ANZJOG

DOI: 10.1111/ajo.13283

ORIGINAL ARTICLE

Detection of small for gestational age babies and perinatal outcomes following implementation of the Growth Assessment Protocol at a New Zealand tertiary facility: An observational intervention study

F. Joyce Cowan[1,2], Christopher J. D. McKinlay[3,4], Rennae S. Taylor[5], Jess Wilson[5,6], Judith McAra-Couper[1], Nick Garrett[7], Andrea O'Brien[8] and Lesley M. E. McCowan[5,9]

[1]Department of Midwifery, Auckland University of Technology, Auckland, New Zealand

[2]Perinatal Institute, Birmingham, UK

[3]Liggins Institute, Faculty of Medical and Health Sciences, University of Auckland, Auckland, New Zealand

[4]Kidz First Neonatal Care, Counties Manukau Health, Auckland, New Zealand

[5]Department of Obstetrics and Gynaecology, Faculty of Medical and Health Sciences, The University of Auckland, Auckland, New Zealand

[6]Department of Paediatrics: Child and Youth Health, Faculty of Medical and Health Sciences, Auckland, New Zealand

[7]Department of Biostatistics and Epidemiology, Auckland University of Technology, Auckland, New Zealand

[8]Health Intelligence and Informatics, Counties Manukau Health, Auckland, New Zealand

[9]South Auckland Clinical School, Middlemore Hospital, Auckland, New Zealand

Correspondence: Dr Joyce Cowan, 1 Monument Road, RD2 Papakura, Auckland 2582, New Zealand.
Email: cowanjoyce@gmail.com

Conflict of Interest: Joyce Cowan is an educator for the New Zealand GAP programme. Lesley McCowan was the lead author on the NZMFMN SGA Guideline. No conflicts of interest were declared by other authors.

Received: 16 June 2020; Accepted: 5 November 2020

Background: Timely detection of small for gestational age (SGA) fetuses is important for reducing severe perinatal morbidity and mortality, and better tools are needed to detect SGA in maternity care.

Aim: We evaluated the effect of the introduction of the Perinatal Institute's Growth Assessment Protocol (GAP) in the Counties Manukau Health region, South Auckland, New Zealand, on antenatal detection of SGA and maternal and perinatal outcomes.

Materials and Methods: Uncontrolled before and after study in women booked under hospital community midwife care with a singleton, non-anomalous pregnancy. Antenatal detection of SGA (birthweight <10th customised centile) was compared pre-GAP (2012, *N* = 1105) and post-GAP (2017, *N* = 1082). Composite adverse neonatal outcome was defined as neonatal unit admission >48 h, five-minute Apgar score <7, and/or any ventilation. Analyses were adjusted for maternal age, body mass index, deprivation, smoking and ethnicity.

Results: SGA rates were similar across epochs (13.8% vs 12.9%) but antenatal detection of SGA increased from 22.9% (35/153) to 57.9% (81/140) post-GAP (adjusted odds ratio (aOR) = 4.8, 95% CI 2.82–8.18). Rates of induction of labour and caesarean section increased between epochs but were similar in SGA, non-SGA, and detected and non-detected SGA subgroups. Among SGA babies, there was some evidence that antenatal detection of SGA may be associated with lower composite adverse neonatal outcome (detected SGA: aOR 0.44 95% CI 0.17–1.15; non-detected SGA: aOR = 1.81 95% CI 0.73–4.48; interaction *P* = 0.03). Pre-term birth did not appear to be influenced by GAP.

Conclusion: Implementation of GAP was associated with a nearly five-fold increase in SGA detection without increasing obstetric intervention for SGA.

KEYWORDS

fetal growth restriction, growth charts, infant, pregnancy outcome, prenatal care, small for gestational age

INTRODUCTION

Small for gestational age (SGA) babies are over-represented among stillborn infants with a population attributable risk of between 23 and 31%.[1] Antenatal identification of SGA infants, along with optimal management of SGA, has been associated with reduced severe perinatal morbidity and mortality.[2,3] Therefore, timely identification of the SGA fetus is a critical component of antenatal care,[2,4] and yet less than 25% of SGA fetuses are usually detected before birth with routine care.[5]

The Growth Assessment Protocol (GAP)[6] is a multifaceted program which incorporates SGA risk selection; specialist review and serial growth scans for high-risk pregnancies; standardised serial fundal height measurement and plotting on a customised growth chart for low-risk pregnancies; a protocol for ultrasound scanning according to fundal height measurements; and an evidence-based guideline for management if SGA is detected. Customised standards have been shown to better identify at-risk SGA babies[7–9] and implementation of GAP in the UK has been associated with increased detection of SGA and a parallel reduction in stillbirth.[10]

There are few publications reporting implementation of GAP outside of the UK,[11] and few data about how implementation of GAP impacts on maternal and perinatal morbidity.

Our aim was to assess the effect of introducing the GAP program in a New Zealand (NZ) setting on antenatal detection of SGA and maternal and neonatal perinatal outcomes. We hypothesised that implementation of GAP would result in improved antenatal detection of SGA and that among SGA pregnancies, there would be an increase in induction of labour, no increase in caesarean section and a reduction in composite adverse neonatal outcome.

MATERIALS AND METHODS

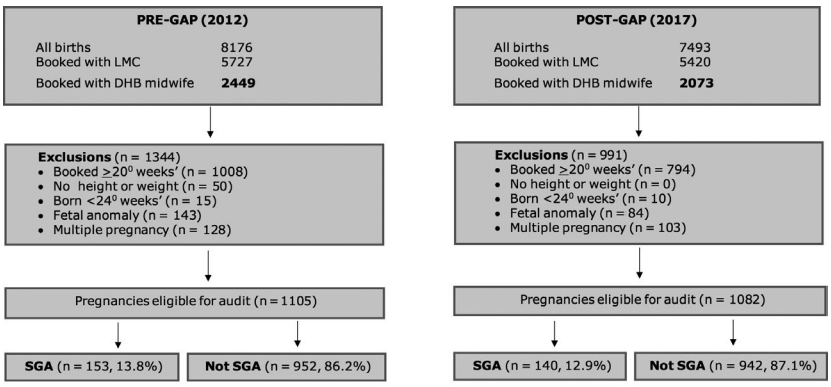
Design, study populations, intervention

This uncontrolled before and after intervention study was performed at Counties Manukau Health (CMH), a tertiary obstetric facility in South Auckland, NZ. CMH is the largest maternity service provider in NZ, serving an ethnically diverse population, with high rates of obesity and socio-economic deprivation, as well as the highest perinatal mortality in NZ.[12] Institutional ethics approval was obtained through the Auckland University of Technology Ethics Committee (approval number 16/68). Full ethics approval was not required as there was no patient involvement.

The pre-GAP cohort comprised all mothers who gave birth between 1 January and 31 December, 2012 in CMH maternity facilities and received care by hospital-employed community midwives working in a continuity of care model. This was prior to widespread use of GROW (Gestation Related Optimal Weight) charts and before the introduction of the NZ Maternal Fetal Medicine (NZMFM) SGA guideline in 2013.[13] Births under the care of self-employed midwives were excluded as clinical records were not accessible. Further exclusions comprised booking >20 weeks and 0 days, no maternal height or weight recorded, multiple pregnancy, baby born <24 weeks and 0 days or with a major congenital anomaly (Fig. 1).

The GAP program was implemented at CMH in February 2016 with a series of workshops for all maternity care providers. Clinicians were provided with an SGA risk assessment tool and management algorithm, summarising the major risk factors for SGA, appropriate care plan depending on risk of SGA, and a guide to management once SGA was suspected (https://perinatal.org.uk/Final_SGA_Algorithm_April_2019_GAP.pdf). Education focused on standardised fundal height measurement, use and interpretation of GROW charts, and management of SGA pregnancies according to the NZMFM SGA guideline.[13] A written test was completed by participants following the workshop. Additionally, an e-learning program was recommended and provided for annual consolidation. GAP education was provided to >90% of hospital-employed community midwives.

The post-GAP cohort comprised all mothers who gave birth between 1 April 2017 and 31 March 2018 in CMH maternity facilities and who received care by hospital-employed community midwives. Exclusions were as per the pre-GAP cohort (Fig. 1).



GAP, Growth Assessment Protocol; LMC, Lead Maternity Caregiver; SGA, small for gestational age; DHB, District Health Board

FIGURE 1 Flow diagram of eligible population pre-GAP and post-GAP. DHB, District Health Board; GAP, Growth Assessment Protocol; LMC, lead maternity caregiver; SGA, small for gestational age.

Outcomes

The primary outcome was the proportion of SGA pregnancies that were detected before birth. Antenatal detection of SGA was defined as an ultrasound estimated fetal weight (EFW) <10th customised centile, abdominal circumference <5th centile, sequential measurements of EFW or abdominal circumference with slow or no growth, and/or one or more abnormal Doppler findings.

Secondary outcomes included induction of labour, caesarean section, pre-term and post-term birth and composite adverse neonatal outcome, defined as one or more of: neonatal unit admission for >48 h, Apgar score <7 at five minutes or use of any positive pressure respiratory support.

Assessments and data collection

Data for the pre-GAP cohort were obtained from the following CMH databases: (i) Healthware™, which is used for recording and storing clinical data; (ii) the patient information management system (PiMS™), primarily used for tracking, coding and resource allocation; (iii) Concerto, a clinical workstation which allows access to clinical records including ultrasound scan reports; and (iv) the Costpro system used for information on clinical coding. Extracted data included maternal age, ethnicity, New Zealand Deprivation Index (NZDPI) (which uses nine variables from the 2013 census reflecting eight dimensions of deprivation and based on geographical areas),[14] parity, date of last menstrual period (LMP), estimated date of delivery (EDD) by LMP, EDD by ultrasound scan, gestation and weight at booking, height, smoking, pre-existing hypertension, pre-eclampsia, stillbirth, induction of labour, mode of birth, date of delivery, gestation at birth, sex of baby, birth weight, Apgar score at five minutes, neonatal respiratory support, admission to the neonatal unit for >48 h, and neonatal death. By 2017, all maternity records were electronic, after the introduction of the Maternity Clinical Information System (MCIS) in 2015. Post-GAP data were retrieved from the MCIS, PiMS™, Concerto and Costpro systems.

The NZ bulk birthweight customised centile calculator version 6.7.8, [15,16] was applied to all births to identify SGA pregnancies during the study periods. In the pre-GAP cohort, case records of SGA pregnancies were hand checked by a single author (FJC) to ascertain whether SGA was identified and confirmed on ultrasound scan. In cases where detection of SGA was uncertain, records were reviewed by a second author (LMEMcC). In the post-GAP cohort two final year medical students who were trained by FJC, reviewed and classified all SGA pregnancies. If the medical students were uncertain about antenatal detection of SGA, further review was undertaken by FJC using the same criteria as for the pre-GAP cohort. If data were missing from the database extraction, they were obtained from clinical notes, where possible. Outlier values were also checked manually against the clinical record.

TABLE 1 Maternal characteristics, and pregnancy and neonatal outcomes in pre- and post-Growth Assessment Protocol (GAP) cohorts

	Pre-GAP, *N* = 1105	Post-GAP, *N* = 1082	*P*
Maternal characteristics			
Age group (years)			
<20	95 (8.6)	48 (4.4)	<0.0001
20–29	491 (44.4)	528 (48.8)	
30–39	445 (40.3)	466 (43.1)	
>40	74 (6.7)	40 (3.7)	
Ethnicity			
Māori	186 (16.8)	187 (17.3)	0.0007
Pacific peoples	453 (41.0)	360 (33.3)	
Asian	286 (25.9)	360 (33.3)	
ME/LA/A†	27 (2.4)	33 (3.1)	
European	150 (13.6)	142 (13.1)	
Other	3 (0.3)	0 (0.0)	
New Zealand deprivation index			
1–2	66 (6.0)	52 (4.8)	0.06
3–4	72 (6.5)	105 (9.7)	
5–6	78 (7.1)	85 (7.9)	
7–8	129 (11.7)	115 (10.6)	
9–10	747 (67.6)	725 (67.0)	
Missing	13 (1.2)	0 (0.0)	
Booking body mass index (kg/m^2)			
<18.5	38 (3.4)	19 (1.8)	0.0025
18.5–24.9	306 (27.7)	342 (31.6)	
25–29.9	239 (21.6)	269 (24.9)	
30–34.9	238 (21.5)	188 (17.4)	
>35	284 (25.7)	264 (24.4)	
Smoker	194 (17.6)	29 (11.9)	0.0002
Chronic hypertension	52 (4.7)	62 (5.7)	0.28
Pregnancy and neonatal outcomes			
Pre-eclampsia	64 (5.8)	77 (7.1)	0.21
Gestation at birth‡ (days)	273.4 (12.3)	271.9 (12.4)	0.005
Birthweight‡ (g)	3420 (596)	3353 (605)	0.009
Stillbirth	6 (5.4/1000)	7 (6.5/1000)	0.75
Neonatal death	1 (0.9/1000)	2 (1.9/1000)	0.55

Data are mean (standard deviation), number (%) or rate/1000 births as appropriate.
†Middle Eastern, Latin American, African.
‡Live births.

Statistical analysis

Analyses were conducted using SAS 9.4 (SAS Institute Inc., Cary, NC, USA). Maternal characteristics were compared between epochs (pre-GAP vs post-GAP) using χ^2 and *t*-test, for categorical

and continuous data, respectively. Outcomes were compared between epochs by logistic regression, with exposure (epoch) effect expressed as odds ratios (ORs) and 95% confidence intervals (CIs). Analyses were adjusted for potential confounding by factors known to be associated with SGA, including the NZDPI, ethnicity, maternal age, body mass index (BMI), and cigarette smoking. Two-tailed alpha level was set at 0.05.

Subgroup analysis, using an interaction test, was undertaken to determine if SGA status influenced exposure (epoch) effect. Further subgroup analysis was undertaken among cases of SGA to determine if antenatal detection of SGA influenced exposure (epoch) effect. Secondary analyses explored if the exposure (epoch) effect on primary outcomes differed by maternal subgroups (SGA vs non-SGA and detected SGA vs undetected SGA).

RESULTS

The pre-GAP and post-GAP cohorts included 1105 and 1082 women, respectively (Table 1). Between epochs there were significant changes in the characteristics of the study populations with fewer young and older mothers, and more Asian and fewer Pacific women post-GAP. There was also a change in BMI distribution with more women with a BMI of 18.5 to 24.9 kg/m^2 and 25 to 29.9 kg/m^2 post-GAP. Fewer women smoked in pregnancy post-GAP. There was a small reduction in gestation at delivery and birthweight between epochs, but no change in SGA rates (pre-GAP 13.8% (153/1105) vs post-GAP 12.9% (140/1082); $P = 0.53$) (Table 2).

Antenatal detection of SGA increased significantly from 22.9% (35/153) pre-GAP to 57.9% (81/140) after introduction of GAP (adjusted OR (aOR) = 4.8, 95% CI 2.82–8.18; $P < 0.0001$). Detection of SGA was more pronounced for Māori and Pacific Island women (18.9% pre-GAP vs 63.8% post-GAP, aOR = 7.76, 95% CI 3.72–16.19) compared to women of other ethnicities (28.6% vs 52.1%, aOR = 2.60, 95% CI 1.25–5.39) (interaction $P = 0.049$) (Table 2). Detection of SGA was similar among smokers and non-smokers, women living in high and low deprivation, women with and without pre-eclampsia and by BMI categories.

Induction of labour and caesarean birth increased between epochs, but increases were similar among SGA and non-SGA pregnancies and did not differ by SGA identification status. Pre-term birth also increased between epochs in both non-SGA and SGA but there was no significant increase in pre-term birth in detected SGA pregnancies and no significant interaction between detected and undetected SGA. In contrast, there was a reduction in overall post-term birth between epochs (Table 3).

There was a significant increase in overall composite adverse neonatal outcome between epochs (Table 4). This increase was statistically significant in non-SGA babies (5.3% pre-GAP vs 9.8% post-GAP; aOR = 1.98, 95% CI 1.38–2.84) but not among SGA babies (16.9% pre-GAP vs 18.2% post-GAP; aOR = 1.05, 95% CI 0.55–1.10), although the evidence for a difference in epoch effect between SGA vs non-SGA subgroups was not strong (interaction $P = 0.09$).

In the SGA subgroup, there was some evidence that increased identification of SGA post-GAP may be associated with lower composite adverse neonatal outcome (SGA identified: 32.4% pre-GAP

TABLE 2 Identification of small for gestational age (SGA) pre-Growth Assessment Protocol (GAP) and post-GAP by maternal subgroup

	SGA pre-GAP cohort, *N* = 153/1105 (13.8%)	SGA post-GAP cohort, *N* = 140/1082 (12.9%)	*P*-value for interaction
Maternal characteristics	**SGA detected *N* (%)**	**SGA detected *N* (%)**	
Māori or Pacific ethnicity			
Yes	17/90 (18.9)	44/69 (63.8)	0.049
No	18/63 (28.6)	37/71 (52.1)	
New Zealand deprivation index			
1–8	8/46 (17.4)	24/42 (57.1)	0.46
9–10 (most deprived)	27/107 (25.2)	57/98 (58.2)	
Booking body mass index (kg/m^2)			
<25	8/38 (21.1)	24/46 (52.2)	0.75
25–29.9	11/39 (28.2)	20/34 (58.8)	
30–34.9	8/37 (21.6)	15/27 (55.6)	
>35	8/39 (20.5)	22/33 (66.7)	
Smoker			
Yes	7/36 (19.4)	14/24 (58.3)	0.66
No	28/117 (23.9)	67/116 (57.8)	
Pre-eclampsia			
Yes	10/25 (40.0)	16/22 (72.7)	0.74
No	25/128 (19.5)	65/118 (55.1)	

TABLE 3 Maternal birth outcomes pre-Growth Assessment Protocol (GAP) and post-GAP

	Pre-GAP		Post-GAP		Adjusted[†] odds ratio (95% CI)	*P*-value for interaction
	N	*n* (%)	*N*	*n* (%)		
Induction of labour						
Total	1105	312 (28.2)	1082	368 (34.0)		
Non-SGA	952	264 (27.7)	942	304 (32.3)	1.23 (1.01, 1.51)	0.19
SGA	153	48 (31.4)	140	64 (45.7)	1.70 (1.03, 2.79)	
SGA subgroup						
Identified	35	15 (42.9)	81	43 (54.3)	1.51 (0.65, 3.55)	0.60
Non-identified	118	33 (28.0)	59	20 (33.9)	1.15 (0.55, 2.39)	
Caesarean birth						
Total	1105	348 (31.5)	1082	395 (36.5)		
Non-SGA	952	289 (30.4)	942	328 (34.8)	1.20 (0.97, 1.46)	0.58
SGA	153	59 (38.6)	140	67 (47.9)	1.68 (1.02, 2.77)	
SGA subgroup						
Identified	35	18 (51.4)	81	45 (55.6)	1.29 (0.55, 3.05)	0.86
Non-identified	118	41 (34.8)	59	22 (37.3)	1.26 (0.61, 2.61)	
Pre-term birth (<259 days)						
Total	1105	82 (7.4)	1082	104 (9.6)		
Non-SGA	952	58 (6.1)	942	76 (8.1)	1.37 (0.96, 1.96)	0.88
SGA	153	23 (15.0)	140	28 (20.0)	1.50 (0.79, 2.84)	
SGA subgroup						
Identified	35	12 (34.3)	81	19 (23.5)	0.76 (0.29, 1.95)	0.16
Non-identified	118	11 (9.3)	59	9 (15.3)	1.30 (0.46, 3.65)	
Post-term birth (>280 days)						
Total	1105	296 (26.8)	1082	241 (22.3)		
Non-SGA	952	253 (26.6)	942	214 (22.7)	0.83 (0.67, 1.02)	0.32
SGA	153	43 (28.1)	140	27 (19.3)	0.65 (0.37, 1.16)	
SGA subgroup						
Identified	35	3 (8.6)	81	6 (7.4)	0.82 (0.17, 4.03)	0.64
Non-identified	118	40 (33.9)	59	21 (35.6)	1.21 (0.59, 2.48)	

SGA, small for gestational age.
[†]Adjusted for New Zealand Deprivation Index, ethnicity, maternal age, maternal body mass index, smoking.

vs 17.5% post-GAP; aOR = 0.44, 95% CI 0.17–1.15; SGA non-identified: 12.3% pre-GAP to 19.3% post-GAP; aOR = 1.81, 95% CI 0.73–4.48; interaction *P* = 0.03).

DISCUSSION

Main findings

Our primary hypothesis, that GAP would increase detection of SGA, was confirmed. A novel feature was that we could explore the efficacy of GAP on detection of SGA by maternal demographic and clinical characteristics. While GAP was associated with increased detection of SGA among all ethnic groups, it was encouraging to note the more pronounced effect among women from Māori and Pacific Island ethnic backgrounds. Additionally, it was reassuring to note similar SGA detection in women who smoked compared with non-smokers, and in women with the highest deprivation compared with other deprivation groups. As obesity is an independent risk factor for both SGA and stillbirth,[16] it was also encouraging to note the high SGA detection rate (66.7%) among women with a BMI >35 kg/m^2.

Contrary to our hypothesis we did not find that GAP was associated with an increase in induction of labour and caesarean section among women with SGA pregnancies. A possible explanation could be that the stratified induction approach recommended by NZ GAP education includes induction of labour by 38 weeks for SGA pregnancies with evidence of fetal growth restriction (EFW <5th centile or Doppler velocimetry abnormalities), and expectant management with induction by 40-41 weeks for SGA pregnancies without evidence of fetal growth restriction. [17] A similar stratified

TABLE 4 Livebirth baby outcomes pre-Growth Assessment Protocol (GAP) and post-GAP

	Pre-GAP		Post-GAP		Adjusted[†] odds ratio (95% CI)	*P*-value for interaction
	N	*n* (%)	*N*	*n* (%)		
Composite neonatal outcome ([‡]						
Total	1098	75 (6.8)	1075	107 (10.0)		
Non-SGA	950	50 (5.3)	938	92 (9.8)	1.98 (1.38, 2.84)	0.09
SGA	148	25 (16.9)	137	25 (18.2)	1.05 (0.55, 1.10)	
SGA subgroup						
Identified	34	11 (32.4)	80	14 (17.5)	0.44 (0.17, 1.15)	0.03
Non-identified	114	14 (12.3)	57	11 (19.3)	1.81 (0.73, 4.48)	
Neonatal admission > 48 h						
Total	1099	52 (4.7)	1075	66 (6.1)		
Non-SGA	950	31 (3.3)	938	44 (4.7)	1.54 (0.96, 2.47)	0.52
SGA	149	21 (14.1)	137	22 (16.1)	1.08 (0.54, 2.17)	
SGA subgroup						
Identified	34	10 (29.4)	80	13 (16.3)	0.42 (0.15, 1.15)	0.04
Non-identified	115	11 (9.6)	57	9 (15.8)	1.86 (0.63, 5.52)	
Apgar < 7 at five minutes (*n* = 1 missing Apgar)						
Total	1098	18 (1.6)	1075	20 (1.9)		
Non-SGA	950	13 (1.4)	938	16 (1.7)	1.24 (0.59, 2.60)	0.65
SGA	148	5 (3.4)	137	4 (2.9)	1.07 (0.26, 4.49)	
SGA subgroup						
Identified	34	1 (2.9)	80	1 (1.3)	–	
Non-identified	114	4 (3.5)	57	3 (5.3)	–	–
Any ventilation						
Total	1099	33 (3.0)	1075	89 (8.3)		
Non-SGA	950	25 (2.6)	938	78 (8.3)	3.38 (2.12, 5.37)	0.13
SGA	149	8 (5.4)	137	11 (8.0)	1.70 (0.63, 4.59)	
SGA subgroup						
Identified	34	2 (5.9)	80	5 (6.3)	–	
Non-identified	115	6 (5.2)	57	6 (10.5)	–	–

SGA, small for gestational age.
[†]Adjusted for New Zealand Deprivation Index, ethnicity, maternal age, maternal body mass index, smoking.
[‡]Neonatal admission> 48 h, Apgar < 7 at five minutes or any ventilation.

approach implemented in Oxford, UK, has also been associated with a reduction in induction of labour.[18] Overall, caesarean rates rose post-GAP at CMH, but there were similar increases in SGA and non-SGA subgroups, and the magnitude of the effect did not differ between SGA and non-SGA pregnancies. Importantly, caesarean birth did not increase in the subgroup of SGA pregnancies identified before birth.

There was a significant increase in composite adverse neonatal outcome between epochs in non-SGA but not among SGA babies, which may reflect the increased maternal and perinatal morbidity across epochs at CMH.[19,20] There was some evidence that increased identification of SGA post-GAP may be associated with lower composite adverse neonatal outcome and reduced prolonged neonatal unit admission. While we cannot determine the factors contributing to the better neonatal outcome among identified SGA we speculate that improved antenatal detection of SGA has resulted in closer monitoring and timely birth that has contributed to these findings.

Strengths and limitations

This is the first NZ study to evaluate the implementation of GAP. The NZ maternity service is unique in that most women have continuity of midwifery care. Our study focused entirely on data from hospital-employed midwives as data on detection of SGA were not available for self-employed midwives, but as hospital-employed community midwives at CMH work in a continuity of care model for antenatal care, our findings closely represent the NZ continuity of care model of working in partnership with a named midwife for each woman.[21] Importantly, our study has

demonstrated the feasibility and potential benefits of the GAP program in a multi-ethnic, high-deprivation community with high rates of maternal obesity.

The main limitation of our study is the retrospective, uncontrolled study design. While the introduction of GAP is the most likely reason for the observed epoch effects, other sources of confounding cannot be entirely excluded. For example, the NZMFMN SGA guideline, while part of the GAP program, was also published separately online in 2013. This may have also contributed to an incremental increase in SGA detection. Another limitation of our study is that detection of SGA pre-GAP was determined by the lead author who was also employed as an educator for the GAP program. This could have introduced ascertainment bias favouring non-detection of SGA in the pre-GAP epoch, although in cases of uncertainty, a final decision was made by a second author. Unfortunately, we do not have data relating to the number of pregnancies investigated for SGA where SGA was not confirmed, including the outcomes for those pregnancies. This should be addressed in future studies.

Nevertheless, our results compare well with a recently published observational study on antenatal detection of SGA following implementation of GAP in an Australian hospital clinic setting.[11] Antenatal SGA detection rates increased significantly following implementation of GAP from 21 to 41% (OR = 2.6, 95% CI 1.3–4.9). Consistent with our findings, these authors also reported reduced overall neonatal unit admission after implementation of GAP.

GAP is a simple, low-cost intervention that appears to have a large effect on antenatal detection of SGA with potentially important clinical benefits. Replication of findings is warranted in a GAP-naive setting using a robust prospective design, such as a cluster or stepped-wedge randomised controlled trial. Such studies should be sufficiently powered to assess the impact of GAP on composite adverse maternal and neonatal outcomes.

In the NZ setting, where women receive continuity of midwifery antenatal care, we found that the introduction of GAP was associated with an almost five-fold increased likelihood of antenatal detection of SGA. While there was an increase in maternal intervention and pre-term birth between epochs, this effect was not more pronounced in SGA pregnancies. Among identified SGA babies, there was some evidence of reduced composite neonatal morbidity and reduced prolonged neonatal admission. GAP is a safe tool for increasing detection of SGA and suitable for application in an ethnically diverse population with high rates of maternal obesity.

ACKNOWLEDGMENTS

We would like to acknowledge the support of the trainee interns Danielle Luinstra and Karen Toh, who audited the post-GAP data.

REFERENCES

1. Flenady V, Middleton P, Smith GC *et al*. Lancet's Stillbirths Series steering committee. Stillbirths: the way forward in high-income countries. *Lancet* 2011; **377**: 1703–17.
2. Lindqvist PG, Molin J. Does identification of small-for-gestational-age fetuses significantly improve their outcome? *Ultrasound Obstet Gynecol* 2005; **25**: 258–64.
3. Gardosi J, Madurasinghe V, Williams M *et al*. Maternal and fetal risk factors for stillbirth: population based study. *Br Med J* 2013; **346**: f108.
4. Cronin RS, Li M, Thompson JMD *et al*. An individual participant data meta-analysis of maternal going-to-sleep position, interactions with fetal vulnerability, and the risk of late stillbirth. *EClinicalMedicine* 2019; **10**: 49–57.
5. Gardosi J, Francis A, Turner S, Williams M. Customized growth charts: rationale, validation and clinical benefits. *Am J Obstet Gynecol* 2018; **218**(2): S609–S618.
6. Clifford S, Giddings S, Southam M *et al*. The growth assessment protocol: a national programme to improve patient safety in maternity care. *MIDIRS* 2013; **23**: 516–523.
7. Anderson NH, Sadler LC, Stewart AW *et al*. Independent risk factors for infants who are small for gestational age by customised birthweight centiles in a multi-ethnic New Zealand population. *Aust N Z J Obstet Gynaecol* 2013; **53**(2): 136–142.
8. Anderson NH, Sadler LC, McKinlay CJD, McCowan LME. INTERGROWTH-21st vs customized birthweight standards for identification of perinatal mortality and morbidity. *Am J Obstet Gynecol* 2016; **214**(509): e1–e7.
9. Cartwright RD, Anderson NH, Sadler LC *et al*. Neonatal morbidity and small and large size for gestation: a comparison of birthweight centiles. *J Perinatol* 2020; **40**: 732–742.
10. Gardosi J, Giddings S, Clifford S *et al*. Association between reduced stillbirth rates in England and regional uptake of accreditation training in customised fetal growth assessment. *BMJ Open* 2013; **3**(e003942): 1–10.
11. Jayawardena L, Sheehan P. Introduction of a customised growth chart protocol increased detection of small for gestational age pregnancies in a tertiary Melbourne hospital. *Aust N Z J Obstet Gynaecol* 2019; **59**: 493–500.
12. PMMRC. Twelfth Annual Report of the Perinatal and Maternal Mortality Review Committee: Reporting Mortality 2016. Wellington: Health Quality & Safety Commission, 2018. Available from URL https://www.hqsc.govt.nz/assets/PMMRC/Publications/12th-PMMRC-report-final.pdf Accessed 1 February 2020.
13. McCowan LM, Bloomfield F.Guideline for the management of suspected small for gestational age pregnancies and infants after 34 weeks' gestation [Guideline], 2014. Available from URL https://www.healthpoint.co.nz/public/new-zealand-maternal-fetal-medicine-network/ Accessed 1 February 2020.
14. Atkinson J, Salmond C, Crampton P. NZDep2013 Index of Deprivation. Department of Public Health, University of Otago, Wellington 2014. Available from URL https://www.otago.ac.nz/wellington/otago069936.pdf Accessed 1 February 2020.
15. Gardosi J, Francis A.Customised Weight Centile Calculator. GROW v6.7.8; Gestation Network, 2016. Available from URL www.gestation.net
16. Anderson NH, Sadler LC, Stewart AW, McCowan LME. Maternal and pathological pregnancy characteristics in customised birthweight centiles and identification of at-risk small-for-gestational-age infants: a retrospective cohort study. *Br J Obstet Gynaecol* 2012; **119**: 848–856.
17. Figueras F, Savchev S, Triunfo S *et al*. An integrated model with classification criteria to predict small-for-gestational-age fetuses at risk of adverse perinatal outcome. *Ultrasound Obstet Gynecol* 2015; **45**(3): 279–285.
18. Veglia M, Cavallaro A, Papageorghiou A *et al*. Small-for-gestational-age babies after 37 weeks: an impact study of risk-stratification protocol. *Ultrasound Obstet Gynecol* 2018; **52**(1): 66–71.

19. Counties Manukau Health. Maternity Quality and Safety Programme. Annual Report 2012/2013. Available from URL https://countiesmanukau.health.nz/assets/About-/Reports-and-planning/Maternity/f9a61a5868/2012–maternity-quality-safety-programme-annual-report.pdf
20. Counties Manukau Health. Womens Health and Newborn Annual Report, 2017–2018. Available from URL https://countiesmanukau.health.nz/assets/Our-services/attachments/48102d3db5/CM-Health-Womens-Health-and-Newborn-Annual-Report-2017-2018-v15-HR-final-digital.pdf Accessed 1 February 2020.
21. Guilliland K, Pairman S. *The Midwifery Partnership: A Model for Practice*. 2nd edn. Christchurch (New Zealand): New Zealand College of Midwives, 2010.