened with the OGTT, reflection by clinical investigators in the different rural sites audited indicates that this is likely due to a range of factors. Both clinician and patient factors may be important and this warrants further research.

One reason for the failure to complete antenatal screening tests might be that the barriers to accessing health services in rural and remote areas, such as distance to clinics, poor health literacy and socioeconomic disadvantage, deter attendance for routine tests that are relatively easily done in urban settings. If this was the case then, all testing would suffer. The data presented here do not suggest that women in remote areas are less likely to complete antenatal care. On the contrary, remote sites with a low rate of OGTT completion had a high rate of alternative testing and a higher overall rate of testing. For GDM to be successfully diagnosed and treated, screening is the first and most important step. If half the population is not screened effectively, many cases will be missed. This is particularly important as this study also highlights a higher rate of diagnosis of GDM in those screened with OGTT than recorded state-wide in the same time period (14.7% versus 7.4%[3]). In the context of ongoing increasing prevalence of diabetes and the known complications of GDM for mothers and babies, this gap in current screening is disturbing.

This study was carried out across diverse settings but might not be fully representative of rural WA. Sites were selected opportunistically and sites from MMM4 and MMM5 are not well represented in our sample group. Of the seven geographical regions identified by WACHS, we have sampled five. The Pilbara and Wheatbelt were not represented.

However, even the best location only reached 72.5%, which is substantially less than is recorded for other routine screening in pregnancy (ultrasound, 97.4% in 2013)[3] and less than ideal screening for this common high-risk condition. A file review depends on the completeness of records. Tests might have been done but not recorded in the notes used for this study. To minimise this effect, we used the most complete notes available in each clinical setting and where possible cross-checked with other sources of medical information, such as discharge summaries from hospitals. However, despite the best efforts, some test results might not have been in the notes and coverage underestimated.

The audit period might have been too soon for the adoption of new guidelines to become established. However, in the multivariate analysis, time since the introduction of universal screening did not affect the likelihood of being screened with OGTT. Requiring a screening test is not sufficient to effect change. Real-world implementation of new programs is a complex, fragmented and ongoing process requiring detailed planning.[23,24] High staff turnover, institutional amnesia and delays need to be factored in. Implementation takes time, effort and resources and requires a multidimensional and multidisciplinary approach that involves extensive consultation with heath care providers and patients. Continuous quality improvement processes need to be built into the implementation of new programs and adequately resourced.[23]

While the OGTT is the gold standard for diagnosing GDM, it has failed as a screening test in rural WA. Strategies to improve coverage in rural and remote areas need to be implemented. Given the problems with OGTT as a screening test, we suggest it is time to also explore simpler tests to reduce the number of OGTTs required.

Acknowledgements

Thanks are extended to Sharon Evans for advice on statistical analysis. We are also grateful for assistance from all health service staff and medical students who

assisted in completing this project and the health services that agreed to participate.

References

1 Danaei G, Finucane MM, Lu Y *et al.* National, regional, and global trends in fasting plasma glucose and diabetes prevalence since 1980: systematic analysis of health examination surveys and epidemiological studies with 370 country-years and 2·7 million participants. *The Lancet* 2011; **378**: 31–40.

2 Gee V. Perinatal Statistics in Western Australia: Eleventh Annual Report of the Western Australian Midwives' Notification System 1993. Maternal and Child Health Studies Unit, Health Services and Statistics Branch, Health Department of Western Australia, 1994.

3 Hutchinson M, Joyce A. Western Australia's Mothers and Babies, 2013: 31st Annual Report of the Western Australian Midwives' Notification System. Department of Health, Western Australia, 2016.

4 Porter C, Skinner T, Ellis I. The current state of indigenous and aboriginal women with diabetes in pregnancy: a systematic review. *Diabetes Research and Clinical Practice* 2012; **98**: 209–225.

5 Templeton M, Pieris-Caldwell I. Gestational diabetes mellitus in Australia, 2005-06. Canberra, Australia: Australian Institute of Health and Welfare, 2008. [Cited 9 May 2013]. Available from URL: http://www.aihw.gov.au/publication-detail/?id=6442468189

6 Tieu J, Middleton P, McPhee AJ, Crowther CA. Screening and subsequent management for gestational diabetes for improving maternal and infant health. *Cochrane Database of Systematic Reviews* 2010; **7**: CD007222. DOI: 10.1002/14651858.CD007222.pub2.

7 Metzger BE, Coustan DR. Summary and recommendations of the Fourth International Workshop-Conference on Gestational Diabetes Mellitus. The Organizing Committee. *Diabetes Care* 1998; **21**(Suppl. 2): B161–B167.

8 Bellamy L, Casas JP, Hingorani AD, Williams D. Type 2 diabetes mellitus after gestational diabetes: a systematic review and meta-analysis. *Lancet* 2009; **373**: 1773–1779.

9 HAPO Study Cooperative Research Group. Hyperglycemia and adverse pregnancy outcomes. *New England Journal of Medicine* 2008; **358**: 1991–2002.

10 Lowe LP, Metzger BE, Dyer AR *et al.* Hyperglycemia and Adverse Pregnancy Outcome (HAPO) Study: associations of maternal A1C and glucose with pregnancy outcomes. *Diabetes Care* 2012; **35**: 574–580.

11 Metzger BE, Gabbe SG, Persson B *et al.* International association of diabetes and pregnancy study groups recommendations on the diagnosis and classification of hyperglycemia in pregnancy. *Diabetes Care* 2010; **33**: 676–682.

12 Australian Government Department of Health. 4.3 Reform of the ASGC-RA rural classification system. Australian Government, 2013. [Cited 17 Nov 2016]. Available from URL: http://www.health.gov.au/internet/publications/publishing.nsf/Content/work-review-australian-government-health-workforce-programs-toc~chapter-4-addressing-health-workforce-shortages-regional-rural-remote-australia~chapter-4-reform-asgc-ra-rural-classification-system

13 Mc Loughlin F, Hadgraft NT, Atkinson D, Marley JV. Aboriginal health research in the remote Kimberley: an exploration of perceptions, attitudes and concerns of stakeholders. *BMC Health Services Research* 2014; **14**: 517.

14 Anderberg EVA, Källén K, Berntorp K, Frid A, Åberg A. A simplified oral glucose tolerance test in pregnancy: compliance and results. *Acta Obstetricia et Gynecologica Scandinavica* 2007; **86**: 1432–1436.

15 Murphy NM, McCarthy FP, Khashan AS *et al.* Compliance with National Institute of Health and Care Excellence risk-based screening for Gestational Diabetes Mellitus in nulliparous women. *European Journal of Obstetrics & Gynecology and Reproductive Biology* 2016; **199**: 60–65.

16 Persson M, Winkvist A, Mogren I. Surprisingly low compliance to local guidelines for risk factor based screening for gestational diabetes mellitus - a population-based study. *BMC Pregnancy and Childbirth* 2009; **9**: 53.

17 Australian Institute of Health and Welfare. Cervical screening in Australia 2013–2014. Cancer series no. 97. Cat. no. CAN 95. Canberra Australia: Aust Inst Health Welfare, 2016. [Cited 17 Nov 2016]. Available from URL: https://www.aihw.gov.au/reports/cancer-screening/cervical-screening-in-australia-2014-2015/contents/table-of-contents

18 AIHW. National Bowel Cancer Screening Program: monitoring report 2016. Cancer series no. 98. Cat. no. CAN 97. Canberra: AIHW. Canberra Australia, 2016.

19 Binns PL, Condon JR. Participation in cervical screening by Indigenous women in the Northern Territory: a longitudinal study. *Medical Journal of Australia* 2006; **185**: 490–494.

20 Wilson J, Jungner G. Principles and practice of screening for disease. WHO Chronicle Geneva:World Health Organization. Public Health Papers, #34 p.1-163: World Health Organization, 1968.

21 Lamar ME, Kuehl TJ, Cooney AT, Gayle LJ, Holleman S, Allen SR. Jelly beans as an alternative to a fifty-gram glucose beverage for gestational diabetes screening. *American Journal of Obstetrics and Gynecology* 1999; **181**: 1154–1157.

22 Racusin DA, Antony K, Showalter L, Sharma S, Haymond M, Aagaard KM. Candy twists as an alternative to the glucola beverage in gestational diabetes mellitus screening. *American Journal of Obstetrics and Gynecology* 2015; **212**: 522.e521–522.e525.

23 Marley JV, Singleton S, Griffiths E *et al.* Integrating best practice and filling knowledge gaps in remote Aboriginal diabetes detection and care: improving case detection and service delivery. Final report to the Australian Primary Health Care Research Institute, 2016. [Cited Apr 2016]. Available from URL: http://rsph.anu.edu.au/files/Marley-Diabetes_case_detection_and_care-FullReportFINAL.pdf

24 Marley JV, Kitaura T, Atkinson D, Metcalf S, Maguire GP, Gray D. Clinical trials in a remote Aboriginal setting: lessons from the BOABS smoking cessation study. *BMC Public Health* 2014; **14**: 579.