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Variation in hospital rates of induction of labour: a population-based record linkage study

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ABSTRACT

BACKGROUND: Understanding the extent of hospital heterogeneity in induction of labour (IOL) practices to identify areas of practice improvement may result in improved maternity outcomes. We examined inter-hospital variation in rates of IOL to identify potential targets to reduce high rates of practice variation.

METHODS: Population-based record linkage study of all births of ≥24 weeks gestation in 72 hospitals in New South Wales, Australia, 2010-2011. Births were categorized into 10 mutually exclusive groups, derived from the Robson caesarean section (CS) classification. These groups were categorised by parity, plurality, fetal presentation, prior CS and gestational age. Multilevel logistic regression was used to examine variation in hospital IOL rates by the groups, adjusted for differences in casemix.

RESULTS: The overall IOL rate was 26.7% (46,922 of 175,444 maternities were induced), ranging from 9.7%- 41.2% (interquartile range 21.8%- 29.8%) between hospitals. Nulliparous and multiparous women at 39-40 weeks gestation with a singleton cephalic birth were the greatest contributors to the overall IOL rate (23.5% and 20.2% of all IOL respectively), and had persisting high unexplained variation after adjustment for casemix (adjusted hospital IOL rates ranging from 11.8%- 44.9% and 7.1%- 40.5% respectively). In contrast, there was little variation in inter-hospital IOL rates among multiparous women with a singleton cephalic birth at ≥41 weeks gestation, women with singleton non-cephalic pregnancies, and women with multifetal pregnancies.

CONCLUSION: Seven of the 10 groups showed high or moderate unexplained variation in inter-hospital IOL rates, most pronounced for women at 39-40 weeks gestation with a singleton cephalic birth. Outcomes associated with divergent practice require determination, which may guide strategies to reduce practice variation.

STRENGTHS AND LIMITATIONS

- We used large, contemporary, longitudinally linked, population-based data that had reliably collected labour and birth information, which enabled the application of a novel, totally inclusive yet mutually exclusive classification system for IOL[15] to understand the variation in hospital IOL rates for different clinical groups of pregnant women.
- Multilevel modelling was used to reduce the effect of random fluctuations and clustering in hospital rates of IOL.
- However, administrative data do not allow exploration of clinical variation in thresholds; indication for and methods of labour induction; physician and patient attitudes; or cultural influences on decision-making.

INTRODUCTION

Variations in clinical practice will occur to some degree, as patient populations vary and healthcare should be individualised. However, for many medical interventions including in obstetrics,[1] much of clinical practice variation is unexplained (i.e. not due to patient profiles, preferences, or medical science).[2] Unexplained clinical practice variation questions the appropriate use of scarce resources,[3] whether medical interventions are too few or too many, and whether healthcare provision is efficient or effective.[4 5]

Induction of labour (IOL) is a common obstetric intervention occuring in approximately a quarter of all births,[6,7] with rates of IOL over time increasing in developing and developed countries.[8] Large differences in overall IOL rates have been described between countries,[9] provinces[10] and hospitals.[11,12] However, only one small study has previously reported overall interhospital IOL rates adjusting for casemix factors[12] and another report described hospital IOL rates for women by parity.[13] Hospital populations differ in the proportions of women with factors (such as parity, prior caesarean section (CS), gestational age, number of fetuses,

and fetal presentation) that play a substantial role in clinical management of pregnant women; for example most women who reach ≥ 41 weeks gestation are offered IOL, as perinatal outcomes are improved.[14] Analysis of variation in hospital IOL rates by these groups[15] allows an assessment of whether variation in an overall pattern of hospital IOL is observed across all these clinical meaningful groups in which decision making is expected to be similar. Hospitals may have high rates of IOL across all scenarios, suggesting inherent clinical attitudes towards offering IOL. Alternatively, the hospital IOL rate may be driven by the IOL rate of a particularly large group of women, eg nulliparous women at term. In this case, targeted intervention strategies may be implemented for these particular groups of women.

Therefore, the aim of the study was to describe variation in hospital IOL rates using a novel classification system of 10 risk-based 'induction groups', while adjusting for casemix and hospital factors.

METHOD

Study population

The study population included pregnancies resulting in a birth of a live-born infant of ≥24 weeks gestation in hospital in New South Wales (NSW) between 2010 and 2011. Multi-fetal pregnancies were treated as a single maternity. Hospitals were excluded if they did not have the capability to perform inductions (n=32), did not perform any inductions in the study period (n=29) or had fewer than 50 births per annum (n=24). Births were excluded if the birth record had missing data on the variables of interest (n=1330). Preterm births (births ≤36 weeks gestation) were also excluded if they occurred at hospitals which lacked the service capability to manage preterm infants (570 births at 27 hospitals, 5.1% of all preterm births), as although they manage preterm births in emergency situations, they were unlikely to perform planned induction of labour for preterm pregnancies and would not contribute to the understanding of variation in IOL rates. The population was then classified into 10 risk based

'induction groups', categorised by parity, prior CS, gestational age, number of fetuses and fetal presentation[15] (Table 1).

Data source and study variables

Data were obtained from the NSW Perinatal Data Collection, a legislated population-based dataset of all live births and stillbirths in NSW.[16] Records were linked longitudinally by the NSW Centre for Health Record Linkage (CHeReL)[17] to create obstetric histories (previous births and caesarean sections) for each woman in the study population. Information was also available on pregnancy, maternal and infant characteristics.[18,19] The primary outcome was the proportion of births at each hospital in which labour was induced within each induction group. In addition to the stratification factors, casemix factors available for adjustment were infant size at birth (<10th centile: small for gestational age; 10th-90th centile: appropriate for gestational age; >90th centile: large for gestational age), as well as maternal age, country of birth, smoking status, diabetes (pre-existing or gestational diabetes), hypertension (including chronic, gestational hypertension and preeclampsia), and type of care (public care in a public hospital, private care in a public hospital or private care in a private hospital).

Statistical Analysis

Pregnancy and maternal characteristics were determined according to onset of labour (spontaneous labour, IOL or no labour in the case of prelabour caesarean section). Multilevel logistic regression models were used to examine between-hospital variation in induction rates within each of the ten induction groups, with hospitals as a random-intercept. These models account for both differences in volume and potential clustering of similar women within hospitals. Hospital-specific induction rates (with 95% confidence intervals) were obtained by converting the odds ratio for each hospital into a relative risk and multiplying it by the state rate.[20] For each group, the unadjusted and adjusted models of hospital induction rates were obtained. The proportion of variance among hospitals explained by adjusting for case-mix was calculated as the difference between the variance of

the adjusted and unadjusted models, expressed as a proportion of the unadjusted model variance. To compare the extent of variation in hospital induction rates across groups, we calculated the percentage of hospitals in each group that were significantly different from the state average rate (i.e. the proportion of hospitals for which the 95% confidence interval of the adjusted induction rate did not cross the state average). We pre-defined cut-offs for variation as: high (>30%), medium (15-30%), or low (<15%) levels of variation. Statistical analysis was performed using SAS (version 9.3; SAS Institute, Cary, North Carolina).

RESULTS

In 2010 and 2011, there were 175,444 maternities at 72 hospitals. Of these 46,922 (26.7%) followed induction of labour. The overall induction rate at NSW hospitals ranged from 9.7% to 41.2% (IQR 21.8%-29.8%).

Pregnancy and maternal characteristics according to onset of labour are shown in Table 2. When compared to women with spontaneous or no labour, women receiving an induction of labour were more likely to be nulliparous, born in Australia, have hypertension or diabetes, or have a prolonged (>41 weeks gestation) pregnancy (Table 2). Women who did not experience labour (ie those that had prelabour CS) were older and more likely to receive private care than women being induced.

Most inductions were among women at 39-40 weeks gestation (without a prior CS) with a singleton cephalic pregnancy (23.5% and 20.2% of all inductions for nulliparous and multiparous women respectively; Table 1). Within the induction groups, induction rates were highest for women without a prior CS at 41 or more weeks gestation with a singleton cephalic pregnancy (58.7% and 48.7% for nulliparous and multiparous women respectively;Table 1) and lowest for women with non-cephalic presentations (4.7%) or a history of having a previous CS (5.1%).

There was marked variation between hospital IOL rates within the induction groups (Figure 1). Adjusting for case-mix considerably *reduced* the variation between hospitals for induction

for multiparous women at 37-38 (Group 4, -30%) and 39-40 weeks (Group 5, -37%) and single non-cephalic presentations (Group 7, -43%) but only by a small proportion for nulliparous women at 37-38 (Group 1, -11%) and 39-40 weeks (Group 2, -1%) and multi-fetal pregnancies (Group 10, -6%) (Table 1). In contrast, adjusting for case-mix slightly *increased* the between-hospital variance in inductions for nulliparous women at 41 or more weeks (Group 3, +6%; Table 1).

After accounting for case-mix, high unexplained variation in hospital induction rates persisted for nulliparous and multiparous women at 39-40 weeks with a singleton cephalic pregnancy (Groups 2 and 5) and for women with at least one previous Caesarean Section (Table 1). There was low variation in induction rates between hospitals for multiparous women at 41+ weeks with a singleton cephalic pregnancy (Group 6, 14%), single non-cephalic presentations (Group 9, 3%) and multi-fetal pregnancies (Group 10, 9%): few hospitals had induction rates for these women that were significantly different from the overall average (Figure 1).

DISCUSSION

Principal Findings

In 2010-2011, just over one quarter of all births in our study population followed an IOL (26.7%), with considerable variation in hospital IOL rates, despite accounting for case-mix. Seven of the ten groups had medium to high variation in hospital IOL rates (nulliparous and multiparous women at 37-38 weeks gestation and 39-40 weeks gestation, nulliparous women ≥41 weeks gestation, women with a prior CS and women ≤36 weeks gestation). The greatest between hospital variation in IOL rates occurred in the two largest groups (Group 2 and Group 5)—women with a singleton cephalic pregnancy at 39-40 weeks gestation—and accounted for 43.7% of all inductions. Only women with a singleton, non-cephalic presenting fetus, women with a multifetal pregnancy and multiparous women with a singleton, cephalic

fetus at ≥41 weeks gestation had low between-hospital IOL rate variation, suggesting uniform clinical management across the hospitals for these groups of women.

Strengths and weaknesses of the study

The strengths of this study were the use of large, contemporary, longitudinally linked, population-based data and the use of availability of reliably collected labour and birth information. This enabled the application of a totally inclusive yet mutually exclusive classification system for IOL[15] allowing for similar pregnancies to be compared. Multilevel modelling was used to reduce the effect of random fluctuations in rates of IOL in low volume hospitals and allowed quantification of the contribution of casemix factors to the variation in hospital IOL rates, while also accounting for similarities of births within hospitals. However, administrative data do not allow exploration of clinical variation in thresholds; indication for and methods of labour induction; physician and patient attitudes; or cultural influences on decision-making. Individual and hospital factors not accounted for in the model could contribute to increased variation between hospital IOL rates. Whilst this study focused on understanding the variation in hospital IOL rates for different clinical groups, differences in hospital IOL rates and pregnancy outcomes needs to be explored to further guide practices to improve clinical care.

Interpretation

Practice variation has been related to medical uncertainty about the indications for and the efficacy of procedures.[21] There is much evidence showing the importance of clinical opinion in influencing rates of procedures, which can also be altered by feedback and review.[22] For example, in Wennberg's seminal work showing wide variations in rates of tonsillectomy in the state of Vermont, there was rapid decline in rates of tonsillectomy after feedback of data to clinicians.[23] The current study demonstrates considerable variation in hospital rates of IOL and is the first step in attempting to reduce unexplained variation.

The large variation in hospital IOL rates were for women at 39-40 weeks gestation with a singleton cephalic pregnancy may indicate heterogeneity in thresholds for clinicians to recommend induction of labour as the patient has now reached 'full term'. Such practice is, for example, indirectly endorsed by the American College of Obstetrics and Gynaecology Committee Opinion for 'nonmedically indicated early term delivery',[24] advising that non-medically indicated deliveries <39 weeks is not justified. This implies that once the parturient has reached 39 weeks, nonmedically indicated full term delivery may be justified. Additionally, the variation may be driven by differences in clinical practice attributable to recent studies regarding the effects of IOL and a reduction in the risks of caesarean section,[25] or some other unmeasured clinician or patient factor.

Among nulliparae, not only did hospital rates of IOL at full term have large variation, but also moderate variation was seen in hospital rates of IOL women at early term (29% of hospitals different from the average). A report from the Royal College of Obstetricians and Gynaecologists found large variation in adjusted hospital IOL rates for nulliparae ≥37 weeks gestation, with 45% of hospitals having IOL rates significantly different compared to the average.[13] Our study found that only a small proportion of the variation in hospital IOL rates for nulliparae were explained by casemix (11% and 1% for Groups 1 and 2 respectively), suggesting that other factors affect IOL in this group. Further investigation of these factors affecting IOL for nulliparae are recommend as nulliparae at early and full term make up one third of all inductions; the proportion of nulliparae at early and full term being induced is increasing;[26] and there appears to be large unexplained variation in intrapartum caesarean section rates following IOL for nulliparae.[27] The importance of the first birth cannot be underestimated as it influences all subsequent births, and thus this large variation suggests that alternatives to a high IOL rate are achievable.

There was also large variation in hospital rates of IOL for women with a prior CS and a singleton cephalic fetus, with 35% of hospitals different from the average. However, only a small proportion of these women had an IOL (5.1% of the group), which may reflect

concerns about adverse outcomes such as uterine rupture. The Royal Australian and New Zealand College of Obstetricians and Gynaecologists statement suggests that IOL should be 'undertaken with caution'.[28] In contrast, other international guidelines, (UK, USA and Canada) state that IOL is 'appropriate' for these women and these countries have a higher proportion of women with a prior CS undergoing an IOL.[29]

There was low to moderate variation in hospital IOL rates for women ≥ 41 weeks gestation. There are many international guidelines recommending IOL for women ≥ 41 weeks gestation,[30-32] to reduce perinatal morbidity with no increase in the CS, based on evidence from a Cochrane review based on 22 randomised controlled trials.[14] For women in this gestational age group, there is clearer evidence regarding the management of this clinical scenario, which is reflected in less variation in hospital IOL rates.

The observed variation in hospital IOL rates is more extensive than the reported between hospital variation in CS rates (ie there are more hospitals where the rate of IOL is significantly different from the state average IOL rates compared to the number of hospitals where the rate of caesarean section is significantly different).[33 34] Different practice styles and clinical decision making around obstetric intervention have been postulated in other studies as being related to overall hospital IOL[11] and CS rate variation.[33 34]

Variations in clinical practice are a form of a natural experiment, with outcomes and rates a result of small groups of health care professionals.[23 35] It is problematic to specify the correct or target intervention rate such as a hospital IOL rate, particularly when the appropriate rate is likely to differ according to the 'induction group'. Instead, the focus should be on achieving the best outcomes (such as the rate of intrapartum caesarean section, post partum haemorrhage, maternal and perinatal morbidity) for mothers and babies with minimum intervention,[1] reflecting improved clinical decision making, but also efficient resource management. Hospitals that have lower rates of IOL, yet have the same outcomes for mothers and babies compared to hospitals with higher rates of IOL, provide opportunities to

suggest changes in clinical practice for other institutions. Conversely, if hospitals with low rates of obstetric intervention such as IOL are associated with worse outcomes for mothers and babies, then interventions should increase to improve pregnancy outcomes. Further investigation into the pregnancy outcomes of the IOL groups that show large variation (such as those women at 39-40 weeks gestation) may be able to identify hospitals that have differing rates of IOL, yet the same pregnancy outcomes. In particular, hospitals with minimum intervention and yet the same outcomes may be studied to examine areas of clinical practice management that differ from other hospitals.

CONCLUSION

Considerable variation in hospital IOL rates persisted after accounting for casemix. In particular, hospital IOL rates for women at 39-40 weeks gestation with a singleton cephalic birth showed high, unexplained variation, especially for nulliparous women. Further determination of outcomes associated with divergent IOL practice is required, which may guide strategies to reduce practice variation.

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COMPETING INTERESTS STATEMENT

Competing interests: All authors have completed the ICMJE uniform disclosure form at http://www.icmje.org/coi_disclosure.pdf and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

CONTRIBUTION TO AUTHORSHIP

CR and JM conceived the study. JT undertook data preparation and provided statistical analysis, with JP providing statistical oversight. TN, JT, JP, JF, CR and JM had full access to all of the data (including statistical reports and tables) in the study, take responsibility for the integrity of the data and the accuracy of the data analysis, took part in interpretation of results, drafting the manuscript, approve and take responsibility for the final manuscript.

TRANSPARENCY DECLARATION

The lead author (TN) affirms that the 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 have been explained.

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DATA SHARING

Data are not available for sharing.

ETHICAL APPROVAL

Ethical approval was obtained from the NSW Population and Health Services Research Ethics Committee (Reference No. 2012-12-430).

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Table 1: Rates of induction and measures of between-hospital variation, separately for 10 induction groups, NSW, 2010-2011.

Induction Group[15]	Births (n)	Relative size of group (%)	Inductions (n)	% of group induced	Inductions as % of all inductions	Inductions as % of all births	% of variance explained by case-mix	% of hospitals different from average[1]
1) Nulliparous, 37-38 weeks gestation, singleton cephalic fetus	14,467	8.2	4,823	33.3	10.3	2.7	11	29
2) Nulliparous, 39-40 weeks gestation, singleton cephalic fetus	39,454	22.5	11,004	27.9	23.5	6.3	1	58
3) Nulliparous, ≥41 weeks gestation, singleton cephalic fetus	14,124	8.1	8,291	58.7	17.7	4.7	-6	21
4) Multiparous, no previous CS, 37-38 weeks gestation, singleton cephalic fetus	15,323	8.7	5,075	33.1	10.8	2.9	30	28
5) Multiparous, no previous CS, 39-40 weeks gestation, singleton cephalic fetus	40,527	23.1	9,465	23.4	20.2	5.4	37	49
6) Multiparous, no previous CS, ≥41 weeks gestation, singleton cephalic fetus	9,538	5.4	4,643	48.7	9.9	2.6	11	14
7) No previous CS, ≤36 weeks, singleton cephalic fetus	6,721	3.8	1,396	20.8	3.0	0.8	20	17
8) Previous CS, singleton cephalic fetus	26,174	14.9	1,335	5.1	2.8	0.8	15	35
9) Singleton, non-cephalic fetus	6,524	3.7	307	4.7	0.7	0.2	43	3
10) Multi-fetal pregnancy	2,592	1.5	583	22.5	1.2	0.3	6	9
Total	175,444	100.0	46,922		100.0	26.7		

[1]proportion of hospitals for which the 95% confidence interval of the adjusted hospital induction rate does not cross the crude state average

Table 2: Maternal and pregnancy characteristics by onset of labour, NSW, 2010-2011

		Spontaneous	Induction	No labour	Total
		n = 96,335	n = 46,922	n = 32,187	n = 175,444
		n (%)	n (%)	n (%)	n (%)
Maternal Characteristics					
Age (years)	< 20	3,821 (4.0)	1,641 (3.5)	314 (1.0)	5,776 (3.3)
	20-34	73,171 (76.0)	34,508 (73.5)	19,973 (62.1)	127,652 (72.8)
	≥ 35	19,343 (20.1)	10,773 (23.0)	11,900 (37.0)	42,016 (23.9)
Born in Australia		62,878 (65.3)	32,951 (70.2)	21,744 (67.6)	117,573 (67.0)
Smoking during pregnancy		11,789 (12.2)	5,007 (10.7)	2,764 (8.6)	19,560 (11.1)
Diabetes		4,196 (4.4)	4,824 (10.3)	2,911 (9.0)	11,931 (6.8)
Hypertension		1,792 (1.9)	5,864 (12.5)	2,133 (6.6)	9,789 (5.6)
Type of care	Private, private hospital	17,901 (18.6)	11,422 (24.3)	11,703 (36.4)	41,026 (23.4)
	Private, public hospital	6,658 (6.9)	4,338 (9.3)	3,926 (12.2)	14,922 (8.5)
	Public, public hospital	71,776 (74.5)	31,162 (66.4)	16,558 (51.4)	119,496 (68.1)

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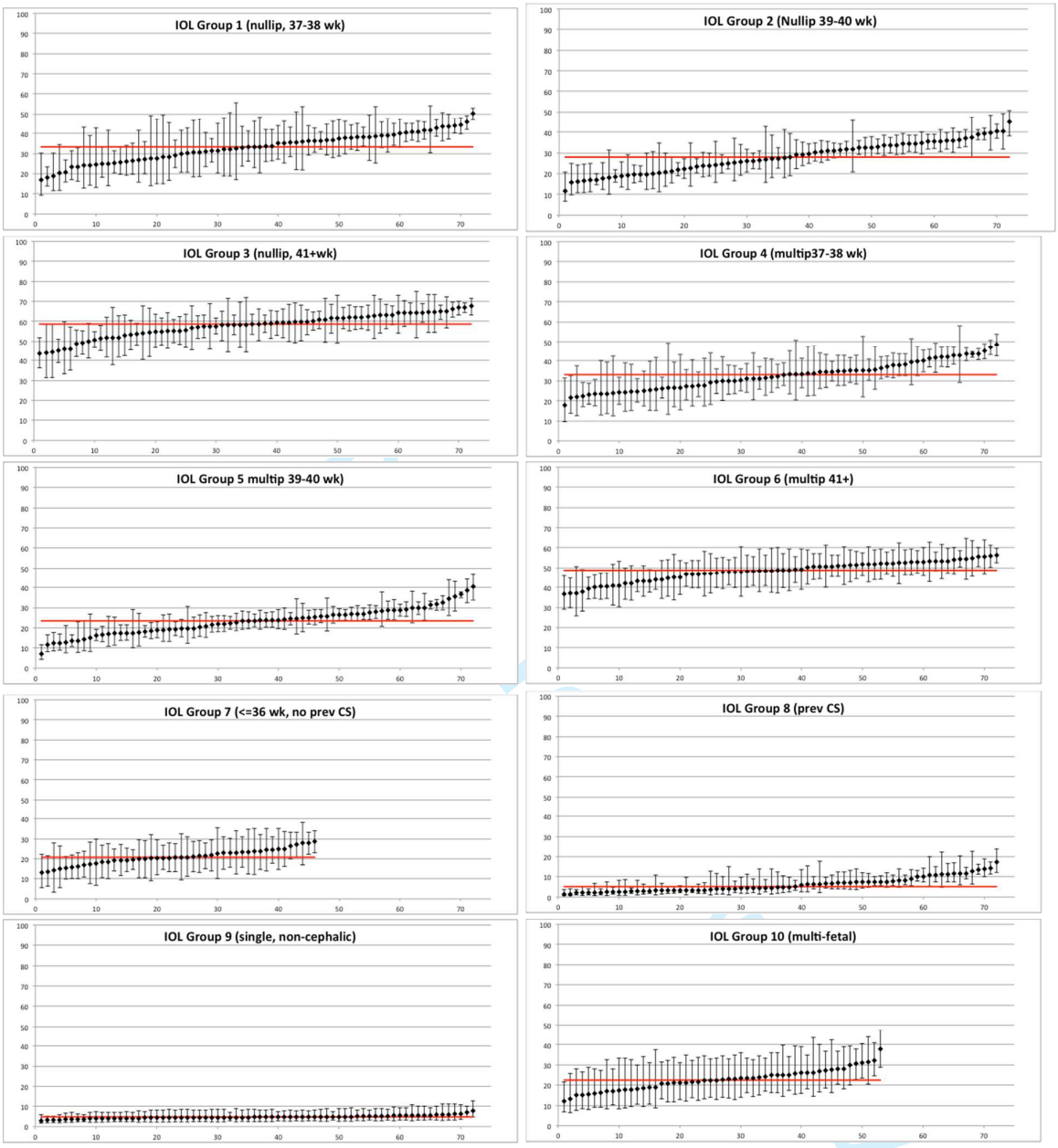
Pregnancy Characteristics					
Nulliparity		42,340 (44.0)	25,242 (53.8)	9,022 (28.0)	76,604 (43.7)
Previous Ceasarean (multiparous only)		7,535 (14.0)	1,359 (6.3)	18,859 (81.4)	27,753 (28.1)
Singleton		95,519 (99.2)	46,339 (98.8)	30,994 (96.3)	172,852 (98.5)
Cephalic presentation		94,449 (98.0)	46,603 (99.3)	27,389 (85.1)	168,441 (96.0)
Gestational age	≤ 36 weeks	5,609 (5.8)	1,610 (3.4)	3,349 (10.4)	10,568 (6.0)
	37-40 weeks	79,787 (82.8)	31,884 (68.0)	27,943 (86.8)	139,614 (79.6)
	≥ 41 weeks	10,939 (11.4)	13,428 (28.6)	895 (2.8)	25,262 (14.4)
Infant size	SGA[1] (<10%ile)	8,759 (9.1)	5,259 (11.2)	2,834 (8.8)	16,852 (9.6)
	LGA[2] (>90%ile)	8,513 (8.8)	4,894 (10.4)	4,476 (13.9)	17,883 (10.2)

[1] Small for gestational age

[2] Large for gestational age

Figure 1: Adjusted hospital-specific induction rates, separately for each induction group, NSW, 2010-2011.

*Red line represents the state average rate for each induction group



STROBE Statement—checklist of items that should be included in reports of observational studies

TITLE: Variation in hospital rates of induction of labour: a population-based record linkage study

Authors:
Tanya Nippita, Judy Trevena, Jillian Patterson, Jane Ford, Jonathan Morris, Christine Roberts.

	Item No	Recommendation	Page No.
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-5
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	4
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4-5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4-5
Bias	9	Describe any efforts to address potential sources of bias	4-5
Study size	10	Explain how the study size was arrived at	4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	5-6
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking	

		account of sampling strategy	
		(*e*) Describe any sensitivity analyses	

Continued on next page

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	4; 6
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6; table 2
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	6-7; table 1; figure 1
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	6-7; table 1-2; figure 1
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	7-8
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	8
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	8-11
Generalisability	21	Discuss the generalisability (external validity) of the study results	8-11
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	13

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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13th May 2015

Dr Trish Groves
The Editor in Chief
BMJ Open

Dear Dr Groves,

We are submitting a manuscript titled ***"Variation in hospital rates of induction of labour: a population-based record linkage study"*** as an original contribution to *BMJ Open*. Thank you for considering it for publication.

In clinical practice, unexplained variation has been highlighted in *BMJ Open* and other journals as a major concern as it raises questions about the appropriate use of scarce resources, whether some interventions are too few or too many, or whether the interventions are effective. In obstetrics, induction of labour is a common intervention, occurring in approximately a quarter of all births. This study explores variation in labour induction practice using clinical meaningful classification derived from the Robson classification system for caesarean section (currently in press; we are happy to supply an in-confidence copy).

We believe this study is of interest to all providers of care to pregnant women (including policy makers, government organisations, general practitioners, midwives, doctors in training, and specialist obstetricians) and should be published in *BMJ Open* for the following reasons:

- This is the first study that systematically describes variation in inter-hospital labour induction rates by induction groups.
- We identified high unexplained variation in inter-hospital IOL rates for women at 39-40 weeks gestation with a singleton cephalic birth, especially for nulliparous women. Targeted guidelines and policy development would potentially benefit this group of women.
- Findings from this study can be generalised to a wide range of maternity care settings at regional and international level including public and private care, doctor and midwifery-led models of pregnancy care.
- Similar to the highly cited Robson classification system for caesarean section and its application, this novel classification system for induction of labour and its application for comparison between hospitals and potentially regions and countries is potentially highly citable.

The study was approved by the New South Wales Population and Health Services Research Ethics Committee. All authors have read and approved the submission of the manuscript; the manuscript has not been published and is not being considered for publication elsewhere, in whole or in part. There was an oral presentation of this work at the RANZCOG/RCOG World Congress in Brisbane, Australia (April 2015). We have no conflicts of interest to report.

Yours sincerely,

Dr Tanya Nippita

BMJ Open

Variation in hospital rates of induction of labour: a population-based record linkage study

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Variation in hospital rates of induction of labour: a population-based record linkage study

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ABSTRACT

OBJECTIVES: To examine inter-hospital variation in rates of IOL to identify potential targets to reduce high rates of practice variation.

DESIGN: Population-based record linkage cohort study.

SETTING: New South Wales, Australia, 2010-2011.

PARTICIPANTS: All women with live births of ≥24 weeks gestation in 72 hospitals.

PRIMARY OUTCOME MEASURE: Variation in hospital IOL rates adjusted for differences in casemix, according to 10 mutually exclusive groups derived from the Robson caesarean section classification; groups were categorised by parity, plurality, fetal presentation, prior caesarean section and gestational age.

RESULTS: The overall IOL rate was 26.7% (46,922 of 175,444 maternities were induced), ranging from 9.7%- 41.2% (interquartile range 21.8%- 29.8%) between hospitals. Nulliparous and multiparous women at 39-40 weeks gestation with a singleton cephalic birth were the greatest contributors to the overall IOL rate (23.5% and 20.2% of all IOL respectively), and had persisting high unexplained variation after adjustment for casemix (adjusted hospital IOL rates ranging from 11.8%- 44.9% and 7.1%- 40.5% respectively). In contrast, there was little variation in inter-hospital IOL rates among multiparous women with a singleton cephalic birth at ≥41 weeks gestation, women with singleton non-cephalic pregnancies, and women with multifetal pregnancies.

CONCLUSION: Seven of the 10 groups showed high or moderate unexplained variation in inter-hospital IOL rates, most pronounced for women at 39-40 weeks gestation with a singleton cephalic birth. Outcomes associated with divergent practice require determination, which may guide strategies to reduce practice variation.

STRENGTHS AND LIMITATIONS

- We applied a novel, totally inclusive yet mutually exclusive classification system for induction of labour (IOL)[17] to understand the variation in hospital IOL rates for different clinical groups of pregnant women.
- We used a large, recent, longitudinally linked, population-based surveillance dataset of reliably collected labour and birth information.
- Multilevel modelling was used to reduce the effect of random fluctuations and clustering in hospital rates of IOL.
- However, population-based data does not allow exploration of variation in clinical thresholds for undertaking IOL; indication for labour induction; physician and patient attitudes; or cultural influences on decision-making.

INTRODUCTION

Variations in clinical practice will occur to some degree, as patient populations vary and healthcare should be individualised. However, for many medical interventions including in obstetrics,[1] much of clinical practice variation is unexplained (i.e. not due to patient profiles, preferences, or medical science).[2] Unexplained clinical practice variation questions the appropriate usage of scarce resources,[3] whether medical interventions are too few or too many, and whether healthcare provision is efficient or effective.[4 5]

Induction of labour (IOL) is a common obstetric intervention occuring in approximately a quarter of all births,[6 7] with rates of IOL over time increasing in developing and developed countries.[8] Large differences in overall IOL rates have been described between countries,[9] provinces[10] and hospitals.[11 12] However, only one small study has previously reported overall interhospital IOL rates adjusting for patient characteristics[12] and another report described hospital IOL rates for women by parity.[13] Hospital populations differ in the proportions of women with factors (such as parity, prior caesarean section (CS), gestational age, number of fetuses, and fetal presentation) that play a substantial role in clinical management of

pregnant women; for example most women who reach ≥ 41 weeks gestation are offered IOL, as perinatal outcomes are improved.[14] Robson used all these factors to classify caesarean sections,[15] but the Robson groups are not directly applicable to IOL due to the heterogeneity of women who are ≥37 weeks gestation and have IOL.[16] Therefore, we developed a classification or grouping system specifically for IOL,[17] based on the same Robson classification factors. Analysis of variation in hospital IOL rates by these groups[17] allows an assessment of whether variation in an overall pattern of hospital IOL is observed across all these clinical meaningful groups in which decision making is expected to be similar. Hospitals may have high rates of IOL across all scenarios, suggesting inherent clinical attitudes towards offering IOL. Alternatively, the hospital IOL rate may be driven by the IOL rate of a particularly large group of women, eg nulliparous women at term. In this case, targeted intervention strategies may be implemented for these particular groups of women.

Therefore, the aim of this study was to describe variation in hospital IOL rates using a novel classification system of 10 risk-based 'induction groups',[17] while adjusting for casemix and hospital factors.

METHOD

Study population

The study population included pregnancies resulting in a birth of a live-born infant of ≥24 weeks gestation in hospital in New South Wales (NSW) between 1st January 2010 and 31st December 2011. Multi-fetal pregnancies were treated as a single maternity. Hospitals were excluded if they did not have the capability to perform inductions (n=32, i.e. excluding hospitals that only provided midwifery-led care), did not perform any inductions in the study period (n=29) or had fewer than 50 births per annum (n=24). Births were excluded if the birth record had missing data on the variables of interest (n=1330). Preterm births (births ≤36 weeks gestation) were also excluded if they occurred at hospitals which lacked the service capability to manage preterm infants (570 births at 27 hospitals, 5.1% of all preterm births),

as although they manage preterm births in emergency situations, they were unlikely to perform planned induction of labour for preterm pregnancies and would not contribute to the understanding of variation in IOL rates. The population was then classified into 10 risk based 'induction groups', categorised by parity, prior CS, gestational age, number of fetuses and fetal presentation (Table 1).[17]

(next page: Table 1)

Variation in hospital IOL rates

Table 1: Rates of induction and measures of between-hospital variation, separately for 10 induction groups, NSW, 2010-2011.

Induction Group[17]	Births (n)	Relative size of group (%)	Inductions (n)	% of group induced	Inductions as % of all inductions	Inductions as % of all births	% of variance explained by case-mix	% of hospitals different from average[1]
1) Nulliparous, 37-38 weeks gestation, singleton cephalic fetus	14,467	8.2	4,823	33.3	10.3	2.7	11	29
2) Nulliparous, 39-40 weeks gestation, singleton cephalic fetus	39,454	22.5	11,004	27.9	23.5	6.3	1	58
3) Nulliparous, ≥41 weeks gestation, singleton cephalic fetus	14,124	8.1	8,291	58.7	17.7	4.7	-6	21
4) Multiparous, no previous CS, 37-38 weeks gestation, singleton cephalic fetus	15,323	8.7	5,075	33.1	10.8	2.9	30	28
5) Multiparous, no previous CS, 39-40 weeks gestation, singleton cephalic fetus	40,527	23.1	9,465	23.4	20.2	5.4	37	49
6) Multiparous, no previous CS, ≥41 weeks gestation, singleton cephalic fetus	9,538	5.4	4,643	48.7	9.9	2.6	11	14
7) No previous CS, ≤36 weeks, singleton cephalic fetus	6,721	3.8	1,396	20.8	3.0	0.8	20	17
8) Previous CS, singleton cephalic fetus	26,174	14.9	1,335	5.1	2.8	0.8	15	35
9) Singleton, non-cephalic fetus	6,524	3.7	307	4.7	0.7	0.2	43	3
10) Multi-fetal pregnancy	2,592	1.5	583	22.5	1.2	0.3	6	9
Total	175,444	100.0	46,922		100.0	26.7		

[1]proportion of hospitals for which the 95% confidence interval of the adjusted hospital induction rate does not cross the crude state average

Data source and study variables

Data were obtained from the NSW Perinatal Data Collection (PDC), a legislated population-based surveillance dataset of all live births and stillbirths in NSW public and private hospitals and homebirths.[18] Private hospitals provide obstetrician-led care, whereas the public hospitals provide a mix of obstetrician- led, midwifery-led and mixed obstetric and midwifery led care. At the time of the birth admission, the treating clinician or midwife completes a record of demographic, medical and obsetric information of the mother and the labour, delivery and condition of the baby, submits this record to NSW Ministry of Health where the information in compiled into the PDC.[19] The available information in the PDC on pregnancy, labour, delivery and maternal and infant characteristics has been validated and can be reliably used to evaluate maternity care.[20-22] In the PDC, 'onset of labour' is collected by a single option check-box as 'spontaneous', 'induced' or 'no labour (sensitivity 92.5%, positive predictive value 96.1%).[20] Records from the PDC were linked longitudinally by the NSW Centre for Health Record Linkage (CHeReL)[23] to create obstetric histories (previous births and caesarean sections) for each woman in the study population. The primary outcome was the proportion of births at each hospital in which labour was induced within each induction group (Table 1). In addition to the stratification factors, casemix factors available for adjustment were infant size at birth (<10th centile: small for gestational age; 10th-90th centile: appropriate for gestational age; >90th centile: large for gestational age), as well as maternal age, country of birth, smoking status, diabetes (pre-existing or gestational diabetes), hypertension (including chronic, gestational hypertension and preeclampsia), and type of care (public care in a public hospital, private care in a public hospital or private care in a private hospital).

Statistical Analysis

Pregnancy and maternal characteristics were determined according to onset of labour (spontaneous labour, IOL or no labour in the case of prelabour caesarean section).

Multilevel logistic regression models were used to examine between-hospital variation in induction rates within each of the ten induction groups, with hospitals as a random intercept. These models account for both differences in volume and potential clustering of similar women within hospitals. Hospital-specific induction rates (with 95% confidence intervals) were obtained by converting the odds ratio for each hospital into a relative risk and multiplying it by the state rate.[24] For each group, the unadjusted and adjusted models of hospital induction rates were obtained. The proportion of variance among hospitals explained by adjusting for case-mix was calculated as the difference between the variance of the adjusted and unadjusted models, expressed as a proportion of the unadjusted model variance. To compare the extent of variation in hospital induction rates across groups, we calculated the percentage of hospitals in each group that were significantly different from the state average rate (i.e. the proportion of hospitals for which the 95% confidence interval of the adjusted induction rate did not cross the state average). We pre-defined cut-offs for variation as: high (>30%), medium (15-30%), or low (<15%) levels of variation. Statistical analysis was performed using SAS (version 9.3; SAS Institute, Cary, North Carolina).

RESULTS

In 2010 and 2011, there were 175,444 maternities at 72 hospitals. Of these 46,922 (26.7%) followed induction of labour. The overall induction rate at NSW hospitals ranged from 9.7% to 41.2% (IQR 21.8%-29.8%).

Pregnancy and maternal characteristics according to onset of labour are shown in Table 2. When compared to women with spontaneous or no labour, women receiving an induction of labour were more likely to be nulliparous, born in Australia, have hypertension or diabetes, or have a prolonged (>41 weeks gestation) pregnancy (Table 2). Women who did not experience labour (ie those that had prelabour CS) were older and more likely to receive private care than women being induced.

Table 2: Maternal and pregnancy characteristics by onset of labour, NSW, 2010-2011

		Spontaneous	Induction	No labour	Total
		n = 96,335	n = 46,922	n = 32,187	n = 175,444
		n (%)	n (%)	n (%)	n (%)
Maternal Characteristics					
Age (years)	< 20	3,821 (4.0)	1,641 (3.5)	314 (1.0)	5,776 (3.3)
	20-34	73,171 (76.0)	34,508 (73.5)	19,973 (62.1)	127,652 (72.8)
	≥ 35	19,343 (20.1)	10,773 (23.0)	11,900 (37.0)	42,016 (23.9)
Born in Australia		62,878 (65.3)	32,951 (70.2)	21,744 (67.6)	117,573 (67.0)
Smoking during pregnancy		11,789 (12.2)	5,007 (10.7)	2,764 (8.6)	19,560 (11.1)
Diabetes		4,196 (4.4)	4,824 (10.3)	2,911 (9.0)	11,931 (6.8)
Hypertension		1,792 (1.9)	5,864 (12.5)	2,133 (6.6)	9,789 (5.6)
Type of care	Private, private hospital	17,901 (18.6)	11,422 (24.3)	11,703 (36.4)	41,026 (23.4)
	Private, public hospital	6,658 (6.9)	4,338 (9.3)	3,926 (12.2)	14,922 (8.5)
	Public, public hospital	71,776 (74.5)	31,162 (66.4)	16,558 (51.4)	119,496 (68.1)
Pregnancy Characteristics					

Variation in hospital IOL rates

Nulliparity		42,340 (44.0)	25,242 (53.8)	9,022 (28.0)	76,604 (43.7)
Previous Ceasarean (multiparous only)		7,535 (14.0)	1,359 (6.3)	18,859 (81.4)	27,753 (28.1)
Singleton		95,519 (99.2)	46,339 (98.8)	30,994 (96.3)	172,852 (98.5)
Cephalic presentation		94,449 (98.0)	46,603 (99.3)	27,389 (85.1)	168,441 (96.0)
Gestational age	≤ 36 weeks	5,609 (5.8)	1,610 (3.4)	3,349 (10.4)	10,568 (6.0)
	37-40 weeks	79,787 (82.8)	31,884 (68.0)	27,943 (86.8)	139,614 (79.6)
	≥ 41 weeks	10,939 (11.4)	13,428 (28.6)	895 (2.8)	25,262 (14.4)
Infant size	SGA[1] (<10%ile)	8,759 (9.1)	5,259 (11.2)	2,834 (8.8)	16,852 (9.6)
	LGA[2] (>90%ile)	8,513 (8.8)	4,894 (10.4)	4,476 (13.9)	17,883 (10.2)

[1] Small for gestational age

[2] Large for gestational age

Most inductions were among women at 39-40 weeks gestation (without a prior CS) with a singleton cephalic pregnancy (23.5% and 20.2% of all inductions for nulliparous and multiparous women respectively; Table 1). Within the induction groups, induction rates were highest for women without a prior CS at 41 or more weeks gestation with a singleton cephalic pregnancy (58.7% and 48.7% for nulliparous and multiparous women respectively;Table 1) and lowest for women with non-cephalic presentations (4.7%) or a history of having a previous CS (5.1%).

There was marked variation between hospital IOL rates within the induction groups (Figure 1). Adjusting for case-mix considerably *reduced* the variation between hospitals for induction for multiparous women at 37-38 (Group 4, -30%) and 39-40 weeks (Group 5, -37%) and single non-cephalic presentations (Group 7, -43%) but only by a small proportion for nulliparous women at 37-38 (Group 1, -11%) and 39-40 weeks (Group 2, -1%) and multi-fetal pregnancies (Group 10, -6%) (Table 1). In contrast, adjusting for case-mix slightly *increased* the between-hospital variance in inductions for nulliparous women at 41 or more weeks (Group 3, +6%; Table 1).

After accounting for case-mix, high unexplained variation in hospital induction rates persisted for nulliparous and multiparous women at 39-40 weeks with a singleton cephalic pregnancy (Groups 2 and 5) and for women with at least one previous Caesarean Section (Table 1). There was low variation in induction rates between hospitals for multiparous women at 41+ weeks with a singleton cephalic pregnancy (Group 6, 14%), single non-cephalic presentations (Group 9, 3%) and multi-fetal pregnancies (Group 10, 9%): few hospitals had induction rates for these women that were significantly different from the overall average (Figure 1).

DISCUSSION

Principal Findings

In 2010-2011, just over one quarter of all births in our study population followed an IOL (26.7%), with considerable variation in hospital IOL rates across many groups of women having IOL, despite accounting for case-mix. Seven of the ten groups had medium to high variation in hospital IOL rates (nulliparous and multiparous women at 37-38 weeks gestation and 39-40 weeks gestation, nulliparous women ≥41 weeks gestation, women with a prior CS and women ≤36 weeks gestation). The greatest between hospital variation in IOL rates occurred in the two largest groups (Group 2 and Group 5: women with a singleton cephalic pregnancy at 39-40 weeks gestation, who accounted for 43.7% of all inductions). Only women with a singleton, non-cephalic presenting fetus, women with a multifetal pregnancy and multiparous women with a singleton, cephalic fetus at ≥41 weeks gestation had low between-hospital IOL rate variation, suggesting uniform clinical management across the hospitals for these groups of women. Efforts to standardise care for women having IOL should focus on groups of women with hospital IOL rates that have high variation, thereby potentially reducing practice variation and unnecessary intervention. Further research is required to understand the clinical decision-making and hospital factors that are driving this variation.

Strengths and weaknesses of the study

The strengths of this study were the use of large, contemporary, longitudinally linked, population-based data with reliably collected labour and birth information. This enabled the application of a totally inclusive yet mutually exclusive classification system for IOL[17] allowing for similar pregnancies to be compared. Multilevel modelling was used to reduce the effect of random fluctuations in rates of IOL in low volume hospitals and allowed quantification of the contribution of casemix factors to the variation in hospital IOL rates, while also accounting for similarities of births within hospitals. Hospitals included in the study were public and private hospitals (having either obstetrician care only or mixed obstetric-midwifery care) where IOL was offered, so did not include any hospitals that were midwifery-only maternity units as these units would not offer IOL in NSW.[25 26] However, population

level perinatal data lack detailed clinical information (such as severity of pregnancy and medical conditions) so do not allow exploration of clinical variation in thresholds; indication for labour induction; physician and patient attitudes; or cultural influences on decision-making. Individual, pregnancy, clinical practice and hospital factors not accounted for in the model could contribute to increased variation between hospital IOL rates. Information on individual practitioners is not available, and individual practitioners with either very high or very low IOL rates may influence an overall hospital rate of IOL. Whilst this study focused on understanding the variation in hospital IOL rates for different clinical groups, differences in hospital IOL rates and pregnancy outcomes needs to be explored to further guide practices to improve clinical care.

Interpretation

Practice variation has been related to medical uncertainty about the indications for and the efficacy of procedures.[27] There is much evidence showing the importance of clinical opinion in influencing rates of procedures, which can also be altered by feedback and review.[28] For example, in Wennberg's seminal work showing wide variations in rates of tonsillectomy in the state of Vermont, there was rapid decline in rates of tonsillectomy after feedback of data to clinicians.[29] The current study demonstrates considerable variation in hospital rates of IOL and is the first step in attempting to reduce unexplained variation.

The large variation in hospital IOL rates were for women at 39-40 weeks gestation with a singleton cephalic pregnancy may indicate heterogeneity in thresholds for clinicians to recommend induction of labour as the patient has now reached 'full term'. Often the heterogeneity is related to differences in tolerance or clinical uncertainty of the risks and benefits of IOL at this gestational age compared to continuing the pregnancy.[30 31] Such practice is, for example, indirectly endorsed by the American College of Obstetrics and Gynaecology Committee Opinion for 'nonmedically indicated early term delivery',[32] advising

that non-medically indicated deliveries <39 weeks is not justified. This implies that once the parturient has reached 39 weeks, nonmedically indicated full term delivery may be justified. Alternatively, variation in hospital IOL rates at term may be driven by differences in clinical practice attributable to recent studies regarding the effects of IOL and a reduction in the risks of caesarean section,[33] or some other unmeasured clinician or patient factor. There is increasing interest in offering IOL at 39-40 weeks gestation, to prevent stillbirths beyond this gestational age (and potentially improve other perinatal outcomes), and there is a randomised trial currently recruiting patients.[34]

Among nulliparae, not only did hospital rates of IOL at full term have large variation, but also moderate variation was seen in hospital rates of IOL women at early term (29% of hospitals different from the average). A report from the Royal College of Obstetricians and Gynaecologists found large variation in adjusted hospital IOL rates for nulliparae ≥37 weeks gestation, with 45% of hospitals having IOL rates significantly different compared to the average.[13] Our study found that only a small proportion of the variation in hospital IOL rates for nulliparae were explained by casemix (11% and 1% for Groups 1 and 2 respectively), suggesting that other factors affect IOL in this group. Further investigation of these factors affecting IOL for nulliparae are recommend as nulliparae at early and full term make up one third of all inductions; the proportion of nulliparae at early and full term being induced is increasing;[35] and there appears to be large unexplained variation in intrapartum caesarean section rates following IOL for nulliparae.[16] The importance of the first birth cannot be underestimated as it influences all subsequent births, and thus this large variation suggests that alternatives to a high IOL rate are achievable.

There was also large variation in hospital rates of IOL for women with a prior CS and a singleton cephalic fetus, with 35% of hospitals different from the average. However, only a small proportion of these women had an IOL (5.1% of the group), which may reflect concerns about adverse outcomes such as uterine rupture. The Royal Australian and New Zealand College of Obstetricians and Gynaecologists statement suggests that IOL should be

'undertaken with caution'.[36] In contrast, other international guidelines, (UK, USA and Canada) state that IOL is 'appropriate' for these women and these countries have a higher proportion of women with a prior CS undergoing an IOL.[37]

There was low to moderate variation in hospital IOL rates for women ≥ 41 weeks gestation. There are many international guidelines recommending IOL for women ≥ 41 weeks gestation,[38-40] to reduce perinatal mortality with no increase in the CS, based on evidence from a Cochrane review of 22 randomised controlled trials.[14] For women in this gestational age group, there is clearer evidence regarding the management of this clinical scenario, which is reflected in less variation in hospital IOL rates.

The observed variation in hospital IOL rates is more extensive than the reported between-hospital variation in CS rates (ie there are more hospitals where the rate of IOL is significantly different from the state average IOL rates compared to the number of hospitals where the rate of caesarean section is significantly different).[41 42] Different practice styles and clinical decision making around obstetric intervention have been postulated in other studies as being related to overall hospital IOL[11] and CS rate variation.[41 42] Apart from hospital size and type of care, there may be other hospital factors such as staffing or resources that may also contribute to variation and warrant further investigation.

Variations in clinical practice are a form of a natural experiment, with outcomes and rates a result of the care provided by small groups of health professionals.[29 43] It is problematic to specify the correct or target intervention rate such as a hospital IOL rate, particularly when the appropriate rate is likely to differ according to the 'induction group'. Instead, the focus should be on achieving the best outcomes for mothers and babies with minimum intervention,[1] reflecting improved clinical decision making, but also efficient resource management. Hospitals that have lower rates of IOL, yet have the same outcomes for mothers and babies compared to hospitals with higher rates of IOL, provide opportunities to suggest changes in clinical practice for other institutions. Conversely, if hospitals with low

rates of obstetric intervention such as IOL are associated with worse outcomes for mothers and babies, then interventions should increase to improve pregnancy outcomes. Further investigation into the pregnancy outcomes of the IOL groups that show large variation (such as those women at 39-40 weeks gestation) may be able to identify hospitals that have differing rates of IOL, yet the same pregnancy outcomes. In particular, hospitals with minimum intervention and yet the same outcomes may be studied to examine areas of clinical practice management that differ from other hospitals.

CONCLUSION

Considerable variation in hospital IOL rates persisted after accounting for casemix. In particular, hospital IOL rates for women at 39-40 weeks gestation with a singleton cephalic birth showed high, unexplained variation, especially for nulliparous women. Further determination of outcomes associated with divergent IOL practice is required, which may guide strategies to standardise medical care, and reduce practice variation and unnecessary interventions.

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COMPETING INTERESTS STATEMENT

Competing interests: All authors have completed the ICMJE uniform disclosure form at http://www.icmje.org/coi_disclosure.pdf and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

CONTRIBUTION TO AUTHORSHIP

CR and JM conceived the study. JT undertook data preparation and provided statistical analysis, with JP providing statistical oversight. TN, JT, JP, JF, CR and JM had full access to all of the data (including statistical reports and tables) in the study, take responsibility for the integrity of the data and the accuracy of the data analysis, took part in interpretation of results, drafting the manuscript, approve and take responsibility for the final manuscript.

TRANSPARENCY DECLARATION

The lead author (TN) affirms that the 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 have been explained.

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DATA SHARING

Data are not available for sharing.

ETHICAL APPROVAL

Ethical approval was obtained from the NSW Population and Health Services Research Ethics Committee (Reference No. 2012-12-430).

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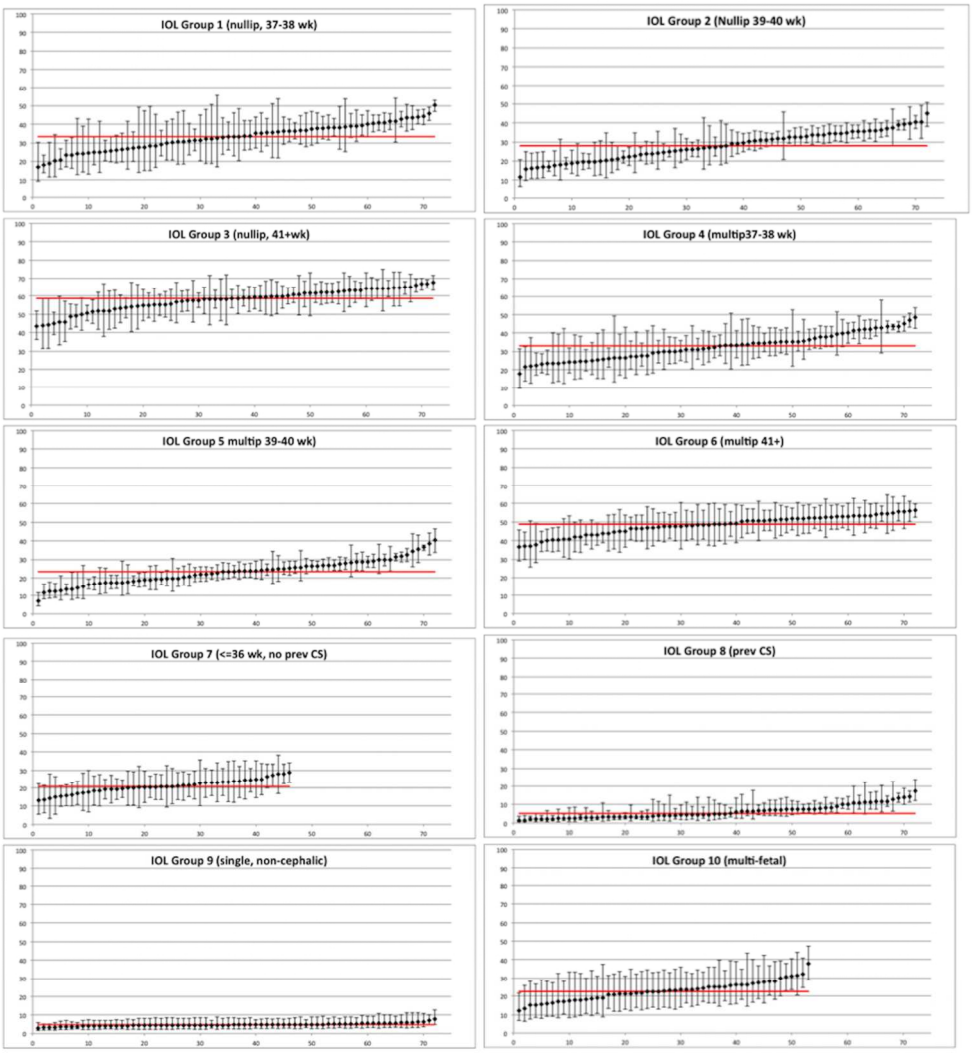

Figure 1: Adjusted hospital-specific induction rates, separately for each induction group, NSW, 2010-2011.
*Red line represents the state average rate for each induction group

140x151mm (300 x 300 DPI)

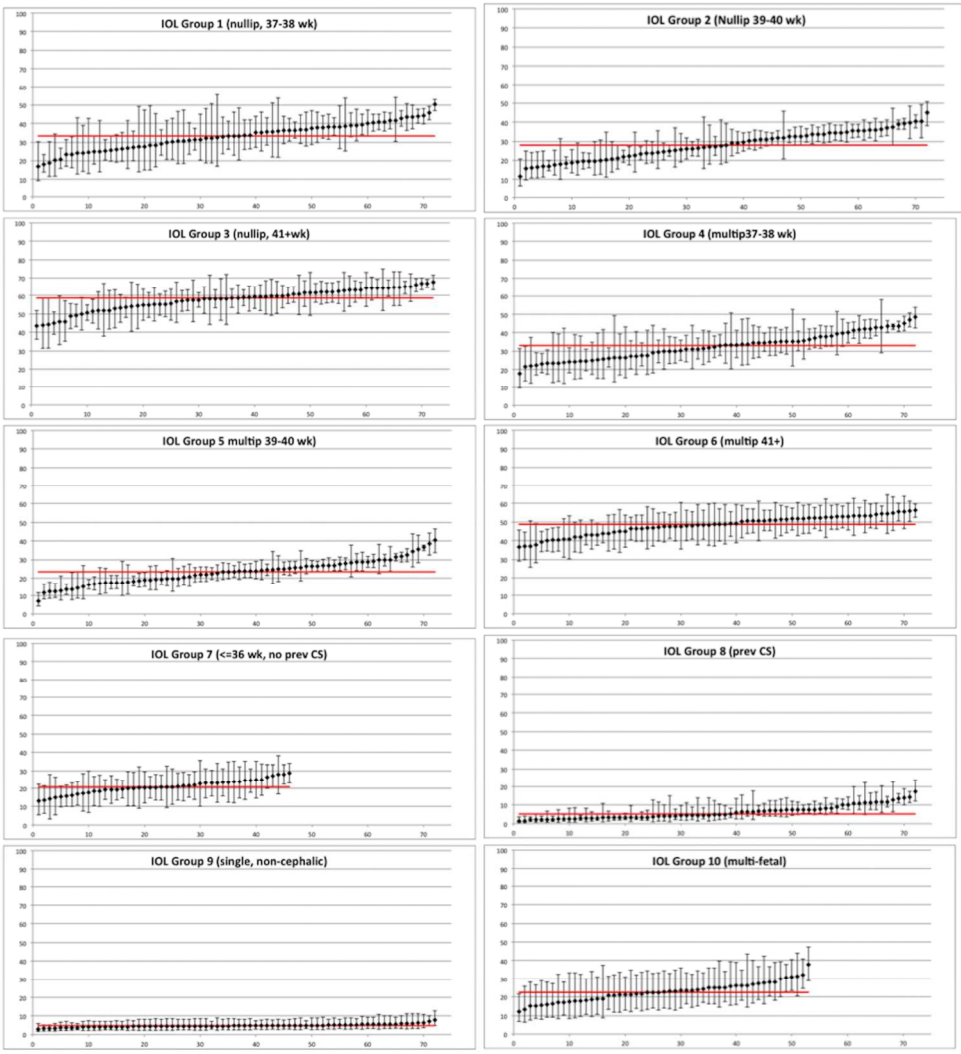

Figure 1: Adjusted hospital-specific induction rates, separately for each induction group, NSW, 2010-2011.
*Red line represents the state average rate for each induction group

173x188mm (300 x 300 DPI)

STROBE Statement—checklist of items that should be included in reports of observational studies

TITLE: Variation in hospital rates of induction of labour: a population-based record linkage study

Authors:
Tanya Nippita, Judy Trevena, Jillian Patterson, Jane Ford, Jonathan Morris, Christine Roberts.

	Item No	Recommendation	Page No.
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-5
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	4-5
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4-7
Bias	9	Describe any efforts to address potential sources of bias	4-7
Study size	10	Explain how the study size was arrived at	4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7-8
		(*b*) Describe any methods used to examine subgroups and interactions	N/A
		(*c*) Explain how missing data were addressed	4
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking	N/A

		account of sampling strategy	
		(*e*) Describe any sensitivity analyses	N/A

Continued on next page

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	4
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8-9; table 2
		(b) Indicate number of participants with missing data for each variable of interest	4 (more detail available if requested)
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	8; table 1; figure 1
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	11; table 1-2; figure 1
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	12-13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13-16
Generalisability	21	Discuss the generalisability (external validity) of the study results	13-16
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	18

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.