RESEARCH ARTICLE

An evaluation of the potential to improve perinatal outcomes by improving antenatal detection of small for gestational age babies in Scotland: a retrospective population cohort study

[version 1; peer review: awaiting peer review]

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Abstract

Background: Small for gestational age (SGA) babies are at high risk of perinatal mortality. We aimed to determine the potential to reduce perinatal mortality by improving antenatal detection of SGA babies in Scotland.

Methods: We conducted a retrospective population study of all singleton SGA babies born in the 15 Consultant-led maternity units in Scotland in a 3-month period (1st Dec 2014 to 28th Feb 2015 inclusive). Demographic and pregnancy outcome data were extracted from Scottish birth records for all pregnancies; case note review was performed for all SGA cases [defined as birthweight less than the 10th centile for their gestational age at delivery as defined by the appropriate sex-specific UK-WHO Child Growth Standards].

Results: The SGA rate in Scotland was 5.5% (673/12218; 95% confidence interval [CI] 5.1, 5.9) and 27.6% (186/673; 95% CI 24.3, 31.2) of SGA cases were identified prior to delivery. SGA was associated with 18.2% (12/66; 95% CI 10.1%, 30.0%) of all perinatal deaths. The majority (10/12, 83.3%) of SGA babies who died had been identified as SGA in the antenatal period. There was no difference in perinatal mortality whether SGA was detected or not (5.4% [10/186; 95% CI 2.8, 10.0] in the SGA detected group vs 0.4% [2/487 [95% CI 0.3, 2.2] in the non-detected group after adjusting for risk factors for SGA, gestation at delivery and birthweight centile (Adjusted odds ratio [AOR] 0.85 [95% CI 0.5, 1.5], p=0.556).

Conclusions: Despite only around a quarter of SGA babies being identified antenatally, the potential to reduce perinatal mortality in the Scottish population by improving SGA detection is limited. Only a minority of perinatal deaths occurred in SGA babies; and in the majority of these SGA was detected antenatally.
Keywords
Pregnancy, Small for Gestational Age, Stillbirth, Perinatal Morbidity, Birthweight

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The SGA cohort was identified by NHS ISD and included >98% Scottish Births between 1 December 2014 and 28 February 2015 inclusive. These deliveries were presumed to be at or above 24 weeks gestation (live births and stillbirths) that were not identified as SGA (i.e. the SGA cohort) by the NHS ISD review of the SMR02 data set (see below). These deliveries were presumed to be at or above the 10th centile as defined by the UK-WHO Child Growth Standards. A comparator “non-SGA group” was all singleton deliveries (live births and stillbirths) that were not identified as SGA (i.e. the SGA cohort) by the NHS ISD review of the SMR02 data set (see below). These deliveries were presumed to be at or above the 10th centile as defined by the UK-WHO Child Growth Standards.

**Database**

The cohort was identified from the Scottish Morbidity Record 02 (SMR02; the Maternity Inpatient and Day Case data set) that is collated by the NHS National Services Scotland, Information Services Division (NHS ISD). SMR02 collects episode level data on all hospital deliveries in Scotland. The dataset includes patient identifiable information, maternal and baby characteristics and is estimated to be 99% complete across all health boards during the study period. The missing data is due to a combination of home births (which are not recorded on SMR02 as there is no hospital admission) and missing data from maternity unit submissions. The National Records of Scotland is a civil registration system of all births in Scotland and was used to cross reference delivery numbers by the NHS ISD. There is a legal requirement to register all live births and all stillbirths (after 24 weeks gestation) within 21 days of birth.

**Ethics and anonymisation**

As this was a quality improvement project formal ethical review was not required. Each individual maternity unit had a designated project lead who completed a "Confidential Data Release Request" that was approved by the Consultant Lead in each unit and the NHS National Services Caldicott Guardian. Data were de-identified in the delivering maternity unit and only anonymised data were returned centrally to the project coordinator.

**Population**

The study population was women with singleton pregnancies delivering at 24 weeks gestation or more, in the 15 Consultant-Led NHS Maternity Units with >1000 deliveries in 2014 (including their alongside midwifery units) in Scotland between 1 December 2014 and 28 February 2015 inclusive.

The SGA cohort included all babies (live births and stillbirths) with a birth weight less than the 10th centile for their gestational age as defined by the appropriate sex-specific UK-WHO Child Growth Standards, used for all Scottish children to define growth disturbance in childhood (as recorded in the Personal Child Health Record that every child receives). The WHO charts define optimal growth standards based on worldwide data of healthy children up to 4 years. These charts have been combined with birth data for gestations 23–42 weeks from the UK 1990 growth reference charts to produce the UK-WHO charts. The 10th centile was chosen as this threshold is used as a definition in guidelines from WHO and countries including the UK, USA and Canada.

A comparator “non-SGA group” was all singleton deliveries (live births and stillbirths) that were not identified as SGA (i.e. the SGA cohort) by the NHS ISD review of the SMR02 data set (see below). These deliveries were presumed to be at or above the 10th centile as defined by the UK-WHO Child Growth Standards.

**Data extraction: outcomes, exposures and variables**

**SGA cohort.** The SGA cohort was identified by NHS ISD and case details were forwarded to the project lead at each hospital, who performed detailed case note review. The SGA cohort included all live births identified as being less than the
For each pregnancy in Stillbirth or Early Neonatal Death SGA detection was defined as documentation of 9th centile for gestational age in SMR02. As the formula used by NHS ISD to calculate the birth weight centiles from the UK-WHO charts was only applied to live births, all stillbirths less than the 10th centile for 42 weeks gestational age (i.e. <3283g for boys and <3165g for girls) were identified to ensure that no cases were missed, with inclusion being clarified at the time of case note review.

A detailed case review of maternity and neonatal records of the cases was performed by each project lead using a standardised proforma (Extended dataa). Birth weight centile was verified and additional variables (see below) were extracted from the hand-held maternity notes, hospital paper notes and/or the maternity paperless patient records systems that was in use in each unit. Data on APGAR scores were extracted from SMR02.

**Non-SGA cohort.** The non-SGA comparator group data was identified by the NHS ISD from the study population by excluding the cases that had been identified as SGA. A detailed hospital case note review was not performed for the non-SGA group. Instead NHS ISD extracted data from SMR02 on pre-specified variables to enable comparison between the SGA and non-SGA cohorts (see below).

**Outcomes and variables**

**Outcomes.** The primary outcome was perinatal mortality in babies in whom SGA was not detected compared to those in whom SGA was detected. We used the definitions of perinatal mortality from the UK Perinatal Mortality Surveillance Report1 (see Table 1). We have reported early neonatal death as this reflects obstetric events more closely than deaths up to 28 days.

Planned secondary outcomes were any admission to a neonatal unit of any level and APGAR score <7 at five minutes. These are both markers of perinatal morbidity.

**SGA cohort.** SGA detection was defined as documentation of SGA, fetal growth restriction or intrauterine growth restriction or small for dates in the case record prior to the onset of labour. Where it was not clear, or data were missing, it was presumed that SGA was not detected. The method of detection was defined as ultrasound diagnosed (ultrasound scan findings of an abdominal circumference or estimated fetal weight as <10th centile when measured on reference growth chart used by the local hospital at that time) or as clinically-suspected (determined by a reduced symphysis-fundal height measurement or clinical palpation, according to local hospital protocol, without ultrasound confirmation).

Additional variables collected at case note review in the SGA cohort were maternal characteristics including age, body mass index (BMI) at booking and ethnicity. Baby characteristics included gestation at delivery (in days) and birth weight (in grams). Mode of delivery was classified as elective caesarean section (scheduled prior to the onset of labour), emergency caesarean section (unscheduled or performed during labour), operative vaginal delivery (forceps or ventouse) or spontaneous vaginal delivery.

Data regarding five clinical risk factors for SGA were also extracted including previously having a SGA baby (parous women), maternal age over 40 years at delivery, smoking over 10 cigarettes at the time of booking (data on any smoking in pregnancy was also collected for comparison with non-SGA cohort), hypertensive disorders in pregnancy (diagnosis of pre-existing hypertension, pregnancy induced hypertension and pre-eclampsia as per the individual unit's diagnostic criteria) and any attendance with reduced fetal movements. These are major risk factors in the Royal College of Obstetricians and Gynaecologists (RCOG)'s Green Top Guideline on SGA detection1 that should trigger growth ultrasound screening and had high levels of completeness in antenatal records.

**Non-SGA comparator group.** Data extracted from SMR02 for the non-SGA comparator group included maternal characteristics (age, ethnicity, BMI at booking and smoking of any cigarettes during pregnancy) and baby details (gestation at delivery, birth outcome [live birth, stillbirth or neonatal death], admission to a neonatal unit, APGAR’s <7 at 5 minutes).

**Growth ultrasound and biometry data.** For each pregnancy in the SGA cohort, the number of growth ultrasound scans performed was recorded. Growth ultrasounds were defined as those scans performed where the main intention was to obtain fetal biometry, from 22 weeks gestation onwards.

**Study size**

Initial scoping of the SMR02 data suggested that the incidence of SGA babies less than 10th centile was approximately 5%, and we estimated an SGA detection rate of 25% based on local audit data (in line with published literature)10-12, 14-15. We therefore estimated we would require a sample of 621 SGA babies to establish the SGA detection rate with 95% confidence level and absolute precision of 3%. Based on an annual delivery rate of approximately 56000 in Scotland13, we calculated a 3-month data collection would provide a study population of around 13000 and a study cohort of 650 SGA babies (allowing for 2% home births which are not recorded on SMR02 and missing data of ~5%).

**Data analysis**

Data were de-identified at source, and anonymised data was collated and cleaned on a central database. Statistical analysis was performed using SPSS, version 22.0 and R software, Version 1.1.453. Where data was normally distributed mean and standard deviation were calculated.
deviation were calculated. The t test was used to calculate p values. Where data was not normally distributed median and interquartile ranges were calculated. For data where proportions were calculated, Pearson’s chi squared test (with Yates’ correction) or Fisher’s Exact Test (for numbers 10 or less) were used. Significance was defined as p<0.05. 95% confidence intervals have also been reported. Logistic regression was performed to explore the influence of antenatal SGA detection on perinatal mortality and neonatal unit admission. Presence of one or more maternal risk factor for SGA (dichotomous variable), gestational age at delivery (continuous variable) and birthweight centile (continuous variable) were included in the model. Results are presented as unadjusted and adjusted odds ratio (OR and AOR; 95% confidence intervals, (CI)). Cases with missing fields were excluded from regression analysis.

To explore the effect of missing data on the cohort, we compared the SGA cohort with and without exclusion of sites with one or more missing data points in >15% cases (4 sites excluded; see supplementary Table S1 in extended data).

Where there was missing data on antenatal SGA detection, SGA was presumed not to have been detected, and these cases were included in the denominator in analyses. The impact of including missing data on SGA detection in the denominator was explored using a sensitivity analysis excluding cases with missing data on SGA detection (25 cases excluded; see supplementary Table S2 in extended data).

**Results**

During the 3-month study period (1st December 2014 – 28th February 2015) there were 12619 births in Scotland, of which 12218 were singleton deliveries. There were 12175 singleton live births (with 25 [0.2%] neonatal deaths) and 43 stillbirths (0.35%). A flowchart is provided in Figure 1.

In total, 791 babies (756 live births and 35 stillbirths) were identified from the SMR02 as being potentially SGA. The remaining 11427 babies formed the non-SGA comparator group.

Following case note review 92 of 756 (12.2%) live births were re-classified as not SGA either due to discrepant birthweight or discrepant gestation. Due to anonymisation of data at source these babies could not be re-identified to include in the comparator group and were excluded from all subsequent analyses.

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**Figure 1.** Flowchart of study population. SGA - small for gestational age, LB - livebirth, SB - stillbirth.
Of the 35 stillbirths with potential SGA (birth weights <10th centile for 42 weeks gestational age) 9 were found on case review to be <10th centile for gestation at delivery, and were included in the SGA cohort. The 25 stillbirths who were not SGA were included in the non-SGA comparator group for comparison of perinatal mortality rates (giving a total of 11453 babies for this comparison).

This gave a total cohort of 673 SGA babies, with an incidence of 5.5% (673/12218; 95% confidence interval [CI] 5.1, 5.9). Complete data was available for 623 cases (89.9%), with one or more field missing from 68 maternity records. The number of fields with missing data for each variable are included in Table 2 and Table 3. Four units had >15% of cases with at least one missing data field. A comparison was made between the full SGA cohort and the cohort with these units excluded. The two cohorts were similar (see supporting information S1 Table), thus all units were included in the analysis presented.

Of the 673 SGA babies, 183 were less than the 3rd centile (27.2% [95% CI 23.3, 31.3] of SGA babies; 1.5% [95% CI 1.1, 1.9] of singleton births); 144 between the 3rd and 5th centiles (21.4% [95% CI 17.5, 25.5] of SGA babies; 1.2% [95% CI 0.8, 1.6] of singleton births) and 346 were above the 5th centile (51.4% [95% CI 47.5, 55.6] of SGA babies; 2.9% [95% CI 2.5, 3.2] of Scottish Births).

Participating units
All 15 consultant-led maternity units in Scotland with >1000 births/year contributed data.

Comparison of SGA and non-SGA pregnancies
The details of the SGA and non-SGA cohorts are shown in Table 2.

As expected, the SGA cohort was higher risk than the rest of the Scottish population, with more primiparous women (59.1% [398/673; 95% CI 55.3, 62.9] versus 43.0% [491/11427; 95% CI 42.1, 44.0], p<0.0001) and smokers (37.1% [250/673; 95% CI 33.6, 40.9] versus 16.4% [1870/11427; 95% CI 15.7,17.1, p<0.0001) in the SGA group compared to the non-SGA group.

The SGA cohort was statistically significantly slightly younger than the non-SGA group (29.1 years versus 29.6 years; p=0.015) but this is unlikely to be of clinical significance. There was no difference in the proportion of women older than 40 years at delivery (2.7% [18/673; 95% CI 1.6, 4.2] versus 2.4% [270/11427; 95% CI 2.1, 2.7], p=0.7), the mean gestation at delivery (39+1 weeks [95% CI 39+1, 39+2] versus 39+2 weeks [95% CI 39+1, 39+3], p=0.38) or the Caesarean Section rate (32.4% [217/673; 95% CI 28.4, 36.3] versus 31.1% [3548/11427; 95% CI 30.2, 31.9], p=0.54) between the two groups.

Ethnicity recorded was recorded as unknown more frequently in the non-SGA group (data from SMR02 routine data; 20.2% [2312/11427] unknown ethnicity) than in the SGA group (data obtained from hand searching of case notes; 2.8% [19/673] ethnicity unknown; p<0.0001). We therefore did not perform formal comparison of ethnicity as any differences are likely to reflect ascertainment bias.

Perinatal mortality was higher in the SGA group than in the non-SGA group (1.78% [12/673; 95% CI 0.9, 3.1] versus 0.44% [52/11451; 95% CI 0.4, 0.6], p=0.0002) as was the stillbirth rate (1.34% [9/673; 95% CI 0.6 -2.3] versus 0.30 [34/11451; 95% CI 0.2, 0.4], p=0.0003). The numbers of early neonatal death were small and no statistically significant differences were seen between the two cohorts (0.45% live births [3/664; 95% CI 0.1-1.3] versus 0.18% live births [20/11419; 95% CI 0.1, 0.3], p=0.13). A higher proportion of SGA livebirths were admitted to the neonatal unit (14.3% [96/664; 95% CI 11.7, 17.1] versus 8.2% [939/11419; 95% CI 7.7, 8.8], p<0.0001).

Antenatal detection of SGA and comparison of outcomes in SGA detected versus SGA not detected groups
In 25 of the 673 SGA cases (3.9%) data was missing on whether SGA was detected antenatally. These cases were presumed not to have been detected antenatally in the subsequent analysis. 27.6% (186/673; 95% CI 24.3, 31.2) of SGA cases were identified prior to delivery (see Table 3). Of the 186 detected cases, 162 (87.1%) were diagnosed by ultrasound scanning, 23 (12.4%) were identified on clinical assessment (i.e. symphysis-fundal height measurements, not confirmed with ultrasound). In one case (0.54%) the method of detection was not documented. 454/673 women (67.5%; 95% CI 63.8%, 71.0%) who had an SGA baby had at least one growth ultrasound performed, with 322/673 (47.9%; 95% CI 44.0%, 51.7%) having more than one growth ultrasound performed in the pregnancy.

There was a higher proportion of mothers with one or more risk factors for SGA in the group with antenatal detection of SGA, than in the group where SGA was undetected (73.7% in SGA detection group [137/186; 95% CI 66.7,69.7] vs 56.7% in SGA not detected group [276/487; 95% CI 52.1, 61.1], p<0.0001) (Table 3). Babies in whom SGA was detected were born earlier (mean gestation at delivery 37+4 weeks [95% CI 37+2, 37+6] in SGA detected group vs 39+6 weeks [95% CI 39+5, 39+6] in the SGA not detected group [p<0.0001]) and were lighter (mean birthweight centile 4.2 [95% CI 4.0, 4.4] vs 5.4 [95% CI 5.3, 5.5], p<0.0001) than babies where growth restriction was not detected (Table 3).

The perinatal mortality was higher in the detection group compared to non-detected group (5.4% [10/186; 95% CI 2.8, 10.0] in the SGA detected group vs 0.4% [2487 [95% CI 0.3, 2.2] in the non-detected group [p=0.0007]) (Table 3). However, the increased odds of perinatal mortality did not remain statistically significant after adjusting for presence of maternal risk factors for SGA, gestation at delivery and birthweight centile (Unadjusted odds ratio [OR] of perinatal mortality in SGA detected group vs non-detected group 13.8 [95% CI 3.6, 90.2], p<0.0001; Adjusted odds ratio [AOR] 2.4 [95% CI 0.4, 18.1], p=0.345). Similarly, the unadjusted rate of neonatal unit admission was higher in the detection group (25.1% [45/179 livebirths; 95% CI 19.1, 32.3] vs 10.6% [51/483 livebirths;
Table 2. Demographics of study population. Small for gestational age (SGA) cohort vs non-SGA cohort. Statistical Tests
*Pearson’s Chi Square with Yates’ Correction †Unpaired 2-sided t test ‡Fisher’s Exact Test §denominator 664 livebirths **denominator 11453 total births ¶denominator 11421 live births.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>SGA cohort (% n=673)</th>
<th>95% CI</th>
<th>Missing (%)</th>
<th>Non-SGA comparator (n=11427)</th>
<th>95% CI</th>
<th>Missing (%)</th>
<th>p</th>
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<tr>
<td>Maternal Demographic</td>
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<td>Primiparous (%)</td>
<td>398 (59.1)</td>
<td>55.3, 62.9</td>
<td>4918 (43.0)</td>
<td>42.1, 44.0</td>
<td>26 (0.2)</td>
<td>p&lt;0.0001*</td>
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<td>Maternal age at delivery (mean [sd] years)</td>
<td>29.1 (6.0)</td>
<td>28.8, 29.3</td>
<td>1 (0.2)</td>
<td>29.6 (5.7)</td>
<td>29.5, 29.7</td>
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<td>p= 0.15†</td>
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<td>BMI (mean [sd] kg/m²)</td>
<td>25.4 (5.5)</td>
<td>25.2, 25.7</td>
<td>3 (0.4)</td>
<td>26.2 (6.0)</td>
<td>26.1, 26.3</td>
<td>136 (1.2)</td>
<td>p=0.0004†</td>
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<td>Maternal age &gt;40 years at delivery (%)</td>
<td>18 (2.7)</td>
<td>1.6, 4.2</td>
<td>1 (0.2)</td>
<td>270 (2.4)</td>
<td>2.1, 2.7</td>
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<td>Any smoking (%)</td>
<td>250 (37.1)</td>
<td>33.6, 40.9</td>
<td>4 (0.6)</td>
<td>1870 (16.4)</td>
<td>15.7, 17.1</td>
<td>394 (3.5)</td>
<td>p&lt;0.0001*</td>
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<td>White British (%)</td>
<td>532 (78.2)</td>
<td>74.9, 81.2</td>
<td>7627 (66.8)</td>
<td>65.9, 67.6</td>
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<td>White Non-British (%)</td>
<td>51 (7.5)</td>
<td>5.7, 9.8</td>
<td>377 (3.2)</td>
<td>2.9, 3.6</td>
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<td>Asian (%)</td>
<td>52 (7.7)</td>
<td>5.8, 10.0</td>
<td>355 (3.1)</td>
<td>2.8, 3.5</td>
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<td>African (%)</td>
<td>15 (2.2)</td>
<td>1.3, 3.7</td>
<td>127 (1.1)</td>
<td>0.9, 1.3</td>
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<td>Other (%)</td>
<td>11 (1.6)</td>
<td>0.9, 3.0</td>
<td>629 (5.5)</td>
<td>5.1, 5.9</td>
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<td>Gestation at delivery (mean weeks+days [sd days])</td>
<td>39+1(17)</td>
<td>39+1, 39+2</td>
<td>0</td>
<td>39+2 (28)</td>
<td>39+1, 39+3</td>
<td>p=0.38†</td>
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<td>Mode of Delivery</td>
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<td>Vaginal birth (%)</td>
<td>365 (54.2)</td>
<td>50.4, 58.3</td>
<td>6459 (56.5)</td>
<td>55.6, 57.4</td>
<td>p= 0.26†</td>
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<td>Operative Vaginal Delivery (%)</td>
<td>91 (13.5)</td>
<td>9.7, 17.5</td>
<td>1418 (12.4)</td>
<td>11.8, 13.0</td>
<td>p=0.43*</td>
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<td>Caesarean Section (%)</td>
<td>217 (32.2)</td>
<td>28.4, 36.3</td>
<td>3548 (31.1)</td>
<td>30.2, 31.9</td>
<td>p=0.54*</td>
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<td>Pregnancy Outcome</td>
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<td>Perinatal mortality (%)</td>
<td>12 (1.78)</td>
<td>0.9, 3.1</td>
<td>54 (0.47)</td>
<td>0.4, 0.6</td>
<td>p&lt;0.0002‡</td>
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<td>Stillbirth (%)</td>
<td>9 (1.34)</td>
<td>0.6, 2.3</td>
<td>34** (0.30)</td>
<td>0.2, 0.4</td>
<td>p&lt;0.0005‡</td>
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<td>Neonatal death (%)</td>
<td>3§ (0.45)</td>
<td>0.1, 1.3</td>
<td>20¶ (0.18)</td>
<td>0.1, 0.3</td>
<td>p=0.13‡</td>
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<tr>
<td>Neonatal unit admission (%)</td>
<td>96§ (14.3)</td>
<td>11.7, 17.1</td>
<td>19 (2.8)</td>
<td>7.7, 8.7</td>
<td>69 (0.6)</td>
<td>p&lt;0.0001*</td>
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</table>

95% CI 8.0, 13.7; p<0.0001) but this relationship was not seen after adjusting for maternal risk factors, gestation and centile at delivery (OR of neonatal unit admission in SGA detected group vs non-detected group 2.6 [95% CI 1.7, 4.1], p<0.0001; Adjusted odds ratio [AOR] 0.85 [95% CI 0.5, 1.5], p=0.556).

Descriptions of the 12 perinatal death cases are given in supplementary material Table S3. Ten of the 12 perinatal deaths (83.3%) were identified as SGA antenatally. Six of these were extremely preterm (less than 28 weeks gestation) and/or extremely growth restricted (birthweight 500 grams or less).

Three (one neonatal death and two stillbirths) occurred at or more 36 weeks, despite being identified as being SGA.

Only two deaths were not detected as being SGA antenatally. One had growth scans performed, but SGA was not identified – and delivered at 41 weeks gestation. The other stillbirth with undetected SGA was a preterm stillbirth at 29 weeks gestation, with no preceding growth scans performed.

A sensitivity analysis was performed comparing the SGA detected cohort with the cohort where SGA was not detected antenatally, excluding the 25 cases with missing data on...
Table 3. Outcomes in small for gestational age (SGA) detected versus SGA not detected groups.

<table>
<thead>
<tr>
<th>Demographic/Outcome</th>
<th>SGA detected (n=186)</th>
<th>95% CI</th>
<th>Missing (%)</th>
<th>SGA not detected (n=487)</th>
<th>95% CI</th>
<th>Missing (%)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal Demographic</td>
<td></td>
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<tr>
<td>Primiparous</td>
<td>102 (54.8)</td>
<td>47.4, 62.1</td>
<td>296 (60.8)</td>
<td>56.3, 65.1</td>
<td>p= 0.189*</td>
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<td></td>
</tr>
<tr>
<td>Maternal age at delivery (mean [sd] years)</td>
<td>29.1 (6.2)</td>
<td>28.7, 29.6</td>
<td>1 (0.5)</td>
<td>29.0 (5.9)</td>
<td>28.7, 29.3</td>
<td>0</td>
<td>p= 0.793†</td>
</tr>
<tr>
<td>BMI (mean [sd] kg/m²)</td>
<td>25.0 (5.5)</td>
<td>24.6, 25.4</td>
<td>25.6 (5.5)</td>
<td>25.3, 25.8</td>
<td>p= 0.184†</td>
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<td></td>
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<tr>
<td>Ethnicity</td>
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<tr>
<td>White (%)</td>
<td>165 (88.7)</td>
<td>83.1, 92.7</td>
<td>411 (84.4)</td>
<td>80.8, 87.4</td>
<td>p= 0.193*</td>
<td></td>
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<tr>
<td>Not white (%)</td>
<td>16 (8.6)</td>
<td>5.16, 13.83</td>
<td>62 (12.7)</td>
<td>10.0, 16.1</td>
<td>p= 0.173*</td>
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<tr>
<td>Risk Factors</td>
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<tr>
<td>One or more risk factors (%)</td>
<td>137 (73.7)</td>
<td>66.6, 79.7</td>
<td>276 (56.7)</td>
<td>52.1, 61.1</td>
<td>p&lt;0.0001*</td>
<td></td>
<td></td>
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<tr>
<td>Smoker &gt;10 cigarettes per day (%)</td>
<td>65 (35.0)</td>
<td>28.2, 42.3</td>
<td>4 (2.2)</td>
<td>136 (27.9)</td>
<td>24.0 32.2</td>
<td>2 (0.4)</td>
<td>p=0.102*</td>
</tr>
<tr>
<td>Maternal age &gt;40 years at delivery (%)</td>
<td>5 (2.7)</td>
<td>1.0, 6.5</td>
<td>1 (0.5)</td>
<td>13 (2.7)</td>
<td>1.5, 4.6</td>
<td>0</td>
<td>p=1.0*</td>
</tr>
<tr>
<td>Previous SGA baby (%)</td>
<td>46 (24.7)</td>
<td>18.8, 31.7</td>
<td>64 (13.1)</td>
<td>10.3, 16.5</td>
<td>p=0.0004*</td>
<td></td>
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</tr>
<tr>
<td>Hypertensive disorder (%)</td>
<td>21 (11.3)</td>
<td>7.3, 17.0</td>
<td>29 (6.0)</td>
<td>4.1, 8.5</td>
<td>p=0.028*</td>
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<tr>
<td>Reduced fetal movements (%)</td>
<td>65 (35.0)</td>
<td>28.2, 42.3</td>
<td>116 (23.8)</td>
<td>20.2 27.9</td>
<td>p= 0.005*</td>
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<tr>
<td>Pregnancy Outcome</td>
<td></td>
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<tr>
<td>Gestation at delivery (mean weeks+days [sd days])</td>
<td>37+4 (23)</td>
<td>37+2, 37+6</td>
<td>39+6 (11)</td>
<td>39+5, 39+6</td>
<td>p&lt;0.0001†</td>
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<tr>
<td>Birthweight centile [mean sd]</td>
<td>4.2 (2.8)</td>
<td>4.0, 4.4</td>
<td>5.4, (2.8)</td>
<td>5.3, 5.5</td>
<td>p&lt;0.0001†</td>
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<tr>
<td>Perinatal mortality (%)</td>
<td>10 (5.4)</td>
<td>2.8, 10.0</td>
<td>2 (0.4)</td>
<td>0.26, 2.21</td>
<td>0.0001c</td>
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<tr>
<td>Stillbirth (%)</td>
<td>7 (3.8)</td>
<td>1.7, 7.9</td>
<td>2 (0.4)</td>
<td>0.07, 1.6</td>
<td>p=0.003‡</td>
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<tr>
<td>Neonatal death (%)</td>
<td>3§ (1.7)</td>
<td>0.4, 5.2</td>
<td>0**</td>
<td>0.0, 1.0</td>
<td>p=0.03‡</td>
<td></td>
<td></td>
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<tr>
<td>Neonatal unit admission (%)</td>
<td>45§ (25.1)</td>
<td>19.1 32.3</td>
<td>51** (10.6)</td>
<td>8.0, 13.7</td>
<td>p&lt;0.0001*</td>
<td></td>
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</tr>
</tbody>
</table>

*Pearson’s Chi Square with Yates’ Correction
†Unpaired 2-sided t-test
‡Fisher’s Exact Test
§denominator 179 live births
**denominator 483 live births

antenatal SGA detection. Findings were similar to when these 25 cases were included in the SGA not detected group.

Discussion
We found that 5.5% of babies in Scotland were SGA at birth and perinatal mortality was higher in these babies compared to non-SGA babies, confirming that these babies are a high-risk obstetric population. The overall antenatal SGA detection rate in Scotland was 27.3%. This detection rate, although low, is consistent with other published studies.\(^{10,12,13,15}\)

Overall, we found that the potential to decrease perinatal mortality by improving detection of SGA in our population was much more limited than the 20% previously estimated\(^2\). Firstly, only one fifth of perinatal deaths occurred in SGA babies; thus, optimising SGA detection would not prevent the majority of perinatal deaths. Secondly, more than two thirds of SGA perinatal deaths were detected as being SGA antenatally, with only two of the SGA babies who died not recognised as being SGA antenatally. One of these was an antenatal stillbirth at 29 weeks gestation, when the risks of iatrogenic preterm delivery of SGA babies is significant and neonatal outcomes less certain. Only one stillbirth was at term (greater than 37 weeks gestation), when death could more certainly be considered preventable by early delivery. Growth ultrasound had been performed in this case, but SGA was not detected. Extrapolating from our data, we
Our findings contrast to previously published UK data, in our study perinatal outcomes were worse in babies where SGA was detected antenatally, compared to SGA babies who had not been recognised antenatally, with cases where SGA was recognised having higher rates of stillbirth, neonatal death and neonatal unit admission. Our findings likely reflect the fact that more severe SGA was more likely to be detected, with higher rates of maternal risk factors, and lower delivery gestations birthweight centiles in the detected group. When these factors were adjusted for, we found no persistent association between antenatal SGA detection and perinatal mortality or neonatal unit admission. These data need to be interpreted cautiously as the numbers are small, and the analysis is post hoc. Our results are consistent with the analysis of a French study where SGA pregnancies identified antenatally had worse neonatal outcomes than those SGA pregnancies not detected. In addition, in the French study, those pregnancies which were wrongly identified as SGA (i.e. false positives) had worse outcomes than the true negative population (i.e. not SGA and correctly identified as that), highlighting the potential for iatrogenic harm in wrongly diagnosing SGA.

Strengths and limitations
Strengths of this study are that it is population based, with supplementary case note review to ensure data quality in the SGA cohort. We used the WHO 1990 birthweight centile charts for the diagnosis of SGA, which is clinically relevant as these are used for the diagnosis of growth disorders in Scottish children. We found 5.6% births less than the 10th centile, which is in line with other recent UK studies and reflects the right shifting of birthweight centiles in high income countries over time.

Our study has several limitations. Firstly, SGA is a surrogate used to identify babies that are growth restricted. Some babies that do not reach their growth potential will have birthweights above the 10th centile (i.e. won’t be SGA by our definition), and these would not be detected within our study. Secondly, stillborn babies lose weight in utero between death and delivery due to the process of maceration, therefore the number of stillbirths associated with SGA are likely to be overestimated if (as in our study) unadjusted birthweights are used. This means the true perinatal mortality rate in SGA babies is likely to be lower than our findings suggest, and our estimates of the potential to reduce perinatal mortality through detection of SGA are overoptimistic. Thirdly, our focus was on detection of SGA and we did not collect data on the management of pregnancies, which is likely to be an important factor in the perinatal outcomes of SGA babies. Fourthly, the comparator non-SGA group data was extracted from NHS ISD and not subject to case review thus comparisons between SGA and non-SGA babies may be at risk of ascertainment bias. Finally, we did not assess false positive rates i.e. those babies delivered due to a suspicion of SGA that subsequently were found to be of normal birthweight.

Conclusions
Although avoiding any preventable perinatal death is extremely important, our findings suggest that focussing resources on improving detection of SGA alone is unlikely to have a major impact on perinatal mortality rates. To improve perinatal outcomes, we should focus on optimising high-quality care based on our current knowledge alongside commissioning high quality research into identifying better screening tools for the “at-risk” fetus.

Data availability
Underlying data
The metadata for this study was provided by NHS ISD who are the data controllers. The Caldicott Guardian agreement by which we sourced the data does not allow for data sharing of the metadata as it is identifiable at a patient and a practitioner level. Any suitably qualified researcher with the appropriate approval would be able to obtain this data directly from NHS ISD. Researchers would need to complete a “Confidential Data Release Form” available from NHS National Services Scotland to gain approval. They can then use our study proforma to request the required data from NHS ISD (see extended data).

Extended data

This project contains the following extended data:
- Study Proforma.xls (Proforma used for data extraction)
- Supporting info.pdf (PDF containing Supplementary Tables 1–3)

Data are available under the terms of the Creative Commons Zero “No rights reserved” data waiver (CC0 1.0 Public domain dedication).

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References


