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Small for Gestational Age Coded Diagnoses in Aotearoa New Zealand's Administrative Health Datasets: A Validation Study

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ABSTRACT

Background and Aims: Inaccurate coding of small for gestational age (SGA) infants in routinely collected health data has implications for research based on those data. We aimed to estimate the sensitivity and specificity of coded SGA diagnoses in New Zealand's routinely collected hospitalisation and mortality data, and determine whether sensitivity and specificity varied by infant, pregnancy, and maternal characteristics.

Methods: We estimated birthweight centiles of live and stillborn infants delivered in New Zealand between 2005 and 2020 using the Fenton Population Reference Calculator and the GROW Customised Bulk Centile Calculator (New Zealand version); values of the relevant variables (including gestational age, birthweight, infant sex, and others) were sourced from routinely collected national health data. We compared the SGA status derived from the calculators with coded SGA diagnoses (ICD-10-AM P051) in hospitalisation and mortality data. We estimated sensitivity and specificity ratios comparing coded diagnoses with each of the birthweight calculators using a generalised linear model, adjusting for infant, pregnancy, and maternal characteristics.

Results: This analysis included 887,871 infants, with 15,850 (1.8%) having a coded SGA diagnosis. By contrast, the number and proportion of babies classified as SGA using the Fenton and GROW calculators were 80,541 (9.1%) and 138,866 (15.6%), respectively. Overall, compared with the Fenton calculator, the sensitivity of coded SGA diagnoses was 13.1% (specificity 99.3%). Compared with the GROW calculator, the sensitivity was 9.8% (specificity 99.7%).

Conclusion: In New Zealand, population-level research involving SGA diagnoses should derive birthweight centiles using an appropriate calculator instead of using ICD-10-AM coded diagnoses.

1 | Background

Infants who are born small for gestational age (SGA), defined as those whose birthweight is below the tenth centile for their gestational age [1], are at increased risk of severe complications, including stillbirth and neonatal mortality [2]. SGA is associated with increased risk of acute problems, including hypothermia and hypoglycaemia [3], while longer term consequences include neurodevelopmental delay [4], and metabolic problems, such as diabetes and cardiovascular disease [5].

Known risk factors for having an SGA infant include smoking, obesity, and increasing maternal age [6]. In utero exposure to medicines may also increase risk, with SGA status often

Summary

Study Question

- What is the sensitivity and specificity of coded ICD-10-AM small for gestational age (SGA) diagnoses in New Zealand's routinely collected hospitalisation and mortality data? Do sensitivity and specificity vary by infant, pregnancy, and maternal characteristics?

What Is Already Known

- In data obtained from administrative health datasets, the proportion of births with coded SGA diagnoses is much less than expected.

What This Study Adds

- Coded ICD-10-AM SGA diagnoses recorded in New Zealand's national health datasets have very poor sensitivity yet high specificity when compared with two different birthweight centile calculators. Researchers utilising these datasets should not rely on coded diagnoses, and instead should ascertain SGA status from recorded birthweight and gestational age.

included in studies assessing medication safety during pregnancy. Therefore, correctly identifying SGA infants, especially for research using routinely collected data, is essential for appropriately interpreting findings.

In Aotearoa New Zealand (NZ), for an infant to receive a coded SGA diagnosis, a clinical team must calculate a birthweight centile, selecting from one of many different centile calculators and clinical guidelines [7, 8]. Crucially, for coding purposes, an SGA diagnosis must be documented in the patient's record. Only then can clinical coders assign the ICD-10-AM (International Classification of Diseases, 10th revision, Australian edition) P051 diagnostic code (newborn SGA), which is then recorded in administrative databases.

A variety of calculators are available to determine birthweight centiles, which may classify infants differently [9]. In NZ, the Fenton Population Reference, which uses birthweight, gestational age at birth, and infant sex to derive a birthweight centile from a general population standard, has been commonly used [10]. However, current clinical guidelines [1] recommend using a customised birthweight calculator (the NZ version of the Gestation Related Optimal Weight [GROW] Customised Bulk Centile Calculator which was developed in 2004 by the UK Perinatal Institute using NZ-specific data and updated in 2016 [11–13]) to better identify at-risk neonates, particularly among the diverse ethnicities in NZ.

In population-based studies using routinely collected data, incomplete identification of SGA infants may bias findings, potentially obscuring important safety signals that may have clinical implications. Furthermore, inconsistent classification of SGA infants may also hinder the appropriate interpretation of findings, for example, if subgroups of infants are more, or less, likely to have the diagnosis recorded. Despite efforts to standardise assessment [14–17], SGA infants may be under-recorded in NZ's administrative datasets. For example, a recent examination of SGA following medication exposure in pregnancy using the population-based New Zealand Pregnancy Cohort (NZPC) [18], found that only 1.2% of infants had a hospitalisation or mortality ICD-10-AM coded SGA diagnosis [19], when, by definition, approximately 10% of infants would be expected to have this diagnostic code.

Therefore, our aims were to (a) estimate the sensitivity and specificity of coded SGA diagnoses recorded in routinely collected hospitalisation and mortality records, compared with SGA status estimated using two different birthweight centile calculators (population reference and customised); and (b) to explore whether the sensitivity and specificity of coded SGA diagnoses varied by infant, pregnancy, and maternal characteristics.

2 | Methods

2.1 | Study Cohort

Data came from the NZPC and linked Baby Cohort, national cohorts constructed to investigate medicine utilisation and safety during pregnancy [18]. In brief, the NZPC was derived from four routinely collected Ministry of Health administrative datasets, including the National Maternity Collection (MAT), National Minimum Data set (NMDS; hospitalisations), Mortality Collection (MORT), and the Laboratory Claims Collection (LAB). The NZPC was updated in 2023 to include pregnancies with a recorded delivery by December 2020 (including 979,008 infants in the updated Baby Cohort).

2.2 | SGA Classification

2.2.1 | Fenton Population Reference Calculator

We used the Fenton 2013 version 6 size at birth population reference calculator to estimate birthweight centiles [20]; inputs were gestational age (weeks), birthweight (grams), and infant sex (male/female).

2.2.2 | GROW Customised Bulk Centile Calculator (New Zealand Version)

Birth weight centiles were also estimated using version 6.7.8.3 (NZ) of the GROW calculator [11–13]; inputs were gestational age (days), birthweight (grams), infant sex (male/female; unrecorded values not adjusted for sex), infant ethnicity (Statistics NZ Level 2 [21]), and maternal height (centimetres), weight (kilograms), and parity (0, 1, 2, 3+).

For both calculators, infants with a birthweight below the tenth centile for their gestational age were classified as SGA. SGA infants were further classified as “mild SGA” if their birthweight centile was at or above the third centile, but below the tenth centile. Infants were classified as “severe SGA” if their birthweight centile was below the third centile.

2.2.3 | National Hospitalisation (NMDS) and Mortality (MORT) Records to Identify Infants With a Coded SGA Diagnosis

All maternity care, including foetal growth monitoring, is publicly funded in NZ and less than 5% of deliveries occur outside of a hospital or birthing unit [22]. Those identified antenatally as being at high risk of having a growth restricted infant are likely to deliver in a hospital; therefore, most SGA infants should have the opportunity to be identified and recorded in the NMDS.

We used ICD-10-AM code P051 recorded in hospitalisation (NMDS) or mortality (MORT) administrative datasets within 1 year of birth to identify infants with a coded SGA diagnosis.

The NMDS is a national collection of patient discharge information from public and private hospitals, including same day and multi-day inpatient stays [23]. Diagnoses appearing on a patient's clinical record are assigned ICD diagnosis codes (up to 99 codes allowed; currently ICD-10-AM, with backward mapping to previous versions) by professional clinical coders. Patient records, including all assigned ICD codes, are regularly electronically submitted to the NMDS administrative database by the treating hospital. Public hospital discharge data are available from 1988; information on private hospital births (which are publicly funded in NZ) is available from 1997.

The Mortality Collection (MORT) classifies the underlying cause of death for all New Zealand registered deaths, including stillbirths, using ICD-10-AM codes and WHO ICD-10 Rules and Guidelines for Mortality Coding [24]. Death records are regularly submitted to MORT by Births, Deaths, and Marriages (including stillbirth registrations), funeral directors (Medical Certificates of Cause of Death), and Coronial Services, with additional underlying cause of death information obtained from the NMDS and other official and informal (e.g., news reports) sources. Gestational age and birthweight are also collected and recorded for foetal and infant deaths.

In NZ, the clinical team must explicitly document an SGA diagnosis in the patient's record with the words “small for gestational age” (or similarly clear wording) before a professional clinical coder (external to the patient's clinical team) can apply the P051 SGA code to the patient's record. These coded diagnoses are then regularly uploaded to the NMDS or MORT administrative databases. If a patient's record lacks the explicit “small for gestational age” wording on their clinical record, the clinical coder is not permitted to assign the P051 code, even when the patient's record contains weight and gestational age data suggestive of SGA.

2.3 | Key Variables

2.3.1 | Infant Characteristics

Gestational age at birth was calculated using the infant's birthdate and LMP date recorded for the pregnancy in the NZPC. Birthweight was sourced from MAT, NMDS, or MORT. Infant sex came from MAT, or if missing, from the National Health Index (NHI) Collection. Infant ethnicity came from MAT, or if missing, from the NMDS delivery admission or another admission within the first year of life. Ethnicity was recorded at Statistics New Zealand Level 2 (required for the GROW customised calculator) but was prioritised into Level 1 groups for the analyses [21]. Infants with a stillborn MORT record, and those recorded as stillborn in MAT after 2018, were classified as stillborn. All other infants were classified as live born.

2.3.2 | Pregnancy Characteristics

Plurality (singleton vs. multiple pregnancy) and parity data came from MAT, with correction of obviously incorrect data. Parity was categorised as 0, 1, 2, or 3+ for use in the GROW customised calculator, but dichotomised into nulliparous (parity $= 0$) and not nulliparous (parity ≥ 1) for the analyses.

2.3.3 | Maternal Characteristics

Maternal age at LMP was calculated using the date of birth recorded in the NHI Collection. Maternal ethnicity was prioritised to the highest priority ethnicity recorded in the data extract (to Statistics NZ Level 1) to minimise potential undercounting of Māori and other non-European ethnicities. The New Zealand Index of Deprivation decile (NZDep; an area-based measure of social deprivation, converted to quintiles for the analyses [25]) and District Health Board region (DHB) variables came primarily from MAT (or from other Collections if not recorded in MAT), according to the mother's residential address at the time of delivery.

2.4 | Analysis

2.4.1 | Overall Sensitivities and Specificities of Coded SGA Diagnoses With the Birthweight Centile Calculators

To estimate the sensitivity of coded SGA diagnoses compared with the two birthweight centile calculators, we calculated the proportion of all infants classified as SGA in each birthweight calculator who also had a coded ICD-10-AM P051 diagnosis in the hospitalisation or mortality national collections.

To estimate the specificity of coded SGA diagnoses, we calculated the proportion of all infants who were not classified as SGA in each birthweight calculator who did not have a coded SGA diagnosis.

2.4.2 | Comparison of Sensitivities and Specificities of Coded SGA Diagnoses Between Sub-Groups

For each birthweight centile calculator, we compared differences in the sensitivity of the coded SGA diagnoses between sub-groups (hereafter referred to as “sensitivity ratio”) for the infant, pregnancy, and maternal characteristics; district health board region; and year of LMP.

First, we compared the sensitivities by the individual covariates separately, using a generalised linear model with a log link, and accounting for correlations between infants born to the same mother using robust standard errors.

Next, we compared these sensitivity ratios using the same generalised linear model adjusting for all of the infant, pregnancy, and maternal characteristics, as well as region and year of LMP. We used a generalised estimating equation to account for the clustering of pregnancies within women (i.e., women in the cohort may have had multiple pregnancies so not all pregnancies are independent).

We used the same methods to compare the specificities of the coded SGA diagnoses with each of the birthweight centile calculators, calculating both unadjusted and adjusted specificity ratios. STATA version 17 was used for all analyses [26].

2.5 | Missing Data

Missing infant sex was recoded as "female" for both calculators. For the GROW customised calculator, missing maternal height, weight, and ethnicity used default New Zealand population median values (height: 165 cm; weight: 70 kg; ethnicity: NZ European) [13].

2.6 | Ethics Approval and Consent

This study was approved by the Northern A Health and Disability Ethics Committee (2022 AM 5554). This study used anonymised routinely collected administrative health data and individual patient informed consent was not possible.

Please see the Appendix for a completed STARD 2015 checklist [27].

3 | Results

We included infants in the Baby Cohort who were born to mothers with a last menstrual period (LMP) from 1 January 2005 and delivery by 31 December 2020 (excluded $n = 44{,}224$ with an LMP date before 2005). We excluded infants with a recorded gestational age under 22 weeks ($n = 2140$), without either an NMDS or MORT record ($n = 26{,}372$), and those with missing ($n = 17{,}595$) or implausible gestational weights (i.e., below 400 g ($n = 735$) or above 9 kg ($n = 71$)). Please see Appendix 1 for a cohort flowchart. Infants with missing sex information ($n = 56$) were recoded as "female" for use in the calculators.

Table 1 shows the characteristics of the 887,871 infants meeting the inclusion criteria. Overall, mean birthweight was 3413 g (standard deviation [SD] 636 g; median 3450 g, interquartile range [IQR] 3085–3800). Mean gestational age was 39 weeks (SD 2.27; median 39 weeks, IQR 38–40).

TABLE 1 | Characteristics of infants included in this analysis ($n = 887{,}871$).

Characteristic		
Birthweight (grams)		
Mean (SD)	3,412.86	635.91
Median (IQR)	3450	3085–3800
Gestational age (weeks)		
Mean (SD)	38.94	2.27
Median (IQR)	39	38–40
	n	**%**
Gestational age		
≥ 37 weeks	810,912	91.3
32–36 weeks	63,167	7.1
28–31 weeks	8284	0.9
< 28 weeks	5508	0.6
Birth status		
Live born	884,154	99.6
Stillborn	3717	0.4
Plurality		
Singleton	862,081	97.1
Twin/Multiple	25,790	2.9
Infant sex		
Female	430,976	48.5
Male	456,839	51.5
Missing	56	< 0.1
Infant ethnicity (prioritised)		
NZ European/Other	392,882	44.3
Māori	249,777	28.1
Pacific	98,677	11.1
Asian	128,052	14.4
MELAA	18,025	2.0
Missing	458	0.1
Parity		
Nulliparous	373,128	42.0
Not nulliparous	514,743	58.0
Maternal age (years)		
15–19	68,784	7.8
20–29	404,436	45.6
30–39	388,977	43.8
40–49	25,674	2.9
Maternal ethnicity (prioritised)		
NZ European/Other	365,879	41.2
Māori	249,914	28.2
Pacific	100,373	11.3
Asian	124,819	14.1
MELAA	46,557	5.2
Missing	329	< 0.1

(Continues)

TABLE 1 | (Continued)

	n	%
Deprivation quintile		
1 (least deprived)	128,511	14.5
2	143,354	16.2
3	163,298	18.4
4	200,999	22.6
5 (most deprived)	250,178	28.2
Missing	1531	0.2
Year of last menstrual period		
2005	57,342	6.5
2006	60,610	6.8
2007	61,515	6.9
2008	61,031	6.9
2009	62,036	7.0
2010	59,973	6.8
2011	59,114	6.7
2012	57,705	6.5
2013	56,511	6.4
2014	57,033	6.4
2015	56,978	6.4
2016	57,267	6.5
2017	56,369	6.4
2018	56,640	6.4
2019	54,228	6.1
2020	13,519	1.5
District Health Board		
Auckland	92,992	10.5
Bay of Plenty	42,703	4.8
Canterbury	91,604	10.3
Capital and Coast	53,484	6.0
Counties Manukau	125,712	14.2
Hawke's Bay	31,579	3.6
Hutt Valley	30,157	3.4
Lakes	22,914	2.6
MidCentral	32,155	3.6
Nelson Marlborough	22,224	2.5
Northland	31,568	3.6
South Canterbury	9,366	1.1
Southern	50,847	5.7
Tairāwhiti	10,640	1.2
Taranaki	22,036	2.5
Waikato	77,860	8.8
Wairarapa	7170	0.8
Waitematā	114,490	12.9
West Coast	5037	0.6
Whanganui	12,350	1.4
Overseas	983	0.1

Abbreviation: MELAA, Middle Eastern, Latin American, African.

3.1 | SGA Classification and Overall Sensitivities and Specificities

Based on coded ICD-10-AM SGA diagnoses, 15,850 babies (1.8%) were classified as SGA. By contrast, the number and proportion of babies classified as SGA using the Fenton and GROW calculators were 80,541 (9.1%) and 138,866 (15.6%), respectively.

Overall, compared with the Fenton calculator, the sensitivity of coded SGA diagnoses was 13.1% (specificity 99.3%). Compared with the GROW calculator, the sensitivity of coded diagnoses was 9.8% (specificity 99.7%).

3.2 | Sensitivity and Specificity Ratios of Coded SGA Diagnoses Compared With the Fenton Calculator

Table 2 shows the sensitivities, unadjusted sensitivity ratios, and adjusted sensitivity ratios of the coded SGA diagnoses compared with the Fenton population reference calculator, by covariate of interest. After adjusting for all covariates, the sensitivity of coded diagnoses were higher for severe SGA (adjusted sensitivity ratio [aSR] 2.06 (95% confidence interval [95% CI] 1.99, 2.13); decreased gestational age (32–36 weeks: aSR 1.18 (95% CI: 1.10, 1.26); 28–31 weeks: aSR 1.43 (95% CI: 1.19, 1.72); and older maternal age (30–39 years: aSR 1.14 (95% CI: 1.09, 1.18); 40–49 years aSR 1.30 (95% CI: 1.18, 1.44). Increasing year of LMP was also associated with increased sensitivity over time.

Coded SGA sensitivity was lower for infants who were stillborn (aSR 0.50 (95% CI: 0.40, 0.64)); male (aSR 0.71 (95% CI: 0.69, 0.74)); Māori ethnicity (aSR 0.88 (95% CI: 0.80, 0.96)); and a not nulliparous pregnancy (aSR 0.91 (95% CI: 0.88, 0.95)). Generally, birth location outside Auckland DHB was also associated with lower sensitivities.

Specificity ratios did not vary substantially by the different covariates (see Appendix 2).

3.3 | Sensitivity and Specificity Ratios of Coded SGA Diagnoses Compared With the Grow Calculator

Table 3 shows the sensitivities, unadjusted sensitivity ratios, and adjusted sensitivity ratios of the coded SGA diagnoses compared with the GROW customised calculator, by covariate of interest. After adjusting for all covariates, the sensitivity of coded diagnoses were higher for severe SGA (aSR 3.12 (95% CI: 3.02, 3.23)); infants of Asian (aSR: 1.43 (95% CI: 1.27–1.61)) and Middle Eastern/Latin American/African (MELAA) ethnicities (aSR: 1.25 (95% CI: 1.10, 1.43)); and older maternal age at birth (40–49 years: aSR: 1.18 (95% CI: 1.09–1.28)). Like the Fenton analyses, increasing year of LMP was associated with increased sensitivity over time.

Coded SGA diagnosis sensitivities were lower for decreasing gestational age (32–36 weeks aSR: 0.81 (95% CI: 0.76, 0.86);

TABLE 2 | Sensitivity of hospitalisation (NMDS) and mortality (MORT) small-for-gestational-age diagnoses compared with the Fenton Population Reference Birthweight Centile Calculator.

Characteristic	SGA from Fenton (n)	SGA from both Fenton & NMDS/ MORT(n)	Sensitivity of SGA diagnosis (%)	Sensitivity ratio (95% CI)	Adjusted sensitivity ratio[a] (95% CI)
Degree of SGA					
Mild SGA	54,558	5467	10.02	Reference	Reference
Severe SGA	25,983	5086	19.57	1.95 (1.89, 2.02)	2.06 (1.99, 2.13)
Gestational age					
≥ 37 weeks	73,342	9415	12.84	Reference	Reference
32–36 weeks	5949	976	16.41	1.28 (1.20, 1.36)	1.18 (1.10, 1.26)
28–31 weeks	613	110	17.94	1.40 (1.18, 1.66)	1.43 (1.19, 1.72)
< 28 weeks	637	52	8.16	0.64 (0.49, 0.83)	0.86 (0.65, 1.14)
Birth status					
Live born	79,515	10,478	13.18	Reference	Reference
Stillborn	1026	75	7.31	0.55 (0.45, 0.69)	0.50 (0.40, 0.64)
Plurality					
Singleton	76,041	9879	12.99	Reference	Reference
Twin/Multiple	4500	674	14.98	1.15 (1.07, 1.25)	1.05 (0.96, 1.14)
Infant sex					
Female	34,037	5277	15.50	Reference	Reference
Male	46,504	5276	11.35	0.73 (0.71, 0.76)	0.71 (0.69, 0.74)
Infant ethnicity					
NZ European/ Other	28,010	3322	11.86	Reference	Reference
Māori	26,099	3028	11.60	0.98 (0.93, 1.03)	0.88 (0.80, 0.96)
Pacific	6811	982	14.42	1.22 (1.14, 1.30)	0.64 (0.83, 1.07)
Asian	17,879	2974	16.63	1.40 (1.34, 1.47)	1.04 (0.91, 1.19)
MELAA	1683	241	14.32	1.21 (1.07, 1.36)	0.98 (0.84, 1.15)
Parity					
Nulliparous	44,423	6099	13.73	Reference	Reference
Not nulliparous	36,118	4454	12.33	0.90 (0.87, 0.93)	0.91 (0.88, 0.95)
Maternal age (years)					
15–19	8304	863	10.39	0.83 (0.78, 0.89)	0.95 (0.89, 1.02)
20–29	39,542	4930	12.47	Reference	Reference
30–39	30,581	4413	14.43	1.16 (1.11, 1.20)	1.14 (1.09, 1.18)
40–49	2114	347	16.41	1.32 (1.19, 1.46)	1.30 (1.18, 1.44)
Maternal ethnicity					
NZ European/ Other	26,100	3127	11.98	Reference	Reference
Māori	26,269	3092	11.77	0.98 (0.94, 1.03)	1.09 (0.99, 1.19)
Pacific	7391	1084	14.67	1.22 (1.15, 1.31)	1.01 (0.89, 1.15)
Asian	17,140	2824	16.48	1.38 (1.31, 1.44)	0.92 (0.80, 1.05)
MELAA	3602	422	11.72	0.98 (0.89, 1.08)	0.97 (0.86, 1.10)
Deprivation quintile					

(Continues)

TABLE 2 | (Continued)

Characteristic	SGA from Fenton (n)	SGA from both Fenton & NMDS/ MORT(n)	Sensitivity of SGA diagnosis (%)	Sensitivity ratio (95% CI)	Adjusted sensitivity ratio[a] (95% CI)
1 (least deprived)	9366	1230	13.13	Reference	Reference
2	11,401	1517	13.31	1.01 (0.94, 1.09)	1.00 (0.94, 1.07)
3	14,300	1787	12.50	0.95 (0.89, 1.02)	0.99 (0.93, 1.06)
4	19,320	2502	12.95	0.99 (0.92, 1.05)	1.05 (0.98, 1.12)
5 (most deprived)	26,005	3498	13.45	1.02 (0.96, 1.09)	1.05 (0.98, 1.12)
Year of last menstrual period					
2005	5560	463	8.33	Reference	Reference
2006	5702	547	9.59	1.15 (1.02, 1.30)	1.14 (1.02, 1.28)
2007	5617	366	6.52	0.78 (0.69, 0.89)	0.79 (0.69, 0.90)
2008	5688	413	7.26	0.87 (0.77, 0.99)	0.90 (0.79, 1.02)
2009	5578	463	8.30	1.00 (0.88, 1.13)	1.02 (0.90, 1.15)
2010	5453	472	8.66	1.04 (0.92, 1.18)	1.07 (0.95, 1.21)
2011	5343	513	9.60	1.15 (1.02, 1.30)	1.18 (1.05, 1.33)
2012	5065	546	10.78	1.29 (1.15, 1.46)	1.33 (1.19, 1.50)
2013	4888	630	12.89	1.55 (1.38, 1.74)	1.61 (1.44, 1.80)
2014	4961	656	13.22	1.59 (1.42, 1.78)	1.63 (1.46, 1.82)
2015	5135	859	16.73	2.01 (1.80, 2.24)	2.08 (1.87, 2.31)
2016	4955	895	18.06	2.17 (1.95, 2.41)	2.18 (1.97, 2.43)
2017	5163	1006	19.48	2.34 (2.11, 2.60)	2.43 (2.19, 2.69)
2018	5146	1152	22.39	2.69 (2.43, 2.98)	2.70 (2.44, 2.98)
2019	5038	1216	24.14	2.90 (2.62, 3.21)	2.94 (2.66, 3.25)
2020	1249	356	28.50	3.42 (3.02, 3.88)	3.48 (3.08, 3.94)
District health board					
Auckland	8464	1643	19.41	Reference	Reference
Bay of plenty	4268	547	12.82	0.66 (0.60, 0.72)	0.66 (0.60, 0.72)
Canterbury	7712	1141	14.80	0.76 (0.71, 0.82)	0.74 (0.69, 0.79)
Capital and coast	4386	795	18.13	0.93 (0.86, 1.01)	0.93 (0.86, 1.01)
Counties Manukau	11,701	2074	17.72	0.91 (0.86, 0.97)	0.94 (0.89, 1.00)
Hawke's Bay	3046	325	10.67	0.55 (0.49, 0.62)	0.56 (0.50, 0.63)
Hutt Valley	2676	210	7.85	0.40 (0.35, 0.46)	0.41 (0.36, 0.47)
Lakes	2229	361	16.20	0.83 (0.75, 0.93)	0.86 (0.78, 0.96)
MidCentral	2918	180	6.17	0.32 (0.27, 0.37)	0.32 (0.27, 0.37)
Nelson Marlborough	1947	108	5.55	0.29 (0.24, 0.35)	0.27 (0.22, 0.33)
Northland	3282	329	10.02	0.52 (0.46, 0.58)	0.52 (0.47, 0.59)
South Canterbury	837	58	6.93	0.36 (0.28, 0.46)	0.36 (0.28, 0.46)
Southern	4414	240	5.44	0.28 (0.25, 0.32)	0.28 (0.24, 0.32)
Tairāwhiti	1105	95	8.60	0.44 (0.36, 0.54)	0.47 (0.38, 0.57)
Taranaki	2095	303	14.46	0.75 (0.66, 0.84)	0.73 (0.66, 0.82)
Waikato	7526	956	12.70	0.65 (0.61, 0.71)	0.65 (0.60, 0.70)

(Continues)

TABLE 2 | (Continued)

Characteristic	SGA from Fenton (n)	SGA from both Fenton & NMDS/ MORT(n)	Sensitivity of SGA diagnosis (%)	Sensitivity ratio (95% CI)	Adjusted sensitivity ratio[a] (95% CI)
Wairarapa	583	41	7.03	0.36 (0.27, 0.49)	0.37 (0.27, 0.50)
Waitematā	9708	1032	10.63	0.55 (0.51, 0.59)	0.54 (0.50, 0.58)
West Coast	378	39	10.32	0.53 (0.39, 0.72)	0.53 (0.39, 0.71)
Whanganui	1180	63	5.34	0.28 (0.21, 0.35)	0.28 (0.22, 0.36)
Overseas	86	13	15.12	0.78 (0.47, 1.29)	0.85 (0.47, 1.52)

[a]Adjusted for all other factors in the table.

28–31 weeks aSR: 0.54 (95% CI: 0.47, 0.62); < 28 weeks aSR 0.40 (95% CI: 0.32, 0.51)); being stillborn (aSR: 0.75 (95% CI: 0.62, 0.91)); twin/multiple pregnancy (aSR: 0.90 (95% CI: 0.84, 0.97)); male infants (aSR: 0.86 (95% CI: 0.83, 0.88)); and a not nulliparous pregnancy (aSR: 0.70 (95% CI: 0.68, 0.72)). As with the Fenton analyses, birth location outside Auckland DHB was associated with lower sensitivities.

As above, specificity ratios did not vary substantially by the different covariates (see Appendix 3).

4 | Comment

4.1 | Principal Findings

Compared with birthweight centiles calculated using both the Fenton Population Reference Calculator and the GROW Customised Bulk Centile Calculator (NZ version), coded SGA diagnoses were substantially under-recorded in NZ's routinely collected hospitalisation and mortality datasets. Moreover, the degree of under-recording was not random, with the sensitivity and specificity of coded SGA diagnoses varying according to several infant, pregnancy and maternal characteristics. Sub-group analyses revealed similarities and differences depending on the birthweight centile calculator.

Higher adjusted sensitivity ratios (aSR) of coded SGA diagnoses were observed in relation to both the Fenton and GROW calculators for several factors, including severe SGA (< 3%), older maternal age, and increasing year of LMP. Higher aSR was also observed in relation to the Fenton calculator for decreasing gestational age, and the GROW calculator for Asian and Middle Eastern/Latin American/African (MELAA) ethnicities.

Lower aSR were observed for both calculators for stillborn infants, males, not nulliparous pregnancies, and being born outside the Auckland DHB. Lower aSR was also observed in relation to the Fenton calculator for Māori ethnicity, and the GROW calculator for decreasing gestational age, and twin/multiple pregnancies. Therefore, infants with a recorded SGA diagnosis in NZ's routinely collected datasets are not representative of all infants with SGA.

To our knowledge, this is the first study assessing the accuracy of coded ICD-10 SGA diagnoses using nationally collected administrative health data. One published study using medical records from a large US hospital has investigated the sensitivity and specificity of SGA ICD-9 coded diagnoses compared with published SGA reference charts [28]. Like us, they also observed overall low sensitivity (14.2%) and high specificity (99.7%).

Although not validation studies, several NZ hospital-based studies have investigated SGA clinical detection and classification. One study examined SGA classification by customised and population birthweight centiles, finding that more infants were classified as SGA using customised centiles compared with population centiles [29]. Another study at the same hospital reported that maternal obesity, older maternal age, nulliparous pregnancy, smoking, and hypertension were associated with SGA infants identified using a customised birthweight calculator [6]. A recent study evaluated SGA detection before and after implementing the Perinatal Institute's Growth Assessment Protocol (GAP), observing that the rate of antenatal SGA identification more than doubled after GAP was implemented [17].

NZ clinical practice guidelines for identifying and managing SGA pregnancies and infants were published in 2014 [15] and updated in 2023 [1]. However, neither of the guidelines nor the aforementioned studies mention the necessity of clinical staff explicitly including “small for gestational age” (or similarly clear wording) on the infant's written medical record. In NZ, professional clinical coders are not permitted to diagnose SGA status from recorded gestational age and birthweight and are reliant on someone within the patient's treatment team noting “small for gestational age” in the clinical notes before the ICD-10 P051 SGA code can be assigned. While we observed a three- to four-fold increase in the sensitivity of coded SGA diagnoses over the study period, updating the practice guidelines to include recommendations on requirements for recording of birthweight centiles for accurate and complete coding purposes would improve the utility of NZ's national health databases for research purposes.

4.2 | Limitations of the Data

We used data recorded in routinely collected administrative databases and it is possible that a small proportion of records may contain inaccuracies (due to data entry error or incorrect self-report), including for birthweight, LMP, and parity. These

TABLE 3 | Sensitivity of hospitalisation (NMDS) and mortality (MORT) small-for-gestational-age diagnoses compared with the GROW Customised Birthweight Centile Calculator.

Characteristic	SGA from GROW centile calculator (n)	SGA from both GROW & NMDS/ MORT (n)	Sensitivity of SGA diagnosis (%)	Sensitivity ratio (95% CI)	Adjusted sensitivity ratio[a] (95% CI)
Degree of SGA					
Mild SGA (< 10%)	83,206	4630	5.56	Reference	Reference
Severe SGA (< 3%)	55,660	8960	16.10	2.89 (2.80, 2.99)	3.12 (3.02, 3.23)
Gestational age					
≥ 37 weeks	119,245	11,787	9.88	Reference	Reference
32–36 weeks	15,312	1519	9.92	1.00 (0.95, 1.06)	0.81 (0.76, 0.86)
28–31 weeks	2736	207	7.57	0.77 (0.67, 0.87)	0.54 (0.47, 0.62)
< 28 weeks	1573	77	4.90	0.50 (0.40, 0.62)	0.40 (0.32, 0.51)
Birth status					
Live born	137,031	13,476	9.83	Reference	Reference
Stillborn	1835	114	6.21	0.63 (0.53, 0.76)	0.75 (0.62, 0.91)
Plurality					
Singleton	127,971	12,619	9.86	Reference	Reference
Twin/Multiple	10,895	971	8.91	0.90 (0.84, 0.97)	0.90 (0.84, 0.97)
Infant sex					
Female	68,745	7179	10.44	Reference	Reference
Male	70,121	6411	9.14	0.88 (0.85, 0.90)	0.86 (0.83, 0.88)
Infant ethnicity					
NZ European/ Other	57,617	4513	7.83	Reference	Reference
Māori	45,316	4037	8.91	1.14 (1.09, 1.19)	0.98 (0.90, 1.06)
Pacific	14,728	1626	11.04	1.41 (1.33, 1.49)	0.98 (0.88, 1.09)
Asian	18,563	3095	16.67	2.13 (2.04, 2.22)	1.43 (1.27, 1.61)
MELAA	2521	311	12.34	1.57 (1.41, 1.76)	1.25 (1.10, 1.43)
Parity					
Nulliparous	58,926	7036	11.94	Reference	Reference
Not nulliparous	79,940	6554	8.20	0.69 (0.66, 0.71)	0.70 (0.68, 0.72)
Maternal age (years)					
15–19	11,807	1062	8.99	0.93 (0.88, 0.99)	0.98 (0.92, 1.04)
20–29	65,024	6259	9.63	Reference	Reference
30–39	57,485	5766	10.03	1.04 (1.01, 1.08)	1.07 (1.03, 1.11)
40–49	4550	503	11.05	1.15 (1.05, 1.25)	1.18 (1.09, 1.28)
Maternal ethnicity					
NZ European/ Other	52,648	4215	8.01	Reference	Reference
Māori	46,458	4152	8.94	1.12 (1.07, 1.16)	1.07 (0.99, 1.16)
Pacific	15,028	1695	11.28	1.41 (1.33, 1.49)	1.05 (0.94, 1.17)
Asian	17,981	2952	16.42	2.05 (1.96, 2.14)	1.03 (0.91, 1.16)
MELAA	6688	572	8.55	1.07 (0.98, 1.16)	1.02 (0.92, 1.13)
Deprivation quintile					

(Continues)

TABLE 3 | (Continued)

Characteristic	SGA from GROW centile calculator (n)	SGA from both GROW & NMDS/ MORT (n)	Sensitivity of SGA diagnosis (%)	Sensitivity ratio (95% CI)	Adjusted sensitivity ratio[a] (95% CI)
1 (least deprived)	16,962	1552	9.15	Reference	Reference
2	19,981	1935	9.68	1.06 (0.99, 1.13)	1.04 (0.97, 1.10)
3	24,216	2204	9.10	0.99 (0.93, 1.06)	1.01 (0.95, 1.07)
4	32,412	3117	9.62	1.05 (0.99, 1.11)	1.07 (1.01, 1.13)
5 (most deprived)	45,038	4759	10.57	1.15 (1.09, 1.22)	1.09 (1.03, 1.15)
Year of Last Menstrual Period					
2005	10,065	571	5.67	Reference	Reference
2006	10,407	644	6.19	1.09 (0.98, 1.22)	1.11 (1.00, 1.23)
2007	9638	439	4.55	0.80 (0.71, 0.91)	0.83 (0.74, 0.94)
2008	9594	486	5.07	0.89 (0.79, 1.01)	0.93 (0.83, 1.04)
2009	9467	539	5.69	1.00 (0.89, 1.13)	1.06 (0.95, 1.19)
2010	9416	566	6.01	1.06 (0.95, 1.19)	1.12 (1.01, 1.26)
2011	9177	598	6.52	1.15 (1.03, 1.28)	1.20 (1.07, 1.33)
2012	8714	673	7.72	1.36 (1.22, 1.52)	1.42 (1.27, 1.58)
2013	8542	791	9.26	1.63 (1.47, 1.81)	1.71 (1.55, 1.90)
2014	8645	849	9.82	1.73 (1.56, 1.92)	1.81 (1.64, 2.01)
2015	8763	1071	12.22	2.15 (1.95, 2.38)	2.24 (2.03, 2.46)
2016	8505	1182	13.90	2.45 (2.22, 2.70)	2.54 (2.31, 2.79)
2017	8792	1346	15.31	2.70 (2.46, 2.97)	2.83 (2.58, 3.11)
2018	8678	1613	18.59	3.28 (2.99, 3.59)	3.34 (3.05, 3.65)
2019	8373	1720	20.54	3.62 (3.31, 3.97)	3.67 (3.36, 4.01)
2020	2090	502	24.02	4.23 (3.79, 4.73)	4.33 (3.89, 4.83)
District Health Board					
Auckland	13,544	2101	15.51	Reference	Reference
Bay of Plenty	7290	680	9.33	0.60 (0.55, 0.65)	0.65 (0.59, 0.70)
Canterbury	13,557	1332	9.83	0.63 (0.59, 0.68)	0.67 (0.63, 0.72)
Capital and Coast	7434	938	12.62	0.81 (0.76, 0.87)	0.88 (0.82, 0.94)
Counties Manukau	20,104	2953	14.69	0.95 (0.90, 1.00)	1.00 (0.95, 1.06)
Hawke's Bay	5487	499	9.09	0.59 (0.53, 0.64)	0.65 (0.60, 0.72)
Hutt Valley	4595	259	5.64	0.36 (0.32, 0.41)	0.39 (0.34, 0.44)
Lakes	3972	547	13.77	0.89 (0.81, 0.97)	1.01 (0.92, 1.10)
MidCentral	5210	216	4.15	0.27 (0.23, 0.31)	0.29 (0.25, 0.33)
Nelson Marlborough	3357	131	3.90	0.25 (0.21, 0.30)	0.27 (0.23, 0.32)
Northland	5805	410	7.06	0.46 (0.41, 0.51)	0.50 (0.45, 0.55)
South Canterbury	1666	73	4.38	0.28 (0.22, 0.36)	0.32 (0.26, 0.41)
Southern	8046	280	3.48	0.22 (0.20, 0.25)	0.25 (0.22, 0.28)
Tairāwhiti	2025	130	6.42	0.41 (0.35, 0.49)	0.47 (0.39, 0.55)
Taranaki	3797	428	11.27	0.73 (0.66, 0.80)	0.80 (0.73, 0.88)
Waikato	12,717	1145	9.00	0.58 (0.54, 0.62)	0.61 (0.57, 0.66)

(Continues)

TABLE 3 | (Continued)

Characteristic	SGA from GROW centile calculator (n)	SGA from both GROW & NMDS/ MORT (n)	Sensitivity of SGA diagnosis (%)	Sensitivity ratio (95% CI)	Adjusted sensitivity ratio[a] (95% CI)
Wairarapa	1132	51	4.51	0.29 (0.22, 0.38)	0.34 (0.26, 0.45)
Waitematā	16,123	1269	7.87	0.51 (0.47, 0.54)	0.51 (0.48, 0.55)
West Coast	732	51	6.97	0.45 (0.34, 0.59)	0.52 (0.40, 0.67)
Whanganui	2108	81	3.84	0.25 (0.20, 0.31)	0.28 (0.22, 0.35)
Overseas	165	16	9.70	0.63 (0.39, 1.00)	0.80 (0.46, 1.37)

[a]Adjusted for all other factors in the table.

inaccuracies may have affected the accuracy of the birthweight centiles calculated by either or both calculators. Although we removed records with clearly implausible data (e.g., birthweight > 9 kg), we note that, despite best efforts, some level of inaccurate data is inevitable when working with population-level administrative datasets. However, as we were interested in population-level trends, rather than individual-level results, our findings provide useful and actionable information regarding patterns of coded SGA diagnoses in NZ's hospitalisation and mortality data.

4.3 | Interpretation

Our findings suggest extreme caution is warranted when using coded SGA diagnoses, which are substantially incomplete, for research purposes, including studies investigating the safety of medicines use during pregnancy. Research involving SGA outcomes should use other information, such as hospital discharge data, to more accurately determine SGA status for individual infants. Although recent national clinical practice guidelines recommend using a customised calculator when determining SGA status [1], it is too soon to assess the impact on coded diagnosis accuracy and whether there will be universal uptake across New Zealand.

5 | Conclusion

In New Zealand, coded SGA diagnoses do not accurately reflect the clinical situation, and these codes should not be used for research purposes, especially for studies investigating adverse outcomes associated with medicine use during pregnancy. Population-level research involving SGA status should derive birthweight centiles using an appropriate calculator instead of ICD-10-AM-coded diagnoses.

Author Contributions

Mei-Ling Blank: formal analysis, investigation, project administration, writing – original draft. **Sarah Donald:** conceptualization, formal analysis, methodology, supervision, writing – review and editing. **Lianne Parkin:** conceptualization, formal analysis, methodology, supervision, writing – review and editing.

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The internal funder had no role in the study design; collection, analysis, and interpretation of the data; writing of the report; or the decision to submit the report for publication.

Ethics Statement

Northern A Health and Disability Ethics Committee (2022 AM 5554).

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

No data are available. The authors are not permitted to share the data directly with third parties. Enquiries about access to data from the National Collections may be sent to data-enquiries@health.govt.nz.

Transparency Statement

All authors have read and approved the final version of the manuscript. Mei-Ling Blank had full access to all of the data in this study and takes complete responsibility for the integrity of the data and the accuracy of the data analysis. Mei-Ling Blank affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.