UNIVERSITY OF TECHNOLOGY SYDNEY

SAFE TIMING OF EMERGENCY CAESAREAN SECTIONS

A review for NSW Health through the Sax Institute

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Final Report

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EXECUTIVE SUMMARY

A review of the literature about safe maximum time intervals between the decision to carry out an emergency caesarean section and the time the procedure is performed was commissioned by NSW Health. The review was commissioned in the context of the Final Report of the Special Commission of Inquiry into Acute Care (Garling, 2009) which made specific recommendations about safe maximum time intervals. Guidelines from the American College of Obstetricians and Gynaecologists (ACOG, 2002) based on survey data (low level evidence) from the 1970s, have previously recommended that maternity institutions have the capability to begin caesarean section operations within 30 minutes. This 30-minute rule has since been cited and used globally as best practice despite the low level of evidence. Therefore, NSW Health sought a review of evidence regarding the time interval which minimises risk of adverse outcomes to mothers and their babies. The purpose of this review is to guide policies on maternity and birthing services in New South Wales hospitals.

A search was undertaken of the academic literature using relevant keywords. The papers were read for direct relevance and their quality was assessed using a standard critical appraisal tool. Websites of professional organisations and colleges were also searched for relevant reports, reviews or research. Fifteen studies of sufficient quality directly addressing decision to delivery intervals for caesarean section were identified. None of these studies provided a high level of evidence with most being either prospective or retrospective cohort studies with varying degrees of suitable comparison groups. Six statements from professional colleges or guideline agencies were also identified. As there was not specific evidence relating to rural and remote issues or for Indigenous women, a number of other relevant studies conducted in these settings were examined.

The evidence from the literature shows that there is no strong evidence that a decision to delivery interval (DDI) of 30 minutes or less is associated with improved outcomes for babies or mothers. Some evidence suggests that a DDI of greater than 30 minutes but less than 75 minutes confers benefit but these findings are confounded by the reason for the emergency caesarean section in the first place. Many of the adverse outcomes for babies were related to prematurity.

Only one of the six recommendations from professional organisations or guideline agencies in relation to timing of emergency caesarean section makes specific comment about 30 minutes. As stated earlier, this is based on low level survey data from the 1970s.

There is limited evidence about specific issues in rural and remote settings and in Indigenous communities. Additional evidence from Canada and New Zealand that did not specifically address DDI but could help address the issues raised were reviewed. The important theme from this

evidence was the importance of risk assessment and screening and appropriate transfer of women during pregnancy or in early labour. In addition, there was a paucity of data related to transfer decisions, timing and transport methods.

The importance of effective training of staff was highlighted in a number of the studies. There seems to be benefit in facilitating intra-uterine resuscitation where feasible. Staff should be trained to recognise and attend to emergency situations and ensure that the woman is appropriately resuscitated prior to transfer to an operating theatre should this be required. In addition, a number of studies highlighted the value of recognising and appropriately managing obstetric emergencies rather than only concentrating on DDI (le Riche & Hall, 2005).

There are a number of limitations and gaps within the evidence. Women with risk factors were included in most of the studies as were preterm births. Risk factors and premature babies confuse the situation as it not clear whether the adverse outcomes are related to the DDI or the underlying conditions. Some studies compared women who required an urgent caesarean section with women who required a less urgent caesarean section thus again making generalisation difficult. A number of papers also highlighted the need to have congruence between the services available at a particular hospital or centre and the type of women who attend. While sometimes in emergency situations there are limited options, effective antenatal and early labour risk screening could assist in timely and orderly transfer rather than an escalation to urgent or emergency scenarios.

The review of the literature also highlighted the inconsistent approaches and nomenclature to describe the degree of urgency and the classification of emergency CS. The identification of the degree of urgency and the communication between the team is critical to effective DDI management. This includes an assessment of the organisational structures, communication processes and transfer mechanisms (Chauleur et al., 2009). In addition, one of the other challenges identified was the lack of prospective data in many settings making measurement difficult.

In summary, the recommended time intervals between the decision to carry out an emergency caesarean section and the time the procedure is performed have been mostly based on low level evidence linking time with outcomes and surveys describing what time frame is possible.

Implications and recommendations

This review of the literature cannot support the assertion that hospitals in NSW must have the "*ability to transfer the mother within 30 minutes travel time to a hospital which has onsite, the workforce and facilities to perform an emergency caesarean section*" (Garling, 2009). The review

does support that urgent CS should occur as soon as possible but there is insufficient evidence to support a definite time frame such as 30 minutes.

The review has also resulted in a number of recommendations.

1. A consistent approach and nomenclature to describe the degree of urgency and the classification of emergency CS needs to be developed and applied across NSW. A consistent approach and nomenclature would enable benchmark criteria to be established and audits could then measure compliance across the state.
2. The collection of prospective data about the decision around urgent CS and the process and timing of transfer. Data collection systems, such as Obstetrix, need to be able to collect data and report on the nuances of emergency transfers in a prospective and rigorous manner. This includes reporting on transfer decisions, timing and transport methods.
3. Staff should be trained to recognise and attend to emergency situations and ensure that the woman is appropriately resuscitated prior to transfer to an operating theatre should this be required. Emergency drills or practice situations are likely to be a useful way to ensure that communication systems are effective when emergency transfer is required.
4. Careful antenatal risk assessment and congruence with role delineation and service delivery capacity is an important factor in making recommendations about place of birth for individual women. Assessment of risk factors should take place in the antenatal period and/or early in labour using a consistent tool across the state. Transfer can then be arranged in a timely manner. While this will not reduce the need for emergency transfer it is likely to contribute to less transfer situations. In particular, women having a preterm labour should be carefully considered to determine the most appropriate time for transfer.

INTRODUCTION

In NSW there were 11,572 emergency caesarean section operations performed in 2007 constituting 12.2% of all births (Centre for Epidemiology and Research, 2010). Indications for emergency caesarean sections are to prevent maternal, and/or neonatal compromise. Due to the reasons for the intervention, an emergency caesarean section operation is usually undertaken as soon as possible to prevent a worsening of the fetal and/or maternal condition, and deliver the baby in the best possible condition

One of the recommendations from the Special Commission of Inquiry into Acute Care in NSW Public Hospitals (Garling, 2009) was that (ii) *the hospital has, on-site, or else has the ability to transfer the mother within 30 minutes travel time to a hospital which has onsite, the workforce and facilities to perform an emergency caesarean section* (Recommendation 8 c). It would seem that this recommendation was based on a guideline from the United States of America (USA) (ACOG, 2007, 2002).

In 2002, guidelines from the American College of Obstetricians and Gynaecologists (ACOG, 2002), based on survey data (low level evidence) from the 1970s, recommended that maternity institutions have the capability to begin these operations within 30 minutes. The 2007 guidelines from the American College of Obstetricians and Gynaecologists were unchanged (ACOG, 2007). The 30-minute rule has been cited and used globally as best practice despite the low level of evidence. Recently, there has been debate about the optimum decision to delivery intervals (DDI) in emergency caesarean situations, and DDIs have been studied more closely in relation to neonatal and maternal outcomes. A systematic review of the literature was undertaken for NSW Health on this topic. The aim was to summarise the evidence on the optimum DDI in emergency caesarean operations which can then be used to guide policies for maternity and birthing services in New South Wales (NSW).

METHOD

The question that guided the review was:

- What does the evidence suggest regarding a safest maximum time interval between the decision to undertake an Emergency Caesarean Section and the time it is actually performed?

The scope of the review was to:

- provide a comprehensive coverage of research in the peer reviewed literature including academic databases (e.g. Cochrane, Medline, PsycINFO),
- provide a comprehensive review of the grey literature including government reports, agency reports (e.g. OECD, WHO, NICE), reports from professional colleges (e.g. Colleges of Obstetricians and Gynaecologists, Midwives),
- focus on literature published since 1995,
- focus on evidence from Australia and other countries with comparably-developed healthcare systems,
- provide commentary on settings that include coverage of rural and/or remote communities, and
- provide commentary on studies conducted within Indigenous communities.

Keywords

Using the PICO model, keywords were identified to guide the search strategy. The PICO model identifies the patient/population and/or problem, the intervention, comparison and outcome. These were articulated for this review as below:

- Patient/Population and/or Problem – Pregnant women, obstetric population, Indigenous and non-Indigenous populations;
- Intervention – Emergency or urgent caesarean section (Category 1 and 2 in the NICE Guidelines (NICE, 2004) were also used[1]); emergency birth;
- Comparison/Control Intervention – The timing or decision to incision time frame
- Outcomes or effects – neonatal outcomes (Apgar scores, admission to neonatal nurseries, neonatal lactate and pH, morbidity and mortality) and maternal outcomes.

Keywords included all the different spellings of caesarean section, emergency/urgency, decision to delivery, time, neonatal/maternal morbidity and infant/maternal mortality, and 30 minute rule.

Search strategy and outcome

A search of relevant databases was undertaken to source the relevant literature using the keywords in the search strategy. The databases included Medline, CINAHL, Maternity and Infant Care (MIDIRS), and CDSR. Exclusion criteria included papers published earlier than 1995 and developing world or

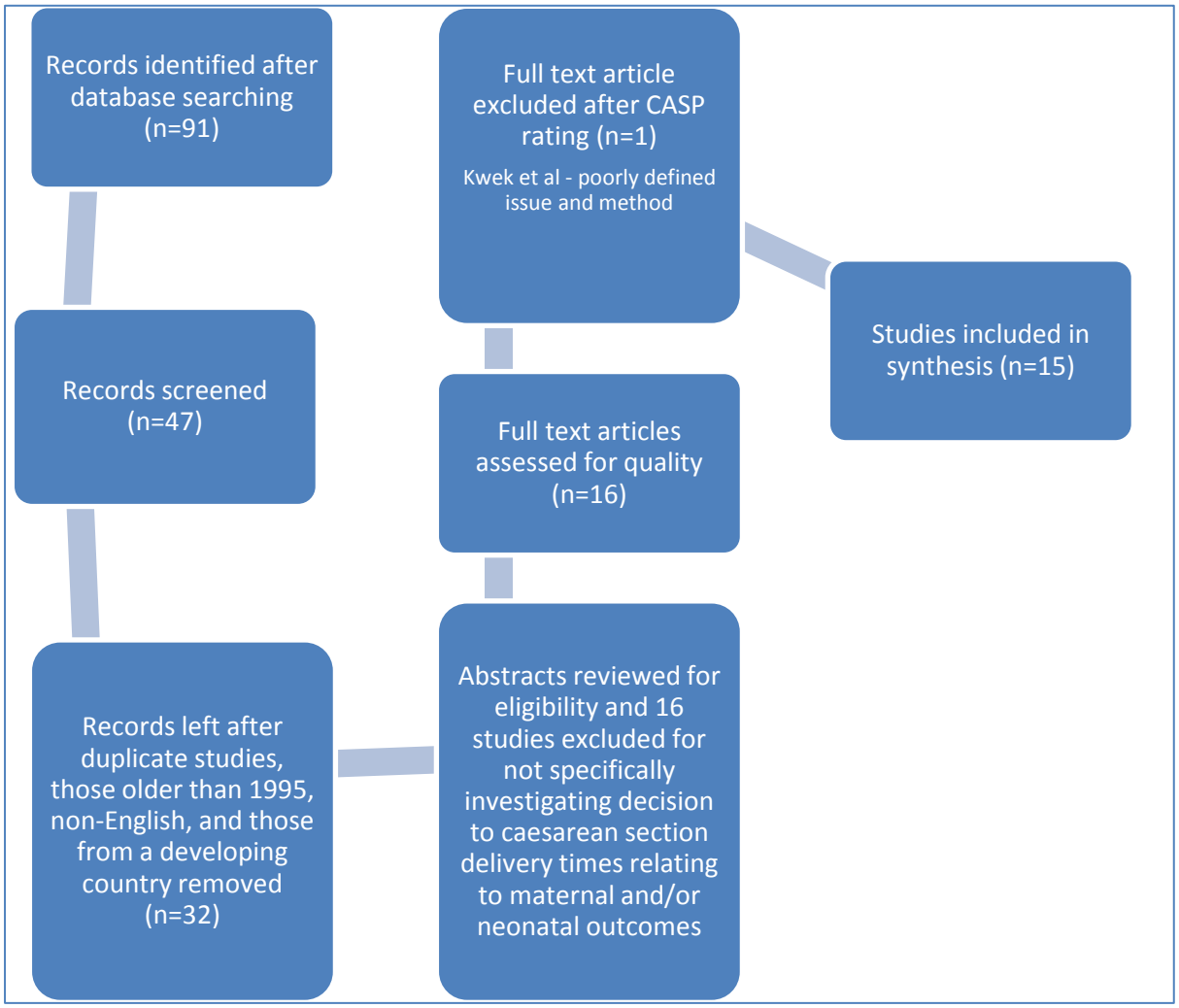
[1] The NICE Guidelines for Caesarean Section (2004) recommend the following standardised scheme to classify the urgency of a CS: 1 - immediate threat to the life of the woman or fetus; 2 - maternal or fetal compromise which is not immediately life-threatening; 3 - no maternal or fetal compromise but needs early delivery; 4 - delivery timed to suit woman or staff.

non-applicable settings. A combination of textwords (free text) and subject heading searches was undertaken. Appropriate truncation for textword searches was also used where applicable.

Combinations of these keywords yielded 91 papers. After duplicates were removed, and exclusion for age (papers older than 1995), non-English papers where translations were unavailable, and studies set in developing countries, 32 papers were left. The reference lists of the papers were searched for additional studies.

The abstracts were all read and eligibility for inclusion was assessed. A further 16 papers were excluded as not investigating DDIs or relating to maternal and/or neonatal outcomes. This left 16 papers, of which the full-text was sought and assessment of quality was undertaken using the Critical Appraisal Skills Programme (CASP) rating (Division of Health Sciences, 2005). The CASP rating considers quality by rating studies out of 12. Within the rating, studies were considered good if scoring 10-12, fair – 6-9 and poor <5. One paper was rated poor (Kwek et al., 2005)(CASP score <5) and was excluded for having a poorly defined method through being reported in a 'short report' format. This left 15 papers (Figure 1).

Figure 1: Flow chart describing the number of papers initially identified and ultimately included



The 15 included studies were classified according to their level of evidence using criteria from the National Health and Medical Research Council (2009) (Appendix 1: Table 1). Of the 15 studies reviewed, 14 were of Level III-2 evidence and one was level IV (Tuffnell et al., 2001).

The websites of professional organisations, governments and colleges were also searched to identify relevant grey literature. Agencies such as the Organisation for Economic Cooperation and Development (OECD), World Health Organisation (WHO), and the National Institute for Health and Clinical Excellence (NICE) were searched as well as reports from professional colleges (e.g. RANZCOG, ACM). Six statements from professional organisations that addressed the safety of decision to delivery intervals in relation to neonatal and/or maternal outcomes were identified.

FINDINGS

Fifteen research papers of sufficient quality and six statements from professional organisations that specifically addressed the safety of decision to delivery intervals in relation to neonatal and/or

maternal outcomes were found. Table 2 in the Appendices summarises each of the 15 papers. This section summarises the findings of the research papers and professional literature.

Analysis of research evidence in terms of the review question

Of the 15 papers, seven (7) reported on prospective cohort studies; six (6) were retrospective cohort studies; one (1) was a case control study and one (1) was an audit and feedback design conducted over four time periods. More than half the studies (at least n=8) included preterm births which in most cases were the babies with the poorer outcomes. Some of the other seven studies probably included preterm births given their design although this was not explicitly stated. There were no studies conducted within Indigenous communities.

Many of the included studies found that neonatal outcomes are poorer when the DDI is <30 minutes (Bloom et al., 2006, Chauleur et al., 2009, Holcroft et al., 2005, Huissoud et al., 2010, Kolas et al., 2006, le Riche & Hall, 2005, Nasrallah et al., 2004, Sayegh et al., 2004). This is often thought to be because the reasons for the caesarean sections in these particular cases were more life-threatening (eg. cord prolapse, uterine rupture, placental abruption), warranting shorter DDIs because of the severity and compromise involved. This corresponds with the poorer neonatal outcome. However, other hypotheses have been discussed, for example, maternal anxiety during such events causes a secretion of catecholamines , constriction of the placental bed and consequent reduced oxygen exchange and fetal acidosis leading to poorer outcomes (MacKenzie & Cooke, 2002). It may also be likely that babies born after a DDI of 30 minutes benefit from the resuscitative measures put in place during the time between decision and incision (eg. intravenous fluid replacement, amnioinfusion, tocolytics) contributing to the better outcomes of babies born after 30 mins. The criteria for classification of an emergency or urgent CS which was often based on abnormal or non-reassuring fetal heart rate tracings also highlights that in some cases, while the CTG was interpreted as evidence of acute fetal distress, they were less distressed in reality (Chauhan et al., 1997).

A number of studies presented data on perinatal deaths (Bloom et al., 2006, Chauhan et al., 1997, Hillemanns et al., 1996, Holcroft et al., 2005, Huissoud et al., 2009, Kayani et al., 2003, MacKenzie & Cooke, 2002, Sayegh et al., 2004, Thomas et al., 2004). From these, it is apparent that a DDI of less than 30 minutes does not guarantee better neonatal outcomes.

One study, the smallest in this review, specifically examined 33 women with severe placental abruption (Kayani et al., 2003). This found, of those cases with fetal bradycardia, a DDI of 20 minutes had more favourable outcomes than a DDI of 30 minutes. The odds ratio and 95% confidence intervals of a poor outcome for delivery at 20 minutes compared with 30 minutes was 0.44 (95% CI

0.22-0.86). However, given the small sample size, there was no adjusting for potential confounders. This study was conducted in a large teaching hospital in the UK. The median gestational age was 34 weeks with a range from 28-42 weeks. Other studies that compared category 1 (eg. cord prolapse, placental abruption) emergency caesarean section DDIs and neonatal outcomes to lesser category caesarean sections, did not find the same significance in neonatal wellbeing related to timing (Huissoud et al., 2010, Lurie et al., 2004, MacKenzie & Cooke, 2002, Chauleur et al., 2009). Many of the included studies state there is little difference between DDIs less than 30 minutes and those up to 75 minutes, however it is highly likely that compromised babies left in an unfavourable environment will continue to deteriorate. This points to the probability that clinicians in these studies correctly selected the most urgent cases who then had a DDI of <30 minutes.

A number of studies have made commentary in their papers about the DDI interval of 30 minutes recommended by the ACOG (2002) in relation to outcomes. For example, Thomas et al's (2004) conclusions suggest that the 30 minute DDI interval should remain but more as a means to prevent complacency in urgency of CS rather than a strict threshold. Their data suggests that neonatal outcomes are favourable up to 75 minutes. Bloom (2006) stresses that the recommendation regarding 30 minutes in many guidelines, despite being a recommendation for a *capability*, has been interpreted as a *requirement*, and has consequently been cited in many medico-legal cases involving poor outcomes and DDIs greater than 30 minutes, despite the lack of good evidence. Chauhan et al. (1997) commented that while the 30 minute mark was a desirable goal, not achieving this was not associated with a measurable negative impact on neonatal outcome.

A number of studies found that meeting the 30 minute DDI was difficult. For example, Chauleur et al. (2009) found that in 50% of cases the DDI exceeded their recommended intervals (which they had defined as within 15 minutes for extremely urgent cases and within 30 minutes for urgent cases). Delays in meeting the ACOG recommendation of 30 minutes were often related to organisational issues such as transportation to the operating theatre and time associated with administering anaesthesia especially if an epidural anaesthesia was not already present.

Summary of the professional literature

There were six statements or guidelines identified from professional organisations or guideline agencies. Many of these used studies that have been presented in this review although some based their recommendations on much older studies.

As stated earlier, much of the current debate comes from the guideline from the American College of Obstetricians and Gynecologists (ACOG, 2002, 2007) which recommended that hospitals have the

capability of beginning a caesarean section within 30 minutes of the decision to operate. The guideline states:

> *'Any hospital providing an obstetric service should have the capability of responding to an obstetric emergency. No data correlate the timing of intervention with outcome, and there is little likelihood that any will be obtained. However, in general, the consensus has been that hospitals should have the capability of beginning a caesarean within 30 minutes of the decision to operate' (p. 158)*.

The Society of Obstetricians and Gynecologists of Canada (SOGC), in a guideline called 'Attendance in Labour and Delivery Guidelines for Obstetrical Care' (SOCG, 2000) provide no time constraints on the time to perform caesarean sections. More recent guidelines are only accessible through 'member-only' sections of their website, and no free-access relevant guidelines were available online. Their accessible, 10 year old guideline, recognises the lack of evidence on DDIs and outcomes and states:

> *'Caesarean section should be initiated expeditiously in collaboration with anaesthetic and other necessary support personnel. Reasons for delay should be documented in the chart by obstetrical, anaesthetic, and nursing personnel' (SOCG, 2000 p. 2).*

The National Collaborating Centre for Women's and Children's Health (NCCWCH) (2007) state that in the UK, the average interval between decision and childbirth for CS for fetal concern ranges between 30 and 40 minutes. They recommend that

> *'clinicians should take into account the time that it will take to achieve birth by both instrumental vaginal birth and caesarean section when making decisions regarding concern over fetal wellbeing during labour' (p. 28).*

The guideline on caesarean section (2004) from the UK's National Institute for Clinical Excellence (NICE) maintains that the 30 minute rule is relevant as a benchmark for grades 1 and 2 urgency, and a 75 minute interval should be used as a '*clinically important audit standard*' within which all emergency caesarean sections should take place.

Again in the UK, The Royal College of Obstetricians and Gynaecologists (RCOG) in a joint guideline with the Royal College of Anaesthetists (2010) encourage an individual, '*case-by-case approach in deciding the specific decision-to-delivery interval* (DDI)'(p. 1). They recommend a classification of urgency based on Lucas (2000), and emphasise the importance of communication, an individualised approach, and having drills to refine staff skills when caring for women needing category 1 emergency caesarean sections.

In Australia, the Royal Australian and New Zealand College of Obstetricians and Gynaecologists (RANZCOG) college statement on the urgency for caesarean section is similar to the RCOG guideline (2009). They also state that '*each caesarean section should have no specific time factors associated, but be performed considering its own merits and individual circumstances'*. The Australian College of Midwives has no specific guidelines on caesarean section, but they endorse the NICE (2004) guidelines.

There were no specific publications or recommendations on safe caesarean section DDI levels from the WHO or OECD websites.

In summary, only one of the six recommendations from professional organisations or guideline agencies makes specific comment about 30 minutes. As stated earlier, this is based on low level survey data from the 1970s.

Quality of evidence and limitations of the research

None of the studies provided a high level of evidence with most being either prospective or retrospective cohort studies with varying degrees of suitable comparison groups. While cohort studies are commonly used to address these types of questions (a randomised controlled trial would probably be ethically impossible) the type of comparison groups and the sample of women included mean that the generalisability is limited in some cases.

Preterm babies were included in eight of the 15 studies and accounted for many of the deaths. It is difficult to determine whether the deaths were related to being premature, the possible reason for the preterm birth or the DDI. In a setting where risk screening would occur, most women with preterm labour could be transferred earlier than in an acute situation in labour, thus potentially decreasing the rate of perinatal deaths.

A number of the other studies are limited because of their comparison groups. It does not seem accurate to compare outcomes for women and babies who required an urgent CS with those who required a less urgent CS as was undertaken in some studies (Hillemanns et al., 1996, Sayegh et al., 2004). The indications for the CS in the two groups are different and preterm births were included. In addition, different definitions have been used to classify level of urgency across most of the studies making comparisons inappropriate.

In some studies, the overall low CS rate makes generalisation to a NSW population difficult. For example, the overall CS rate in the Norwegian study (Kolas et al., 2006) was 14% which suggests a different set of clinical decision making process were occurring compared with current systems in

NSW where the overall CS rate was 29% (Centre for Epidemiology and Research, 2010). In addition, studies like Kolas et al (2006) looked at reasons for DDI rather than comparing outcomes for the same indications.

Studies in rural and remote settings

Only three of the included studies were based in non-university or tertiary hospital settings. These included a range of maternity units in their samples. In two of these, a network was used which included a number of units with different services. In the first, conducted in France (Huissoud et al., 2009), the 31 maternity units were classified according to the level of paediatric service available. The lowest level (Level 1) did not have a paediatric unit although, in some hospitals, an obstetrician and anaesthetist were always present.

The second study was conducted in Norway (Kolas et al., 2006). In this the lowest level (Level 1) were maternity homes with less than 400 births per year and only staffed by midwives. Level 2 hospitals had obstetricians and anaesthetists on call but not in the hospital. Level 3 hospitals had a neonatal intensive care unit as well as obstetricians, paediatricians and anaesthetists on duty at all times. The average DDI for all emergency CS was 52 minutes. This study probably has the most relevance for a NSW setting although the overall low CS rate makes widespread generalisation difficult. In Norway at the time, the CS rate in the country and in the study hospitals was less than 14%. In NSW, the overall rate is currently 29% which limits the applicability of the study (Centre for Epidemiology and Research, 2010).

The final study that included non-university or larger hospitals was Thomas et al. (2004) who conducted a national cross sectional survey in a range of maternity units in England and Wales. Outcomes by level of maternity unit or rurality were not reported which makes generalising to a NSW population difficult.

None of the studies reviewed were conducted specifically in remote settings or included Indigenous communities. An additional search for evidence about maternity care in remote settings was undertaken in relation to emergency transfer for CS and DDI. Three studies from remote Inuit communities in northern Canada were found (Simonet et al., 2008, Van Wagner et al., 2007, Houd et al., 2003) however none discussed emergency transfer or presented DDI data. Nonetheless, the retrospective birth cohort study in 14 Inuit communities of Nunavik, Canada over an 11 year period did not demonstrate any significant differences in perinatal death rates between women attended by Inuit midwives in the remote Hudson Bay region compared with women attended by physicians in the more rural area of Ungava Bay (Simonet et al., 2008). All 14 Nunavik communities are isolated,

fly-in-only communities without road connections between communities or to southern towns and cities.

The second Canadian study, built on the first, undertaking an evaluation of outcomes of more than 2200 births in Puvirnituq, 200 births in Inukjua and 40 births in Salluit, with approximately 3000 women cared for in total since the Puvirnituq birth centre opened in 1986 (Van Wagner et al., 2007). Between 2002 and 2005 of the 374 births planned for Inuulitsivik birth centres, 9.3% involved maternal transfer (antepartum, intrapartum, or postpartum), and 1% involved neonatal transfer. Of the maternal transfers, 7.8% were transferred to Montreal, and 1.6% transfers were to Puvirnituq. The most common reason for transfer was preterm labour (14/42; 33%) however nine of the women transferred for preterm labour delivered at term, often after returning to the north. There were 16 medical evacuations antenatally or during labour. Of these, the most relevant for the purposes of this review were two for placental abruption and two for labour dystocia. While emergency transfers for CS were not specifically reported, the overall CS rate in the Hudson Bay birth centres since opening ranged from 2-3% suggesting that the risk screening and transfer process was effective. The perinatal mortality rate was nine per 1000 births which is consistent with previous research in the Western Arctic and Canada as a whole.

The third study in this group was an earlier review of outcomes from the remote Inuit communities (Houd et al., 2003). In this paper, 4.5% of women required medical transfer during pregnancy, labour or immediately after birth. The two main reasons were postpartum haemorrhage and preterm labour and birth. The preterm birth rate was 3.3% and of the women transferred to Montreal, one required a CS (rate of 0.5% in total). Again, while times to transfer were not presented, the only CS transfer was for prematurity.

In addition, a paper from the Society of Obstetricians and Gynaecologists of Canada (Couchie & Sanderson, 2007) highlighted the need to collaboratively develop protocols regarding transfer from remote communities. They provide the example from the remote Inuit communities of Puvirnituq, Inukjjuak, and Salluit where a structured review of the charts of all women booked in those services occurs at 34 weeks' gestation. This is where risk is assessed, and a care plan is made for each woman. The plan may be for the woman to give birth in her own remote community, which has no transfusion or CS capacity; to give birth at the Inuulitsivik Health Centre maternity, which has transfusion capacity; or to be sent to a tertiary care centre in Montreal if further intervention may be required.

It is recognised that these Canadian examples are not directly relevant to the NSW setting. They do however provide some reassurance that with effective systems for consultation, referral and risk screening, the need for emergency evacuation for CS is likely to be very low.

Another study from a more similar context is from New Zealand and is included here as some of the issues of rurality and transfer are similar to those in NSW. This was a mixed methods research study that gathered to gather data from a national survey of rural maternity units together with individual and small group interviews of women and of midwives (Patterson, 2009). Data for almost 5000 women were collected for rural maternity units for a two year period (2004-2006) although the study did not focus on outcomes as such but focussed on the process of the decision making around transfer out. In total, more than 700 women were transferred during labour and up to 6 hours postpartum. Slow progress in labour was the most common reason for transfer and road ambulance was most commonly used for these transfers. Travelling times and distances to the nearest secondary referral centre ranged from 30 – 150 minutes (mean of 78 minutes; median of 60 minutes). It was also noted that transfer for prolonged labour, while stressful, was rarely an emergency. The strategy of 'thinking ahead' emerged as a common theme in the study. This strategy allowed for the distance and time involved in the transfer and in anticipation of critique from the secondary care system and local community.

Despite the lack of clear and relevant research in this area, it is evident that transfer processes, decisions and outcomes are an important area for future research and evaluation. It is important to ensure that data collection systems, such as Obstetrix in NSW, are able to collect the nuances of decisions around transfer in a prospective and rigorous manner.

Risk assessment, transfer patterns and workforce configuration

There is limited evidence that specifically addresses risk assessment, inter-hospital transfer patterns and workforce configurations. It seems clear however that many of the adverse outcomes in relation to DDI for CS are related to prematurity. Careful risk assessment and congruence with role delineation and service delivery capacity would seem to be important factors in making recommendations about place of birth for individual women.

Transfer patterns were not discussed in any of the papers reviewed. It is likely that a range of modes of transfer are used depending on the situation and the setting. Two reports from primary maternity models of care in NSW were reviewed to better understand issues of transfer. The Ryde Midwifery Group Practice (RMGP) provides continuity of midwifery care to low risk non-insured women who book at Ryde Hospital. If required, CS and other interventions are available at the Royal North Shore

Hospital, a 15-30 minute drive depending on the traffic. In the evaluation of the RMGP (Tracy & Hartz, 2005), of the 179 women who commenced labour at Ryde Hospital, 44 (25%) were transferred during labour. Depending on the urgency of the situation or the availability of transport, women were transferred by ambulance or private car. The most common reason for intrapartum transfer was a prolonged first stage of labour (28/44). In relation to this review, there were three more urgent transfers – one for fetal distress, one for prolonged second stage and the other for a placental abruption. Of the 44 women transferred, 15 had a CS including these three. There were two DDI reported – one at 62 minutes and one 69 minutes. There were no perinatal deaths since the implementation of the Ryde Midwifery Group Practice and no emergency operative births performed under emergency circumstances at Ryde Hospital.

The second model is the Belmont Birthing Service (BBS). The BBS provides continuity of midwifery care to low risk women. It is based on the campus of the Belmont District Hospital, but has no medical support on that campus. All medical consultation and referral, including for CS, takes place on the John Hunter campus, 20 minutes by road away. A review of the first seven months of operation showed that 8 women were transferred in labour, by ambulance (Shaw et al., 2006). This gives an intrapartum transfer rate of 7.4%. Overall, six women had a CS but it is not clear if these were those transferred in labour. A larger number of women had transferred before the onset of labour for reasons including antepartum haemorrhage, gestational diabetes and group B streptococcus. There were no maternal or neonatal adverse outcomes in this report.

One of the difficulties with examining outcomes of women in smaller settings that do not have quick access to CS is the lack of data about planned place of birth at the onset of labour. Many women may book into a small either rural or standalone maternity unit at 12-16 weeks but develop risk factors or complications during pregnancy that means their planned place to birth shifts to a higher facility. Currently, in England, a national prospective study of planned place of birth is being undertaken – the Birthplace in England Research Programme which is due to finish in late 2010 (www.npeu.ox.ac.uk/birthplace). The study is comparing outcomes for women and infants for births planned at home at the onset of labour, in different types of midwifery units, and in hospital units with obstetric services. The exposure (planned place of birth) is measured at onset of labour. Many of the smaller midwifery units in this study do not have access to a CS within 30 minutes and so this will provide important data to answer this question.

In a similar manner, the *Birthplace in NZ* study is exploring mode of birth and rates of obstetric intervention in women identified as low risk at commencement of labour, comparing women who are in the care of a midwife and intending to give birth at home with women in primary maternity

facilities or secondary and tertiary hospitals. All women identified as low risk with a record in the Midwifery Maternity Provider Organisation database and giving birth in 2006 and 2007 were included. The risk of CS was higher for women planning a birth at a tertiary or secondary facility compared with a primary facility (which does not have access to CS). Babies were more likely to be admitted to a neonatal intensive care unit if they were born in a tertiary or secondary facility. While this study did not examine DDI to CS, the low rates of adverse events in facilities without ready access to CS suggests that the DDI was not a critical factor for the most part (Davis et al., 2010).

Training and workforce considerations are critical in this context. A recent study found that interdisciplinary team training was associated with a shorter decision-to-incision time (33.3 minutes vs. 21.2 minutes) compared to hospitals that did not participate in team training (Nielsen et al., 2007). Helmy et al. (2002) introduced a structured time sheet with improvements found upon audit and feedback over 5 different periods. Tuffnell et al. (2001) also did a series of audits and feedback with a resultant streamlining of procedures surrounding emergency CS.

Commentary of other studies not included in the review

A small number of other studies were found that did not directly address the question but provide some context and inform the recommendations.

One study looked at the process of measuring the DDI and examined when the starting point should be. Leung et al. (2009) specifically examined cases of fetal bradycardia and recommended that the DDI be considered alongside a 'bradycardia-to-delivery' interval. They found this interval correlated significantly with the deterioration of cord arterial pH, and suggested it may help to explain some cases of poor neonatal outcomes, despite a short DDI.

The method of incision has also been studied in relation to DDIs. (Bjorklund et al., 2000, Sayegh et al., 2004, Xavier et al., 2005) found the Misgav Ladach method of incision superior to the Pfannenestiel method in enabling rapid extraction at emergency CS. A systematic review by Abalos (2009) also found the method had advantages over the Pfannenstiel, including a shorter DDI. Conversely, Chauleur et al. (2009) state the Misgav Ladach technique of incision was not significant in the DDI. The method of incision at caesarean section regarding DDI and maternal/neonatal outcomes has not been widely researched.

A number of studies discuss the use of anaesthesia and its relation to DDIs – often a general anaesthetic for the very urgent CS significantly reduces the DDI (McCahon & Catling, 2003, Bruce et al., 2002, Helmy et al., 2002, Tuffnell et al., 2001), although the many other issues and health risks of

having a GA were not taken into consideration in these studies. Mode of anaesthetic may be important to consider in future studies.

Assessment and classification of urgency is another important area. A number of hospitals already use colour coding to help streamline the emergency CS procedure, and differentiate between the urgent and acute cases. One study in a large Singapore hospital (Kwek et al., 2005) reported a designated telephone hotline accessible via the switchboard. This had a code green specifically for alerting staff to an emergency CS allowing several processes to be conducted together (eg. preparation of woman, transport prep of the operating theatre by anaesthetic and nursing teams, NICU activation). Another study by the same group (Wee & Quek, 2001) reported that this 'code green' system enabled a specific team to be mobilised in the case of emergency CS – making the average DDI at this hospital 15 minutes.

Recommendations or implications arising from the evidence

This review of the literature cannot support the assertion that the hospitals in NSW must have the "*ability to transfer the mother within 30 minutes travel time to a hospital which has onsite, the workforce and facilities to perform an emergency caesarean section*" (Garling, 2009). The review does support that urgent CS should occur as soon as possible but there is insufficient evidence to support a definite time frame such as 30 minutes.

The review has also resulted in a number of recommendations.

1. A consistent approach and nomenclature to describe the degree of urgency and the classification of emergency CS needs to be developed and applied across NSW. A consistent approach and nomenclature would enable benchmark criteria to be established and audits could then measure compliance across the state.
2. The collection of prospective data about the decision around urgent CS and the process and timing of transfer. Data collection systems, such as Obstetrix, need to be able to collect data and report on the nuances of emergency transfers in a prospective and rigorous manner. This includes reporting on transfer decisions, timing and transport methods.
3. Staff should be trained to recognise and attend to emergency situations and ensure that the woman is appropriately resuscitated prior to transfer to an operating theatre should this be required. Emergency drills or practice situations are likely to be a useful way to ensure that communication systems are effective when emergency transfer is required.
4. Careful antenatal risk assessment and congruence with role delineation and service delivery capacity is an important factor in making recommendations about place of birth for

individual women. Assessment of risk factors should take place in the antenatal period and/or early in labour using a consistent tool across the state. Transfer can then be arranged in a timely manner. While this will not reduce the need for emergency transfer it is likely to contribute to less transfer situations. In particular, women having a preterm labour should be carefully considered to determine the most appropriate time for transfer.

APPENDICES

Appendix 1: Levels of evidence used

Table 1 provides a summary of the NHMRC Evidence Hierarchy (National Health and Medical Research Council, 2009) that was used to assign the levels of evidence in the review.

Table 1: NHMRC Evidence Hierarchy: designations of 'levels of evidence' according to type of research question

Level	Intervention	Diagnostic accuracy	Prognosis	Aetiology	Screening Intervention
I	A systematic review of level II studies	A systematic review of level II studies	A systematic review of level II studies	A systematic review of level II studies	A systematic review of level II studies
II	A randomised controlled trial	A study of test accuracy with an independent, blinded comparison with a valid reference standard, among consecutive persons with a defined clinical presentation	A prospective cohort study	A prospective cohort study	A randomised controlled trial
III-1	A pseudo-randomised controlled trial (i.e. alternate allocation or some other method). A comparative study with concurrent controls:	A study of test accuracy with an independent, blinded comparison with a valid reference standard, among non-consecutive persons with a defined clinical presentation	All or none	All or none	A pseudo-randomised controlled trial (i.e. alternate allocation or some other method)
III-2	Non-randomised, experimental trial Cohort study Case-control study	A comparison with reference standard that	Analysis of prognostic factors amongst	A retrospective cohort study	A comparative study with concurrent controls:

	Interrupted time series with a control group	does not meet the criteria required for Level II and III-1 evidence	persons in a single arm of a randomised controlled trial		Non-randomised experimental trial Cohort study Case-control study
III-3	A comparative study without concurrent controls: Historical control study Two or more single arm study Interrupted time series without a parallel control group	Diagnostic case-control	A retrospective cohort study	A case-control study	A comparative study without concurrent controls: Historical control study Two or more single arm study
IV	IV Case series with either post-test or pre-test/post-test outcomes	Study of diagnostic yield (no reference standard)	Case series, or cohort study of persons at different stages of disease	A cross-sectional study or case series	Case series

Appendix 2: Tabulation of the relevant papers

Table 2 provides a summary of the 15 papers included in the review. In particular, the country, setting, sample, calculation of DDI and the findings are summarised.

Table 2: Summary of the 15 included studies

Study No.	Author, year, country	Design	Level of evidence	Sample and setting	Calculation and recording of DDI	Findings	CASP rating
1	Bloom et al. 2006; USA	Multi centred prospective cohort over 2 year period	III-2	*Sample*: Women in active labour (≥4cm dilated); CS performed for cord prolapse, abruption, placenta praevia, non-reassuring FHR, uterine rupture 2,808 women had emergency CS for these criteria (24% of all CS in study period) *Setting*: University teaching hospitals as part of a network	Calculated from progress notes and operation records by trained research nurse	65% of included emergency CS performed within 30 min. Most common indication non-reassuring FHR. 98% CS for 'obstetric accident' (cord prolapsed, praevia or abruption/rupture) commenced within 30 mins of the decision to operate Babies born within 30 mins more likely to be compromised than those born after 30 mins Two infants who died were born within 30 min interval	GOOD

Study No.	Author, year, country	Design	Level of evidence	Sample and setting	Calculation and recording of DDI	Findings	CASP rating
						DDI interval had no impact on maternal complication rates	
2	Chauleur et al. 2009; France	Prospective cohort using clinical audit (12 month period)	III-2	*Sample*: Consecutive emergency CS in hospital with 3000 births per year CS classified according to level of urgency (Class 1=extremely urgent (DDI 15min) ; Class 2=urgent (DDI 30min); Class 3=non-urgent DDI 60min) 68 had emergency CS • 34 Class 1 and 2 • 34 Class 3 *Setting*: Large university hospital	Not described	Class 1 and 2 CS DDI – mean 30 min (range 9-73); Class 3 CS DDI – mean 44 (range 17-415). Class 1 and 2 CS undertaken for fetal bradycardia, haemorrhage, cord prolapse. DDI interval exceeded recommendation interval in 50% of cases No differences in neonatal lactate or pH when DDI >30 min compared with <30 min Babies needed more resuscitation if DDI exceeded 30 mins	FAIR
3	Chauhan et	Retrospective	III-2	*Sample*: Women at term	From when	61 women delivered $\leq$ 30 min	GOOD

Study No.	Author, year, country	Design	Level of evidence	Sample and setting	Calculation and recording of DDI	Findings	CASP rating
	al. 1997; USA	cohort (1990-1993) using chart audit		who required CS for fetal distress identified In total, 9,137 term deliveries of which 117 (1.3%) met inclusion criteria. *Setting*: University medical centre	patient was informed of need for CS (from records) to incision time in anaesthetic records	56 women delivered >30 min Mean umbilical artery pH less in babies born ≤ 30 min (7.16 vs 7.26); 8 babies in ≤30 min group had mean umbilical artery pH<7.00 vs none in >30 min group Two neonatal deaths – both in babies born ≤30 min	
4	Hillemanns et al. 2003; Germany	Retrospective cohort using comparisons with matched controls (1988-1997)	III-2	*Sample:* Cases: 'Crash' emergency CS defined as being for severe fetal distress or critical maternal condition (cord prolapse, abruption, bradycardia). Controls: Next delivery after case within gestational age who had non-emergency CS	Defined as time from decision to delivery. Documented in central book in the delivery ward	All cases performed within 30 min (median 10 min) with CS performed in the room itself Main reasons for crash CS – abnormal fetal heart rate, cord prolapse, abruption Statistically significant differences between groups in neonatal outcomes but not clinically different (eg. mean	GOOD

Study No.	Author, year, country	Design	Level of evidence	Sample and setting	Calculation and recording of DDI	Findings	CASP rating
				(eg. failure to progress, preeclampsia, malpresentation). Sample: 109 cases vs 109 controls. *Setting*: University hospital		Apgar at 5 min in cases 8.2 vs 8.8 in controls). Higher perinatal mortality in cases. No differences in maternal outcomes Unhelpful comparative study as the indications for CS in the two groups are different. Preterm babies included in study (29% of cases and 28% controls).	
5	Holcroft et al. 2005; USA	Retrospective cohort (16 months - 2001-2003)	III-2	*Sample*: All CS deliveries for non-reassuring fetal status. All women had electronic fetal monitoring (EFM) prior to delivery. Classified as emergent (need to deliver as soon as possible) or urgent (willing to wait up to 30min) based on EFM assessment post hoc	Decision for CS noted when EFM tracing removed in labour room. Documentation of incision time not described.	Mean DDI in emergent cases 23 min and in urgent cases 37 min. Apgar scores similar between groups. Mean umbilical artery pH lower in emergent group (7.12 vs 7.22) More babies with cord pH <7.00 in emergent group (17.7% vs 2.4%) One neonatal death in emergent group vs none in urgent group. The majority of babies with metabolic	GOOD

Study No.	Author, year, country	Design	Level of evidence	Sample and setting	Calculation and recording of DDI	Findings	CASP rating
				117 cases identified (5% of all births) – 34 classified as emergent and 83 as urgent. *Setting*: Large university hospital		acidosis were born within 30 mins, but it is hard to identify which babies need expeditious delivery – EFM was a poor predictor	
6	Huissoud et al. 2010; France	Prospective multicentred cohort (2007 over 1-5 mths)	III-2	*Sample*: Women attending one of 31 maternity units in three levels with a range of onsite capacities. CS classified into non urgent CS; urgent CS (desirable DDI 30min); very urgent (desirable DDI less than 15min, eg. cord prolapse, uterine rupture, bradycardia, eclampsia) In total, 1456 CS included (unplanned and planned) -	Obstetrician or midwife noted time of decision and delivery in the patient file	Median DDI for urgent CS ranged from 22-48min and for very urgent 13-35 depending on level of the unit No difference in neonatal outcomes for urgent CS according to whether DDI was more or less than 30min or for very urgent CS as to whether DDI was more or less than 15min. The prolongation of the DDI did not influence neonatal outcome significantly. Shorter DDIs associated with poorer neonatal status, reflecting severity of	GOOD

Study No.	Author, year, country	Design	Level of evidence	Sample and setting	Calculation and recording of DDI	Findings	CASP rating
				447 classified as urgent and very urgent *Setting*: 31 maternity units in a network – with 3 levels depending on paediatric services.		reason for CS Five neonatal deaths (all preterm - 25-36 weeks) – DDIs of 15min; 20min; 35min; 38min; 90min Onsite obstetrician and anaesthetist reduced DDI	
7	Kayani et al. 2003; UK	Case control (cases and controls were women severe abruption over 10 year period with known outcome)	III-2	*Sample*: Cases: singleton, gestation >28 weeks. Abruption, fetus alive on admission, emergency CS. Cases and controls defined by outcome – good or poor. 33 cases and controls identified – 22 good outcome, 11 poor outcome. *Setting*: Large inner city teaching hospital	Not described	88% of women delivered within 30min and 55% within 20min. Poor outcome less likely to occur with delivery at 20min compared with 30min.	GOOD

Study No.	Author, year, country	Design	Level of evidence	Sample and setting	Calculation and recording of DDI	Findings	CASP rating
8	Le Riche & Hall 2005; South Africa	Prospective cohort (Feb-Apr 2003)	III-2	*Sample*: Women attending a tertiary referral hospital. Women requiring CS divided into – emergency fetal distress, abruption, cord prolapse, uterine rupture, failed instrumental delivery) or urgent (maternal/fetal condition to immediately life threatening). In total, 269 CS - 100 emergency CS; 78 urgent CS. *Setting*: Large teaching hospital	Structured timesheet filled in for duration of study. Process for detailing decision for CS not described.	DDI for emergency CS – 48min (range 10-179); urgent CS 59min (range 25-180). Median DDI for fetal distress 50min (range 20-179) and abruption 31min (range 17-65). More babies required resuscitation in emergency group (33% vs 17%)). No other neonatal outcome data presented by DDI.	GOOD
9	Lurie et al. 2004; Israel	Retrospective cohort (2002)	III-2	*Sample*: Consecutive non-elective CS at a tertiary hospital Emergency CS group divided	Decision for CS made by senior consultant	Mean DDI in emergency CS group 26min overall; 18min in crash CS group and 28min in non-crash group. No significant differences in Apgar score	GOOD

Study No.	Author, year, country	Design	Level of evidence	Sample and setting	Calculation and recording of DDI	Findings	CASP rating
				into crash CS (bradycardia, cord prolapse, heavy bleeding) and non-crash (failure to progress, non-reassuring FHR). During study period, 71 Emergency CS – 22 classified as emergent-crash CS and 49 as emergent-non-crash CS. *Setting*: Large university hospital	obstetrician. Process of documenting timing is not described.	and umbilical arterial pH between crash and non-crash CS. No correlation found between DDI and umbilical arterial pH or Apgar score at 1 or 5 min in infants in each CS group.	
10	Kolas et al. 2006; Norway	Prospective cohort (multi-centred 6 months Dec 1998-June 1999)	III-2	*Sample*: Women attending one of 24 maternity units in two levels with a range of onsite capacities A total of 2,778 CS occurred - 1511 classified as emergency CS with DDI provided.	Clinicians prospectively filled in data form.	Mean DDI for all emergency CS 52mins – 59min in acute CS and 12min in urgent CS A higher proportion of term infants were transferred to NICU when the DDI was shorter Level 3 units (hospitals with >1500	GOOD

Study No.	Author, year, country	Design	Level of evidence	Sample and setting	Calculation and recording of DDI	Findings	CASP rating
				Emergency CS divided into acute (n=1297) or urgent (n=214) using a list of 31 pre-specified indications. *Setting*: range of maternity units across Norway who had at least 500 births per year – midwife-led to tertiary.		deliveries/yr, obstetric paediatric and anaesthetic depts. – on duty at all times and NICU) had longer DDIs There was no difference in the number of cases with low Apgar scores in relation to level of hospital (3 levels studied). The most important predictors to reduce DDI were the indications of placental abruption, cord prolapse and fetal stress	
11	MacKenzie & Cooke 2002; UK	Prospective cohort (one year – 1996)	III-2	*Sample*: Women with CS classified into 4 groups: crash (cord prolapse, abruption, uterine rupture); emergency (fetal distress, failing labour, maternal reasons); urgent (made in 24	Staff required to record time when a decision to assist delivery.	Mean DDIs • Crash CS 24min • Emergency CS 55min • Urgent 94min Less than 40% CS for fetal distress were achieved within 30mins. No evidence to indicate that DDI up to	GOOD

Study No.	Author, year, country	Design	Level of evidence	Sample and setting	Calculation and recording of DDI	Findings	CASP rating
				hrs due to deteriorating fetal or maternal health); pre-empted (decision made more than 24 hrs). In total, there were 5846 births, 901 (15%) were CS, 533 during labour: • 24 Crash CS • 385 Emergency CS • 67 Urgent CS • 57 Pre-empted *Setting*: Major teaching hospital		120 mins adversely affected neonatal outcomes, unless it was a crash CS A trend of improving cord arterial pH values with more prolonged DDI. Two stillbirths – one at 30 weeks after a previous CS scar dehiscence and one after a placental abruption (DDI 38min). Four neonatal deaths – 3 at 29 weeks gestation and one a known serious congenital abnormality at 34 weeks.	
12	Nasrallah et al. 2004; USA	Retrospective cohort	III-2	*Sample*: All women with emergent CS between 32-42 weeks gestation identified. Categorised into 2 groups • Group 1 - Women with	Process of documenting DDI not described	Overall median DDI 20min (range 5-57) Most CS undertaken for non-reassuring FHR; abruption and cord prolapse. No statistically significant differences in neonatal or maternal outcomes	GOOD

Study No.	Author, year, country	Design	Level of evidence	Sample and setting	Calculation and recording of DDI	Findings	CASP rating
				DDIs ≤30 mins (n=83) • Group 2 - Women with DDIs >30 mins (n=28) *Setting*: Not described but a hospital with access to NICU		between groups The 30min rule does not improve neonatal nor worsen maternal outcomes GA reduced DDI by 5-7mins compared to regional anaesthesia	
13	Sayegh et al. 2003; France	Retrospective cohort (6 months in 2000)	III-2	*Sample*: Women with CS divided into 4 groups – emergency (bradycardia, cord prolapse, haemorrhage); urgent (abnormal FHR, failed assisted vaginal delivery); scheduled (malpres, failure to progress, booked elective CS in labour); elective (timed to suit women and team). In total, 153 cases – 15	DDI calculated from midwives' records, obstetric and anaesthetic files and CTG readings	Mean DDI 40min (range 12-245min) Few differences between DDI , 30min vs >30min. Only difference in mean arterial cord pH 7.21 in <30min group vs 7.26 in >30min group; and percentage of pH<7.12 (13.6% vs 2.3%). No differences in neonatal deaths. Six cases severe fetal acidosis (pH≤7.05) – all with DDI ≤30min (3 from abnormal FHR, 1 uterine rupture; 1 AFE, 1 failed assisted vaginal delivery).	GOOD

Study No.	Author, year, country	Design	Level of evidence	Sample and setting	Calculation and recording of DDI	Findings	CASP rating
				emergency, 81 urgent and 57 scheduled CS. *Setting*: University-based tertiary hospital			
14	Thomas et al. 2004, UK	Prospective cohort using national cross sectional survey (May-July 2000)	III-2	*Sample*: National Sentinel CS audit used. Urgency of CS graded – Grade 1 – immediate life threatening; 2 – compromise not immediately life threatening; 3 – no compromise but early delivery needed; 4 – delivery timed to suit women and staff. In total, 17,780 Emergency CS – Grade 1=4622; Grade 2=9122; Grade 3=3689. *Setting*: Range of maternity	Not described	DDI 30 min: 46% of women with Grade 1, 16% Grade 2; 9% Grade 3. Babies who were born <30min or >75min were more likely to require special care with poorer outcomes. No significant difference in outcomes for babies delivered in <30min compared with 31-75min. >75min DDI associated with poorer maternal outcomes	GOOD

Study No.	Author, year, country	Design	Level of evidence	Sample and setting	Calculation and recording of DDI	Findings	CASP rating
				units in England and Wales			
15	Tuffnell et al. 2001; UK	Audit and feedback (1993; 1995; 1996; 1997)	IV	*Sample*: Four audit cycles in large general hospital: Sept-Nov 1993; Oct-Dec 1995; Apr-Jun 1996 plus continuous audit from 1997. Audit results presented to all staff. Audit cycles identified emergency CS – 188; 107; 135; 1344 cases respectively. *Setting*: Large district general hospital	Not described	Longer DDI made no difference to rate of admission to SCN for babies >36 weeks gestation. Three neonatal deaths at gestations of 28-32 weeks had DDI 26-41min. Most CS that have DDI >50 mins were related to anaesthetic problems.	GOOD

Appendix 3: Excluded studies

The excluded studies are listed in Table 3. In summary, 13 did not report outcomes, one was a secondary article reporting the same data from an original study which is already included in the review, one was an audit of anaesthetic practice, two were reviews of the literature and one was a case report.

Table 3: Summary of excluded studies

Study number	Author and date	Reasons for exclusion
16	Bruce 2002	Before and after study - 152 and 226 women. No intervention, just a review of practice to see if practice had improved. delivery times for 'fetal distress'; only 39% of cases were performed within the recommended time of 30 minutes in both years, and 16% took longer than 1 hour in 1999—three times higher than the previous year (5%). **Excluded as no DDI related to outcomes reported.**
17	Dupois 2007	Retrospective study of potentially avoidable factors in neurological damage to infants investigated. Found DI important but did not report outcomes specifically. **Excluded as no DDI related to outcomes reported.**
18	De Regt 2009	This study found shorter DDIs were possible with a collaborative multidisciplinary approach, and identification and feedback of specific delays. **Excluded as no DDI related to outcomes reported.**
19	Elvedi-Gasparovic 2006	Undertaken in Croatia, defined in the study as a 'developing country'. **Excluded due to setting.**
20	Kinsella 2010	A national study of management of category 1 caesarean sections. 81% units used the NICE CS guideline, however only 9% complied with the recommended DDI of 30 mins for category1-2 caesarean sections. **Excluded as no DDI related to outcomes reported.**
21	Helmy 2002	This study audited all caesarean sections over five different periods of time. The final survey found 71% caesarean sections were performed within 30 minutes, and states that the 30-minute rule is unrealistic. **Excluded as no DDI related to outcomes reported.**
22	Hillemans 2005	This was a secondary article of same data as 2003 study which is included in the review (Study #4). **Excluded as a duplicate.**
23	Livermoore2006	Large retrospective review of DDIs in one hospital in the UK. The mean DDI for all caesarean sections was 59.9 minutes, and the median for 'crash' caesarean sections was 44 minutes, falling short of the recommendations. **Excluded as no DDI related to outcomes reported.**
24	Moriarty 2006	This audit recorded DDIs for urgent caesarean sections in 2004. It found 90% women were delivered within 40 minutes, and that non-random, institutional factors within the Delivery Suite adversely

		affect DDIs. **Excluded as no DDI related to outcomes reported.**
25	Nicholson 2006	Retrospective cohort study estimating the optimal gestational age ranges for neonates in four risk-defined groups. Found that based on obstetrical risk, specific optimal times of delivery could improve birth outcomes. DDIs were calculated for these. **Excluded as no DDI related to outcomes reported, and not specific to caesarean section.**
26	KcKelvey 2010	Retrospective Irish study of the morbidity of caesarean sections performed at full dilatation over a one year period. Found 57% maternal morbidity was related to instrumental birth. 15% caesareans were performed at full dilatation. **Excluded as no DDI related to outcomes reported.**
27	Popham 2007	An audit of anaesthetic practice. **Excluded as no DDI related to outcomes reported.**
28	Rashid 2007	Review article. **Excluded as not a primary source.**
29	Schauberger 2009	Review article. **Excluded as not a primary source.**
30	Spencer and MacLennan, 2001	DDIs in the majority of CS are longer than times commonly advocated and are influenced by facilities and staff available **Excluded as no DDI related to outcomes reported.**
31	Stehr 2007	Case report **Excluded as insufficient data.**
32	Kwek 2005	Retrospective review of 'crash' caesarean sections over a one year period. Data showed the feasibility of achieving DDI below 30 minutes in practically all cases with a reliable activation process and a multidisciplinary team. **Excluded as poor study quality due to its 'short report' format and poorly defined method and results sections.**

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