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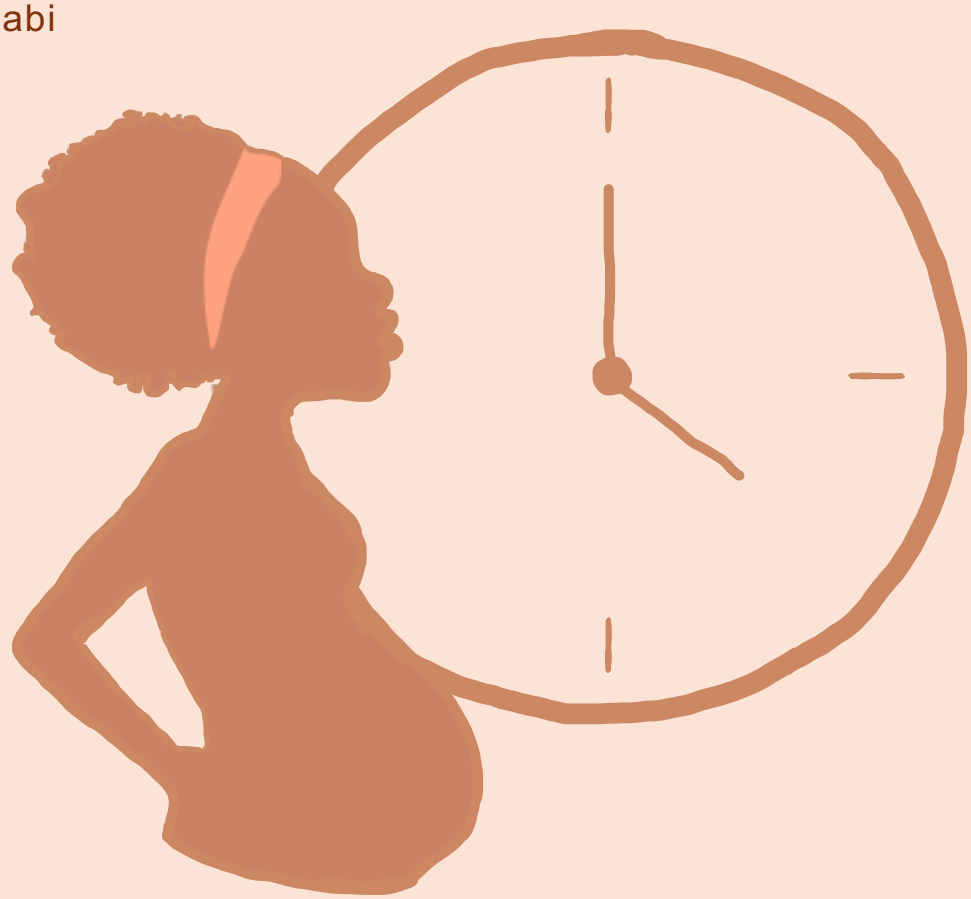
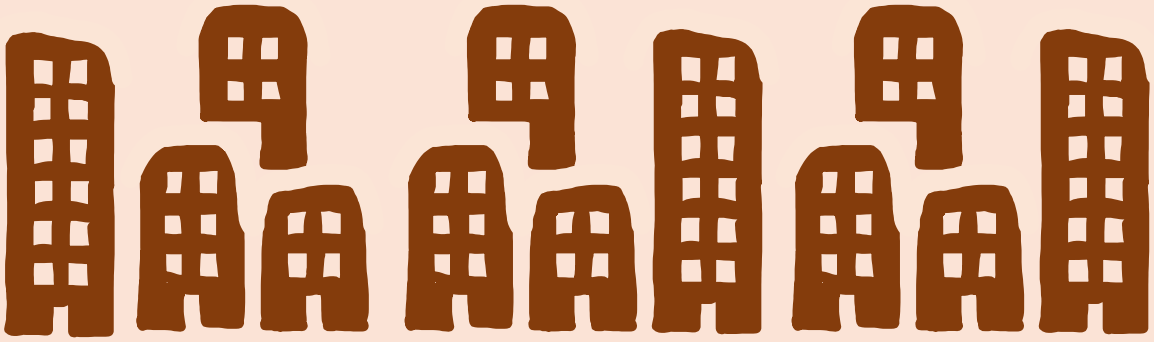
Labour progression in urban resource-constrained maternity units and beyond: An appeal for change

PhD Thesis

Monica L. Kujabi





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Author: Monica Lauridsen Kujabi

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Afiliation: Global Health Section, Department of Public Health, University of Copenhagen

Academic advisors: Professor Flemming Konradsen
Department of Public Health, University of Copenhagen, Denmark
Novo Nordisk Foundation, Hellerup, Denmark

Professor Kidanto Hussein
Medical College East Africa, Aga Khan University, Dar es Salaam, Tanzania

Assistant Professor Nanna Maaløe
Department of Public Health, University of Copenhagen, Denmark

Assistant professor Jane Brandt Sørensen
Department of Public Health, University of Copenhagen, Denmark

Professor Thomas van den Akker
Athena Institute, VU University Amsterdam, the Netherlands

Associate Professor, Dan W. Meyrowitsch
Department of Public Health, University of Copenhagen, Denmark

Assessment committee: Associate Professor Emmanuel Raju
Department of Public Health, University of Copenhagen, Denmark

Professor Andrea Pembe
Muhimbili University of Health and Allied Sciences, Tanzania

Associate Professor Helena Litorp
Karolinska Institute, Sweden

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"In every ending, there is a new beginning" – Deborah Harkness

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INCLUDED PAPERS

This thesis is based on the following five papers:

Paper I: **Kujabi ML**, Mikkelsen E, Housseine N, Obel J, D'Mello BS, Meyrowitsch DW, Hussein K, Schroll JB, Konradsen F, van Roosmalen J, van den Akker T, Maaløe N. Labor augmentation with oxytocin in low- and lower-middle-income countries: a systematic review and meta-analysis. AJOG Global Reports, 2022; Oct 21;2(4):100123.

Paper II: **Kujabi ML**, Maembe L, Maaløe N, Kidanto H, Pallagyo E, van Roosmalen J, van den Akker T, Konradsen F, Nkungu D, Dmello BS, Skovdal M, Sørensen, JB. Temporalities of oxytocin for labour augmentation: A mixed-methods study of time factors shaping labour practices in a busy maternity unit in Tanzania. BMC Pregnancy and Childbirth. 2022; in second peer-review. Sub-id: fe2ab6a1-ae5e-4400-869d-b7e8f3879eec.

Paper III: Hansen S, **Kujabi ML**, Maimburg RD, Macha A, Maembe L, Kabanda I, Hudson M, Msumi RJ, Mtingele S, Housseine N, Dmello BS, Hussein K, van den Akker T, Meyrowitsch DW, Maaløe N. Unfolding non-medically indicated caesarean sections in five high-volume urban maternity units in Tanzania: A criteria-based clinical audit (a PartoMa sub-study). Not submitted.

Paper IV **Kujabi ML**, Housseine N, Kabanda I, Msumi R, Maembe L, Sangalala M, Hudson M, Hansen S, Macha A, Dmello BS, Meyrowitsch DW, Konradsen F, Hussein K, Maaløe N, van den Akker T. Prolonged labour as a driver of the "caesarean section pandemic" – A criterion-based audit of caesarean sections among women with prolonged labour in five urban maternity units in Tanzania. 2023; Not submitted.

Paper V: Maaløe N, **Kujabi ML**, Nathan NO, Skovdal M, Dmello, BS, Wray S, van den Akker T, Housseine N. Inconsistent definitions of labour progress and over-medicalisation cause unnecessary harm during birth. BMJ 2023;383:e076515

TABLE OF CONTENT

ABBREVIATIONS AND TERMINOLOGY

Terminology and definitions

Prolonged labour	Any slowing of labour, regardless of the cause. Also referred to in the literature as dystocia.
Labour arrest	No further cervical progression between two vaginal examinations.
Mechanical disproportion	A mechanical mismatch between the presenting part and maternal pelvis, which can cause prolonged and obstructed labour.
Obstructed labour	A result of mechanical disproportion where the foetus is stuck in the maternal pelvis causing high risk of mortality and morbidity if a caesarean section is not performed.
Latent labour	Until cervical dilatation of 4-6 cm, depending on guideline. In this thesis until 5 cm is used.
Active labour	From cervical dilatation of 4 – 6 cm, depending on guideline and until full dilatation. In this thesis 5 cm is used.
Second stage of labour	Fully dilated cervix (10 cm) until birth of the foetus.
Partograph alert and action line	The alert line reflects a cervical progression of 1 cm per hour. The action line has the same inclination but is placed 4 hours later. Women crossing the action line have prolonged labour while the alert line is an early warning of slow progress (Figure 1).
Hyperbolic progression	Labour curve shape where progression is slow in early active labour and accelerates at 6-7 cm. (Figure 1)
Tolerant labour curves	Labour curves that allow labour to take more time.
Labour Care Guide	The recent WHO labour management tool where assessment of labour progression is based on tolerant, hyperbolic labour curves. Each cervical dilatation has a threshold, e.g. for 5 cm the threshold is six hours and for 9 cm the threshold is two hours (Figure 1).
Birth attendant	An educated nurse-midwife, clinical officer or doctor assisting women during childbirth.
Physiological labour	Natural labour progression resulting in a vaginal birth without medicalisation.
Too little, too late versus too much, too soon care	A concept describing the issue of care that is delayed or not provided at all according to standards (neglect) versus providing care that is not indicated (over-medicalisation).
Non-medically indicated caesarean section	Caesarean section decision which does not comply with defined medical criteria.

Abbreviations

ASOG	American Society of Obstetrics and Genecology
CI	Confidence interval
FGD	Focus group discussion
FHR	Foetal heart rate
HIC	High-income country
LLMIC	Low- and -lower-middle-income country
LMIC	Low- and middle-income country
MDG	Millenium Development Goals
MMR	Maternal mortality ratio
MSF	Médecins Sans Frontières
OR	Odds ratio
RCT	Randomised controlled trial
RR	Rate ratio
SDG	Sustainable Development Goals
WHO	World Health Organisation

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SUMMARY

Everyday, at least 800 women and 6,400 babies die in relation to pregnancy and childbirth. With appropriate care most would survive. In Tanzania an urban disadvantage in maternal health is growing. The rapidly increasing caesarean sections in urban areas are not followed by a decrease in perinatal mortality. As prolonged labour accounts for most caesarean sections, aim of this thesis was to investigate management of labour progression globally, with an in-depth case study from Dar es Salaam, urban Tanzania.

Two literature reviews were conducted. One on oxytocin for labour augmentation in low- and lower-middle income countries (LLMIC) (Paper I) and the other on prolonged labour globally (Paper V). Paper II is a mixed-methods study in one of the five maternity units, with data from 220 hours of participant observations, 234 structured labour observations and 13 interviews with birth attendants. Papers III and IV are criterion-based audits of 2,949 caesarean section case files at the five maternity units in Dar es Salaam with an in-depth focus on those with an indication of prolonged labour.

The systematic literature review (Paper I) included 42 studies from 25 LLMICs. The rate of oxytocin for labour augmentation exceeded by 30% in 14 of the countries. Rates, however, varied greatly between settings (0.7% to 97.0%). Meta-analysis of seven observational studies found that oxytocin used to augment labour was associated with increased stillbirths and day-one neonatal mortality (1.45; 95% CI, 1.02−2.06), neonatal resuscitation (2.69; 95% CI, 1.87−3.88), low Apgar score 1.54 (95% CI, 1.21-1.96), and neonatal encephalopathy (2.90; 95% CI, 1.87−4.49).

Paper II found that 146/234 (62.4%) labouring women received oxytocin to augment labour and that 43.8% had uncomplicated labour progression when oxytocin was administered. The main explanation for applying oxytocin to augment labour was to ensure patient-flow at the labour ward to avoid congestion and associated poor outcomes. A general fear of prolonged labour existed and oxytocin was mainly seen as a helpful medication to facilitate a speedy birth. Women were not allowed birth companions and the overall environment appeared unconducive for physiological birth.

The clinical audit of caesarean section case files from the five maternity units (Papers III and IV) showed that 788/1517 (47.9%) caesarean sections in the unscarred uterus were conducted because of prolonged labour. Of 456 caesarean sections with prolonged labour as indication, 243 (53.3%) had uncomplicated progression. Fear of poor outcomes in vaginal births appeared to drive defensive caesarean section decisions.

Paper V unfolds fundamental gaps related to prolonged labour, including a global overuse of oxytocin for labour augmentation and caesarean sections because of prolonged labour. While oxytocin may be harmful, its effectiveness remains unproven and research is alarmingly scarce. Evidence-based practices as labour companions and ambulant upright positions are neglected in many places in Sub-Saharan Africa and many existing guidelines are outdated.

In conclusion, over-medicalisation of prolonged labour is driven by unconducive labour environments, unfit clinical guidelines and major research gaps. On a macro-level this thesis unfolds a health system failure where women's basic rights at birth are violated and birth attendants demoralised trying to provide acceptable care under unacceptable conditions. Unconducive maternity units may indirectly be the strongest driver of the caesarean section epidemic in low-resource settings, by not allowing safe and respectful vaginal births.

MUHTASARI

Kila siku, takriban wanawake 800 na watoto wachanga 6,400 hufariki kutokana na matatizo yanayohusiana na ujauzito na kujifungua. Iwapo wangepata huduma sahihi, wengi wangeweza kuishi. Nchini Tanzania, matatizo ya afya ya uzazi katika maeneo ya mijini yanazidi kuongezeka. Ongezeko kubwa la uzazi kupitia njia ya upasuaji katika maeneo ya mijini haliendani na upungufu wa vifo vya kina mama na watoto wachanga. Kwa kuwa uchungu wa uzazi wa muda mrefu ndio sababu kuu ya kujifungua kupitia njia ya upasuaji, lengo la utafiti huu lilikuwa kuchunguza usimamizi wa maendeleo ya uchungu kwa viwango vya kimataifa kulinganisha na na utafiti wa kina kwenye hospitali jijiniDar es Salaam, Tanzania.

Tulifanya mapitio ya fasihi mbili. Moja kuhusu matumizi ya maji ya uchungu (oxytocin) kama kichochezi cha kujifungua katika nchi zinazoendelea na zenye kipato cha chini na cha kati (LLMIC) (Jarida la 1) na nyingine juu ya uchungu wa muda mrefu kimataifa (Jarida la 5). Karatasi ya Jarida la 2 ni utafiti katika moja ya vituo vitano vya uzazi, na data kutoka saa 220 za uchunguzi wa washiriki, uchunguzi wa kujifungua wa kimuundo 234 na mahojiano 13 na wahudumu wa kujifungua. Jarida la 3 na la 4 ni tathmini zilizoongozwa na vigezo vya faili za kesi 2,949 za uzazi kupitia njia ya upasuaji katika vituo vitano vinavyozalisha akina mama jijini Dar es Salaam, na uchunguzi wa kina kuhusu wale walio na dalili za uchungu wa muda mrefu.

Mapitio ya fasihi kwa njia ya mfumo (Jarida la 1) yalijumuisha tafiti 42 kutoka nchi 25 za LLMIC. Kiwango cha maji ya uchungu kama kichochezi cha uchungu kilizidi kwa 30% katika nchi 14. hata hivyo viwango,, vilikuwa tofauti sana kati ya mazingira (0.7% hadi 97.0%). Meta-analysis ya tafiti saba za uchunguzi uligundua kuwa matumizi ya maji ya uchungu yalihusishwa na ongezeko la vifo vya watoto wachanga hasa wenye katika siku moja (1.45; 95% CI, 1.02−2.06), shida ya kupumua watoto wachanga waliozaliwa kwa upasuaji (2.69; 95% CI, 1.87−3.88), kiwango cha chini cha Apgar ya chini 1.54 (95% CI, 1.21-1.96), athari za ubongo wa watoto wachanga (2.90; 95% CI, 1.87−4.49).

Jarida la 2 lilionesha kuwa 146/234 (62.4%) ya wanawake wanaojifungua walipewa maji ya uchungu kwa ajili ya kuharakisha kujifungua na kuwa 43.8% walikuwa na maendeleo mazuri ya uchungu yasiyo na matatizo wakati dawa ya uchungu ilitolewa. Sababu kuu ya kutumia maji ya uchungu ilikuwa kuhakikisha kuna mzunguko wa wagonjwa katika chumba cha kujifungua ili kuepuka msongamano na matokeo mabaya wakati wa uzazi. Kulikuwepo na hofu kubwa ya uchungu wa muda mrefu na oksitosini hasa ilionekana kama dawa yenye manufaa kwenye kusaidia kufanikisha kujifungua kwa haraka. Wanawake hawakuruhusiwa kuambatana na ndugu wala wenza wakati wa wa kujifungua na mazingira kwa ujumla yalionekana kutokuwa na uwezo wa kufanikisha kujifungua kwa kawaida.

Uchunguzi wa faili za kliniki za kesi za wanawake waliojifungua kwa njia ya upasuaji kutoka kwa vituo vitano vya uzazi (Jarida la 3 na la 4) ulionesha kuwa wazazi 788/1517 (47.9%) waliofanyiwa upasuaji wa mara ya kwanza zilifanyika kutokana na uchungu uliodumu kwa muda mrefu. Kati ya kesi 456 za upasuaji zenye dalili ya uchungu wamuda mrefu, 243 (53.3%) walikuwa na maendeleo ya kujifungua yasiyo na matatizo. Hofu ya matokeo mabaya katika kujifungua kwa njia ya kawaida inaonekana kusukuma maamuzi yakutumia upasuaji kwa ajili ya kujifungua kama kinga ya matokeo mabaya ya uzazi.

Jarida la 5 linafunua mapengo ya msingi yanayohusiana na uchungu wa muda mrefu, ikiwa ni pamoja na matumizi makubwa ya maji ya uchungu kwa ajili ya kuchochea kujifungua na uzazi kupitia njia ya upasuaji kwa sababu ya uchungu wa muda mrefu ulimwenguni kote. Ingawa maji ya uchungu yanaweza kuwa na madhara, ufanisi wake bado haujathibitishwa na utafiti ni wa kushtua. Mazoea yaliyo na ushahidi kwa mfano, wasaidizi wa kujifungua na nafasi ya kusimama ambayo ni maeneo mengi katika Afrika Kusini mwa Jangwa la Sahara hayazingatiwi, na mwongozo wengi uliopo ni wa kizamani.

RESUMÈ

Hver dag dør 800 kvinder og 6.400 babyer i forbindelse med graviditet og fødsel. Med rigtig behandling ville de fleste overleve. I Tanzania's storby, Dar es Salaam, ses en voksende ulighed i kvinders sundhed. Det hastigt stigende antal af kejsersnit i byområder følges ikke af fald i mødre- og perinatal død. Da dystoci (langvarig fødsel) udgør flertallet af første-gangs kejsersnit, var formålet med denne afhandling at forstå håndteringen af dystoci globalt og via et case studie af fem store hospitaler i Dar es Salaam, Tanzania.

Afhandlingen indeholder to litteraturgennemgange. En fokuserer på brugen af oxytocin til at stimulere fødsler i lav- og lav-mellemindkomstlande (Paper I) og den anden omhandler dystoci på globalt plan (Paper V). Paper II er et mixed-methods studie på et af de fem hospitaler, med data indeholdende 220 timers kvalitative fødselsobservationer, 234 strukturerede fødselsobservationer og 13 interviews med jordemødre og læger. Paper III og IV er kriterie-baseret audit af 2.949 kejsersnit-journaler på de fem fødeafdelinger, med fokus på dystoci som indikation.

Den systematiske litteraturgennemgang (Paper I) omfattede 42 studier fra 25 lavindkomstlande. Oxytocin stimulering blev givet til mere end 30% i 14 af landene, med stor variation (0,7% til 97,0%). En meta-analyse af syv observationsstudier fandt, at oxytocin brugt til at stimulere fødslen kan være forbundet med øget antal dødfødsler og dødelighed på dag 1 (1,45; 95% CI, 1,02−2,06), neonatal genoplivning (2,69; 95% CI, 1,87−3,88), lav Apgar-score (1,54 95% CI, 1,21-1,96) og neonatal encephalopati (2,90; 95% CI, 1,87−4,49).

Paper II viste at 146/234 (62,4%) fødende kvinder fik oxytocin til at stimulere fødslen og 43,8% havde ukompliceret fødselsprogression, da oxytocin blev administreret. Hovedforklaringen på at anvende oxytocin var at sikre patientflow på fødegangen for at undgå trængsel og dertilknyttede risici. Der eksisterede generel frygt for dystoci, og oxytocin blev primært set som virksom til at facilitere en hurtig fødsel. Kvinder fik ikke lov til at have ledsager ved fødslen, og miljøet var generelt ikke understøttende for en fysiologisk fødsel.

Kejsersnitsjournaler fra de fem fødeafdelinger (Papers III og IV) viste, at 788/1517 (47,9%) af førstegangskejsersnit blev udført på grund af dystoci. Af 456 kejsersnit med dystoci som indikation blev 243 (53,3%) udført på trods af at kvinden havde ukompliceret fødselsprogression. Frygt for dårlige resultater ved vaginale fødsler syntes at drive defensive kejsersnitbeslutninger.

Paper V afdækker grundlæggende misforhold i forhold til langvarig fødsel, herunder et globalt overforbrug af oxytocin stimulation og kejsersnit på grund af dystoci. Mens oxytocin kan være skadelig, er dens virkning til at forebygge kejsersnit stadig ikke bevist og forskning alarmerende sparsom. Modsat er evidensbaserede tiltag som ledsager ved fødslen og mobilisering ikke implementeret mange steder og mange guidelines er forældede.

Afhandlingen viser, at over-medicinering af dystoci er drevet af fødemiljøer, der ikke understøtter fysiologisk fødsel, ubrugbare kliniske retningslinjer og betydelig mangel på forskning. På makroniveau afslører denne afhandling dermed et sundhedssystemssvigt, der forsøger at levere acceptabel behandling under uacceptable forhold. Ikke-understøttende fødemiljøer er indirekte den stærkeste drivkraft bag kejsersnitepidemien i lavindkomstlande, ved ikke at tillade sikre og respektfulde vaginale fødsler.

JUSTIFICATION

I started my journey working for the lives of women and their unborn babies in 2013. I was a young medical student with little knowledge of the inequities in the world. With half of my family in the Gambia in West Africa and with my mother growing up in Tanzania, both my parents told me stories about the beauty of two countries in tropical Africa where a rich culture of hospitality blossomed. The small organisation Masanga led me to Sierra Leone, a place I came to love because of its beautiful nature, small rivers and palm trees and because of the friendliness of its people. But underneath the smiles were numerous devastating stories of young deaths – children, men and women whose lives were lost too early. Not long after my arrival, I experienced my first maternal death arriving at the hospital entrance. Shocking to me, her story was not unique. This woman left a lasting impression on me. She was someone's sister, daughter and mother and she came to symbolise a fundamental inequality in the world. Consequently, working to save lives around birth became my trajectory.

When I reached Dar es Salaam the story was different from what I had seen in Sierra Leone. Tanzania has undergone massive economic growth and I experienced a much wealthier health system with specialist doctors, theatres and medication. Coming from the rural hospital in Sierra Leone the sight of Dar es Salaam's maternity units shocked me in another way. There were women everywhere sharing beds and birth attendants who looked tired and burned out. This showed me the complexity of maternal health. Suddenly the three delay model that had worked so well in rural Sierra Leone appeared oversimplified. I realised a new phenomenon that was not yet well-described in the literature: Urban over-crowded maternity units.

By talking to peers, I realised that many coping strategies existed to manage this difficult reality, though they were not explicitly described anywhere. Being a doctor myself I could vividly imagine how stressful it had to be to provide care in these unacceptable conditions. I reflected upon whether I, as a Danish researcher, was too privileged to undertake this work? Me, who at any time could go on a plane back to my labour ward that, in comparison, was well-staffed and -resourced. Was it fair to stand on the outside pointing at the gaps? By reflecting on my role in global maternal health, I realised that if I wanted to contribute I needed to commit long-term and I needed to engage closely with Tanzanians. Until today I am trying to add research from Dar es Salaam that will be useful for Dar es Salaam. I do this in close collaboration with Tanzanian colleagues who throughout my PhD process have challenged my views, while I have challenged theirs. The truth is not definitive. By making sense of lived realities and seeing them from outside new understandings are created. Hopefully in this lies solutions that both capture and challenge the status quo.

This thesis reflects my attempt to provide an understanding of labour care that recognises health system and cultural factors seen from the outside and explored from the inside. My thesis is about coping in a constrained health system and I call to leaders and the global community with an appeal to change – make women's lives matter.

To the world's women,

Monica Lauridsen Kujabi

Dar es Salaam. Photo by Nanna Maaløe.

CHAPTER 1: INTRODUCTION

In 2020, 287,000 women were estimated to have died related to pregnancy and childbirth.[1,2] The main causes of maternal mortality are obstetric haemorrhage, obstructed labour and eclampsia.[3] The Millennium Development Goals (MDGs) carried crucial improvements where the maternal mortality ratio (MMR) reduced steadily.[2] Devastatingly, however, MMR following the MDG era has stagnated and even regressed in some countries.[2] Moreover, these estimates may be seen as the tip of the iceberg. Compared to maternal mortality, the number of babies born dead has received little attention. It is estimated that 2.6 million babies die in the third trimester every year, 2.5 million neonates die during the first month of life and many more suffer from lifelong disabilities caused by complications during birth.[1,4] Devastatingly, stillbirths remain absent from both the MDGs and the subsequent Sustainable Development Goals (SDGs) and the decline in stillbirth rate is far behind the decline in under-five mortality.[4]

The three-delay model developed by Thaddeus and Maine in the 1980s placed the need for reducing delays at the centre of maternal health.[5] During the MDG era, many countries reached remarkable results by reducing distances to and scaling up the number of health facilities.[2] In many places facility births have not been higher than they are today. But the landscape is changing and getting to the hospital is no longer enough.[6] Urbanisation has accelerated demand for care in the big cities. In 2050, 68% of the world's population is predicted to live in urban areas with 90% of the growth taking place in Asia and Africa.[7] Correspondingly, there is a burning need to understand urban maternity care, including quality of continuum of care from conception to birth, infrastructure, social determinants and disease burden.

In resource-constrained settings increased demands without an increase in human resources, facilities and infrastructure may result in overcrowded facilities and contribute to what researchers suggest to be an "urban disadvantage" where rural-urban disparities are narrowing.[8–11] For the first time, a study based on times series of Demographic Health Surveys showed higher neonatal mortality in urban areas of Tanzania compared to rural areas.[8] The same trend appears in other countries, such as Ghana, Ethiopia, Malawi, Uganda, Zambia, and Kenya.[8] In Nairobi, the MMR is almost double the national MMR (706 versus 362 per 100,000 live births).[12] Hence, the increasing proportion of facility births has yet to be matched with intra-facility quality care. We know from other fields of medicine that a high workload negatively influences health outcomes.[13,14] Within maternal health, studies suggest that overcrowding influences care practices and Miller et al. explain how interventions are over- and underused in settings with limited resources.[15–17]

The stagnating maternal and perinatal deaths in Dar es Salaam have occurred despite a rapid increase in caesarean sections.[18–20] As prolonged labour is the leading cause of caesarean sections globally, studying prolonged labour may explain the reasons behind the rise in caesarean sections while also providing insight

into the provision of care in urban hospitals.[21] Appropriate management of labour requires patience, with continuous caring support being the cornerstone.[22] This corresponds poorly to urban congested settings with a lack of human resources and space at facilities. While studies report substandard management around labour progression in low-resource settings, little research has been conducted focusing on urban high-volume maternity units.[8,23–26]

Substandard prolonged labour management may lead to maternal and perinatal deaths, lifelong disabilities due to hypoxia or neonatal sepsis, dangerous caesarean sections, injuries to the maternal pelvic floor and traumatic birth experiences, all of which reach into the postpartum period and the wider lives of women and families.[2,27] To meet the global targets of an MMR of 70 deaths per 100,000 live births, 10 stillbirths and 10 newborn deaths per 1000 live births, an improved understanding of care provision in urban high-volume hospitals is needed.[28,29]

Birth attendants at the study sites looking at notes/the partograph. Photo by: Lara Meguid.

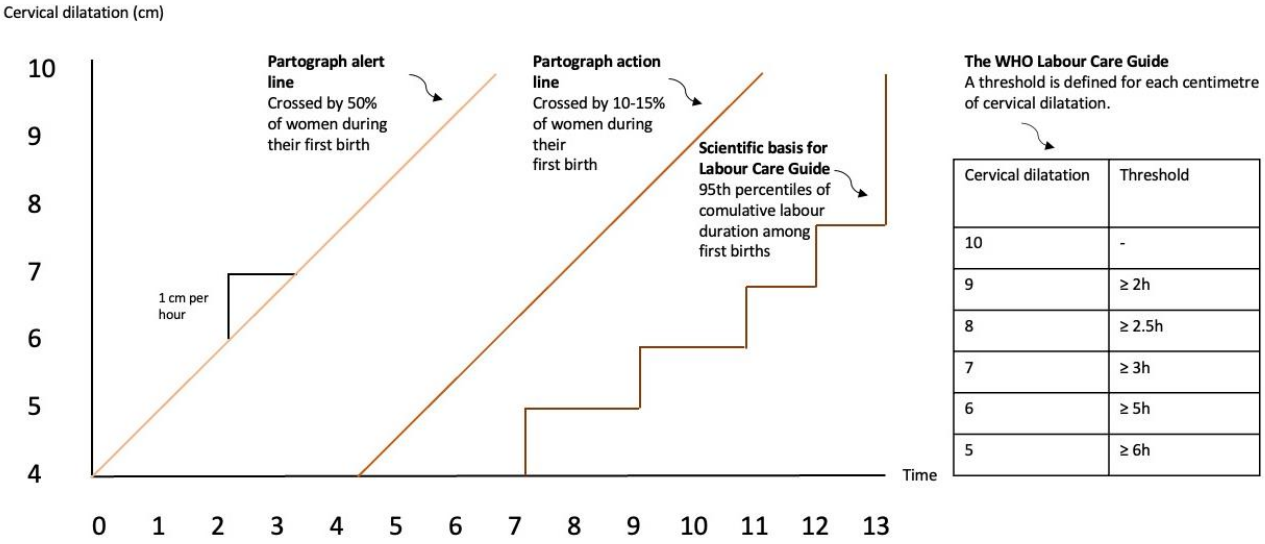
CHAPTER 2: BACKGROUND

Through the lens of urban maternal health, this PhD thesis focuses on the clinical management of labour progression. Estimating the amount of women experiencing prolonged labour is challenged by lack of clarity in defining prolonged labour.[30,31] Some studies base it on progression alone while others base it on whether oxytocin for labour augmentation was applied.[32,33] Even studies using the same definition find huge differences; Oladappo et al. estimates that 15% women in Uganda and Nigeria cross the partograph action line, while Zhang et al find that it is crossed by 47% in a Norwegian cohort.[34,35] This probably reflects substantial facility-level differences in clinical practice and reporting. Factors, such as parity, body-mass-index, maternal age, stage of labour at admission, stage of labour at diagnosis and induction may add to the differences in prolonged labour estimates across settings.

Labour progression curves

Active labour is the most debated phase of labour. Historically, active labour has been visualised on labour curves that depict progression versus time (Figure 1). Since the 1950s, active labour was said to progress with a cervical dilatation of 1 cm per hour from 4 cm until full dilatation, which is also known as Friedman's curve.[36] Friedman's curve gave rise to the partograph, developed by Philpot, which is used in many low-resource settings, including Dar es Salaam.[37–39] The partograph has an alert line, representing a cervical dilatation of 1 cm per hour and an action line four hours after (Figure 1).[36] Studies from the United States, Sweden, Nigeria and Uganda dating back to 2002 have questioned the 1 cm-per-hour-rule as unrealistically fast and suggest a more tolerant labour curve with a hyperbolic pattern (Figure 1).[40–47] Particularly before 6 cm, cervix may take 5-6 hours to dilate 1 cm. Zhang and colleagues tested this tolerant labour curve against the partograph action line in a Norwegian population and found no differences in interventions and outcomes.[48] They did, however, find a reduction in caesarean sections in both groups, suggesting a general effect led by an increased focus on reducing caesarean sections.[48] The American Society of Obstetrics and Gynaecology found that diagnosing prolonged labour only after 6 cm of cervical dilatation and minimum four hours of arrest with good contractions reduced caesarean sections.[21] Several labour progression tools have been suggested but none, since the partograph, has managed to reach global consensus.[48–51] The World Health Organisation (WHO) recently introduced its Labour Care Guide based on the tolerant labour curve (Figure 1).[22,41,44,52] Research shows satisfaction from health providers and non-significant reductions in oxytocin use (from 27.3% to 9.3%, relative risk, 0.85; 95% Confidence Interval (CI), 0.54–1.33) and caesarean sections (from 45.2% to 39.7%, relative risk, 0.34 95% CI, 0.01–15.04).[49,53] It is currently being implemented in a few places while most settings still use the partograph.

Figure 1: Prolonged first stage of labour according to the WHO partograph and Labour Care Guide



Alert line: If women follow the alert line, their labour progresses 1 cm per hour.
Action line: Is placed parallel, four hours after the alert line.
Hyperbolic labour curve: Labour progression curve based on 2,166 nulliparous singleton, vertex, term pregnancies giving birth vaginally. Multistate markow analysis. *Oladapo OT, Souza JP, Fawole B, et al. Progression of the first stage of spontaneous labour: A prospective cohort study in two sub-Saharan African countries. PLoS Med. 2018 Jan 16;15(1):e1002492.*

Maaløe et al. Inconsistent definitions of labour progress and over-medicalisation cause unnecessary harm during birth. BMJ 2024.

Causes of prolonged labour

Despite limited research in labour pathophysiology, a variety of underlying causes have been suggested.[30] Traditionally the 3 P's, Power, Passenger and Pelvis have been used to distinguish between causes.[54] Power relates to inadequate contractions. This can be caused by either by uterine muscle fatigue with associated hypoxia and increased lactate in the uterine muscle or inadequate natural oxytocin.[55–57] Pelvis and passenger relates to mechanical disproportion, where contractions are adequate but the foetal presenting part fails to pass through the maternal pelvis.[30] Mechanical disproportion may lead to obstructed labour where caesarean section is the only treatment.[30] Regardless of the underlying cause, all women are recommended a trial of labour and management regimens in guidelines are the same.

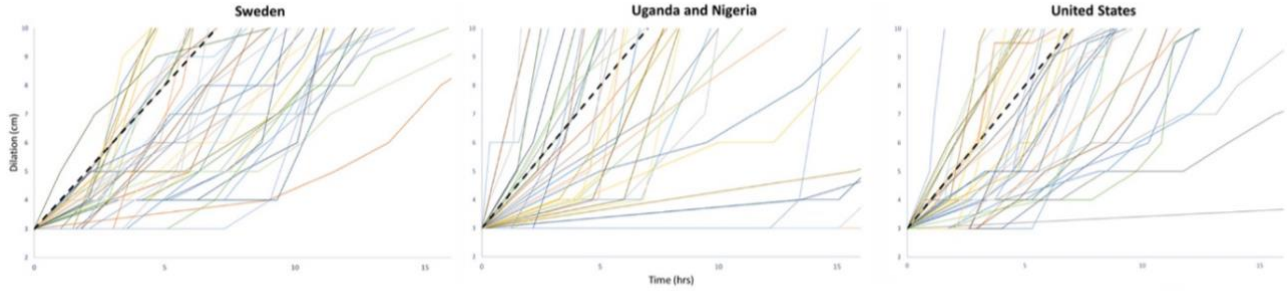
Prolonged labour outcomes

While prolonged labour alone has shown to be a poor predictor of adverse outcomes, obstructed labour can cause severe harm.[58,59] However, so can the use of medical interventions such as oxytocin to augment labour and caesarean section.[59–61] The poor correlation between labour duration and outcomes is probably because women's individual progression varies greatly (Figure 2, coloured lines) and other factors mediate how foetuses tolerate labour.[40,44,62] Hamilton and colleagues, therefore, argue against the relevance of using average population curves.[31] In contrast, recent progression studies identify "slowest yet normal progression curves", defined as the 95th percentile of women with vaginal birth and good outcome (Figure 1).[41,44] Importantly, they represent "normality" rather than "abnormality". While applying this strategy is reassuring

for low-risk women with slow labour and can prevent interventions, it may delay action for high-risk women. It requires appropriate monitoring as a long labour including its interventions is not tolerated by all foetuses and risks of postpartum haemorrhage and chorioamnionitis increase with labour duration above twelve hours.[62–64] Concludingly, clinicians must focus on identifying vulnerable foetuses where the combination of labour duration and interventions may be fatal.[62] Thus, average labour duration thresholds must be used with caution.[62]

Particularly in low-resource settings, the balance between risks and benefits is difficult to establish.

Figure 2: A random sample of nulliparous dilatation patterns from three countries



Individual dilatation (coloured lines) and the alert line (dashed black line) from random sample of nulliparous women from Sweden, Uganda and Nigeria, and the United States
Hamiltion. Evolution of the labor curve. Am J Obstet Gynecol 2023.

Mechanical disproportion, where there is a misfit between the foetus and maternal pelvis, is a rare but feared cause of prolonged labour where caesarean section is the only treatment.[30] In the distant past, women and babies died from obstructed labour because there were no treatment options if the baby could not pass through the birth canal. Caesarean sections became a life-saving milestone in medical history and where women do not have access to a caesarean section they still face substantial mortality from obstructed labour.[59] But even for survivors, long-term sequelae are reported.[59] This includes physical disabilities, such as vaginal fistulas and pelvic floor dysfunction and substantial psychological and social disabilities.[59] Fistulas leave women impoverished, living in life-long isolation and excluded from society due to stigma, and suffering a stillbirth can lead to depression and anxiety.[59] Not all long-term sequelae are counted in global disease burden estimates and therefore go largely unnoticed.[59] Survivors from obstructed labour in low-resource settings are, therefore, a highly neglected group. Appropriate intervention on time is crucial in preventing death and disabilities from obstructed labour and its treatments.

Management of labour progression

Management of prolonged labour includes non-medical interventions (amniotomy, ambulation, hydration, urination and birth companionship), medical interventions (oxytocin and vacuum-assisted birth) and caesarean section as a last resort.

Non-medical interventions

Non-medical interventions have been suggested to prevent or treat prolonged labour. Most of these practices have been scarcely researched and except for hydration in women where free fluid is restricted,[65] continuous birth support[66] and ambulant upright position,[67] recommendations for these are weak.[54] Less researched but increasingly recognised to influence labour progression, and the lack thereof, are mental distress and pain.[55,68] Non-medical interventions are recommended if labour is slowing down or as part of basic labour care but not to treat prolonged labour.[22]

Synthetic oxytocin

Synthetic oxytocin was discovered in the 1950s. It is identical to the body's natural oxytocin and is, among others, used to augment labour by stimulating contractions. It was highly welcomed as prolonged labour occasioned severe perinatal mortality and morbidity.[58,59] Regimens for oxytocin for labour augmentation differ around the globe and no consensus seems to exist on its appropriate use.[69] In 12 countries, 21 different regimens were identified.[69] Studies reserving oxytocin to women crossing the partograph action line reduce overall use to 10-15% without an increase in caesarean sections while rates up to 93% are reported.[37,70,71] Oxytocin applied to augment labour reduces labour duration by two hours in low-risk women with delayed labour but has no documented effect on caesarean section in underpowered randomised controlled trials (RCTs).[72,73] In too high doses, oxytocin may cause harm to women and their foetuses.[74,75] Potential complications of its use include uterine rupture and stillbirth.[54]

The required dose of oxytocin to augment labour differs per individual and correct dosing requires titrating oxytocin against the woman's contractions whilst monitoring the foetal heart rate (FHR). Dosing in many low-resource settings often happens by visual drop count rather than electronic infusion, which is time-demanding and increases the risk of under- or overdosing.[76] The website, UpToDate, which synthesises evidence into global clinical recommendations, recommends only using oxytocin to augment labour if continuous monitoring is possible, while the WHO states that women must not be left unattended.[54,77] Importantly, Cochrane reviews of oxytocin for labour augmentation fall short by mainly including studies from high-income countries (HIC).[72,78,79] Therefore, the use of oxytocin for labour augmentation in low-resource settings is poorly understood.

Vacuum-assisted birth

Vacuum-assisted birth can be applied during the second stage of labour if the foetal head is below the level of the ischial spine and there are no progressive signs of obstruction. In such cases, it can prevent a caesarean section and is associated with decreased mortality.[80] Studies from Tanzania have reported

underutilisation of vacuum-assisted birth.[81,82] Causes include lack of equipment and training and myths around this practice from both health providers and women.[82]

Caesarean section

Prolonged labour is the leading cause of caesarean section in unscarred uteri and is thought to be a crucial driver for the increasing caesarean section rates.[23,83–88] It is estimated that between one-third to one-fourth of all caesarean sections are performed because of prolonged labour.[23,25,26,89,90] Studies suggest that many of these caesarean sections are carried out on doubtful indication or without appropriate management preceding the caesarean section.[23,25,26,91] While caesarean sections can be lifesaving, the rise in caesarean sections globally without decrease in adverse perinatal outcomes is concerning.[60,88,92,93] In Sub-Saharan Africa, women's risks in relation to caesarean section is hundred times the risk for women in HIC.[60] The risk of complications following surgery is 18.2% in Africa, with 2.1% patients dying.[94] In addition, the risk of uterine rupture, placenta accrete spectrum disorder and ectopic implantation in subsequent pregnancies, particularly in areas with poor access to surgery, may be fatal.[95,96] Compared to vaginal birth, the risk of short-term severe maternal outcomes is fifteen fold in caesarean sections without medical indication.[97] Caesarean sections are costly and the human and material resources spent on unnecessary caesarean sections may indirectly cost lives elsewhere.[98–100] Recommendations on when prolonged labour should lead to a caesarean section remain vague in most guidelines.

Clinical challenges related to management of labour progression

Multiple studies from Sub-Saharan Africa have suggested substandard management of prolonged labour where caesarean section was conducted without preceding rupture of membranes, oxytocin for labour augmentation and vacuum-assisted birth.[23,24,26,82,85,91,101] Other studies describe overuse of oxytocin for labour augmentation driven by local demands from communities and women themselves and low focus on risks associated with oxytocin from women, societies and health providers.[102–105] Studies identify lack of skills in diagnosing prolonged labour and timing of interventions (oxytocin for labour augmentation and caesarean sections).[102–104,106,107] This represents two poles: care that is “too little, too late” and care that is “too much, too soon” which seem to co-exist.[17] Looking particularly at congested maternity units, shortages of beds and hands have been described as reasons for nearly universal oxytocin use for labour augmentation in Egypt where one health provider had to look after up to 20 women.[105,108] The consequences of congested urban maternity units on prolonged labour outcomes have received little attention. Maaløe et al. describe sub-standard monitoring of labour and high use of oxytocin for labour augmentation in Zanzibar’s tertiary hospital with 3-6 labouring women per birth attendant and Osaki et al. describe how low health provider-to-women ratio at the study sites included in this thesis lead to delays in decision making.[109,110]

This PhD thesis seeks to understand how labour progression is managed by reviewing existing literature and using five urban high-volume hospitals in Dar es Salaam as a case study. Time-scarcity, resulting from many women giving birth and few staff conflicts with slow physiological labour. Choosing an urban setting as the case study, I wished to explore how the mismatch between time availability and time needed for physiological labour materialises in reality.

The outside of one of the hospitals (left) and a Pinard stethoscope (right). Photos by: Lara Meguid

CHAPTER 3: OBJECTIVES

Nested in the PartoMa Intervention, this PhD study aimed to investigate management around labour progression and co-create prolonged labour decision-support tools that suit the overburdened, congested, urban maternity units.[111,112] Particularly, this PhD study fed into the situational analysis of the PartoMa intervention to gain an in-depth understanding of how prolonged labour was managed and challenges in providing best possible care. Findings included in this thesis were used when developing PartoMa guidelines on prolonged labour for five hospitals in Dar es Salaam.

Overall objective

To investigate the management of labour progression globally, with an in-depth case study of five urban maternity units in Dar es Salaam, Tanzania.

Specific objectives

i. To evidence labour progression management globally, with a focus on low- and lower-middle-income countries. (Papers I and V)

ii. To explore birth attendants' practices and perceptions of labour progression and oxytocin used for labour augmentation in a maternity unit in Dar es Salaam, Tanzania. (Paper II)

iii. To investigate management preceding caesarean sections in women with an indication of prolonged labour and estimate the proportion of non-medically indicated caesarean sections. (Papers III and IV)

Outside and inside the hospitals showing laundry, registry books, stock-outs and Pinard fetoscopes.
Photos by Tarek Meguid, Lara Meguid and Monica Kujabi.

CHAPTER 4: SETTING AND CONTEXT

The United Republic of Tanzania is a country in East Africa covering 945,000 square kilometres, with a population of 61,741,120 in 2022 (44,928,923 in 2012). The country consists of Mainland Tanzania (59,8851,347 people) and Zanzibar (1,889,773 people). Statistics for Tanzania (Mainland and Zanzibar combined) from the demographic health survey of 2022 are available in Table 1. Its urban population has increased from 18.3% in 1996 to 29.6% in 2022. Basic drinking water is available for 63.8% of the population, life expectancy is 62 years and fertility rate 4.8 (3.6 in urban areas and 5.5 in rural areas).[20] The climate is tropical with two rainy seasons. The Tanzanian economy relies heavily on agriculture. Tanzania has sustained impressive economic growth over the past 20 years and reached middle-income status in 2020. The country, however, still ranks as one of the fifteen poorest nations in the world and more than two-thirds live below the poverty line.

Maternal and perinatal health in Tanzania

Between 1996 and 2022 Tanzania experienced an impressive improvement in maternal and child health (Table 1). Maternity mortality ratio reduced from 529 to 104 per 100,000 live births, early neonatal deaths reduced from 88 to 20 per 1,000 live births and under-five mortality reduced from 137 to 43 per 1,000 live births.[18,20] Devastatingly, however, perinatal mortality seems to have stagnated since 2010 and is higher in urban than in rural areas.[8,27,113] This is surprising as urban areas are typically expected to have lower mortality rates. Reasons suggested include underreporting of perinatal mortality in rural areas and inclusion of peri-urban areas. It is, however, worth noting that post-neonatal and child mortality find an opposite trend, with higher mortality in rural areas.[19,20] This strongly calls for a focus on intrapartum care to reduce this urban disadvantage in maternal and neonatal health. The main causes of maternal mortality continue to be haemorrhage, hypertensive disorder, obstructed labour and sepsis, while neonatal deaths are due to birth asphyxia, sepsis and malaria.[27] Though maternal and neonatal care is free in Tanzania, out-of-pocket fees are often applied and women are expected to bring cotton wool, gloves, intravenous-sets and a catheter for birth.[113]

Table 1: Characteristics of Tanzania based on Demographic Health Surveys 1996 and 2022

	1996	2022
Population and livelihood indicators		
Total population	44,928,923 (2012)*	61,741,120*
Urban population	18.3%	34.9%*
Population growth rate	2.7 (2012)*	3.2%*
Urban growth rate		4.8%*
Basic drinking water service	-	63.8%
Health insurance	-	10%
Life expectancy	50 years	62 years
Formal education, women	51.7%	79%
Formal education, men	60.5%	84%
Maternal and neonatal health indicators		
Maternal mortality ratio	529 per 100,000	104 per 1,000,000
Under five mortality rate	137 per 1,000	43 per 1,000
Early neonatal mortality rate	88 per 1,000	20 per 1,000
Stillbirth rate > 28 weeks' gestation	-	18 per 1,000
Fertility rate	5.8	4.8
Women aged 15 to 19 with a live birth	26%	16%
Currently married women using contraceptives	18%	38%
Unmet need for contraceptives for currently married women	20%	21%
Facility births	47%	81% (75% in public hospitals)
Birth by skilled birth attendant	48%	85%
Antenatal care, 4 or more	70%	65%
Caesarean section rate	2%	11%

Demographic health survey 1996 and 2022. *Population distribution report, Tanzania 2022

The Tanzanian health system

Health care is provided by governmental hospitals, non-governmental organisations and the private sector and women choose where to receive care (Table 2). As private hospitals are typically more expensive, public hospitals cater to women of low socioeconomic status.

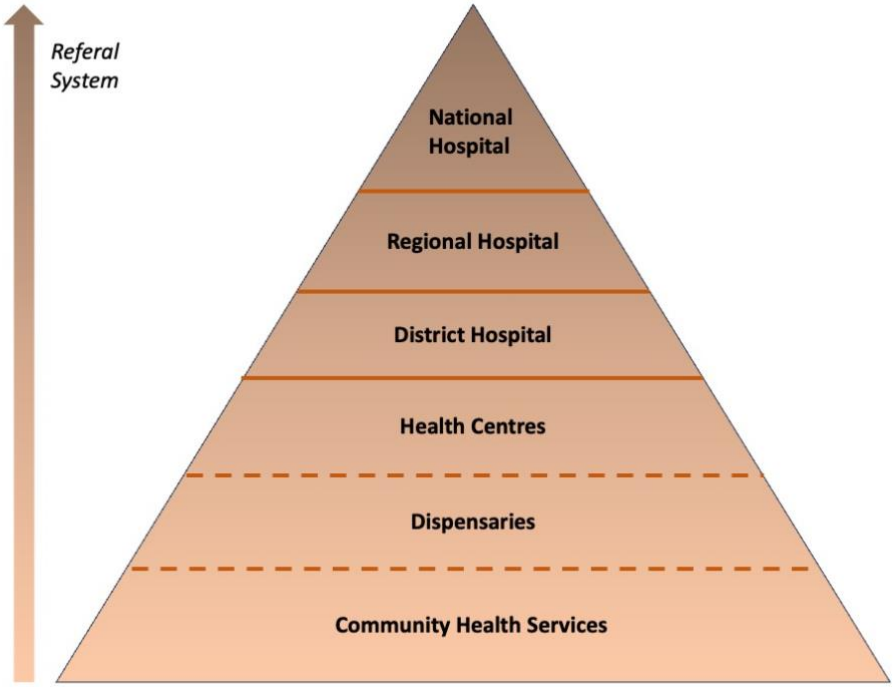
Table 2. Number of government and NGO/private health facilities in Tanzania

Facility	Government	NGO/private	Total
Hospitals	207	197	404
Health centres	679	277	956
Dispensaries	5491	1698	7189
Total	**6377**	**2172**	**8,549**

Source: Ministry of Health, Community Development, Gender, Elderly and Children, statistical abstract of 2021.

The referral system has a pyramidal structure from dispensaries and health centres to district and regional hospitals (Figure 3). Dispensaries and health centres provide basic essential obstetric services, while hospitals provide comprehensive obstetric services, including blood transfusion and caesarean sections. Regional and national hospitals provide specialist services. Women are referred from dispensaries or health centres (whether private or public) to hospitals and to the national tertiary hospital. All levels cater to low-risk women coming from home.

Figure 3: Pyramidal structure of the Tanzanian referral system



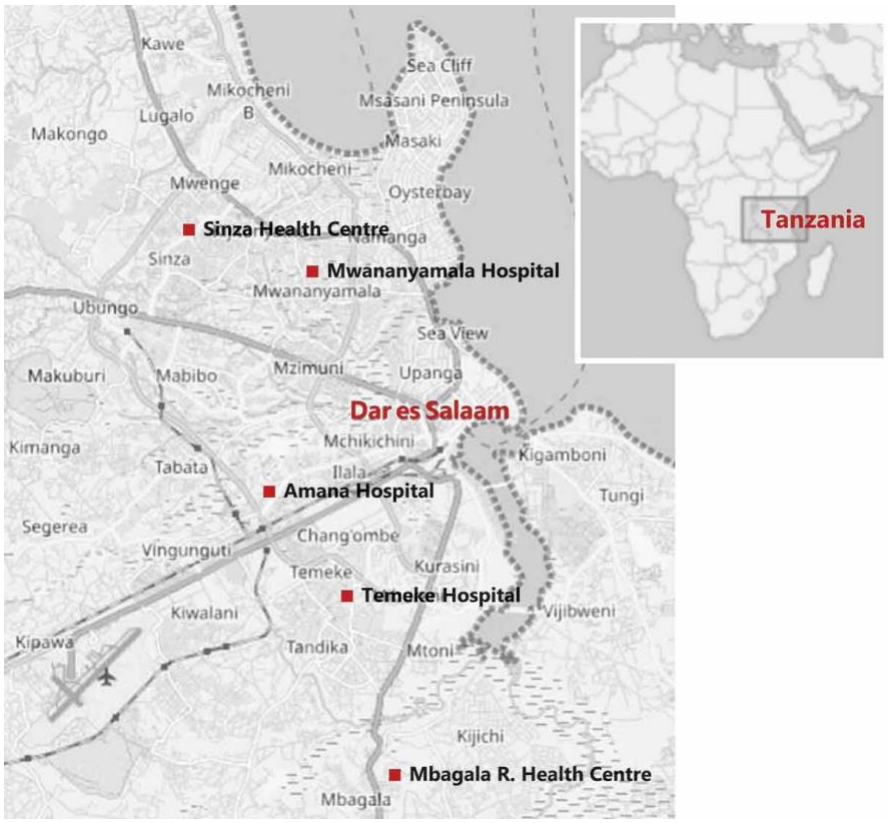
With 0.6 nurses-midwives per 1,000 people in 2018, Tanzania suffers from an extreme shortage of staff.[114] According to the WHO, the estimated minimum required number of physicians, nurses and midwives is 4.45 per 1,000 population. [115] Doctors are centred in urban areas and many specialist doctors support their income by serving private clinics. Maternity care is provided by nurse-midwives, intern doctors, registrar doctors and specialist doctors. In 2006, the shortage of staff in government hospitals was estimated to be 65% and in 2008 the Ministry of Health declared a workforce crisis resulting from a decline in workforce concurrently with an increasing population.[116] Tanzania experienced a doctors' strike in 2012 and went through a retrenchment in 2016.[117] To date, the country suffers from an extreme shortage of staff in both rural and urban health facilities.

Dar es Salaam

The setting of intrapartum care in Dar es Salaam is relevant to explore the urban disadvantage in perinatal health earlier described. Dar es Salaam, where Papers II-IV were conducted, is the biggest city in Tanzania and among the fastest-growing cities in Africa (Figure 4).[118] From 2.3 million people in 2000, Dar es Salaam is projected to become a megacity with ten million people by 2030.[119] Dar es Salaam suffers from heavy traffic, flooding due to poor draining systems and increasing inequalities with huge urban slums.[120]

While perinatal mortality has stagnated, this contrasts the increase in caesarean sections in Dar es Salaam from 17% in 2015 to 26% in 2022.[18,19,121] Such rapid increase without simultaneous reduction in maternal and perinatal deaths calls strongly for exploration of intrapartum factors. According to the latest demographic health survey, 90.2% of women received four antenatal care visits and all women gave birth at a health facility with a skilled birth attendant, of which 90% occurred in public health facilities.[20,117] Answers to the trends observed, therefore, may unfold upon looking closer into intrahospital care provision around birth. In Dar es Salaam, three health facilities catered for 90% of the city's 69,008 annual births.[117] Such centralisation resulted in extreme congestion and overburdened staff.[117,122,123] These three hospitals are included in this study (Figure 4).

Figure 4: Map of Dar es Salaam



The five hospitals included are marked with a square.
Source: Open Street Map.

The five study hospitals

Data collection for Papers II-IV was conducted at five mega maternity units between March 2021 and September 2022 (Figure 4). They included two district hospitals, Sinza and Mbagala, and three regional referral hospitals, Temeke, Amana and Mwanyanamala. Table 3 provides data on the characteristics of the five maternity units.

The five hospitals are government-run and cater to women of low socio-economic status. The five maternity units have the highest number of annual births in the Dar es Salaam region. In 2011, the biggest of them had 22,666 annual births. In 2019, the three regional referral hospitals introduced user fees to support shortage of supplies and to decongest the maternity units by encouraging women with uncomplicated pregnancies to deliver, free of charge, in other facilities. This led to a 41% reduction in births from 2011-2019 in the three regional referral hospitals and an increase in births of 125% and 544% in the two district hospitals. In 2021, the hospitals had 30-52 nurse-midwives and 12-14 doctors employed to assist in the 6,089 to 9,085 annual births. There was a high staff turnover and a big teaching obligation. In 2019, MMR at the hospitals were 25 – 162 per 100,000 live births, perinatal mortality was 23 – 53 per 1,000 live births, caesarean section rate 20% – 43% and vacuum assisted birth 1.6% - 4.4%. These numbers are from the PartoMa baseline study, which have not yet been published. Numbers are visualised in Table 3.

The structure of the five hospitals is similar. They are divided into an antenatal ward, labour/delivery ward and postnatal ward. Mbagala differs from the others by having a combined antenatal and labour ward with two separate beds for birth. Each ward has a designated team. For example, Mwanyanamala has 22 beds in the antenatal ward staffed by 12 nurse-midwives and 16 beds in the labour ward staffed by 16 nurse midwives. The hospitals have one to two theatres dedicated for obstetric surgeries. Women with obstetric complications are referred to Muhimbili National Hospital if intensive care is needed. Mwananyamala and Amana Hospitals have a Neonatal Intensive Care Unit for babies with severe complications. From the remaining hospitals, babies are transferred to higher facilities and severely ill babies are referred to Muhimbili National Hospital.

Table 3: Characteristics of the five included hospitals

	Mbagala	Sinza	Amana	Mwananyamala	Temeke
Facility type	District hospital	District hospital	Referral Hospital	Referral Hospital	Referral Hospital
Catchment population size	77,317	20,000	31,083	2,226,692	1,526,881
Maternal and newborn health					
Annual births, 2011*	1,870	4,182	22,666	16,353	21,093
Annual births, 2019*	12,039	9,412	13,707	11,149	9,893
Total number of deliveries (2021)	9,085	7,972	7,997	7,446	6,089
Maternal mortality ratio per 100,000	25	151	88	162	146
Perinatal mortality per 1,000 life births	25	23	52	53	48
Caesarean section (%)	20	22	26	43	34
Vacuum-assisted birth (%)	1.6	1.8	4.4	2.7	2.0
Space					
Number of antenatal(pre-labour) beds	12	10	20	22	14
Number of beds in labour ward		7	12	16	12
Post partum beds	25	16	84	40 (mixed with other surgical patients)	34
Number of maternity theatre rooms	2	2	1	2	2
NICU	No	No	Yes	Yes	Yes
Staffing					
Number of staff in maternity	60	69	43	65	64
Nurse-midwives	36	32	30	52	52
Antenatal	24	6	12	12	10
Labour ward		9	10	16	15
Postnatal	13	10	8	24	27
Specialists	2	3	4	5	3
Non-specialist doctors	12	9	9	8	9

Numbers are from the PartoMa baseline study, which is based on MTUHA.

*Based on data from MTUHA (registration system in Tanzania)[117]

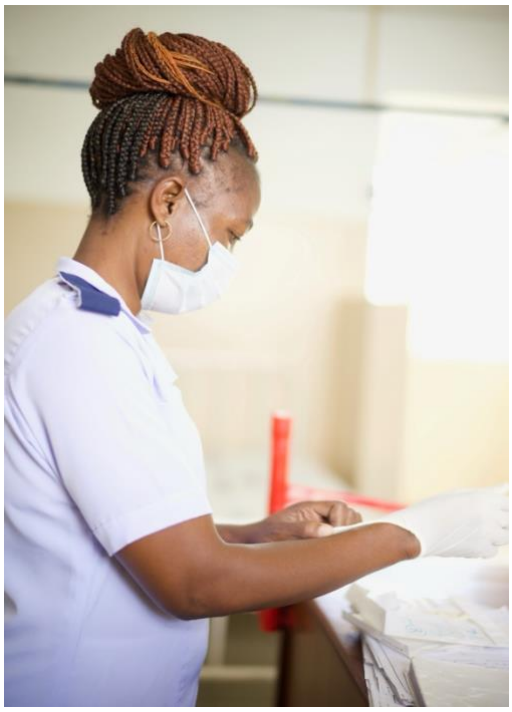
The facilities have clinical protocols on different topics posted visibly on the walls. However, no guidelines were found on routine labour monitoring and management, oxytocin augmentation, prolonged labour management and pain treatment. The WHO partograph is used to monitor labour. One hospital (Paper II) had a standard operating procedure in place, whereby women must give birth within six hours (multiparous) or eight hours (nulliparous) of reaching the labour ward. There were no financial incentives related to caesarean sections. Foetal heart rate is monitored intermittently with Pinard fetoscope or Doppler ultrasound and oxytocin for labour augmentation is given through infusion-sets without an electronic drip-count. Often, only 1-2 blood pressure machines and foetal heart monitoring devices are available for all of the antenatal and labour wards.

In the labour room, beds are lined side by side. Privacy is provided in the form of curtains and screens. As beds are lined side by side, upright ambulant position is possible but the space is scarce. Women usually share beds in the antenatal and postnatal wards and have their own bed when in active labour. The beds are stationary and not made for different birthing positions. Toilets are available, although cleanliness and function are not optimal. The health facility does not allow birth companionship during labour, childbirth and

the immediate postnatal period and relatives are asked to leave or to wait in an outdoor space. Women are not allowed their mobile phones in the hospital.

While maternal and newborn health is free, women often have to pay for laboratory tests and medications such as antibiotics. Women are also expected to buy their own delivery pack consisting of catgut suture, syringe, surgical blade, cord clamp, four pairs of surgical gloves, cottonwool, pads and two disposable macintoshes. Unofficial payments to individual staff or the hospital are prohibited. At Temeke, women pay 6,000 TZS (1 dollar = 2,500 TZS) for registration, 25,000-75,000 TZS for vaginal delivery, and 50,000-200,000 TZS for caesarean section.

Essential medicines and intravenous fluids are mostly available; however, often intravenous sets and urine catheters are out of stock. Oxytocin is mostly present and stored in a refrigerator. Analgesia during labour is not available. All hospitals have electricity around the clock and running water. However, water is not safe for drinking and this must be either brought or bought.



A box with case files (top). Birth attendants (low left) and a research assistant entering data (low right). Photos by: Lara Meguid, Brenda D'Mello and Nanna Maaløe.

CHAPTER 5: METHODOLOGY OF THE THESIS

This section firstly describes the pre-conceptions and position in scientific disciplines and thereafter how the PhD is nested within the PartoMa intervention and the framework used for the thesis. It ends with a definition of prolonged labour applied throughout the thesis. The methodology of the individual studies is described later.

Reflexivity and pre-conceptions

As argued by Alvesson et al., qualitative researchers draw on pre-conceptions in their work and knowledge is never developed from "ground zero".[124] It is therefore crucial to acknowledge and carefully consider the role of pre-conceptions in the study.[124] Before engaging with the PhD study, I had obstetric clinical experience from Denmark, Sierra Leone and Somaliland. In Sierra Leone and Somaliland, I experienced how challenging oxytocin drips were to administer without advanced equipment. I was often worried, because in Denmark, I was used to cardiotocography to monitor the foetus. This worry led to my initial interest in oxytocin for labour augmentation in low-resource settings.

My position as an "outsider" with obstetric experience from other settings appeared crucial in recognising and reflecting on the practices.[125] My pre-conception was different from the pre-conceptions of the Tanzanian health providers. My thorough understanding of clinical obstetrics enabled me to deeply explore the mechanisms at play around the management of labour progression and areas of particular concern in clinical practice. I did not approach the research with the intention to confirm or reject any hypotheses. Instead, the research was driven by an interest in understanding how prolonged labour, particularly oxytocin augmentation, was managed and the challenges associated with it in these busy hospitals. While I had a clear idea of my research subject other aspects of labour care received less focus.

On multiple occasions, findings were informally and thoroughly discussed with a Tanzanian PhD fellow and obstetric specialist, Brenda D'Mello with 20 years of experience in different hospitals in Dar es Salaam as well as specialists and leaders from the study hospitals. This facilitated a more profound reflection and understanding of the healthcare setting in Dar es Salaam than what I, as an outsider, had. This also meant that findings represent pre-conceptions of the people I engaged with. In my case, pre-conception was a circular process where initial pre-conception became enriched and perhaps more complete through the research.[124] Furthermore, my qualitative findings were triangulated with quantitative data.

Position in scientific disciplines

This thesis engages implicitly with post-positivistic epistemology, challenging positivist tenets by recognising the limitations of objectivity.[126] Employing mixed-methods research, it combines qualitative and quantitative approaches, reflecting a post-positivist acknowledgement of the complexity inherent in prolonged labour

management in crowded hospital settings and recognising the value of both data types. Qualitative insights align with post-positivism's emphasis on context and interpretation, for example in understanding the use of oxytocin for labour augmentation. Quantitative findings add objectivity.

In addition to post-positivism, the thesis resonates with pragmatic epistemology, emphasising the practical consequences and utility of knowledge. The mixed-methods approach pragmatically acknowledges the unique strengths of different research methods, while not practicing any of these to perfection. Emphasising on context adaptation in the discussion and conclusion, the thesis aligns with pragmatism, underscoring the practical relevance of the research.

In summary, the thesis embraces post-positivistic epistemology through its methodological choices and a pragmatic orientation emphasising practical application to address real-world challenges.

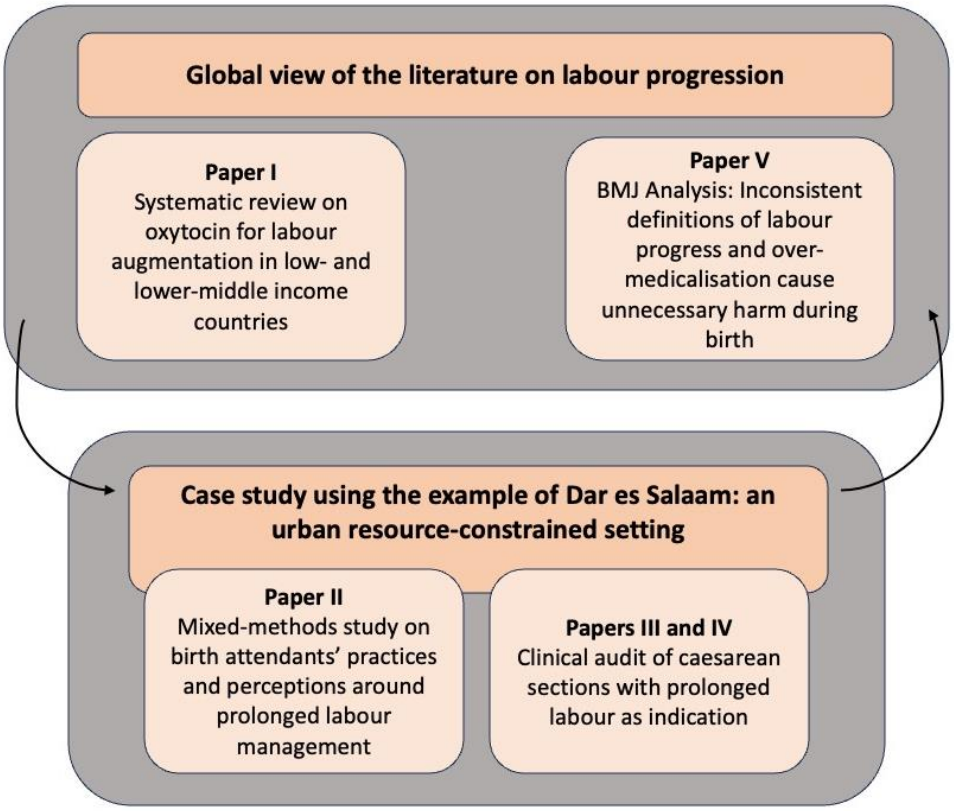
Nested within the PartoMa intervention

The PhD study is nested within the larger PartoMa Intervention: enabling best possible childbirth care in Tanzania.[111,112] The PartoMa intervention co-created context-adjusted clinical practice guidelines for intrapartum care with birth attendants in Tanzania. The guidelines were formatted into the PartoMa booklet (publichealth.ku.dk/partoma/). The content was based on available evidence and a thorough situational analysis and underwent multiple rounds of adjustments to suit the needs of staff and ensure feasibility, given the resource-constrained context. The PartoMa intervention was conducted in five mega maternity units in Dar es Salaam, Tanzania. This PhD study feeds into the PartoMa Intervention by adding to its evidence base and situational understanding of management of labour progression in the five urban high-volume maternity units. The findings of this PhD study were used to co-create context-adjusted guidelines for prolonged labour management for the five facilities. Other parts of the PartoMa Intervention can be found in the study's protocol papers.[111,112]

Framework of this PhD

The thesis is organised in two parts: A global view, including reviews of literature on labour progression with a focus on low-resource settings and a case study of five urban maternity units in Dar es Salaam (Figure 5).

Figure 5: Framework of the PhD thesis



Reviewing existing literature serves as a valuable method for outlaying research discoveries, demonstrating evidence at a meta-level and revealing gaps that warrant further investigation. Conversely, employing a case study approach enables thorough, multi-faceted explorations of intricate issues within their real-life contexts.[127,128]

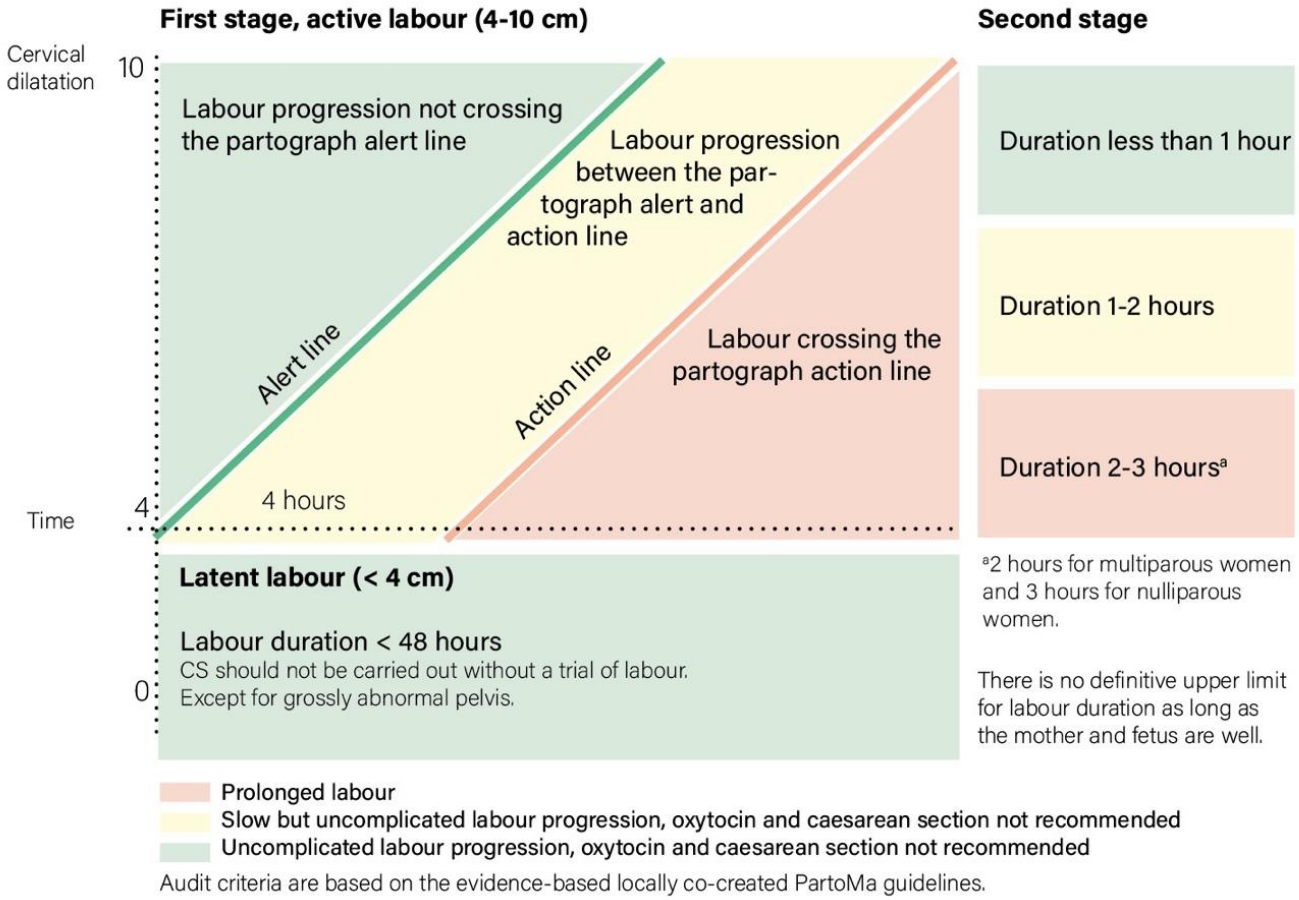
These two components mutually complement each other, offering a comprehensive examination of prolonged labour, both from a macro viewpoint and in a real-life setting. This provides more depth into understanding the complexity of labour progression. Dar es Salaam is an example of marked urbanisation. Although the findings from one extreme case may possess limited generalisability, instances of extremity confer an advantage by "revealing more information because they activate more actors and more basic mechanisms in the situation studied".[129] Given the escalating trend of urbanisation, it is probable that numerous settings will encounter similar challenges in due course.

The thesis commences with Paper I, presenting a systematic review addressing the utilisation of oxytocin in managing prolonged labour in LLMIC. This review shows national-level oxytocin for labour augmentation rates, the timing of oxytocin administration based on the partograph and the perinatal adverse outcomes associated with oxytocin for labour augmentation. Afterward, the thesis delves into the specific case of Dar es Salaam through a mixed-methods study outlined in Paper II. This study explores the strategies employed for managing prolonged labour, as well as the utilisation and perceptions surrounding oxytocin for labour augmentation within one of the five hospitals in Dar es Salaam. Papers III and IV scrutinise 2,949 caesarean sections across the five hospitals, focusing particularly on those attributed to prolonged labour. They explore management leading up to the caesarean section and assess whether labour was indeed prolonged at the time of the decision. The thesis culminates at a global scale with a critical review of the existing evidence-practice gaps within prolonged labour management. This synthesis incorporates insights derived from Papers I-IV, framing them within a global perspective.

Definition of prolonged labour

The definition of prolonged labour used in this thesis follows the WHO partograph used in Tanzania and many other low-resource settings. The definitions are based on the PartoMa clinical guidelines creating best possible, evidence-informed obstetric standards when taking the local context into account.[130] The PartoMa guideline was peer-reviewed by an external committee of experts and is in alignment with international guidelines.[86,131] The definitions are shown in Figure 6 below and place labour progression into 3 categories: 1) normally progressing labour (green); 2) slow labour progression (yellow); and 3) prolonged labour (red). Definitions are applied separately for women who had not reached active labour, women in first stage of active labour and for women in second stage of labour at time of caesarean section decision.

Figure 6: Definition of prolonged labour used in this thesis



Audit criteria are based on the evidence-based locally co-created PartoMa guidelines.

A live-born and a still-born baby. Photo by: Monica Kujabi.

CHAPTER 6: ETHICAL CONSIDERATIONS

Ethical approval for The PartoMa Scale-Up Study was obtained from the Tanzanian National Institute of Medical Research (NIMR/HQ/ R.8a/Vol. IX/3324, NIMR/HQ/R.8c/Vol. I/1679, NIMR/HQ/R.8c/Vol. I/926). Further permission was obtained from the Tanzania Commission of Science and Technology, regional and district medical officers in Dar es Salaam and included hospitals. Women were given an anonymous ID. Thus, the data collected is unidentifiable. Data was collected in Kobo Toolbox and when completed the data will be erased and placed in the sif drive in the University of Copenhagen, a secure personal data storage site. Transcriptions of interviews were placed in the sif drive as well. The PartoMa study is registered in clinicaltrials.gov (NCT04685668). All respondents for interviews gave their written informed consent. Informed verbal consent was obtained from women and staff during observations.

During my fieldwork, I was stationed in a maternity unit where I refrained from obtaining a license to practice as a doctor. This decision was made to prevent excessive involvement in caregiving responsibilities. My intention was to engage in discussions with the staff, understand their decision-making rationales for providing care and cognitive processes around their working environment, while refraining from direct interference in their decisions or managerial activities. I did, however, not want to observe instances of substandard care without the ability to intervene, especially in situations where staff were too few. To address this ethical dilemma, I engaged in supportive tasks devoid of decision-making, such as clearing trays and post-birth cleaning. This approach enabled me to contribute meaningfully without assuming direct responsibility for the care of labouring women. While I interacted with the staff and gained insights into the dynamics of a busy labour ward, I deliberately avoided being alone with labouring women. A meeting was held with the staff preceding my fieldwork. They were informed of my presence as a researcher, my focus and what they could and could not expect from me.

In two instances in an extremely busy labour ward, I assisted women in giving birth when no skilled birth attendant was available. In these critical moments, my sense of obligation to provide essential care superseded my role as a researcher. This hands-on involvement provided a deeper understanding of situations where even basic care could not be readily provided. Assisting birth attendants with small tasks during less hectic times fostered a sense of appreciation and strengthened our relationships. For me, this compromise struck a balance between active participation and detached observation.

The ethical dilemma of conducting research in a setting where basic care is not always feasible posed additional challenges. The scarcity of research from such settings complicates the provision of context-adjusted recommendations. Engaging in research, therefore, becomes imperative in the broader context, while solely providing clinical care as a foreigner represents only a temporary solution to more fundamental challenges. Throughout my PhD, I balanced the costs and needs of each project. For example, while

conducting the caesarean section audit, the option of double entry for all case files was considered but deemed too resource-draining. Instead, I opted for double entries only in cases where errors were frequent. Likewise, although the quality of case files was inconsistent, conducting structured observations of 3,000 women to increase data quality would have been immensely expensive and time-consuming. Thus, the study design was tailored to work with the available data, emphasising the importance of balancing costs against potential gains. This does not negate the necessity of conducting expensive, high-quality studies in low-resource settings; rather, it underscores the importance of a careful consideration of costs and benefits when doing research.

Finally, ethical considerations around doing research in a low-resource setting are related to how the research benefit the country. As part of the PartoMa research team we focus on ensuring development of all staff. For example, research assistants were invited to contribute to papers they collected data for and thereby learn about the process of writing manuscripts. Some were offered to engage with further research as master students on the continuing PartoMa project and one Tanzanian PhD student was offered a postdoctoral position to continue with the PartoMa project. Once the PartoMa project ends these individuals will have developed into stronger researchers who can contribute positively to the country. The PartoMa project has a strong local engagement and is driven locally by Tanzanian researchers. Therefore, all decisions are in alignment with local needs and wishes. A dissemination workshop is planned in 2024 to share all findings from the project, including this PhD study, and discuss the way forward. The team continues to raise funds to be able to go on with its work and the Danida Fellowship Centre has already provided a grant to fund the next five-year PartoMa project, where I will be employed as a postdoctoral researcher. It is always difficult to ensure that one's findings are used but staying involved at least enables me to follow up over the next few years. Together with PartoMa team members, I also have other research ideas in the pipeline, which have been developed from the findings of this PhD. However, this relies on the success of raising funds.

One of the labour wards. Photo by: Lara Meguid.

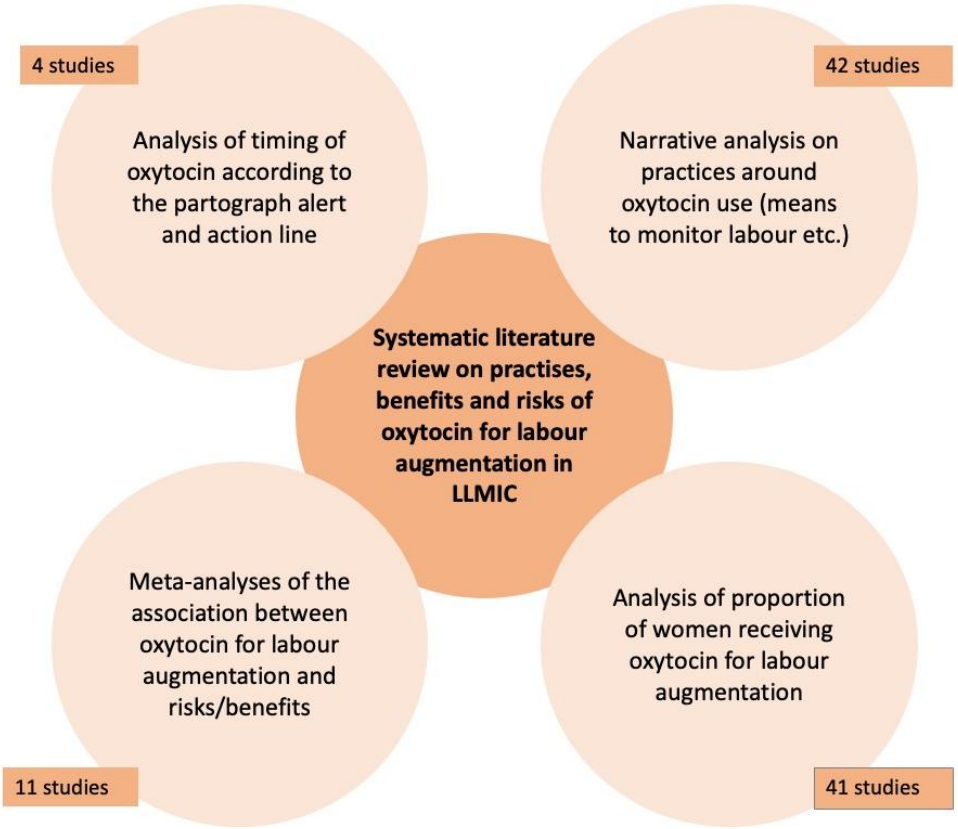
CHAPTER 7: METHODS FOR INDIVIDUAL STUDIES

This thesis employs several methods: Papers I and V are systematic and critical reviews, respectively. Paper II is a mixed-methods study and Papers III and IV are cross-sectional criteria-based audits. They will each be explained below.

Paper I: Oxytocin for labour augmentation in LLMIC: A systematic review and meta-analysis

Paper I of the PhD thesis is a systematic review and meta-analysis. Given the limited number of studies from LLMIC, this study aimed to comprehensively identify research pertaining to the use of oxytocin for labour augmentation specifically conducted in LLMIC. The broad and exploratory analyses include 1) a narrative presentation of the context in which oxytocin is administered (means to monitor labour etc.); 2) a calculation of oxytocin augmentation rates; 3) an evaluation of timing of oxytocin for labour augmentation; and 4) a meta-analysis of the association between oxytocin for labour augmentation and perinatal outcomes (Figure 7).

Figure 7: Areas covered in the systematic literature review (paper I)



Search strategy

The study was registered in PROSPERO using PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.[74] A systematic literature search was conducted in Pubmed, Embase, Psycinfo, Cochrane, Index Medicus and Google Scholar Citations until January 1, 2022.[74] Search terms are provided in Table 4. References of all included studies were screened.[74] English and French publications from peer-reviewed and non-peer-reviewed journals were eligible.[74]

Table 4: Search strings

Search strings	Terms
Oxytocin for labour augmentation	”Oxytocin”, ”syntocinon”, ”augmentation”
Birth outcomes	”perinatal mortality”, “neonatal resuscitation”, “Apgar score”, “neonatal encephalopathy”, “uterine rupture”, “labour duration” and “caesarean section”
LLMICs (World Bank 2020 country classification)	All countries in this group.

Definition of exposure and outcome

Exposure: Oxytocin for labour augmentation, defined as oxytocin given after onset of labour and before the third stage of labour.[74]

Outcome: Intrapartum stillbirth, day-1 neonatal mortality, neonatal resuscitation, neonatal encephalopathy, low Apgar score, caesarean section for prolonged labour, labour duration and uterine rupture.[74]

Inclusion criteria

Oxytocin augmentation rates: Studies providing oxytocin augmentation rates were included.

Timing of oxytocin augmentation: Studies providing timing of oxytocin were included. Only studies of women in spontaneous labour were included.

Effect of oxytocin for labour augmentation: randomised and quasi-randomised trials, cohort studies, case-control studies[74]

Exclusion criteria

Studies investigating only subgroups of women (i.e. high-risk women). Did not include oxytocin for labour augmentation. Did not distinguish oxytocin from other methods of augmentation. Did not differentiate between oxytocin used for induction or augmentation. Conference abstracts, case series and case reports were also excluded.[74]

Data extraction and risk of bias assessment

Titles and abstracts were screened for eligibility followed by full-text screening when necessary.[74] Data were extracted into pre-piloted sheets and assessed for risk of bias. Literature search, study inclusion, extraction of data and quality assessment were conducted independently by me and another researcher. In case of disagreement, a third researcher was conferred.

Data synthesis

Data on oxytocin administration practices, partograph use, health provider-to-women ratio, monitoring of FHR and contractions and hospital volume were collected to provide information on the context for a narrative analysis.[74]

Rates of oxytocin for labour augmentation were analysed as proportion of women augmented among all women in the study. For pre-post studies, only pre-intervention data were included as that best represents baseline care.[74] For case-control studies, only data from controls were included as that reflect exposure in the study population.[74]

Timing of oxytocin augmentation was investigated using studies that reported oxytocin use according to the partograph alert and action line and descriptive analysis was performed.

A meta-analysis was conducted to assess the association between oxytocin augmentation and birth outcomes. Cochrane Collaboration Review Manager Software version 5.4.1 (RevMan) was used for the meta-analysis.[132] Adjusted effect measures or crude Risk Ratio (RR) or Odds Ratio (OR) were included with 95% CI.[74] "Generic inverse variance" outcome was used for effect measures.[74] Because of rare outcomes, ORs and RRs were combined in the meta-analyses.[74] A random-effects model was used for analysis as heterogeneity among studies was expected.[74]

Paper II: Temporalities of oxytocin for labour augmentation: A mixed-methods study of time factors shaping labour practices in a busy maternity unit in Tanzania

Paper II was conducted at one of the five study sites. It was selected because it was placed near to where I stayed, facilitating flexibility in coming and going.

Mixed-methods research approach

Mixed-methods research was chosen as a component of the thesis because of its ability to uncover intrinsic layers of complex questions drawing on the strength of both qualitative and quantitative methods.[133] The mixed-methods design allowed a comprehensive understanding of the mechanisms that shape practices around prolonged labour. I used an exploratory sequential design where I conducted participant observations and interviews first. Based on preliminary findings the quantitative study was designed.[133] As such, methods were sought to complement each other, thereby enabling richness.[134] Qualitative methods enable in-depth exploration of "what" and "why" and explorations of meanings, doings and saying.[125,135] Quantitative methods provide insight into "how many/much".[136] This integration allowed the quantitative component to present measurable data on how labour was managed and the frequency of oxytocin augmentation. Simultaneously, the qualitative aspect investigated the reasons behind labour management practices and examined factors alongside labour management, such as managerial and political influences on care. Providing numerical data, such as the frequency of prolonged labour occurrences, was instrumental in fostering reflection. Interestingly, health providers, for example, perceived prolonged labour as common, whereas the data suggested otherwise.

Specifically, data for Paper II were obtained using three different data collection methods (Table 5): (i) participant observations to explore labour ward practices; (ii) in-depth individual semi-structured interviews to explore birth attendants' perceptions; and (iii) structured observations of labour to assess practices around oxytocin augmentation (timing, dosing etc.). These three methods were triangulated to obtain an in-depth comprehensive understanding of practices in the labour ward.[134] Participant observations were selected to gain a first-hand experience of practices in the labour ward. Health providers may not always be fully aware of their own practices, habits and cultural norms, particularly those practices that have become ingrained or normalised over time.[135] Observations offered the ability to uncover real-world practices, including those that were not mentioned during interviews. Observations provided insight into "what" actually happens in the labour ward, as compared to merely how it is experienced by health providers. Interviews, on the other hand, were used to understand the "why" behind practices.[135] Interviews, however, are limited to what is reported by the interviewee. Data were collected between 15 March 2021 and 15 February 2022 and each method is described further in the following text.

Table 5: Data collection methods

220 hours participant observations by the thesis author	15.03.2021 – 11.06.2021
234 structured observations by two research assistants	01.04.2021 – 31.06.2021
11 individual in-depth interviews by the thesis author and a research assistant	01.04.2021 – 11.06.2021
Two individual in-depth reinterviews by the thesis author	05.01.2022 – 15.02.2022

Data collection

Structured observations

Observation sheets were developed by me and pre-piloted with two research assistants. The two research assistants conducted the structured observations following two weeks of training by double entering sheets and checking for differences. Collected data included whether the woman received oxytocin for labour augmentation, timing of oxytocin augmentation and how much it was titrated. It further included monitoring of FHR and contractions during oxytocin augmentation as well as birth outcomes. As the labour ward was one big room with eight beds, the assistants could document practices on all women and cover for each other when needed. The assistants spoke Swahili and had no obstetric experience. This was to avoid them feeling obliged to provide care and make decisions in the busy labour ward. Women were included when they reached active labour and followed until giving birth. To avoid selection bias, they were included consecutively during each observation period. Only singleton cephalic pregnancies at term with positive FHR on admission were included. Women who were referred from another facility and women with severe hypertensive disorders or previous caesarean section were excluded. The aim was to include a low-risk population.

Participant observations

Participant observations were conducted by me equally during days, evenings and nights over three months. I did not make clinical decisions during the observations. I engaged in discussions around care practices and supported with tasks such as filling up medication or cleaning. Extensive field notes were written to document observations during and after observations.

In-depth semi-structured interviews

A research assistant and I conducted interviews. Participants were selected through purposive sampling until saturation (no new topics appeared in interviews). The research assistant was a midwife, had prior experience with qualitative interviews and conducted interviews in Swahili in my presence. During interviews, we had short breaks for me to be briefed on what was said and to be able to steer the direction of the interview without too much interruption. Follow-up questions were asked if needed and main findings were discussed immediately after interviews. English interviews were conducted by me. Minor adjustments

were made after the first two interviews to ensure clarity. Respondents included nurse-midwives (n=3), intern doctors (n=2), registrars (n=3) and obstetric specialists (n=3), all working in the labour ward at the time. Re-interviews were carried out with two respondents one year later to discuss and get input to the preliminary findings. Interviews were conducted outside work hours at a private place. Interviews were audio-recorded, transcribed and translated ad verbatim to English by an experienced translator. The first two translations were checked by a Swahili speaking PhD colleague to ensure quality. The remaining were checked by two research assistants.

Analysis

A thematic network analysis was conducted employing a combined deductive and inductive approach, with particular focus on the emergence of time as a central theme.[137] The coding of textual data was performed using Nvivo (version 1.6.2), involving both predefined and emergent themes. Triangulation of data from observations and interviews was executed, leading to the identification of basic, organising and global themes within the temporal framework. Data from structured observations were assessed using descriptive statistics (IBM SPSS (version 28.0.0.0)). To maintain confidentiality, staff members are referred to as respondents or birth attendants throughout the document.

Papers III and IV: Timeliness of Caesarean sections at the five hospitals in Dar es Salaam

Both Papers III and IV utilise the same dataset, which includes all women who gave birth by caesarean section during a three-month period at each of the five hospitals. Data collection took place between 1 October 2021 and 31 August 2022. Paper III includes all women who gave birth by caesarean section and Paper IV includes women who gave birth by caesarean section due to the diagnosis of prolonged labour, as indicated in the case file.

Audit criteria

The study aimed to estimate the proportion of caesarean sections because of prolonged labour that could potentially have been avoided according to pre-defined audit criteria. The audit criteria are shown in Figure 6, Chapter 5 and placed women into three categories: 1) caesarean section during normally progressing labour (including women who were never given a trial of labour) (green); 2) caesarean section during slow labour progression (yellow); and 3) caesarean section during prolonged labour (red). Categories green and yellow were considered non-medically indicated as labour was not prolonged. The audit criteria did not include management of prolonged labour (ambulation, hydration, urination, rupturing membranes, and oxytocin augmentation). Data on use of oxytocin for labour augmentation and ruptured membranes were collected and included in the tables. (Paper IV)

Prolonged labour definition

Prolonged labour can be considered an “umbrella indication” and in this study the following diagnoses were reported: “prolonged labour”, “poor progress of labour”, “failure of augmentation”, “cervical arrest”, “cephalopelvic disproportion”, “obstructed labour” and “big baby”. These diagnoses seemed to be used interchangeably. (Paper IV)

Exclusion criteria

Referred women with cervical dilatation above 6 cm upon admission or where referral diagnosis was prolonged labour, non-cephalic pregnancies, multiple pregnancies, intrauterine foetal deaths, failed induction or women with a previous caesarean section. Women were excluded if they had more than one indication for caesarean section and the additional indication, apart from prolonged labour, constituted a potentially absolute indication for caesarean section. Absolute indications included placental abruption, foetal distress, foetal malformation, cord prolapse, chorioamnionitis, vaginal infection/warts and severe pre-eclampsia or eclampsia. Therefore, our cohort did not represent this group of high-risk women. The aim was to establish a cohort of women for whom caesarean section was performed solely due to prolonged labour. (Paper IV)

Data collection

The complete data collection and analysis process is illustrated in Figure 8. All caesarean section files were collected from hospital storage within one month after birth. Case files were located from different desks and boxes, as only one hospital had an organised system for storage. Case files were cross-checked with the birth registry (MTUHA) to identify as many files as possible. In cases of missing files, dedicated staff members assisted in the search. The indication for caesarean section and birth outcome were extracted from MTUHA to provide an overview of possible bias in missing files. All births were extracted from birth registries to establish overall estimates of vaginal births and caesarean sections. Data was extracted from the full case file only for caesarean sections. Caesarean sections with prolonged labour as written indication were identified from the decision note/operating report. For these women, data from birth registries, delivery notes, operating report and partographs were reviewed in depth. Data was entered into a pre-piloted form using KoBo Toolbox on tablets/laptops. Data collection and data entry were carried out by four research assistants, all of whom had medical backgrounds. The research assistants underwent training by double-entering case files together with me until no new misunderstandings arose (a minimum of 10 files). The research assistants visited the hospitals one by one, three to five days a week, and physically reviewed each file to extract data. Double entry was performed on 30% of all cases, including all prolonged labour records. After double-entering 50-100 records, I compared them using SPSS. Subsequently, the research assistants corrected all discrepancies record by record, and a meeting was held to evaluate and discuss common mistakes. It appeared that mistakes often occurred in relation to time and date. Therefore, prolonged labour records, where dates and times were crucial, were all double-entered. Double-entry variables such as parity, age, indication of caesarean sections revealed that values matched in > 95% of the double-entries. Data collectors refrained from making interpretations. In cases of uncertainty, the hospital staff or I was consulted (e.g. due to difficult handwriting, contradictory information in the notes etc.). If a procedure was not documented, it was assumed not to have been performed.

Figure 8: Data collection process for Papers III and IV (criterion-based audit)

Data validation Conducted by research assistants	Data source Routine data filled by birth attendants	Data collection Conducted by research assistants supervised by the thesis author	Data analysis Conducted by the thesis author
Comparison of observed and recorded practices 140 women observed from admission to discharge **Analysis of accuracy and completes** 9985 observations included with assessment of - vaginal examinations - filling of the partograph (contractions, fetal heart rate etc.)	**Birth registry (MTUHA)** (filled out after birth) Mode of birth Birth outcome Indication for caesarean section Date and time of admission **Labour and delivery files** (filled out during woman's admission) Cervical dilatations inkl. time Oxytocin augmentation Date and time of birth Complications Date of discharge **Operating report** (filled out after surgery) Caesarean section indication Date and time of birth Bleeding during operation	**KoboToolBox** Entry of all data by research assistants, including - background characteristics - cervical dilatations incl. time - interventions incl. time - indications for caesarean section - clinical descriptions related to decision **Double entry of all prolonged labour case files** - Comparison conducted by the thesis author - mismatched corrected by the research assistants - Meeting held between research assistants and thesis author to discuss common mistakes	**Exported to excel and analysed using R** Data cleaning Descriptive analysis **Audit process** - categorization according to the audit criteria in "normal labour progression", "slow but normal labour progression", and "Prolonged labour progression".

Data validation

Data validation was carried out prior to the study. It included observation of 140 women from admission to discharge, resulting in a total of 9,985 data points for the assessment of accuracy (the proportion of data that can be confirmed by observations) and completeness (the proportion of missing individual data points compared to expected data points in files) of case files. The findings showed an accuracy and completeness of 90.8% and 76.0%, respectively, for vaginal examinations. Accuracy and completeness of admission characteristics such as date and time of admission, age, referral status, onset of labour, and parity were 100%. When measuring contractions, it was observed that falsely recorded actions accounted for a high proportion (32.6%), and the accuracy was 64.6%. Regarding oxytocin augmentation, 20% of the cases where oxytocin was applied had no recorded data and the accuracy was 80%. The study further showed that the partograph was completed by the end of the shift in 30.6% of women. Based on the results of the validation study, I decided to exclude contractions from the study.

Analysis and variables

Descriptive statistics were carried out using R version 4.1.2 (2021-11-01). Prevalence of indications of caesarean sections was calculated. Background characteristics included hospital, age, gestational age, parity, referral status, stage of labour on admission, maternal complications, perinatal outcomes and birth weight. The following analyses were conducted only on records of prolonged labour. To assess intrapartum management, information on labour duration, labour progression and labour interventions (induction, status of membranes, oxytocin augmentation and vacuum-assisted birth) were collected. Caesarean sections were

evaluated based on stages of labour: 1) Before active labour (defined as cervical dilatation <4 cm); 2) First stage of active labour (defined as cervical dilatation of 4 – 9 cm); and 3) Second stage (full dilatation)). In cases where the partograph was not used, the data collectors plotted cervical dilatation measurements to visualise the progress of labour on a partograph. In cases where time of birth was not recorded, the time of reaching post-operative ward minus 45 minutes was employed as a substitute. Active labour was defined as the time when the partograph was started. In cases where no partograph was used, it was defined as the point when cervical dilatation reached 4 cm or above the first time. (Paper IV)

Audit process

The audit was carried out by evaluating the entered data against the audit criteria objectively (Figure 6, Chapter 5). This was carried out by me after data collection had commenced. Finally, caesarean sections were categorised into: 1) “Uncomplicated progression” (green); 2) “Slow but uncomplicated progression” (yellow); and 3) “Prolonged labour” (red) at the time caesarean section was decided on. Proportions for each category in each phase of labour were calculated. The proportion of caesarean sections that did not meet the audit criteria (including the first two categories) was calculated and defined as the proportion of “non-medically indicated” caesarean sections.

Paper V: Inconsistent definitions of labour progress and over-medicalisation cause unnecessary harm during birth: a critical review

The analysis for this paper aimed to provide a balanced, even-handed look at the evidence surrounding prolonged labour definition and management. The method applied is described below.

Search strategy and analysis

Firstly, overall themes were defined: labour pathophysiology, prolonged labour definition, labour duration, prolonged labour treatment, oxytocin for labour augmentation, women's views and (congested) labour wards. For each area, peer-reviewed and grey literature, including original studies and reviews, were identified. To ensure scientific heft, arguments and counterarguments were specifically looked for to balance views of each statement that was put forward and avoid cherry-picking. As the literature was heterogenic a unified quality assessment did not seem appropriate. When relevant, however, the methodology, strengths and limitations of the referenced studies were presented in an objective way. The study did not aim to provide firm conclusions as a traditional systematic literature review but rather to put forward existing knowledge. To ensure that different angles were included, the study involved a basic scientist with more than 10 years exploring labour physiology, a social scientist knowledgeable in birth as a sociocultural phenomenon, obstetric specialists with many years of experience in both clinical work and research from the Netherlands, Denmark, and Tanzania, a midwife and women who had given birth themselves. Finally, the study builds on the systematic review of oxytocin for labour augmentation described in Paper I, a scoping review on definition of labour (in peer-review) and a specialist review of hypoxia and labour[56] written by individuals of the author group. Finally, we did a critical reflection on the literature as a core group of researchers and with a group of external experts.

A birth attendant listening with a Pinard stethoscope (top), oxytocin bottle (low left), oxytocin mixture (low middle) and a woman in labour (low right). Photos of study sites by Lara Meguid and Monica Kujabi.

CHAPTER 8: SUMMARY OF RESULT

Paper I: Oxytocin for labour augmentation in LLMIC: A systematic review and meta-analysis

A total of 2,340 studies were initially identified by the search, of which 42 were included in the review. The study types are shown in Figure 7, Chapter 7. No studies that assessed effect of oxytocin for labour augmentation on caesarean sections or uterine ruptures met the inclusion criteria and no RCTs were identified. Studies were of varying quality. Many were based on hand-written case files and not validated.

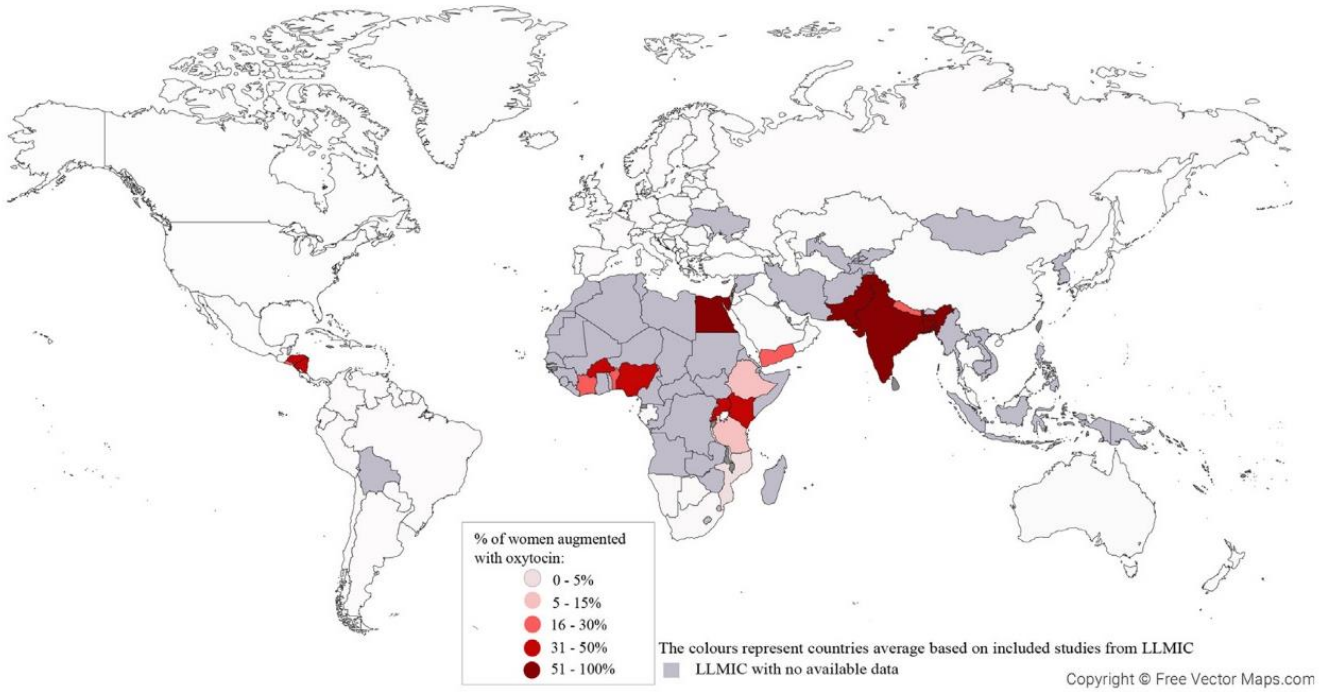
Narrative analysis

Overall, descriptions of the context and practices were limited. When reported, it showed that advanced equipment, such as electronic infusion pumps and cardiotocography, was rarely available. Foetal heart rate was listened to intermittently with a Pinard stethoscope or Doppler ultrasound and the partograph was underutilised.

Facility-based oxytocin augmentation rates and timing

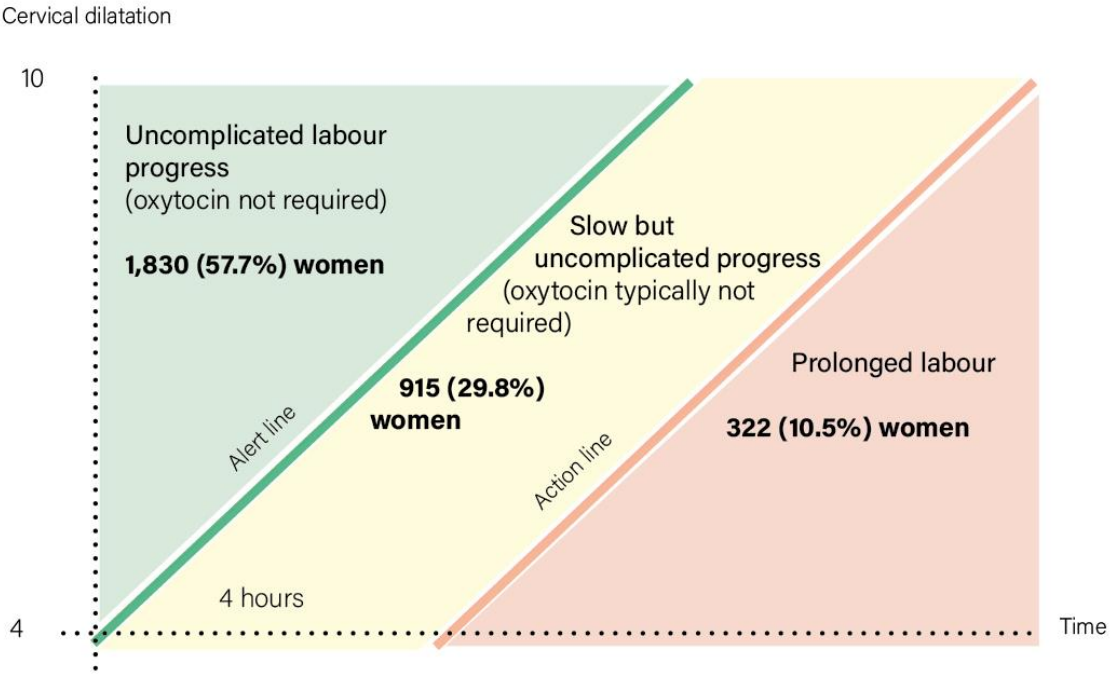
Figure 9 includes studies conducted after 2000 and presents average rates of oxytocin for labour augmentation in each country. Facility-based studies from Bangladesh, Pakistan, India and Egypt (N=3,698 women) reported oxytocin rates of more than 50% of labouring women, 10 countries (N=101,954) reported 30% to 49%, 5 countries (N=3,586 women) reported 15% to 29%, and 3 countries (N=2,245 women) reported <14%.[74] No study before 2000 (N=17,819 women) had rates above 21%.[74] Figure 10 shows findings from four studies from three countries (Benin, Rwanda and India, 9,000 women) on timing of oxytocin to augment labour.[74] Augmentation rate was 34.1% (3,067/9,000 women). Of these, 57.7% were augmented with oxytocin during active labour and did not cross the partograph alert line, whereas only 10.5% had prolonged labour (crossed the action line).[74]

Figure 9: Average percentage of labours augmented with oxytocin in LLMICs



Average facility-based use of oxytocin for labour augmentation in LLMICs (World Bank 2020 classification) after year 2000. Based on 41 studies reporting from 885 health facilities in 24 countries.
LLMIC: low- and lower-middle-income country.
Kujabi. A systematic review of oxytocin augmentation in low- and lower-middle-income country. Am J Obstet Gynecol Glob Rep 2022.

Figure 10: Assessment of 3,067 women augmented with oxytocin during active labour

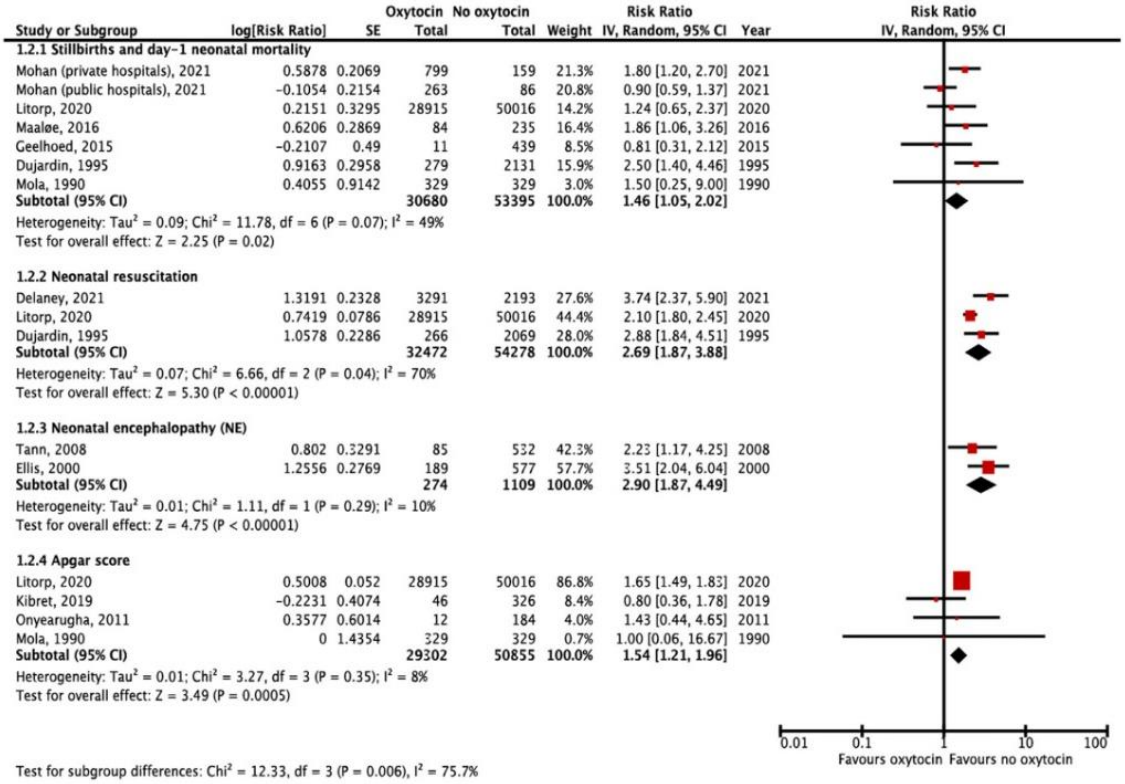


Including studies from Benin, India, and Rwanda (9000 women in spontaneous labor).
Kujabi. A systematic review ofoxytocin augmentation in low- and lower-middle-income country. Am J Obstet Gynecol Glob Rep 2022.

Association between oxytocin for labour augmentation and neonatal outcomes

The meta-analysis included four cohort and seven case-control studies with differing quality. Meta-analysis found that oxytocin used to augment labour was associated with adverse perinatal outcomes (Figure 11), including: stillbirth and day-1 neonatal mortality (RR, 1.45; 95% CI, 1.02 −2.06; N=84,077; 6 studies); low Apgar score (RR, 1.54; 95% CI, 1.21−1.96; N=80,157; 4 studies); Neonatal encephalopathy (RR, 2.90; 95% CI, 1.87−4.49; N=1383; 2 studies) and neonatal resuscitation (RR, 2.69; 95% CI, 1.87−3.88; N=86,750; 3 studies).[74]

Figure 11: Association between oxytocin for labour augmentation and perinatal outcomes



CI, confidence interval; IV, inverse variance; SE, standard error.

Kujabi. A systematic review ofoxytocin augmentation in low- and lower-middle-income country. Am J Obstet Gynecol Glob Rep 2022.

Paper II: Temporalities of oxytocin for labour augmentation: A mixed-methods study of time factors shaping labour practices in a busy maternity unit in Tanzania

Paper II triangulates qualitative and quantitative findings around prolonged labour management and timely use of oxytocin for labour augmentation at one of the five maternity units.

Intra-facility congestion drives up dangerous oxytocin use

Congestion and too few healthcare providers were identified as underlying reasons for substandard monitoring of labouring women, irrespective of whether they received oxytocin infusion:

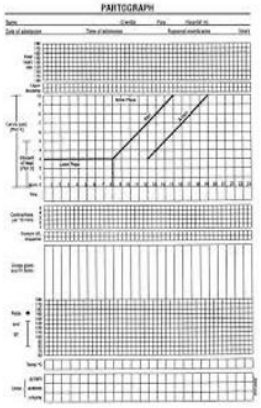
"*It was busy, everyone was running around. Nobody kept an overview, it was impossible because the women were everywhere, constantly crying for help: "Nurse, nurse, nurse, come". It was stressful and overwhelming. Everyone did their best and all hands were in use. Two women were pushing with assistance from students, a woman had just given birth, but there was no time to clean up and help her get settled with her newborn. A foetal head was crowning in bed three, but there was no birth attendant to assist. In another bed the drip with oxytocin was running, the woman unattended. An assistant was running with birth trays and medication for prevention of haemorrhage. There were not enough suturing sets, so the intern doctor struggled to repair bleeding tears. All hands were in use, care was limited to what was most necessary. After a few hours the labour ward became less chaotic. Exhaustion filled the room. Now, the paperwork had to be filled, stocks recharged and curtains and floors cleaned for blood. Until the next wave of women filled the beds.*"
(Observation notes 01.04.21). (quote from Paper II)

The use of oxytocin for labour augmentation was assessed by looking at the influence of time factors (Figure 12). Among the most mentioned reasons for augmenting labour with oxytocin was congestion. When the beds started to fill up, oxytocin infusions were started to ensure a higher flow of women through the labour ward and avoid situations as described in the quote above. Many women received oxytocin to augment labour regardless of their individual labour progression. Further, chronic understaffing had resulted in reduced monitoring of FHR and contractions as well as titration of oxytocin (Table 6). This resulted in a dangerous situation where "too little, too late" and "too much, too soon" care co-existed: oxytocin augmentation was used too much, too soon, while monitoring of FHR, drips and contractions were too little, too late. Table 6 presents how 146/234 (62.4%) of women in labour received oxytocin to augment labour and that 21/58 (43.8%) women in active labour received it when labour was, in fact, not prolonged (here defined as progression faster than 0.5 cm/hour). While the study was not designed to assess associations, poor birth outcomes were more common in the oxytocin group (five perinatal deaths compared to one in the group without oxytocin).

Figure 12: Time-factors shaping oxytocin for labour augmentation in a busy urban maternity unit in Dar es Salaam

Care reduces during the night. Interventions increases during ward rounds and shifts turn-over.

Too many women and too few beds. Oxytocin used to ensure flow of the women.



Partograph filled after birth

Too few staff : limited time for monitoring

Table 6: Structured observations of 234 consecutive women in active labour

All women	***234***
Characteristics	
Oxytocin for labour augmentation	
No	88 (37.6)
Yes	146 (62.4)
Initiated during 1st stage	100 (68.5)
Initiated during 2nd stage	46 (31.5)
Birth outcome	
Discharged home	214 (92.3)
Admitted into neonatal intensive care unit	13 (5.6)
Stillbirth	4 (1.7)
Neonatal death < 24 hours	1 (0.4)
Missing	2
Birth outcome in cases with oxytocin augmentation	146
Discharged home	132 (90.4)
Admitted into neonatal intensive care unit	8 (5.4)
Stillbirth	3 (2.1)
Neonatal death < 24 hours	1 (0.7)
Missing	2 (1.4)
Subgroup of women who received oxytocin during 1st stage of active labour	***58[a]***
	n (%)
Contractions measured	
Yes	3 (7.1)
No	39 (92.9)
Missing	16
Foetal heart rate (FHR) measured	
Yes	5 (11.9)
No	37 (88.1)
Missing	16
Oxytocin rate adjusted	
None	28 (48.3)
Once	24 (41.4)
≥ 2 times	6 (10.3)
Labour progression on initiation of oxytocin[b]	
≤ 0.5 cm/hour	27 (56.2)
>0.5 cm/hour	21 (43.8)
Missing	10

Legend: Data include consecutive structured observations of birthing women with low risk pregnancies

[a]Only includes labours where time of oxytocin initiation was observed.

[b]Defined as cervical dilatation of 4 cm and above.

[d]Measured as dilatation/hour from first cervical dilatation of 4 cm and above to time of administration of oxytocin.

The unpredictable maternity unit leads to untimely oxytocin augmentation

Performing cervical assessments every two to four hours, as recommended in most guidelines, was difficult to adhere to in this busy maternity unit. Instead, care-cycles followed the natural events in the labour ward, for example, care often accelerated during ward rounds and at shift turn-over. A doctor explained:

"*Because it can become very busy as the day progresses, we never know when we are able to come back. So many hours can pass before someone is checking the woman* (R7)."

As such, to avoid delayed care, it was better to be one step ahead. Furthermore, staff were told to ensure women in their shift gave birth before handing over to the next team:

"*We always tell them to make sure the women in their shift give birth. That it is their responsibility, these women. This is how we avoid women are there during one, two or three shifts*."

Observations confirmed that doctors were proactive when they were around, but many hours could pass, particularly during the night, where they were not around. As an example, one woman progressed 2 cm over 17 hours without the membranes being ruptured or labour augmented with oxytocin. The following morning she gave birth two hours after augmentation when oxytocin was started.

Understanding of labour progression

Unanimously, staff expected labour to progress 1 cm per hour. It was common that the expected time of birth was written on the woman's partograph "expected vaginal birth at X hours", calculating 1 cm per hour until full dilatation with no additional time for second stage. Staff often referred to incidences of prolonged labour with poor outcomes. It was evident that prolonged labour was feared while oxytocin was mainly seen as helpful:

"*Oxytocin can be dangerous, but I believe that it is more dangerous if we have a congested labour ward where staff cannot monitor the women. We used to see much neglect at these times*" (R4).

Other respondents explained how no one would ever associate oxytocin with adverse outcomes. When discussing concrete cases, birth attendants would usually blame low Apgar scores on prolonged labour and not the fast-running oxytocin drip, while in many cases labour was not prolonged. In the observations carried out, only 9/234 women had a labour lasting above 12 hours, illustrating the effectiveness of the strategies applied to avoid prolonged labour.

The labour-ward environment

While oxytocin was used to augment many labours and perceived efficient in speeding up labour, evidence-based non-medical interventions, such as upright position and one-to-one care, were limited in this labour ward:

"Beds were lined side by side with little space to ambulate and women were often told to lay in supine position. While the room included eight beds with a curtain in between there was little privacy and the cry from labouring women from all sides was exhausting and stressful. A woman was surrounded by staff and students walking in and out with little respect for her privacy. Hard language and a slap on the leg were applied to a woman in bed four who had to push the baby out. The toilets were not clean, and no labouring women used them, instead they were catheterised when there was time. But today there were no catheters. Birth companions were not allowed and pain relief not available. Overall, this did not seem like a comfortable place to give birth" Field note 10/4/21.

Papers III and IV: Timeliness of caesarean sections at the five hospitals in Dar es Salaam

Paper III is an audit of management and decision-making preceding 2,949 caesarean sections in the five hospitals in Dar es Salaam. Overall, the caesarean section rate at the five hospitals was 31.5% (2949/9364). Time between decision and birth was more than one hour in 91% of women in active labour. Maternal complications occurred in 3% and stillbirth in 2% of women before or after surgery. The main indications for caesarean sections were previous caesarean section (1133/2674, 42%), prolonged labour (746/2674, 28%), foetal distress (554/2674, 21%) and hypertensive disorders (216/2674, 8%) (Table 7). Prolonged labour accounted for 727/1517 (47.9%) of caesarean sections in the unscarred uterus and it was thereby the most commonly applied indication for first time caesarean section. After going through the inclusion/exclusion criteria, 456 of caesarean sections with prolonged labour as indication were analysed in-depth. These caesarean sections due to prolonged labour is the focus of Paper IV, and the findings are unfolded below.

Table 7: Distribution of indications for 2,674 caesarean sections
Each case may have more than one indication.

Indications		Proportion of each indication
Previous CS	1133	42%
Prolonged labour	746	28%
Foetal distress	554	21%
Hypertensive disorders in pregnancy	216	8%
Abnormal presentation	134	5%
Breech	84	3%
Other indication(s)[a]	446	17%

[a]Includes the following: Cord prolapse with pulsation cord n=38, placenta abruptio n=23, placenta praevia n=23, uterine rupture n=7, bad obstetric history n=73, oligohydramnios n=38, placenta calcification n=26, long interpregnancy interval n=19, failure of induction n=49, antepartum bleeding n=36, and other occurring ≤ 5 times.

Non-medically indicated caesarean sections due to prolonged labour

Of the women with a caesarean section decision before active labour, 78/89 (87.6%) were categorised as non-medically indicated because they were not given a trial of labour or duration from admission-to-decision was less than two days in latent labour with no grossly abnormal pelvis described and no other indication for the surgery. Of the women with caesarean section decided due to prolonged labour during first stage of active labour, 145/346 (41.9%) were categorised as non-medically indicated because they were performed before the partograph action line was crossed. Figure 14 shows progression curves in relation to partograph alert and action line of women with a caesarean section decision during active labour. Of women in second stage of labour, 20/21 (95.2%) were categorised as non-medically indicated because second stage lasted less than one hour. One woman had an attempted vacuum-assisted birth reported before the surgery. In total, 243/456 (53.3%) were conducted despite uncomplicated labour progression and could be categorised as non-medically indicated (Figure 13).

Figure 13: Evaluation of Caesarean Sections (CS) because of prolonged labour in 456 cephalic, singleton pregnancies with no previous CS.

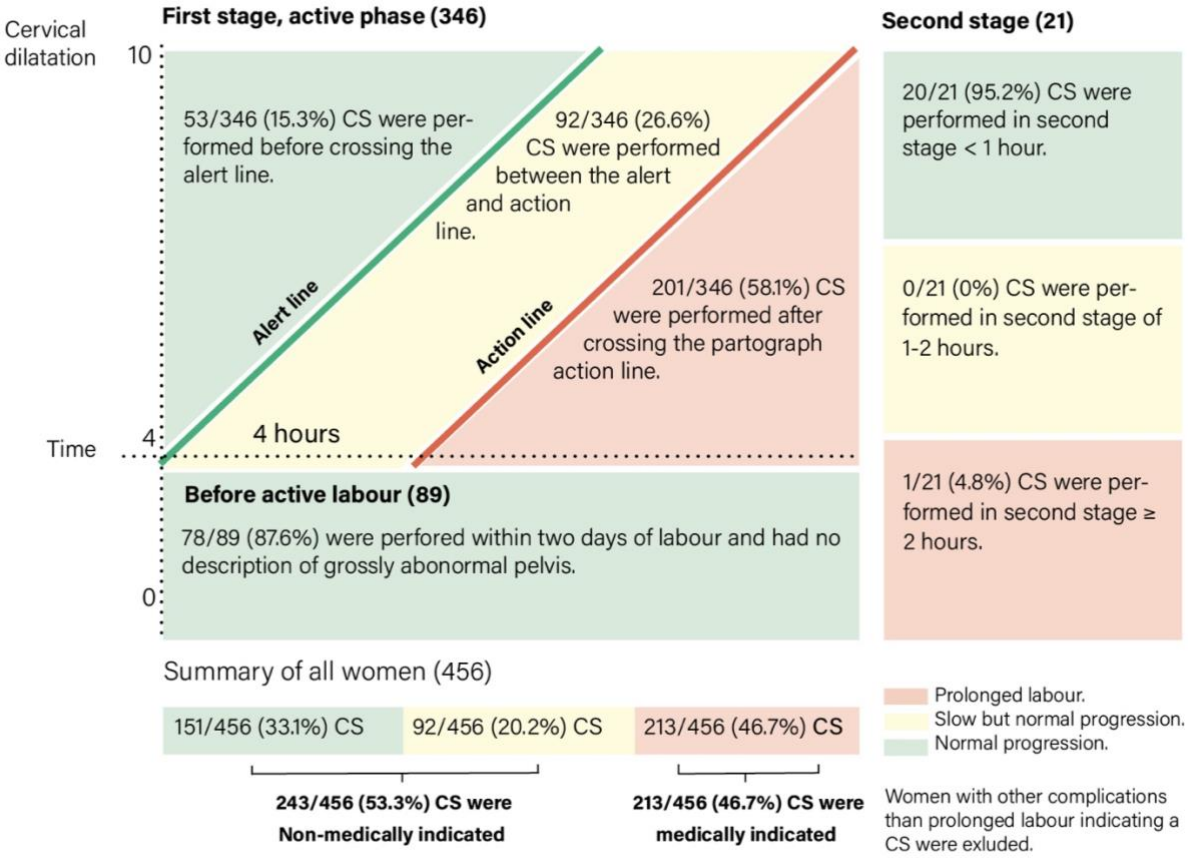
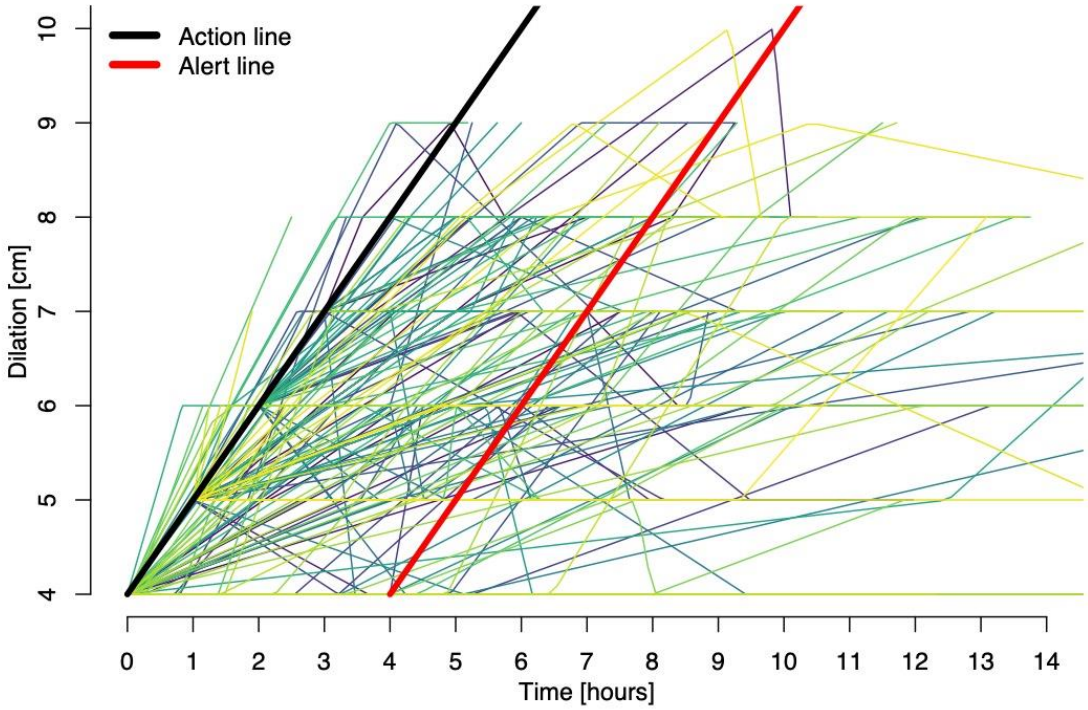


Figure 14: Labour progression curves of 346 women with a caesarean section during active labour



Accuracy of diagnosis

As shown in Table 8, many different terms for prolonged labour were used and description of the diagnosis was often inappropriate. For example, only 51/160 (31.9%) of women with obstructed labour had cervical arrest (no dilatation between the last to vaginal examinations) and 46/160 (28.8%) had head 1/5 or more palpable above the pelvic brim while 39/160 (24.4%) had no obstructive signs described. Caput succedaneum +2 was described in 60/160 (37.5%). For women with an indication of cervical arrest, 27/78 (34.6%) had cervical arrest for four hours or more. Further, for women with big baby as the indication, 33/119 (27.7%) had a birth weight ≥ 4 kg.

Table 8: Terms used to diagnose prolonged labour and associated clinical findings

Terms	N = 456 (%)
Obstructed labour	160 (35.1%)
Cervical arrest between last 2 vaginal examinations	51 (31.9%)
Head 1/5 or more palpable per abdomen	46 (28.8%)
Station above the ischial spines (-1, -2, -3)	4 (2.5%)
Severe caput succedaneum (+3)	10 (6.3%)
Caput succedaneum (+2)	60 (37.5%)
Severe moulding (+3)	1 (0.6%)
Moulding (+2)	15 (9.4%)
Others[a]	5 (3.1%)
No description	39 (24.4%)
Big baby	119 (26.1%)
Birthweight ≥ 4 kg	33 (27.7%)
Prolonged labour/poor progress	118 (25.9%)
Latest cervical progression slower than 0.5 cm/hours	87 (73.7%)
Cervical arrest	78 (17.1%)
No progression between last to vaginal examinations	39 (50.0%)
No progression within the last four hours	27 (34.6%)
CPD	63 (13.8%)
Borderline/inadequate pelvis	9 (14.3%)
Prominent pubic angle/unfavourable pelvimetry	2 (3.2%)
Others[b]	4 (6.3%)
No description	48 (76.2%)

[a] blood-stained urine and swollen cervix blood in catheter, head high, swollen cervix

[b] Cervix swollen, contracted pelvis, hip joint deformity, and maternal heigh 146 cm

Paper V: **Inconsistent definitions of labour progress and over-medicalisation cause unnecessary harm during birth: a critical review**

Analysing global trends in prolonged labour management, Paper V unfolds several evidence-practice gaps.

Firstly, two contradicting trends appear. At one pole, evidence dating back to 2002 consistently shows that labour takes more time than what many guidelines stipulate.[21,22,42,44,52,73,138] At the other pole, as seen in Paper I and II, studies from Norway and France find that women are treated for prolonged labour despite uncomplicated progression.[35,139] While labour progression studies indicate that prolonged labour affects 10-15% of women in active labour, facility-based studies report that 30-90% of women are treated with oxytocin and caesarean sections in unscarred uterus are on the rise – many due to prolonged labour.[43,84]

While oxytocin has become the cornerstone of prolonged labour treatment, the evidence supporting its use is alarmingly scarce. The only three RCTs including 239 women in total date back to the 1990s and are inconclusive. Meanwhile, in studies from Tanzania, Palestine, India and Norway, reducing use of oxytocin augmentation appears, in fact, to reduce caesarean sections and improve outcomes.[53,109,140,141] Other studies find that early versus late use of oxytocin augmentation or discontinuation of use, do not affect caesarean sections.[72,78,142–144] While oxytocin may prevent caesarean sections in some women, these consistent findings question the universal use of oxytocin in prolonged labour. In addition, studies report Inconsistent associations with adverse perinatal outcomes in LMIC and in HIC.[75,141,143,145,146] Importantly, a Swedish study found oxytocin to be involved in 33% of malpractice claims supporting cautious restrictive use.[147]

Birth companions, one-to-one care, mobile upright position, hydration if dehydrated, pain-relief, mental support and a safe environment are known to facilitate physiological birth.[66–68,148–150] .[148] Yet, these practices find a hard time getting established into the centre of prolonged labour management. In many maternity units in Sub-Saharan Africa, particularly in congested maternity units, birth companions are not allowed, one-to-one care not possible, adequate pain relief not offered and women are still encouraged to lay in supine position.[148,151–153]

Not to forget, women with prolonged labour are at increased risk of negative birth experiences.[154] Still, women's voices are scarcely influencing prolonged labour guidelines.[22,54] Particularly, it is possible that the new trends of tolerant labour curves will reduce interventions during labour. Nevertheless, in settings with no pain relief, without a birth companion or time for caring support and with little privacy, women may be left traumatised after being in labour for hours.

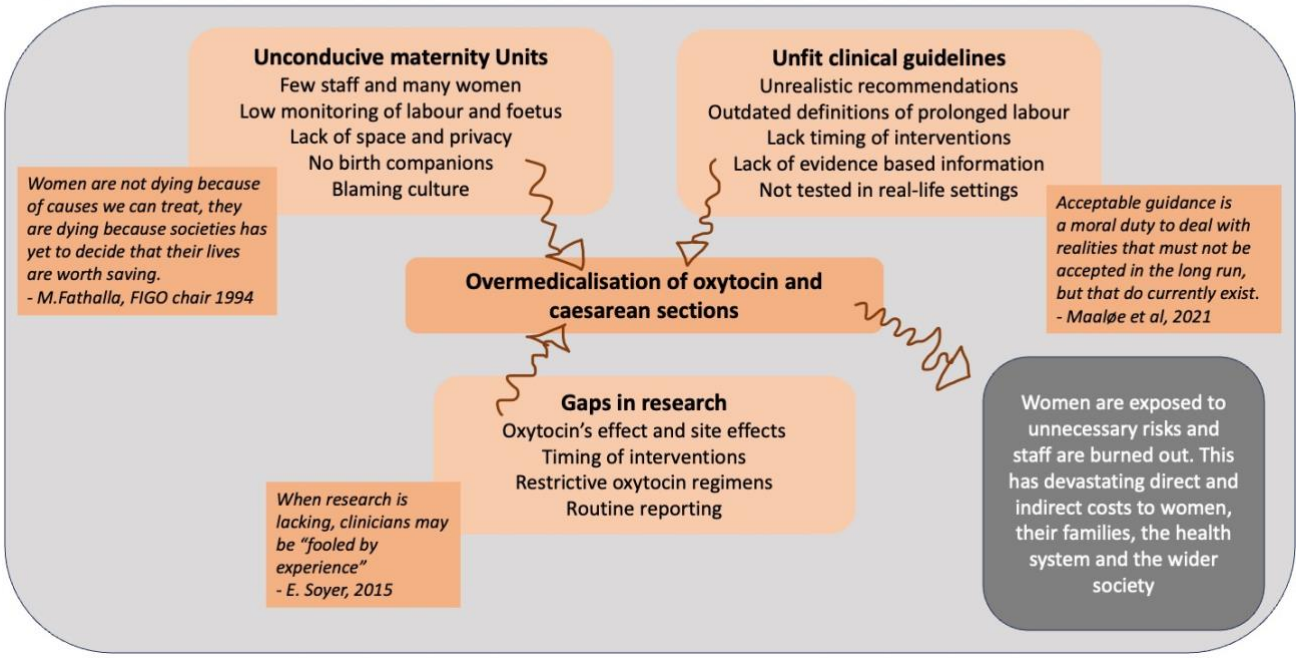
Photo of a woman in a labour bed. Photo by Lara Meguid.

CHAPTER 9: MAIN FINDINGS AND DISCUSSION

While prolonged labour stands as one of the most prevalent complications during childbirth, its management remains a fundamental clinical challenge.[155] This thesis unfolds over-medicalisation of prolonged labour with oxytocin and caesarean sections globally. Through the case study of an extreme setting in urban Tanzania, it further provides novel insights into how over-medicalisation is driven by crowded low-resource labour wards where the women are many and the staff few. Over-medicalisation incurs substantial costs and inflicts unnecessary harm with severe direct and indirect consequences. Zooming out, this thesis provides an example of how birth attendants cope in crowded low-resource maternity units and how women's basic rights during labour are violated. This thesis, therefore, stands as an example of fundamental inequalities between men and women and the rich and the poor.

In this chapter, I discuss how the unconducive birth environment, unfit clinical guidelines and major research gaps drive the over-medicalisation unfolded in the thesis (see Figure 15 below). Given the projected population increase in Sub-Saharan Africa and Southeast Asia, understanding the implications of crowded low-resource hospitals becomes imperative.[7,8]

Figure 15: Unconducive maternity units, unfit clinical guidelines and gaps in research lead to over-medicalisation of prolonged labour



Unconducive urban maternity units

Papers II-IV were situated in five high-volume maternity units of Dar es Salaam. With the urban disadvantage in maternal and neonatal health seen in Dar es Salaam, it is relevant to dive into care provided in such high-volume maternity units. With an outset in the case study of Dar es Salaam, here I discuss time-scarcity, the risk of birth and the environment itself.

Globally, hospital environments face escalating demands for services without a corresponding increase in resources.[156] High fertility rates, urban growth and increasing facility births combined with a human resources crisis render urban areas in LMIC particularly vulnerable.[9,120] The findings from Paper II where oxytocin to augment labour was used as a form of crowd control are not unique.[108,157] In a Swedish qualitative study of midwives it is described how midwives had to speed up labour if rooms were insufficient.[157] In Egypt, lack of beds was the reason for near-universal use of oxytocin for labour augmentation.[108] Veenstra et al's manuscript "too busy to care" in a busy Tanzanian hospital underscores the devastating effect of insufficient time for routine monitoring, linking it to maternal deaths.[158] The study reports a correlation between staffing levels and mortality rates.[158] The rationale in expediting labour to free hands and avoid harmful congestion, as was found in Paper II, hence makes sense – albeit without due consideration to the potentially harmful effects of oxytocin and caesarean sections. If the maternity unit was less crowded, all women could be monitored closer. It, therefore, appears that in busy settings the focus may shift from individual patient needs to time- and ward management.[108,157,159] Labour wards in many places are already stretched. When asked, the staff found it difficult to imagine using less oxytocin, as they feared further overcrowding (unpublished observations). Many women in Paper IV arrived in latent labour because early admission was recommended to avoid the multiple delays seen at these hospitals.[110] Admission in latent labour is, however, shown to increase interventions.[160,161] Since latent labour can last for several days, this practice further strains hospital capacity. The current speed of population growth in Sub-Saharan Africa with heavier traffic jams and more women arriving in (early) labour will exacerbate hospital-crowding in urban areas. Getting to the hospital is no longer enough when hospital capacity cannot accommodate the increasing demand. Considering the effect of time- and space capacity on care provision thus becomes increasingly relevant and strongly calls for strategies to decongest, upscale capacity or provide care in urban congested settings.

As explained by Vigan et al. in a Beninese study, limited ability to monitor labour means being in labour "is a risky journey through the unknown".[162] A stillborn baby is a tragedy, not only for women and families, but also for the birth attendant. Consequently, the unsafe setting may prompt birth attendants to convert to a caesarean section *before* complications arise. Conversations with staff, in relation to this thesis, showed how "doctors' distress" influences decisions and how poor monitoring requires them to be one step ahead.[110]

This is in line with the early caesarean section decisions that were unfolded in Paper IV. Diagnosis, such as "bad obstetric history" used as indication for caesarean section in Paper III further illustrates how vaginal births were seen as unsafe compared to a caesarean section. Health providers expressed little focus on long-term effects of caesarean sections (unpublished observations). Defensive management and fear of litigation are commonly mentioned drivers for the caesarean section rise globally and in Tanzania.[163–165] Maternal health is highly politicised and has given rise to statements such as "prolonged labour is not acceptable" (Paper II). It might be understandable as its severe consequence, obstructed labour, is a source of much morbidity.[59] However, it misses that prolonged labour, in itself, is a poor predictor of adverse outcomes.[34] When deaths happen, the staff on duty are often held accountable through audits. This may give rise to a blaming culture, which can become counterproductive when losing sight of the bigger picture.[163,166] On the other hand, caesarean sections are some places perceived as the highest level of childbirth care - a life-saving intervention. Despite risks, many women in Tanzania accept caesarean sections as a choice made to save the baby while others go far for a vaginal birth after caesarean section.[110,167] Dispelling that caesarean sections represent the pinnacle of care and that prolonged labour (or merely labour) in itself is dangerous is essential in reversing these perceptions both among clinicians and wider society.[168] It is inarguable that the unsafe birth environment and culture of blame must be tackled to refrain from defensive, fear-driven management and allow women their physiological labour.[163 169,170]

Evidence demonstrates an association between labour environments and vaginal birth.[149] Factors, such as space to walk freely, control over visitors, privacy, cleanliness, not hearing other women and easy access to a toilet were significantly related to vaginal birth in a British national survey.[149] Other studies show the same trend.[149,171,172] This corresponds poorly to the crowded low-resource maternity unit with little privacy, poor toilet facilities and noise from other women.[151,173] In addition, many women in Sub-Saharan African countries report mistreatment, abuse, lack of information and consent and no birth companions allowed.[151 174] While Sub-Saharan Africa has historically prioritised mortality and morbidity, there is a growing call to shift focus towards creating respectful and empathetic environments.[175] Prioritising empathetic environments not only supports physiological birth through women's well-being but also upholds autonomy and basic human rights.[176,177]

Unfit clinical guidelines

This thesis unfolds significant evidence-practice gaps, which are particularly illustrated by the shortcomings of prolonged labour clinical guidelines. Here, I unfold the general gap between guidelines and low-resource realities, the lack of integrating evidence into guidelines and the ambiguity and unclarity of guidelines.

As I and colleague discuss, guidelines based on one-to-one care are of little use when simultaneously caring for multiple women with individual needs.[178] My observations in Paper II unfold the challenges when guidelines are too far from reality, leading to unstructured and sometimes dangerous adaptations.[178] Precise administration and monitoring of oxytocin for labour augmentation without advanced equipment presents a profound challenge. Studies from India, Sierra Leone and Cambodia echo my findings reporting uncounted drops, lack of titration, little monitoring and even unconventional use such as intramuscular injection.[71,76,106] Despite global recommendations for oxytocin for labour augmentation, Paper I shows a notable potential risk when applying oxytocin in these real-world scenarios. Paper I thus provides an insightful view on the possible side effects of unstructured adaptations.

The gap between guidelines and reality is typically assessed through the lens of substandard care. This often results in an implicit blame on the birth attendant for not performing well, while only few studies conclude that the criteria set out were simply unrealistic for the birth attendant to achieve.[179] While we strive for perfection, we must recognise that birth attendants in the frontline carry the burden when standards are unachievable.[178,180] While it is ethically difficult to develop acceptable guidelines for unacceptable realities, it is equally unethical to hold birth attendants accountable to unrealistic targets.[178,180] Importantly, the PartoMa intervention in Tanzania found that creating best-possible care guidelines, in fact, reduced perinatal mortality.[109] Time is overdue for thinking that the highest level of evidence is RCTs, when the RCTs do not represent reality.[181] It is arguable that in some cases the highest level of evidence is that derived from health workers in the front.[178] This is also illustrated by the WHO-INTEGRATE that emphasises on several pillars to consider when developing new guidelines.[182] This includes equity aspects, health system feasibility, balancing costs and benefits and societal views. [182]

Furthermore, inconsistent, unclear and outdated guidelines also contribute to untimely use of interventions. As evidenced in Paper V physiologically labour progression is considerably slower than previously reported and varies greatly depending on factors such as body-mass-index and maternal age.[41,44,46] Yet, most guidelines still use 0.5 to 1 cm per hour, persistently apply one-size-fits-all labour curves and include definitions that vary hugely.[31,90] In addition, the recent WHO Labour Care Guide, based on the newest progression curves, only delineates criteria for identifying prolonged labour. However, as I and colleagues argue, it lacks specific recommendations on when to intervene with oxytocin and caesarean section.[22,183]

While this respects the ability to provide individualised care, it also leaves health providers with no guidance and may, therefore, unintentionally cause harm.[178] Including timing of interventions is indispensable for utilising the Labour Care Guide as a decision-support tool. Several studies have succeeded in reducing oxytocin augmentation rates without compromising outcomes.[53,109,140,141,184] An Indian study reported a reduction in oxytocin from 78% to 32% after implementing a coaching-based intervention using the WHO childbirth checklist which prohibits routine oxytocin for labour augmentation altogether.[184] Oxytocin, however, increased to 48% six months after the intervention had ended.[184] It, thus, appears that reducing use of oxytocin for labour augmentation is possible through clinical guidelines and training but contextual factors that withhold its use, such as crowded labour wards, must be tackled to make changes sustainable.

As seen in Paper III, a variety of synonyms for prolonged labour exists, including poor progress, dystocia, obstructed labour, cervical arrest and cephalopelvic disproportion. Further, labour slower than 1 cm per hour was perceived to be abnormal and descriptions such as moulding and caput succedaneum were often applied, while they also occur in physiological vaginal birth. This is not unique to this setting but represents fundamental challenges in prolonged labour diagnosis.[90] Some places use pelvimetry and weight estimation to diagnose mechanical disproportion before onset of labour.[185,186] Evidence, however, shows that this practice increases caesarean sections without improving outcomes.[187–189] This may explain caesarean sections on doubtful indications, as in Paper IV and several low-resource settings, including Tanzania, Rwanda and Malawi.[23,26,85,91] Following, guidelines and audits are among the few practices that have shown to significantly reduce caesarean sections.[190–192] Despite this, caesarean section decision-support tools are scarce and decisions are highly impacted by clinicians' characteristics and skills and local cultures.[165,193] The famous Robson Classification puts women into defined categories based on parity, previous mode of birth, onset of labour, foetal position and number of foetuses.[194] It is excellent in showing which women get a caesarean section, but does not classify why caesarean sections are performed and whether the indication was justified. Decision-tools are needed to avoid clinicians performing caesarean sections on vague indications, to hold them accountable to globally agreed standards and to support them in evidence-based practices.[192] Finally, guidelines on prolonged labour lack essential evidence-based elements that enhance physiological labour.[66,67,149] This may partly explain the underuse of non-medical interventions and little focus on labour environments as seen in Paper II.

Guidelines, importantly, do not function in a vacuum and external factors, such as the defensive blaming culture described must be simultaneously addressed. As others have proposed, multifaceted interventions are needed to tackle the ongoing caesarean section pandemic.[165,169,170] For example, pre- and postgraduate training in prolonged labour management, including clinical assessment and training in vacuum-assisted birth.[107]

Gaps in research drives over-medicalisation

Except for the Labour Care Guide, no new medical treatment or decision-support tool has been introduced for prolonged labour since oxytocin came on the market in the 1950s and the partograph in the 1990s.[37,195] This has left oxytocin and caesarean section as the central treatments for prolonged labour.[72,196] The following describes how overuse is driven by a gap in research in oxytocin for labour augmentation, labour physiology and caesarean section and lack of routine data.

While the meta-analysis in Paper I suggests adverse outcomes in LLMIC, these findings need confirmation by more robust studies. Observational studies from HIC echo the potential harm. A recent RCT from France, however, find no adverse outcomes when continuing versus stopping oxytocin at active labour.[143] This raises the question whether it is possible to sufficiently avoid residual confounding in observational studies. Nevertheless, given the inability to provide continuous monitoring and use of electronic infusion pumps, harmful effects are highly plausible. Restrictive regimens are, therefore, encouraged in low-resource settings particularly. The lack of research into restrictive oxytocin augmentation regimens allowing more time for labour, however, withholds its current global use. Further, the balance between prolonged labour in congested low-resourced labour wards and the use of oxytocin to expedite labour remains elusive. While research has predominantly centred on labour progression, there is a pressing need for research into the optimal timing of interventions in different settings, for example, in settings without electronic drip-count and continuous monitoring. This is particularly relevant in light of the newer tolerant labour curves.[41,44]

It is puzzling that a potentially harmful medication such as oxytocin has become so integrated into care practices (Papers I, II and V), while its benefits remain unproven.[72] This is in stark contrast to how medicine is usually characterised by being evidence-based. The reality, however, is that many medical practices are not founded on robust clinical trials.[197] Particularly, old treatments approved before robust trials were mandated do not require re-approval. This explains the scarcity of studies on oxytocin augmentation facilitating its approval in the 1950s. With the level of evidence available, it is safe to say that oxytocin for labour augmentation would not have been approved today. The case is, however, not unique. “Medical reversal” is when clinical trials of existing practices show that it does not work or cause harm.[197] This is illustrated by the example of hydroxyethyl starch for intensive care patients with sepsis revealing severe harmful effects after 40 years of common use.[198] This underscores the importance of also questioning commonly used medications. Since 2011, “choosing wisely” organisations worldwide conduct research aiming to reduce overuse and unnecessary practices in an era where patients request more services and legal claims drive defensive over-medicalisation.[199] They argue that billions can be saved if choosing more wisely, while not compromising outcomes. The lack of research on the effects and safety of oxytocin uncritically upholds its use.

Oxytocin is a helpful endogenous birth-facilitating drug, a lifesaving drug for postpartum haemorrhage, shortens labour and for selected women it may prevent a caesarean section.[196] In addition, no other medication exists to support women with prolonged labour and oxytocin is therefore the only available medical option.[30] These factors may contribute to why oxytocin is used globally despite the lacking research and why perceptions favouring oxytocin augmentation, as seen in Paper II, have become so incredibly strong. Today, a normalisation appears to have been established whereby many clinicians do not question or are aware of the lacking research but use it because it appears to work. This phenomenon is also referred to as being "fooled by experience".[200] While, in fact, nobody knows what would have happened had oxytocin not been applied.

The central role of oxytocin for labour augmentation in practice also represents a clear gap in the understanding of labour physiology. Oxytocin represents only one link in the chain of factors required to facilitate birth.[30] The remaining factors are unknown or scarcely understood.[30] Increase in amniotic fluid lactate due to uterine muscle fatigue has received attention in the past decades. In prolonged labour, lactate levels are high and it is suggested that labour with high lactate levels does not benefit from oxytocin.[201] Buffering lactate with bicarbonate or simply allowing rest are possible alternatives scarcely researched.[201] Importantly, it challenges the universal application of oxytocin to *all* women with prolonged labour.

Research gaps driving over-medicalisation also include long-term consequences of caesarean sections. Most studies are from HIC where caesarean sections are much safer.[60] A systematic review, however, reported association between caesarean section and maternal and perinatal mortality.[60] There may, as well, be substantial differences depending on whether caesarean sections are performed "defensively" (as in Paper III and IV) or "delayed", with the latter associated with poorer outcomes. The lack of research on long-term risks supports the positive view on caesarean sections even in settings where caesarean sections can be fatal. Databases, as seen for many surgical procedures, are highly needed to be able to track caesarean section outcomes robustly.

Finally, in many studies, routine data do not include sufficient details on prolonged labour. The validation study at the five hospitals studied in Papers III and IV showed how oxytocin augmentation in 20% of case files was not recorded even though it was applied. As in Paper I, reporting often omits key information (such as timing or dose of oxytocin), use outdated unspecific International Classification of Disease (ICD) criteria for prolonged labour and inconsistently describes non-medical interventions and arguments for caesarean sections. This hinders accountability and monitoring of these practices. Unified reporting tools and updated ICD criteria could enhance monitoring and facilitate meaningful comparison between hospitals.[31]

Consequences of over-medicalisation

Over-medicalisation not only exposes women and their unborn babies to unnecessary risks but also incurs substantial direct and indirect costs. Maternal death and disability, perinatal deaths and children living with life-long disabilities carry significant burdens for the woman and her family, health providers, the health system and broader society.[202] Working in constraint settings under constant pressure to run faster and take extra shifts contribute to demotivation and burnout among staff.[203] Inability to adhere to guidelines imposes a moral injury on birth attendants striving to provide the best care, yet systemic constraints hinder their efforts. When lives are lost, health providers often bear blame for the failure of the health system leaving deep mental scars.[203] Additionally, women left alone in labour wards, stripped of autonomy and lacking mental support during one of the hardest moments in their lives may be left traumatised. This has consequences on mental well-being and capability of caring for her newborn.

The economic costs of over-medicalisation have not been estimated. According to the Lancet series on stillbirths, a stillborn baby demands far more resources than a live-born baby.[202] Caesarean sections, oxytocin augmentation and their complications drain human and financial resources. Allocating these costs into increasing staff levels and improving environments could potentially reverse these trends and improve outcomes. While the case for change is clear, solutions are complex and require a multifaceted approach.


The PatoMa research team. Photos by: Thomas John and Nanna Maaløe

CHAPTER 10: DISCUSSION OF METHODOLOGICAL ISSUES

In this chapter, I first discuss the strengths and limitations of the thesis as a whole, followed by a detailed exploration of each individual study.

Applying multiple methods

Overall, the strength of this thesis lies in its application of several methodologies enabling a multidimensional understanding of prolonged labour.[133,204] Starting with a focus on Dar es Salaam, the thesis investigates how the over-medicalisation of prolonged labour is rooted in broader global issues. The inclusion of Paper V expanded the relevance of the findings from Dar es Salaam to a global context, adding depth to the overall conclusions.

The quantitative methods served distinct purposes, each contributing in their way to the understanding of prolonged labour management. On the other hand, qualitative methods added richness to the research.[133,134] The application of several methodologies demanded more effort to master each one.[134] Despite achieving less expertise in single methods, employing multiple- and mixed methods, I gained proficiency in triangulating findings. To ensure quality of the various methods, I collaborated with researchers possessing diverse backgrounds in biomedical and social science. This approach enhanced my ability to apply diverse methods, leading to a more comprehensive understanding of the research subject. The gains from applying several methods outweighed the challenges in mastering each.

Cross-cultural research

Doing research in another country meant that there were things I did not know or understand.[125] To overcome this, I spent six months in Tanzania to familiarise myself with the culture and ways of doing and saying things. I spent most time at one of the study sites engaging in the daily discussions around labour management. Six months is not a long time. I, therefore, also relied on collaborating and discussing my findings with Tanzanian colleagues and staff at the hospitals during observations, analysis and interpretation of the data. After returning home, I further attended three virtual meetings with frontline health workers from Dar es Salaam to triangulate and deepen my understanding of the findings. This collaborative approach aimed to establish the credibility and applicability of the findings within the Dar es Salaam setting.

Other research components

A crucial limitation of this thesis is the absence of women's voices. Adding this would have been a valuable contribution and would have significantly enriched the findings. It should be noted, however, that I conducted ten interviews with women who had caesarean section performed because of prolonged labour. These results have not been analysed yet. Integrating these perspectives would have been a valuable contribution, providing a more comprehensive and nuanced understanding of caesarean sections.

My primary focus was the practical use of oxytocin. However, literature describes that the quality of oxytocin is compromised by inappropriate storage from manufacturing to administration. A review in LMIC found that 45.6% oxytocin samples failed quality tests, with concentrations falling below 90% of the stated content.[205] In the five hospitals included in this thesis, oxytocin was stored correctly in refrigerators and based on assessments of the women's reactions to the drug, it seemed to be effective to some extent. Nonetheless, experience with low-quality drugs could potentially explain the high concentrations observed in Paper II. Including an assessment of oxytocin quality would have been highly relevant.

The qualitative study focused on prolonged labour during vaginal birth and the decision-making process concerning oxytocin for labour augmentation. However, a similar exploration of the decision-making process around caesarean section could have added depth to the research. The choice of a case file review (Papers III and IV) to assess caesarean sections allowed for a quantitative measure, revealing the frequency of non-medically indicated caesarean sections, showing the extent of the problem. An in-depth qualitative study on the decision-making process would have complemented the findings in Papers III and IV. Informal meetings were held with frontline birth attendants and specialists from the five study sites to discuss findings. These revealed underlying causes and were integrated into the discussion in a less scientifically rigorous manner.

This thesis explores the overuse of interventions. Importantly, underuse also happened and in other setting underuse may be more prevalent. The findings are therefore not translatable to any setting. Instead, the thesis tries explicitly to understand overmedicalisation of prolonged labour in urban low-resource settings.

Actionable steps

Finally, many of the findings of this thesis are not ground-breaking and the primary novelty of the thesis lies in building upon, revealing and synthesising existing knowledge to make a strong case for action. What is mostly needed are actionable steps to change current patterns. Such actionable steps are suggested in the final chapter. It is essential to perceive this research project as an integral part of the PartoMa intervention, which actively focused on developing context-tailored guidelines, including those for prolonged labour. The insights gained from this thesis will be integrated in the ongoing PartoMa intervention, contributing to meaningful and crucial changes in the field.

Paper I: Oxytocin for labour augmentation in LLMIC: A systematic review and meta-analysis

The main strength of Paper I, the systematic review, lies in its inclusion of studies from 25 out of 79 LLMICs, 42 studies in total. This was facilitated by a rigorous search in regional databases. On the other hand, the explorative approach yielded a diverse range of studies that were heterogeneous and of varying quality. This hampered generalisability and comparability. However, it enabled me to delve into the complexity of prolonged labour, allowing for the identification of crucial gaps in both research and practice. The following will discuss the quality of the included studies, address issues such as confounding by indication and misclassification bias and conclude with a few additional considerations.

Quality of included studies

A crucial limitation includes the use of non-validated hand-written medical records used in many studies, potentially leading to poor quality. This may explain some of the variation in, for example, reported oxytocin rates. The low quality of some of the studies makes the conclusion less robust compared to meta-analyses based on homogeneous RCTs. An alternative approach could have been to apply strict quality criteria, which is typically more appropriate for meta-analyses.[206] However, Cochrane reviews on oxytocin for labour augmentation including exclusively RCTs already exist.[72,78,144] As these reviews are underpowered or scarcely include LMICs, I aimed for a broader perspective and intentionally did not impose restrictions on quality. When studies are scarce, even low-quality studies can offer valuable insights.[206] Conclusions, however, must be made more cautiously.

Confounding by indication

The studies included in meta-analysis revealed a notable level of consistency in the association between oxytocin for labour augmentation and perinatal outcomes. A crucial limitation is the potential for confounding by indication, which could overestimate the strength of the association.[207] The studies did not adequately distinguish between risks stemming from the duration of labour versus those arising from oxytocin augmentation.[208–211] In comparing groups with and without oxytocin for labour augmentation, studies reported no differences in prolonged labour. This could be attributed to the high levels of oxytocin augmentation in uncomplicated labour, minimising impact on confounding by indication. While labour duration in itself poorly predicts adverse outcomes, mediators are possibly even more important to consider but were not investigated in the studies.[34,62] The extent to which the duration of labour and residual confounding explain the observed association and the role of mediators remains unknown. Nevertheless, the results emphasise the need for cautious use of oxytocin for labour augmentation.

Randomised control trials are considered the strongest design for avoiding residual confounding.[207] Conducting an RCT for a potentially harmful drug, like oxytocin, which may also prevent a caesarean section

is ethically challenging. Both giving it and withholding it expose women to risks. A reasonable alternative could be a well-designed cohort study, employing methods such as propensity score matching or, at the least controlling for labour duration.[207] Sensitivity analysis exploring mediators e.g. foetus with intrauterine growth restriction or pre-eclamptic women, could facilitate cautious selection of foetuses that may not tolerate oxytocin. RCTs are expensive and the use of advanced epidemiological methods is crucial in balancing costs for research.

Misclassification bias

Studies find that pre-hospital, intra-hospital, macerated and fresh stillbirths are often poorly recorded in case files.[212] Likewise, Apgar score is a subjective measure. The risk of misclassification is therefore important. In routine data on stillbirths, there is a tendency to overreport pre-hospital stillbirths and underreport intra-hospital stillbirths.[212] Routine data on Apgar scores (given by the staff) exhibits a tendency for scores to be overestimated (unpublished observations). Both may result in differentiated misclassification leading to an underestimation of the associations and could potentially explain why stillbirths and Apgar scores are more inconsistent in the meta-analysis. While resuscitation is considered a reasonable measure, resuscitation may represent care practices and availability of equipment rather than actual need for resuscitation. This would misclassify babies needing resuscitation but who did not receive it and thereby underestimate the association between oxytocin for labour augmentation and need for resuscitation. In the included studies, neonatal encephalopathy emerged as the most reliable outcome measure, with encephalopathy scores given by a dedicated research assistant unaware of oxytocin exposure. Studies aiming to measure possible causality rely heavily on accuracy of exposure and outcomes. Consequently, non-validated routine data may be less appropriate for this purpose, given the potential misclassification biases.

Other limitations

Some studies were not designed to assess oxytocin for labour augmentation. This increases the risk of type 1 error due to random findings and publication bias.[70,74,94,211] Finally, the complex landscape of oxytocin administration includes aspects such as timing, duration, monitoring, titration and administration forms (intravenous/intramuscular). These factors particularly relate to LLMIC and can explain the potential risks of adverse outcomes reported. They were unfortunately not included in the studies. Finally, the review only included quantitative studies. The inclusion of qualitative studies could have facilitated more depth to the findings, such as perceptions of risks and benefits, reasons for overuse and challenges related to administration. While the meta-analysis fails to provide robust evidence because of the explained limitations, it crucially identifies the need for research in low-resource settings and provides methodological considerations that future research must consider.

Paper II: Temporalities of oxytocin for labour augmentation: A mixed methods study of time factors shaping labour practices in a busy maternity unit in Tanzania

The mixed methods study included three methods. First, I will address the structured labour observations, followed by a discussion on the choice of qualitative studies, the Hawthorne effect, translation challenges and generalisability.

Structured labour observations

The quantitative part of this mixed methods study used structured labour observations. This method is labour-intensive and, therefore, only 234 women were observed. This number was sufficient to provide a cross-sectional view of how labour is managed. Importantly, it allowed for a detailed examination of aspects such as oxytocin titration that was unavailable in case files. The sample size, unfortunately, lacked power to interpret associations between oxytocin for labour augmentation and rare outcomes, such as perinatal mortality.

Choice of qualitative methods

Within the qualitative part, two methods were employed: in-depth semi-structured interviews and participant observations.[135] The interviews captured the perspectives of birth attendants, while the observations uncovered workflows and patterns in the environment of a maternity unit, some of which were not always apparent to the birth attendants themselves. The combination of these methods facilitated an exploration of differences between reported views and observed practices and explorations of why certain practices were carried out or not.[135] Qualitative methods, such as photovoice or other participatory approaches could have brought out the views of the participants more vividly.[213] While examples from the observations were used in interviews, a strategic use of vignettes could have brought further depth to some scenarios. Finally, focus group discussions could have confirmed and unfolded the collective perceptions and beliefs related to oxytocin for labour augmentation and prolonged labour.

Hawthorne effect

Observations may be susceptible to the Hawthorne effect, wherein birth attendants might have altered their practice when aware of being observed.[214] To mitigate this, the research assistants were not trained in obstetrics and were younger than the staff and had little foundation to influence on care practices. Further, the findings were largely a result of the busy low-resource environment which did not change throughout the study. Therefore, I do not believe that the Hawthorne effect was profound. For example, when beds filled up, birth attendants coped by applying oxytocin. I addressed the potential risks of oxytocin for labour augmentation with the staff. Knowing that it could influence their care, it felt unethical not to discuss it as I perceived the current use as being dangerous. Health providers, however, had a positive view of oxytocin

and it appeared to be deeply ingrained in routine practices. Assumingly, to lower usage or even stop it would require fundamental changes in the labour ward management. On the contrary, it is plausible that oxytocin use increased during observations because it was perceived as a beneficial medication.

Translation challenges

In Tanzania, Swahili is the national language. Research assistants spoke fluent English but birth attendants and women spoke varying levels of English. During observations, I discussed mostly with birth attendants who spoke English, while translations were needed when engaging with the remaining participants. Views from English-speaking birth attendants dominated informal conversations. Interviews conducted in Swahili by a research assistant were not ideal. It worked, however, because being a midwife and experienced qualitative researcher, my research assistant understood the clinical aspects and was able to conduct interviews independently. I gained much trust in her ability to conduct interviews. Importantly, the interviews were not interrupted as much as they would have been with direct translation.[215] Interviews were translated from Swahili and nuances may have been missed during this process. I ensured the quality of the transcriptions by having colleagues double-check the transcripts. Using translators meant that I got more detached from the interview and was not able to steer the interview, follow important tracks or get deeper into certain topics. For these interviews I had to rely heavily on the research assistant and the interview guide.

Generalisability

Though qualitative research does not seek to be generalisable, findings of the study are of particular interest to LMICs where congestion and high use of oxytocin for labour augmentation is an issue. Nevertheless, culture and habits may differ substantially from hospital to hospital. Thus, findings must be generalised with caution even within similar settings. Rural hospitals, for example, may experience underuse of oxytocin due to absence of staff, lack of storage capacity, stock-outs or low quality of oxytocin.

Papers III and IV: Timeliness of caesarean sections at the five hospitals in Dar es Salaam

Criterion-based audit is a strong method to evaluate quality of care by comparing practices against fixed standards. This criterion-based audit relied on case files. Below, I discuss the quality of case files, the selection of audit criteria and the objectivity gained through the criteria-based audit.

Data quality

Research based on case files in low-resource settings poses its own challenges. As observed in the validation study, the accuracy and completeness of data in the case files can be notably low. This study was based on a data validation study conducted preceding data collection. This ensured considerations related to the reliability of the data and the selection of appropriate variables for analysis. Despite the presence of well-trained research assistants, human errors in data entry are common, underscoring the importance of double-entry of data to assess the extent of these errors. An important strength is the double-entry process applied to all case files related to prolonged labour and 30% of all caesarean section case files. While the ideal scenario would have been to double-enter all case files, resource limitations made this impractical. Therefore, prolonged labour case files with the highest likelihood of errors were prioritised. By basing my analysis on the data validation study and by performing double entry, the internal validity of the study is considered reliable. Misclassification may have occurred due to the general low quality of the case files; such misclassification will be non-differential and not influence the results.

Audit criteria

We aimed to use conservative criteria to estimate non-medically indicated caesarean sections to avoid unfairly overestimating them. To achieve this, it was decided that if labour was not prolonged at the time of decision the caesarean section was categorised as being non-medically indicated. In practice, when labour is prolonged, actions such as rupturing membranes and/or administering oxytocin for labour augmentation are often carried out before performing a caesarean section. Some guidelines consider these interventions as criteria to justify a caesarean section.[23,25] Furthermore, the definition of prolonged labour is debated and there are more tolerant definitions of prolonged labour compared to the action line used in this study (Figure 1).[22] However, these definitions had not been tested in low-resource settings and as the partograph was used in Dar es Salaam, it seemed most appropriate to use this approach. Finally, evidence-based prolonged labour management includes continuous labour support, which were not practised in these labour wards.[66,67] Considering all these factors, the occurrence of non-medically indicated caesarean sections is likely underestimated. On the other hand, basing the audit on retrospective case files without involving the decision-makers may overestimate non-medically indicated caesarean sections because factors which were not documented in the case file but which may have influenced the decision were not taken into account. It is important to recognise that the decision to perform a caesarean section is rarely

straightforward. A caesarean section that appears non-medically indicated based on fixed clinical criteria may in reality have been indicated due to other contextual factors. To limit the influence of other factors, all women with other conditions/indications that could require a caesarean section were excluded. Finally, some of the women ultimately would undergo a caesarean section later. Non-medically indicated caesarean sections are only based on the diagnosis at the time of decision.

Objective versus subjective approach

This study adopted an "objective" black-and-white- approach to inform audits. The term non-medically indicated was applied to acknowledge the nuanced nature of caesarean section decision-making, which is inherently complex and not always clear-cut. In constrained settings non-medical factors such as availability of staff may influence decisions. Therefore, non-medically indicated, strictly refers to medical and not contextual arguments for deciding to perform a caesarean section. In contrast, other studies apply audit processes where a team of experts review the case file.[24] This offers the advantage of capturing more nuances, particularly related to external factors. As caesarean section decisions can be vague, making it easy to find arguments for a caesarean section decision, I opted for an objective measure with a sample size large enough to show trends. This study, therefore, cannot stand alone but is a great stepping stone to explore external factors driving non-medically indicated caesarean section decisions using other research methods.

Paper V: Inconsistent definitions of labour progress and over-medicalisation cause unnecessary harm during birth: a critical review

The strength of Paper V lies in its ability to incorporate targeted and relevant literature regardless of its type. In contrast to traditional literature reviews that often focus on narrowly defined research questions and rigorously explore them to reach a single conclusion, this analysis takes a more comprehensive approach. By strategically selecting and presenting relevant literature, the paper aimed to provide a holistic view of the subject, encompassing diverse perspectives. This selective process demands expertise from the authors, who must possess a thorough understanding of the field and the ability to discern crucial elements. It is, however, important to acknowledge that a non-systematic approach may introduce bias, as authors prioritise aspects they personally find important. To mitigate this, the analysis involved authors from diverse disciplines, relied on systematic literature reviews and included counterarguments where applicable. Research findings were presented objectively, allowing readers to form their own judgments. Many reviews related to prolonged labour exist but this particular view focusing on evidence-practice gaps appeared missing.[30,31,56,216,217]

Woman who recently gave birth. Photos by: Lara Meguid

CHAPTER 11: CONCLUSION & PERSPECTIVES FOR THE FUTURE

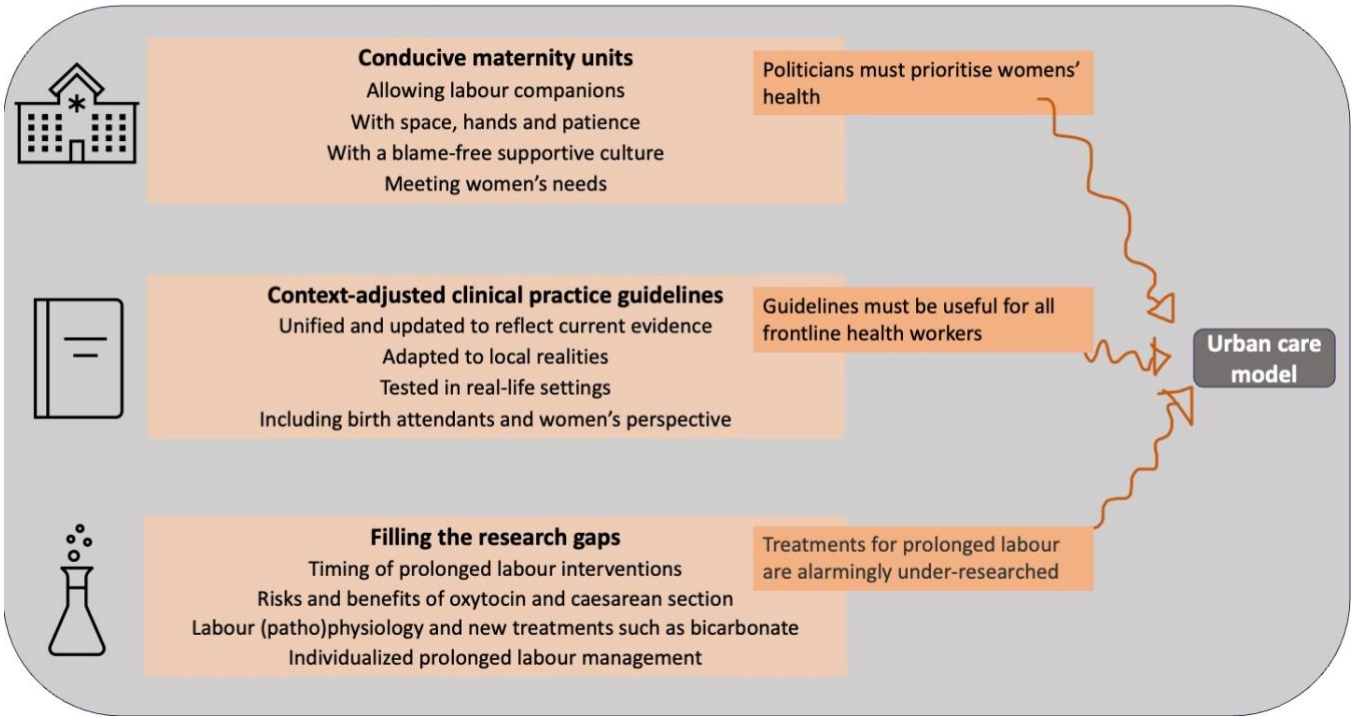
This thesis unveiled concerning evidence-practice gaps at the global level (Paper V): while 10-15% of labours are prolonged, up to 90% are augmented with oxytocin; while labour is physiologically slower than previously believed, caesarean sections for prolonged labour are on the rise; and while labour companions have shown to improve physiological labour, they are not allowed in many maternity units in Sub-Saharan Africa. Oxytocin for labour augmentation may cause potential harm, particularly in low-resource settings, yet its effect on caesarean sections remains unproven.

These global gaps were explored in the case study of Dar es Salaam, which provided novel insights into prolonged labour management in five busy urban maternity units. In one maternity unit (Paper II) oxytocin for labour augmentation was applied in 62.4% of labours, many with uncomplicated progression. The most mentioned reason for applying oxytocin was ensuring flow of women through the labour ward to free up beds. In many ways birth attendants preferred to augment labour with oxytocin: it solved dangerous congestion, responded to a fundamental fear around prolonged labour and there was little alertness towards the harmful effects of oxytocin for labour augmentation. On the other hand, non-medical prolonged labour management was limited and the environment appeared unconducive to physiological labour.

Prolonged labour accounted for half of caesarean sections in the unscarred uterus (Paper III). Just over half were carried out despite uncomplicated labour progression (Paper IV). The early diagnosis may be driven by a fundamental fear of blame in unsafe labour environments and a positive view on caesarean sections. As prolonged labour accounts for many caesarean sections, the unconducive maternity units may indirectly drive the caesarean section epidemic by not allowing for safe evidence-based prolonged labour management.

On a macro-level, this thesis unfolds a much deeper health system failure, whereby overcrowded hospitals are not able to provide respectful care during childbirth. The call for action represents this underlying inequality (Figure 16). Despite almost half of the world's population giving birth, research is scarce on prolonged labour, prolonged labour guidelines are unrealistic to follow in low-resource maternity units and many labour environments are unacceptable. As Mahmoud Fathallah, FIGO President in 1994, said, “women are not dying because of untreatable diseases. They are dying because society has yet to make the decision that their lives are worth saving”.[218] Thirty years later, this statement is still true – in urban high-volume hospitals, individual women’s needs are replaced by crowd management because resources are too few. Not only does it drive the caesarean section epidemic but it also demoralises birth attendants and violates women’s rights. Time is overdue for politicians and leaders to prioritise respectful care around birth. The needs are many, and three areas of future action related to this thesis are outlined below.

Figure 16: Towards improved prolonged labour management in urban low-resource labour wards and beyond



Maternity units in urban low-resource settings need a paradigm shift to effectively address the escalating demand for obstetric services. Addressing this challenge requires more staff, space and beds and a safe and blame-free environment for women and health providers. The allowance of birth companions is crucial and women must be asked for their perspectives on empathetic birthing environments. With the human resource crisis in many countries in Sub Saharan Africa, task shifting to upgraded doulas and low-intervention areas for women in latent labour could be crucial steps. Even in busy hospitals in HIC increasing staff and space are needed to facilitate a shift towards respecting physiological labour as being slower.

Clear and updated guidelines for prolonged labour are long overdue. While much has still to be learned, the evidence-practice gap is distorting. Step one must be to implement into the guidelines what we already know. Box 1 provides recommendations as a minimum content of a prolonged labour guideline based on findings from this thesis. Importantly, guidelines must consider that in many places around the world one-to-one care is far from the reality. Guidelines must, therefore, be stratified to ease local adaptations and include women's and birth attendants' perspectives. Finally, guidelines must be tested in real-life settings and followed by training. Audits on caesarean sections for prolonged labour have proven useful in sustaining accountability to guidelines.

Box 1: Prolonged labour guideline must include:

- Updated definition of prolonged labour, including factors that may affect individual labour progression – when should we start to worry? When should we intervene?
- A diagnostic tool enabling categorisation into causes of prolonged labour, e.g. expanding the traditional 3 Ps (power, passenger and pelvis) to include pain, passing urine, psyche, hydration and fatigue and recognising the complexity of prolonged labour.
- Timing and choice of interventions, perhaps using a check-list – have relevant actions been offered? when should oxytocin for labour augmentation be applied? Can we wait a little longer?
- Elaborated considerations related to oxytocin's effects and side-effects, including safety measures - how much monitoring is needed and what to do if adequate monitoring is not possible?
- Caesarean section decision-support tool – when is a long labour long enough?

The need for research into oxytocin's timing, effects and side-effects, is indispensable. Continuous understanding of the complexity of labour may spur the development of novel treatments. This may provide alternatives to those who, despite oxytocin administration, ultimately undergo a caesarean section. Novel findings, such as lactate as a diagnostic marker to forecast oxytocin's effectiveness and bicarbonate in treating or preventing prolonged labour represent avenues for further exploration.[201] Increased research into individualised management may pave the way for modelling and machine learning to guide decision-making. Finally, strengthening routine data is fundamental to assess prolonged labour management moving forward.

Through the lens of prolonged labour, this thesis gave an insightful understanding of care in the busiest maternity units in Dar es Salaam, Tanzania. To meet the SDG health targets and put a hold to the increasing urban disadvantages in maternal health, more research into urban health fostering urban care models is needed within and beyond maternal health.

CHAPTER 12: REFERENCES

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Paper I

Labor augmentation with oxytocin in low- and lower-middle-income countries: a systematic review and meta-analysis. AJOG Global Reports, 2022; Oct 21;2(4):100123.

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Supplementary material is available through the journal's webpage.

Labor augmentation with oxytocin in low- and lower-middle-income countries: a systematic review and meta-analysis

Monica Lauridsen Kujabi, MD; Emmeli Mikkelsen, MD; Natasha Housseine, MD, PhD; Josephine Obel, MD; Brenda Sequeira D'Mello, MD; Dan W. Meyrowitsch, PhD; Kidanto Hussein, MD, PhD; Jeppe Bennekou Schroll, MD, PhD; Flemming Konradsen, PhD; Jos van Roosmalen, MD, PhD; Thomas van den Akker, MD, PhD; Nanna Maaløe, MD, PhD

OBJECTIVE: Despite its worldwide use, reviews of oxytocin for labor augmentation include mainly studies from high-income countries. Meanwhile, oxytocin is a potentially harmful medication and risks may be higher in low-resource settings. We conducted a systematic review and meta-analysis of practices, benefits, and risks of oxytocin for labor augmentation in low- and lower-middle-income countries.

DATA SOURCES: PubMed, Embase, PsycINFO, Index Medicus, Cochrane, and Google Scholar were searched for publications until January 1, 2022.

STUDY ELIGIBILITY CRITERIA: All studies evaluating oxytocin augmentation rates were included. To investigate benefits and risks, randomized and quasi-randomized trials comparing oxytocin augmentation with placebo or no oxytocin were included. To explore risks more broadly, cohort and case–control studies were also included.

METHODS: Data were extracted and quality-assessed by 2 researchers using a modified Newcastle–Ottawa scale. Generic inverse variance outcome and a random-effects model were used. Adjusted or crude effect measures with 95% confidence intervals were used.

RESULTS: In total, 42 studies were included, presenting data from 885 health facilities in 25 low- and lower-middle-income countries (124,643 women). Rates of oxytocin for labor augmentation varied from 0.7% to 97.0%, exceeding 30% in 14 countries. Four studies investigated timing of oxytocin for augmentation and found that 89.5% (2745) of labors augmented with oxytocin did not cross the partograph's action line. Four cohort and 7 case–control studies assessed perinatal outcomes. Meta-analysis revealed that oxytocin was associated with: stillbirth and day-1 neonatal mortality (relative risk, 1.45; 95% confidence interval, 1.02–2.06; N=84,077; 6 studies); low Apgar score (relative risk, 1.54; 95% confidence interval, 1.21–1.96; N=80,157; 4 studies); neonatal resuscitation (relative risk, 2.69; 95% confidence interval, 1.87–3.88; N=86,750; 3 studies); and neonatal encephalopathy (relative risk, 2.90; 95% confidence interval, 1.87–4.49; N=1383; 2 studies). No studies assessed effects on cesarean birth rate and uterine rupture.

CONCLUSION: This review discloses a concerning level of oxytocin use, including in labors that often did not fulfill criteria for dystocia. Although this finding is limited by confounding by indication, oxytocin seems associated with increased perinatal risks, which are likely mediated by inadequate fetal monitoring. We call for cautious use on clear indications and robust implementation research to support evidence-based guidelines for labor augmentation, particularly in low-resource settings.

Key words: Apgar score, birth asphyxia, childbirth, clinical guidelines, low- and lower-middle-income countries, low-resource setting, neonatal encephalopathy, neonatal mortality, neonatal resuscitation, oxytocin augmentation, partograph, perinatal mortality, prolonged labor, stillbirths

From the Global Health Section, Department of Public Health, University of Copenhagen, Copenhagen, Denmark (Drs Kujabi, Obel, D'mello, and Meyrowitsch, Konradsen, and Dr Maaløe); Department of Gynecology and Obstetrics, Aarhus University Hospital, Aarhus, Denmark (Dr Mikkelsen); Department of Clinical Medicine, Aarhus University, Aarhus, Denmark (Dr Mikkelsen); Medical College, East Africa, Aga Khan University, Dar es Salaam, Tanzania (Drs Housseine and D'mello, Hussein, and Dr Maaløe); Julius Global Health, Julius Center for Health Sciences and Primary Care, University Medical Center Utrecht, Utrecht University, Utrecht, the Netherlands (Dr Housseine); Comprehensive Community Based Rehabilitation in Tanzania, Dar es Salaam, Tanzania (Dr D'mello); Department of Obstetrics and Gynecology, Copenhagen University Hospital Hvidovre, Hvidovre, Denmark (Dr Schroll); Athena Institute, Vrije Universiteit Amsterdam, Amsterdam, the Netherlands (Drs van Roosmalen and van den Akker); Department of Obstetrics and Gynecology, Leiden University Medical Center, Leiden, the Netherlands (Dr van den Akker)

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Corresponding author: Monica Lauridsen Kujabi, MD monica.kujabi@sund.ku.dk

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AJOG Global Reports at a Glance

Why was this study conducted?

Reviews of oxytocin for labor augmentation include mainly studies from high-income countries. We hypothesize that risks are more pronounced in low- and lower-middle-income countries (LLMIC).

Key findings

In studies from LLMIC, rates of oxytocin augmentation exceeded 30% in 14 countries (56%). In many cases, criteria for dystocia were not fulfilled. Although limited by confounding, this meta-analysis indicates the association between oxytocin for labor augmentation and stillbirth, day-1 mortality, neonatal resuscitation, neonatal encephalopathy, and low Apgar score.

What does this add to what is known?

This review suggests that suboptimal intrapartum care in LLMIC drives risks mediated by oxytocin augmentation. Robust implementation research is warranted to understand overuse and guide realistic, safe, and effective use based on clear indications.

Introduction

Oxytocin has been used to stimulate uterine contractions since the 1950s and is the most commonly used drug during labor around the world. Although oxytocin augmentation is proven to reduce labor duration by 2 hours, evidence that it reduces cesarean birth for prolonged labor is missing.[1,2]

Oxytocin remains on the list of 12 specific high-alert medications that require "special safeguards to reduce the risk of errors" (Institute for Safe Medication Practices).[3] Oxytocin has a variable individual therapeutic index, whereby the effect of 1 dose may result in no effect in some women and hypertonic uterine contractions in others. Hypertonic contractions can cause decreased placental blood perfusion and oxygen flow to the fetus, which may lead to brain damage or intrauterine death.[4,5] Randomized controlled trials from high-income countries suggest that oxytocin for labor augmentation is associated with fetal heart rate (FHR) abnormalities. These randomized trials are, however, underpowered to assess perinatal death and Apgar score.[1] Observational studies, from high-income countries mainly, suggest an association with acidemia, low Apgar score, and neonatal encephalopathy (NE).[6–8]

We hypothesize that adverse effects caused by oxytocin are likely to be much larger in low-resource settings because of absence of 1-to-1 care, electronic infusion pumps, continuous fetal and uterine monitoring, and delays in access to cesarean birth if fetal distress occurs.[9] Use of oxytocin for labor augmentation seems to follow the trend of increasing medicalization of childbirth seen in many parts of the world.[10] For instance, the World Health Organization's (WHO) Better Outcomes in Labour Difficulty (BOLD) study showed that 35% of Nigerian and Ugandan women had labor augmented with oxytocin.[11]

This study aimed to perform a systematic review investigating clinical practices, benefits, and risks of oxytocin for labor augmentation in low- and lower-middle-income countries (LLMIC). In addition, by using an exploratory approach, we unfold gaps for future research.

Materials and Methods

Search strategy

As registered in the International Prospective Register of Systematic Reviews (PROSPERO) and in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) and MOOSE (Meta-analyses of Observational Studies in Epidemiology) guidelines, a systematic literature search and meta-analysis was carried out. PubMed, Embase, PsycINFO, Cochrane, Index Medicus, and Google Scholar Citations were searched for publications until January 1, 2022 (Supplementary table 1). Search terms included 3 themes for search strings: oxytocin for labor augmentation, birth outcomes ("perinatal mortality," "neonatal resuscitation," "Apgar score," "neonatal encephalopathy," "uterine rupture," "labor duration," and "cesarean section"), and LLMICs (World Bank 2020 country classification). Medical Subject Headings terms were used whenever available. References of included studies were screened to identify additional studies. Language was restricted to papers in English and French (spoken in 60 of 79 LLMICs). Studies were published in both peer-reviewed and non−peer-reviewed journals.

Selection criteria

Exposure to oxytocin for labor augmentation was defined as oxytocin given after onset of labor and before the third stage of labor. Outcomes were intrapartum stillbirth, day-1 neonatal mortality, neonatal resuscitation, NE, low Apgar score, cesarean birth for prolonged labor, labor duration, and uterine rupture. All studies providing oxytocin augmentation rates were included. For assessing timing of oxytocin, only women in spontaneous labor were included. To investigate benefits and risks, randomized and quasi-randomized trials, comparing oxytocin augmentation with placebo or no oxytocin augmentation, were included. To explore possible oxytocin-mediated risks more broadly, cohort and case−control studies were also included. Studies that investigated only subgroups of women (ie, with a previous cesarean birth), did not include oxytocin for labor augmentation, did not differentiate between oxytocin used for induction vs augmentation, or did not distinguish oxytocin from other methods of augmentation were excluded. Likewise, conference abstracts and studies without a reference group, such as case series or case reports, were excluded.

Data extraction and risk of bias assessment

Titles and abstracts were screened for eligibility according to predefined criteria. If immediate exclusion was impossible, the full text was assessed for

eligibility. Data were extracted into a structured, pilot-tested sheet, which included a risk of bias table. Assessment of risk of bias was based on the Newcastle−Ottawa scale and Cochrane Handbook for Systematic Reviews of Interventions (Supplementary table 2 and 3). Literature search, inclusion of studies, data extraction, and quality assessment were conducted independently by 2 researchers. In case of discrepancies, a third researcher was consulted.

Data synthesis

Data on oxytocin administration practices, monitoring of FHR and contractions, partograph use, ratio of birth attendants to women, and hospital volume were collected for narrative analysis of the context. Rates of oxytocin for labor augmentation were analyzed as proportion of women augmented among all women in the study. For pre-post studies, only preintervention data were included to represent baseline care. For case−control studies, only data from controls were included to reflect exposure in the study population. A definition was needed to assess appropriate timing of oxytocin initiation because no definition is uniformly applied.[12] WHO's partograph is the most prevalent labor monitoring tool in LLMICs, and crossing its action line was defined as the appropriate time to apply oxytocin. This correlates well with WHO's recommendation that "a slower than 1 cm/hour cervical dilatation rate alone (ie, the partograph's alert line) should not be a routine indication for obstetric intervention" and to WHO's recent labor progression study from Nigeria and Uganda, where few women would have received oxytocin augmentation unnecessarily if an action-line-based indication had been used.[11,13,14]

Cochrane Collaboration Review Manager software (RevMan, version 5.4.1; Cochrane, London, England) was used for meta-analysis.[15] Adjusted effect measures were applied when available. If unavailable, crude risk ratios (RRs) or odds ratios (ORs) were included with 95% confidence intervals (CIs). Effect measures were entered into RevMan using the "generic inverse variance" outcome. Because of rare outcomes, ORs and RRs were combined in the meta-analysis. Low Apgar score was included as 1 composite outcome regardless of the definition used by the author. A random-effects model was used for analysis because we expected heterogeneity among studies.

Results

Study selection

A total of 2340 studies were identified, of which 413 were duplicates and 1652 were excluded on the basis of titles or abstracts (Figure 1). Of 275 full-text articles, 246 did not meet eligibility criteria (Supplementary table 4), leaving 29 studies for inclusion. By screening references of included articles and through Google Scholar Citation search, 13 additional studies were identified. Finally, 42 studies were included: 27 studies simply provided rates of oxytocin augmentation (Figure 2), 4 studies reported oxytocin use according to labor progress (Figure 3), and 4 cohort and 7 case−control studies reported associations between oxytocin and perinatal outcomes (Table; Figure 4). No studies assessed effects of oxytocin augmentation on cesarean birth rates, labor duration, or uterine rupture. No randomized trials met the inclusion criteria.

Monitoring of labor in low- and lower-middle-income countries

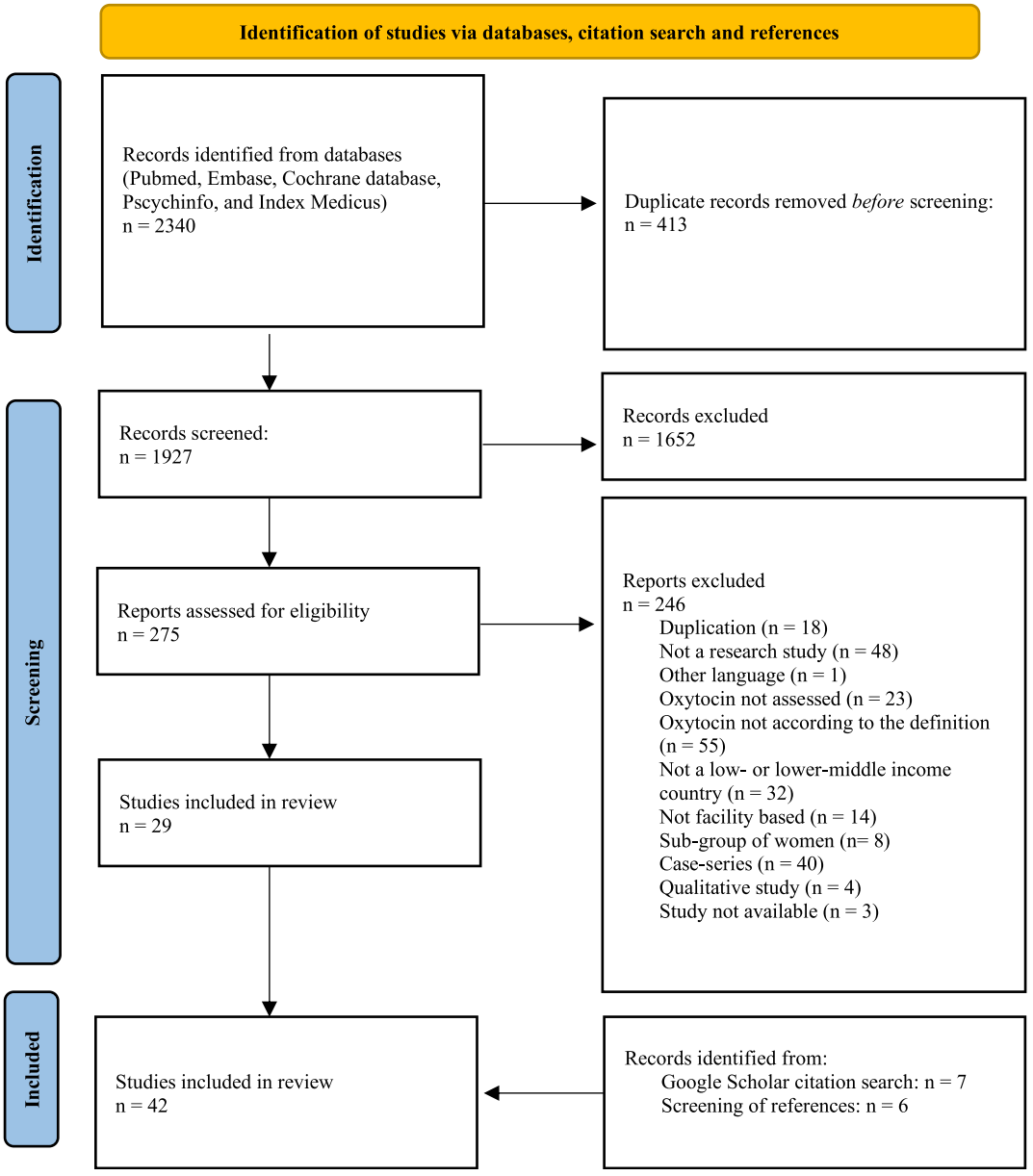
The 42 studies presented data from 885 health facilities in 25 countries (Table; Supplementary table 5). Of these, 32 (76.2%) included exclusively hospitals and 10 (23.8%) included both hospitals and lower-level health facilities. Inclusion periods of participants spanned from 1989 to 2021, with 35 of 42 (83.3%) conducted after 2000. Substandard use of the WHO partograph was described in facilities in India, Nigeria, Uganda, Zimbabwe, and Côte d'Ivoire.[11,16,21,27,31−33] Intermittent auscultation with fetoscope or Doppler was reported in 20 of 42 (47.6%) studies as the FHR monitoring method. In the remaining studies, no information was given about FHR monitoring devices. Information on actual monitoring frequencies was scarce in most studies; 10 studies reported substandard FHR recordings in >40% of laboring women or substandard monitoring of contractions.[21,26,27,31,34−36] In an Egyptian hospital, drip count in gravity-fed oxytocin infusions was only checked in 62 of 171 (36.3%) women receiving oxytocin augmentation.[35] Only 1 study from Nepal reported that a motor-driven infusion pump was sometimes used.[21] Studies from India, Côte d'Ivoire, and Nepal reported intramuscular oxytocin injections during labor.[24,31,35,37−39] No studies reported on titration practices and maximum doses of oxytocin.

Rates and timing of oxytocin augmentation

To assess the rate of oxytocin for labor augmentation, 41 studies were eligible, including either all women in labor,[16,22,33,34,40−43] vaginal births only,[9,31,37,39,44−46] women with uncomplicated singleton cephalic pregnancies at term,[11,17−19,32,35,38,47−51] or other criteria.[36,52−54] Data collection methods were by nonvalidated medical records,[11,16,17,19,28,32,33,40−43,45,46,51,54] clinical observations,[9,18,28,31,34−38,48−50,53] questionnaires,[44] or interviews with women,[39,47] whereas 4 studies had no methods described.[18,23,29,52] Studies reported up to 24% missing data.[30,33,45,46] Figure 2 presents average rates of oxytocin for labor augmentation in each country in studies after the year 2000. Studies from Bangladesh, Pakistan, India, and Egypt (totally 3698 women) reported >50% of women receiving oxytocin labor augmentation, 10 countries (101,954 women) reported 30% to 49%, 5 countries (3586 women) reported 15% to 29%, and 3 countries (2245 women) reported <14% (Supplementary table 6). Notably, no study before 2000 (17,819 women) had oxytocin augmentation rates of >21%.

To assess timing of oxytocin for labor augmentation, 4 studies from Benin, Rwanda, and India (9000 women) assessed oxytocin augmentation in relation to progress on the partograph and divided women into 3 groups: (A) at or to the left of the partograph's alert line (ie, progress of cervical dilatation ≥1 cm/h); (B) between the alert and action lines (the action line is located parallel to the alert line, but 4 hours later); and (C) crossing the action line (Figure 3).[16−19] In these

FIGURE 1
PRISMA flow diagram



PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

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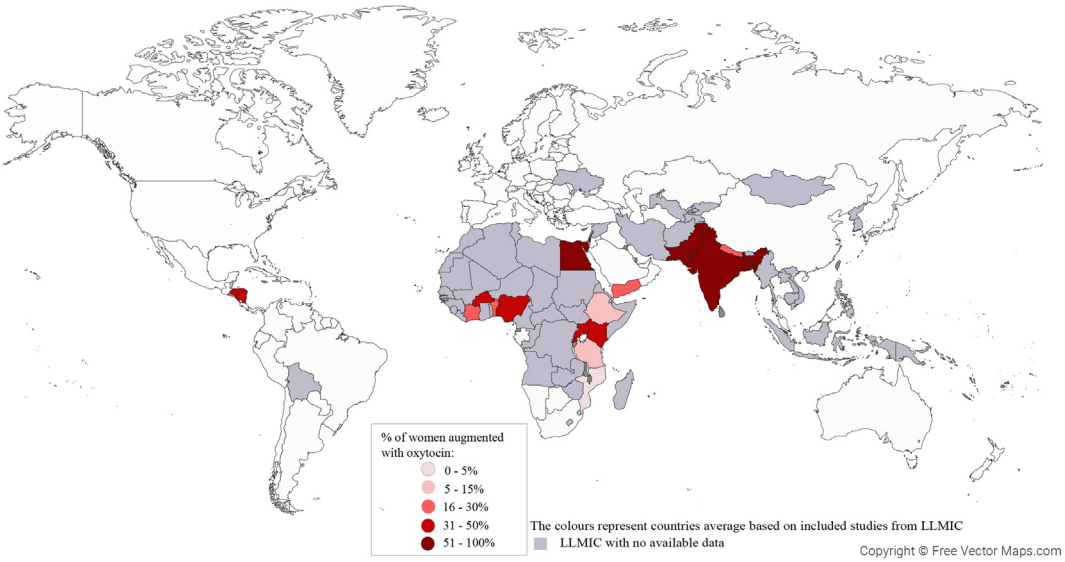
studies, a total of 3067 women were augmented with oxytocin (augmentation rate, 34.1%). Among these, 1830 (59.7%) were still in group A when giving birth, 915 (29.8%) in group B, and 322 (10.5%) in group C. In other words, 59.7% of women augmented with oxytocin during active labor had labor progress of ≥1 cm per hour, whereas only 10.5% actually had prolonged labor.

Association with adverse birth outcomes

To assess risks of oxytocin for labor augmentation, 4 cohort[20−23] and 7 case−control studies were identified in Tanzania, Nepal, Benin, Democratic Republic of the Congo, Senegal, Papua New Guinea, Uganda, Nigeria, and Ethiopia (Table).[24−30] The studies had varying quality (Supplementary table 3); all but 2 studies[20,22] used nonvalidated records[21,23,25−30] or verbal autopsies[24] to assess oxytocin exposure; 4 studies assessed used clinical observations to assess outcomes,[22,25,26,28] whereas the remaining studies used nonvalidated records. All studies had high risk of confounding because they did not adequately adjust for labor duration. Finally, 6 studies did not adjust for any

FIGURE 2
Average percentage of labors augmented with oxytocin in LLMICs



Average facility-based use of oxytocin for labor augmentation in LLMICs (World Bank 2020 classification) after year 2000. Based on 41 studies reporting from 885 health facilities in 24 countries.

LLMIC, low- and lower-middle-income country.

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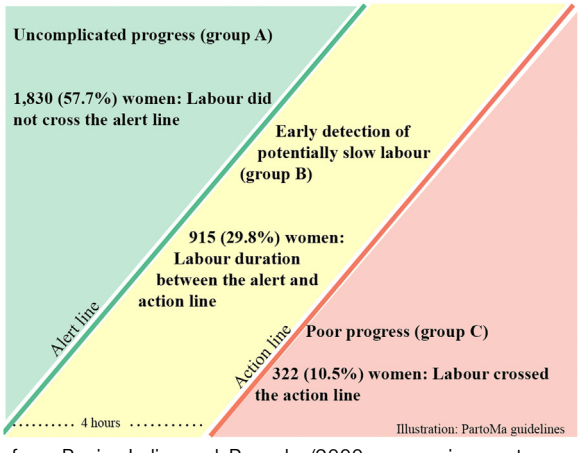
confounders.[20,23,27–30] Results of the meta-analysis unanimously suggest that oxytocin used for labor augmentation may be associated with adverse perinatal outcomes (Figure 4), including: stillbirth and day-1 neonatal mortality (RR, 1.45; 95% CI, 1.02–2.06; N=84,077; 6 studies)[21–24,27,30]; low Apgar score (RR, 1.54; 95% CI, 1.21–1.96; N=80,157; 4 studies)[21,23,28,29]; NE (RR, 2.90; 95% CI, 1.87–4.49; N=1383; 2 studies)[25,26]; and neonatal resuscitation (RR, 2.69; 95% CI, 1.87–3.88; N=86,750; 3 studies).[20–22] No studies assessed association with cesarean birth rate, labor duration, or uterine rupture.

FIGURE 3
Assessment of 3067 women augmented with oxytocin



Including studies from Benin, India, and Rwanda (9000 women in spontaneous labor).[16–19] Of these, 359 (3.9%) crossed the action line and 3067 (34.0%) received oxytocin for labor augmentation.

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Comments

Principal findings

This review discloses major practice variations and high frequencies of oxytocin augmentation in many LLMICs. In many cases, the criteria for dystocia were not fulfilled. Although compromised by confounding by indication, our meta-analysis amplifies these concerns by indicating associations between oxytocin augmentation and stillbirth, day-1 neonatal mortality, neonatal resuscitation, NE, and low Apgar score. For decades, potential risks of unsafe use of oxytocin for labor augmentation have been a concern, and this review confirms that risks are most pronounced in the context of busy low-resource settings with poor means to monitor FHR and contractions—possibly compromising the desired effects of its use.[9,55]

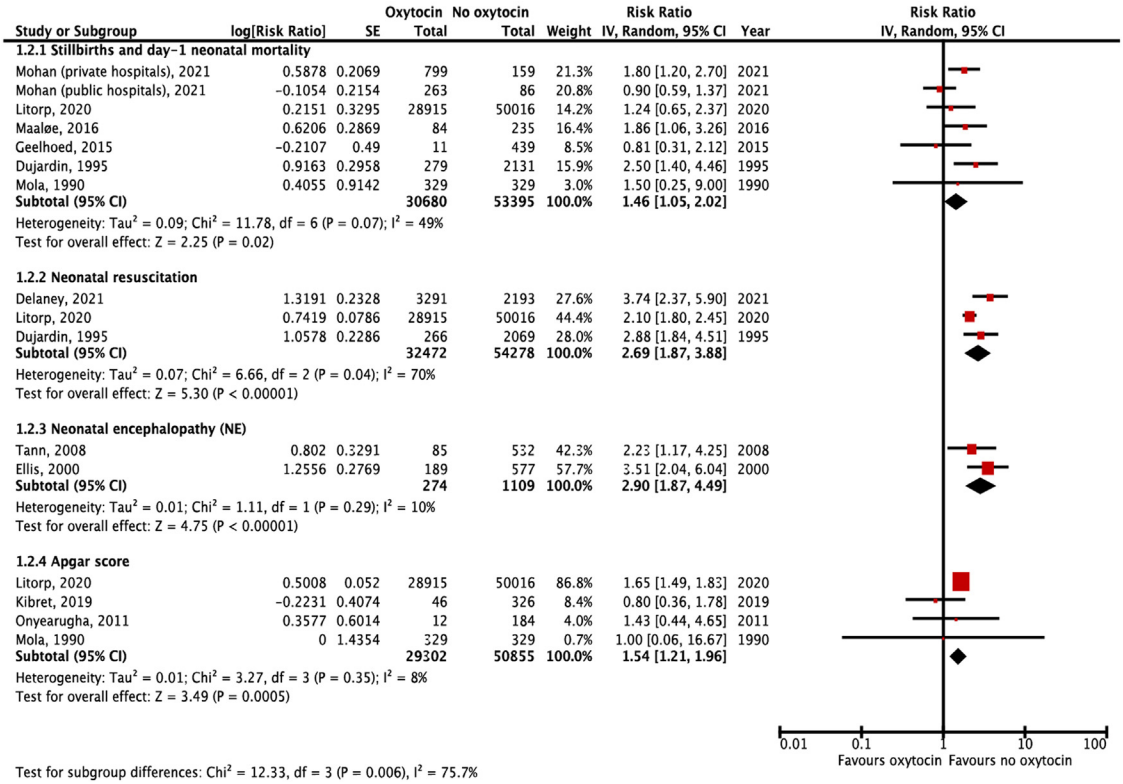
Oxytocin augmentation: too much, too soon

In only 10.5% of women who received oxytocin for labor augmentation, the drug was administered in women with prolonged labor, defined as crossing the partograph's action line. Similar findings have been reported in studies from high-income countries. For instance, in Norway and Sweden, approximately half of all women in labor were augmented with oxytocin, with more than a third augmented without being diagnosed with prolonged labor.[56,57] Notably, this contradicts the growing evidence that spontaneous labor progression is slower than previously anticipated, which is further reflected in the recently adopted WHO Labour Care Guide.[58,59]

The recommended rate of oxytocin for labor augmentation has not been defined, but rates above 6% to 12% do not seem to result in lower cesarean birth rates.[33,34] Likewise, only 3.9% of 9000 women in our studies and only 15% of 8489 women in the WHO multicenter BOLD study crossed the partograph's action line, which has been proposed as a relevant indication for when to consider initiating oxytocin for labor augmentation.[60] Therefore, rates of oxytocin for labor augmentation >15%, which was the case in most studies, cause worry for inappropriate use. However, heterogeneity of studies on oxytocin rates makes it difficult to provide generalizable recommendations for rates, which depend on the characteristics of women giving birth in the facilities. Importantly, other parts of prolonged labor management (mental support, ambulation, pain relief, etc.) and decision-making around cesarean births are likely to be just as influential on mode of birth as oxytocin itself.

With the currently limited evidence available,[20,56] 3 drivers seem central for such overuse in LLMICs. Firstly, overburdened maternity units: as illustrated in an Egyptian hospital with 8 laboring women per health provider, a high caseload contributing to massive bed shortages was an important reason that 91% of laboring women were given oxytocin to enhance labor and free up beds and hands.[35] Secondly, increasing availability of obstetrical care in LLMICs has led to overmedicalization, whereas other aspects of maternity care are still absent. This may cause a dangerous coexistence of "too little, too late" and "too much, too soon" care where oxytocin is overused, whereas labor monitoring remains limited.[10] Finally, vague and ambiguous clinical guidelines for diagnosis and

FIGURE 4
Association between oxytocin for labor augmentation and perinatal outcomes



Forest plots include studies from Tanzania, India, Uganda, Benin, Democratic Republic of the Congo, Senegal, Papua New Guinea, Nepal, Mozambique, Ethiopia, and Nigeria.

CI, confidence interval; *IV*, inverse variance; *SE*, standard error.

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management of prolonged labor and oxytocin seem crucial[12,61]; that is, although WHO meticulously describes how to up-titrate oxytocin, recommendations about when to prescribe, reduce, stop, and possibly restart oxytocin are absent, even in the recent WHO Labour Care Guide.[58,61] Furthermore, guidance regarding safe maximum rates does not account for clinical realities where lack of 1-to-1 care, controlled infusion pumps, and delays in monitoring and treatment inevitably result in higher risks of unsafe oxytocin use, particularly if many women are treated simultaneously.

In contrast, unambiguous clinical guidelines for restricted oxytocin augmentation seem effective in promoting timely and safe use.[33,60] For example, WHO's multicenter trial among 35,484 women in Indonesia, Malaysia, and Thailand in the 1990s introduced the partograph with clear guidelines recommending that oxytocin be first administered after crossing the action line.[60] After implementation, a decline in oxytocin for labor augmentation from 20.7% to 9.1% was reported, together with an insignificant reduction in emergency cesarean birth rate (9.9% to 8.7%; *P*=.68). Following this strategy seems promising in reducing rates of oxytocin augmentation. In India, reduction of the use of intrapartum oxytocin through a coaching-based intervention led to a decrease from 77.8% to 32.1%; however, 1 year after implementation, the rate increased to 48.2%.[20] This indicates that understanding the multiple factors influencing oxytocin use is highly needed to sustainably reduce current overuse.

Possible risks and no studies on benefits

Our meta-analysis revealed associations between oxytocin for labor augmentation and adverse perinatal outcomes. This is in line with observational studies from high-income countries, but with more severe consequences.[6–8,62,63] Suboptimal monitoring of FHR and contractions, as described in the studies, is likely mediating the severity of risks. The influence of substandard care was, however, not assessed in the studies.

Supporting the association between oxytocin for labor augmentation and adverse perinatal outcomes is a high level of consistency between studies. A recent study in India, furthermore, supports a causal link between oxytocin augmentation and adverse effects given that the association between oxytocin augmentation and day-1 neonatal mortality seemed to be mediated entirely by birth asphyxia.[24] The association was strongest for stillbirths, waned during the first 24 hours, and was negligible in the subsequent 6 days of life.[24] Yet, a few inconsistent results related to stillbirths require further discussion. A multisite cohort study of 78,931 births in Nepal found associations between oxytocin augmentation and low Apgar score, neonatal resuscitation, and neonatal mortality before discharge, but no association with stillbirth (Table).[21] Given that these outcomes are all part of the spectrum of morbidity caused by intrauterine hypoxia, such inconsistency warrants further exploration. The study excluded 3828 (3.7%) women because of absent or no recording of FHR on admission, which probably concealed underreported intrahospital stillbirths, of which the study reported only 194 (0.3%). Distinguishing between prehospital, intrahospital, macerated, and fresh stillbirths in medical records is a well-known challenge.[64] A similar situation was observed in a recent study from India, in which oxytocin augmentation was associated with bag-and-mask ventilation and perinatal mortality, but not with stillbirths.[20] Likewise, a multicountry study from Benin, Democratic Republic of the Congo, and Senegal found stronger associations between oxytocin augmentation and stillbirth when macerated stillbirths were excluded, indicating that including these may underestimate harmful effects.[22] The remaining studies included only women with positive FHR on admission.

One of the studies from India found increased risks of intrapartum stillbirth and day-1 neonatal mortality only in private hospitals and home births, but not in public hospitals with similar augmentation rates.[24] This supports the notion that the risks mediated by oxytocin for labor augmentation are influenced by factors related to care, such as fetal monitoring and administration practices; therefore, inconsistent findings are not surprising. In fact, it is promising that this study did not find such an association in public hospitals, which suggests that oxytocin augmentation may be safely used in a low-resource setting. What precisely constitutes such safe use, when advanced equipment is not available, is yet to be explored.

Unfortunately, no studies met the inclusion criteria for assessing the influence of oxytocin augmentation on cesarean birth and labor duration. Absence of studies supporting the effect of oxytocin on reducing cesarean birth rates is especially worrying because prolonged labor is the most common indication for first cesarean birth.[65] The high frequency of use together with other factors affecting decision to perform cesarean birth possibly explain why studies globally fail to document any effect of oxytocin on cesarean birth rates.[1,2,66] Because of the scarcity of evidence, it remains unknown whether reducing the use of oxytocin finally increases or reduces cesarean birth rates.

Strengths and limitations

The main strength of this review is its comprehensive inclusion of studies from LLMICs targeting vulnerable populations, which is currently overlooked in reviews of oxytocin augmentation.[1,2,66] Through searching in international and regional databases to ensure that all available data were included, we found studies from 25 out of 79 LLMICs. Although the explorative approach resulted in heterogeneous studies, which hampered generalizability, unfolding the complexity enabled us to identify important gaps in research and practice. An important limitation is confounding by indication, which may bias the results of the meta-analysis. Distinguishing between risks of prolonged labor and risks of oxytocin augmentation is challenging. The studies did not elaborate sufficiently on this. It is

TABLE
Study characteristics of case–control and cohort studies

Case-control studies								
Author, y; study year, country, data source	Facility	Study population	Confounders	Oxytocin	Outcome	Exposed cases/all cases	Exposed controls/all controls	Effect estimate
Delaney et al,[20] 2021[a]; 2014–2017, India. DO (oxytocin and bag-mask). MR (stillbirths and oxytocin). IN (perinatal mortality).	30 facilities: 8 primary health centers; 18 community health centers; 4 first referral units.	All women admitted to a study facility for childbirth (stillbirths and bag-mask). All women with known health outcomes (perinatal mortality).	Not adjusted	32%–78%. Intramuscular injections	Perinatal mortality, not defined	1597/87	1265/47	OR, 1.47 (0.99–2.16)
					Bag-and-mask ventilation	3291/247	2193/44	OR, 3.74 (2.37–5.90)
					Stillbirths	Numbers not available	Numbers not available	No difference (numbers not available)
Litorp et al,[21] 2021[a]; 2017–2018, Nepal. MR.	12 public referral hospitals.	All women excluding women with elective CD (5.4%), missing data on augmentation of labor (15%), and absent or no recording of FHR on admission (3.7%).	Multivariate logistic regression adjusted for parity, induction, maternal age, GA, complications during pregnancy or labor, BW, suboptimal partograph use, suboptimal FHR monitoring, ethnicity, educational level, and mode of delivery.	37%. Gravity-fed infusion or electronic infusion pumps.	All	All exposed: 28,915 (applies to all outcomes)	All unexposed: 50,016 (applies to all outcomes)	aRR
					Stillbirths and day-1 neonatal mortality	64	130	1.24 (0.65–2.40)
					Neonatal death at discharge	234	422	1.93 (1.46–2.56)
					5-min Apgar <7	1136	1553	1.65 (1.49–1.86)
					Bag-and-mask ventilation	439	346	2.10 (1.80–2.50)
					ECD	356	968	0.62 (0.59–0.66)
					Postpartum hemorrhage	67	155	0.80 (0.55–1.20)
Dujardin et al,[22] 1995[a]; 1990–1991, Benin, Democratic Republic of the Congo, and Senegal. DO.	8 peripheral maternity clinics and 2 reference hospitals.	All women, <10 cm dilated, singleton, vertex, BW >1000 g.	Multivariate logistic regression adjusted for primiparity, previous complicated delivery, presence of meconium during labor, ruptured membranes, education.	Benin: 21%; Senegal: 11%; Congo: 6%. Gravity-fed infusion.	Stillbirths (analysis restricted to oxytocin applied in normally progressing labor)	279/16	2131/53	RR, 1.9 (1.06–3.40)
					Manual respiratory assistance	266/76	2069/206	aOR, 2.88 (1.84–4.50)[b]
Mola and Rageau,[23] 1990[a]; 1989, Papua New Guinea. DO.	General hospital.	All women in spontaneous labor, singleton, vertex. Cases: oxytocin augmentation. Controls: next delivery with same parity.	Not adjusted, but matching was done on parity, and only women in spontaneous labor were included.	10.3%. Gravity-fed infusion, no infusion pumps available.	Stillbirths, intrapartum or neonatal death not defined	329/3	329/2	RR, 1.50 (0.25–8.92)
					5-min Apgar £6	329/1	329/1	RR, 1 (0.06–16.6)

(continued)

TABLE
Study characteristics of case–control and cohort studies *(continued)*

Case-control studies								
Author, y; study year, country, data source	Facility	Study population	Confounders	Oxytocin	Outcome	Exposed cases/all cases	Exposed controls/all controls	Effect estimate
Case–control studies								
Author, y; study year, country, data source (variable)	Facility	Study population	Confounders	Oxytocin	Outcome	Exposed cases/all cases	Exposed controls/all controls	Effect estimate
Mohan et al,[24] 2020[a]; 2008–2010[b], India. IN.	All facility births in India.	Cases: neonatal day-1 mortality. Controls: death between day 8 and 28 (late neonatal deaths).	Adjusted for the presence of skilled birth attendant. Stratified by sex and parity. The following were included in a supplementary adjusted analysis with 2% difference in point estimate: age, multiple pregnancy, APH, prolonged labor[c], foul smelling amniotic fluid, PROM, cord prolapse, preterm, assisted deliveries, malpresentation, fever on the day delivery began, received ANC.	Cases: 74%. Controls: 62%. Intramuscular injections.	Neonatal day-1 mortality	Government hospitals: 212/28 Private hospitals: 672/792	51/67 127/166	aOR, 0.96 (0.59–1.6) aOR, 1.8 (1.2–2.5)
Ellis et al,[25] 2000; 1995–1996, Nepal. DO.	Principal maternity hospital.	GA >37. Cases: NE. Controls: unmatched, every 25th infant. Excluding congenital malformations, hepatosplenomegaly, cataracts, signs of infection, infants who normalized after hypoglycemia was corrected.	Adjusted for maternal age, parity, education, height, previous neonatal death, antenatal care, preeclampsia, BW, sex of infant, and plurality. No infants were >4 kg. Balance between groups for prolonged labor.	Cases: 39%. Controls: 22%. Administration not described.	NE within 24 h,Amiel–Tison score assessed by trained Junior doctors	50/131	139/635	aOR, 3.51 (2.04–6.07)
Tann et al,[26] 2018; 2011–2012, Uganda. MR.	Referral hospital.	GA >27. Cases: NE. Controls: unmatched, Thompson score <3, recruited in a ratio of 79:21 from high-risk and low-risk wards, respectively. Excluding antibiotics given, mothers living 20 km away, out-born infants.	Adjusted for primiparity, socioeconomic group, age >20 y, weight <50 kg, height <150 cm, >4 ANC visits, sex, previous birth asphyxia, previous perinatal death, severe anemia, hypertension, HIV, sex, BW, twins, noncephalic, no IAS of FHR during labor, prolonged rupture of membranes >24 h, obstructed labor. Balance between the groups for prolonged labor.[c]	Controls: 10.5%. Cases: 20.1%. Administration not described.	NE: Thompson score >5 within 12 h assessed by the author or other study doctors	42/209	43/408	aOR, 2.23 (1.17–4.23)

(continued)

TABLE
Study characteristics of case–control and cohort studies *(continued)*

Author, y; study year, country, data source	Facility	Study population	Confounders	Oxytocin	Outcome	Exposed cases/all cases	Exposed controls/all controls	Effect estimate
Case-control studies								
Maaløe et al,[27] 2016; 2014–2015, Tanzania. MR.	Tertiary referral hospital.	Singleton, BW ³2 kg, positive FHR on admission. Cases: stillbirths. Controls: unmatched, Apgar ≥7, every 10th delivery, ratio 1:4.	Not adjusted. Balance between the 2 groups for induction and parity. More cases crossed the partograph alert and action line than controls.	Cases: 36%. Controls: 23%. Infusion, not further specified.	Stillbirths with positive FHR on admission	26/72	58/249	OR, 1.86 (1.06–3.27)
Onyearugha and Ugboma,[28] 2010; 2004, Nigeria. DO (Apgar score), MR (oxytocin).	Tertiary hospital, serving both as a secondary healthcare center and referral center for peripheral hospitals.	Cases: severe birth asphyxia. Controls: same weight bracket, Apgar 8–10, consecutively recruited. Excluding severe congenital malformation.	Not adjusted. Prolonged labor was more common in cases than in controls.	Cases: 7%. Controls: 5%. Administration not described.	Apgar 1–3 at 1 min and <5 at 5 min, assessed by the author or a resident	7/98	5/98	OR, 1.43 (0.44–4.67)
Hailu et al,[29] 2018; 2018 Ethiopia. MR.	5 hospitals (2 governmental and 3 private).	Cases: infants with asphyxia. Controls: unmatched, ratio 1:4.	Not adjusted. Balance between the 2 groups for parity. Labor duration >12 h was more common in cases than in controls.	Cases: 10.5%. Controls: 12.5%. Administration not described.	Asphyxia: inability to sustain adequate respiration with an Apgar <7 at 5 min, assessed by trained midwives	8/76	38/296	OR, 0.80 (0.36–1.79)
Geelhoed et al,[30] 2015; 2009–2011, Mozambique. MR.	2 urban health centers (providing basic emergency obstetrical care) and 1 provincial hospital (providing comprehensive emergency obstetrical care).	Cases: stillbirths with GA >28 wk and BW >1.5 kg; 33% had positive FHR on arrival. Controls: live births matched on health facility attended, maternal age, and parity. First subsequent delivery.	Not adjusted. Active first stage of labor >6 h was more common in cases than in controls.	Cases: 2%. Controls: 2.7% Intravenous infusion, not further specified.	Stillbirths (including prefacility stillbirths)	3/150	8/300	OR, 0.81 (0.31–2.16)

ANC, antenatal care; *aOR*, adjusted odds ratio; *APH*, antepartum hemorrhage; *aRR*, adjusted risk ratio; *BW*, birthweight; *CD*, cesarean delivery; *DO*, direct observations; *ECD*, emergency cesarean delivery; *FHR*, fetal heart rate; *GA*, gestational age; *IAS*, intermittent auscultation; *IN*, interviews; *MR*, medical records; *NE*, neonatal encephalopathy; *OR*, odds ratio; *PROM*, prelabor rupture of membranes; *RR*, risk ratio.

[a] Studies with an objective of assessing the association between oxytocin augmentation and perinatal outcomes; [b] Combined OR including OR from the 4 countries is calculated using RevMan 5.3, inverse variance outcome; [c] Defined as labor duration >12 hours for multiparous women and >24 hours for nulliparous women.

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important to notice that for women who actually had prolonged labor when oxytocin was administered, it is not possible to distinguish whether the harm was a marker of oxytocin or prolonged labor, or a combination. Some studies, however, reported no differences in prolonged labor between groups.[21,24–26] This may be explained by high levels of use without clear indication or routine use suspected in studies with high oxytocin rates. New studies including women with documented prolonged labor are highly warranted to provide stronger conclusions and guidance for practice.

Some studies did not have a primary objective to investigate oxytocin, thereby increasing the risk of type 1 error because of random findings and publication bias.[25–27] Another limitation is the use of nonvalidated hand-written medical records in some studies, which may have been of poor quality. Lack of quality restrictions in the studies is a central limitation. However, stratifying by quality levels did not change conclusions. Finally, use of oxytocin involves aspects related to timing, titration and duration, manual administration of gravity-fed infusion, frequency of fetal monitoring, administration forms (intravenous/intramuscular bolus injections), and human resources. These factors may be important mediators of increased risks. Many of these factors are particularly pertinent to the context of busy low-resource settings and were often not included, suggesting an important area for future research.

Research implications

Although new medications must pass through multiple testing phases before approval, use of oxytocin for labor augmentation was approved before strong trials were the standard. Postapproval monitoring of medications is now standard; however, oxytocin has not been evaluated in this way, and we continue to use oxytocin for labor augmentation with scarce evidence of effect and data suggesting risks. Although this review provides a starting point, more research is needed to provide insight into such use of oxytocin in low-resource settings. In response, we recommend 3 simultaneous areas of action. Firstly, clear and unambiguous clinical guidelines, adjusted to the context, must be established to assist frontline health providers in LLMICs. As called for by the WHO-INTEGRATE framework, aspects of safety, benefits, health system feasibility, and women's and health providers' views should inform such guidelines.[67] Secondly, because physiological labor involves multiple receptors and biomarkers in addition to oxytocin, such as lactate, embedded studies of the pathophysiology of prolonged labor may foster novel, effective, and safer approaches to diagnosing and treating prolonged labor.[68] Last, but not least, the unconducive low-resource clinical realities that women and health providers work in both compound increased harm and seem to drive overuse of oxytocin augmentation in LLMICs. Therefore, broader efforts remain essential to tackle the human resource crisis in health, the increasingly overloaded urban maternity units, suboptimal routine monitoring during labor, and delays in accessing emergency cesarean birth.

Conclusion

Our review discloses great practice variation and high frequency of oxytocin use for labor augmentation. In half of the studies, rates of oxytocin for labor augmentation exceeded 30%. Meanwhile, a recent WHO multicenter study presented that only approximately 15% of labors crossed the partograph's action line. This indicates high levels of use in normally progressing labors and is in line with studies where data on labor progression were available: 89.5% of women augmented with oxytocin did not cross the partograph's action line.

Alarmingly high rates in settings with the poorest resources for childbirth amplify concern for safety. Evidence from these studies suggests that labor augmentation with oxytocin may result in severe adverse outcomes. Importantly, however, the studies had methodological limitations that hamper quantification of confounding by indication. Harmful effects are likely mediated through suboptimal quality of care in the busy low-resource context, including lack of electronic drip count, intermittent rather than continuous FHR monitoring, and lack of electronic contraction monitoring. Robust implementation research in real-world low-resourced labor wards is warranted to bridge the gap between universal guidelines and clinical realities.[69] Finally, we urge judicious use of oxytocin on clear indications (such as crossing the partograph's action line) while calling for prioritization of safe childbirth care, particularly where most of the world's preventable deaths occur. ■

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.xagr.2022.100123.

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Paper II

Temporalities of oxytocin for labour augmentation: A mixed-methods study of time factors shaping labour practices in a busy maternity unit in Tanzania.

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Title page

Title: Temporalities of oxytocin for labour augmentation: A mixed-methods study of time factors shaping labour practices in a busy maternity unit in Tanzania

Authors: *Monica Lauridsen Kujabi[a,b], Luzango Maembe [c], Daniel Nkungu[d], Nanna Maaløe[a,e], Brenda Sequeira D'mello[a,f,g], Jos van Roosmalen[h,i], Thomas van den Akker[h,i], Flemming Konradsen[a,j], Kidanto Hussein[f], Eunice Pallangyo[k], Morten Skovdal[l], Jane Brandt Sørensen[a]
*Corresponding author

Affiliations
[a] Global Health Section, Department of Public Health, University of Copenhagen, Denmark
[b] Department of Gynaecology and Obstetrics, Aarhus University Hospital Skejby, Denmark
[c] Department of Gynaecology and Obstetrics, Mwanyanamala Regional Referral Hospital, Dar es Salaam, Tanzania
[d] Department of Gynaecology and Obstetrics, Morogoro Regional Referral Hospital, Morogoro, Tanzania
[e] Department of Gynaecology and Obstetrics, Copenhagen University Hospital Herlev, Denmark
[f] Medical College East Africa, Aga Khan University, Dar es Salaam, Tanzania
[g] CCBRT Hospital, Dar es Salaam, Tanzania
[h] Athena Institute, VU University Amsterdam, the Netherlands
[i] Department of Obstetrics and Gynaecology, Leiden University Medical Center, Leiden, the Netherlands
[j] Novo Nordisk Foundation, Hellerup, Denmark
[k] School of Nursing and Midwifery East Africa, Aga Khan University, Dar es Salaam, Tanzania
[l] Section of Health Services Research, Department of Public Health, University of Copenhagen, Denmark

Abstract

Background:
High rates of labour augmentation with oxytocin have been found in some low- and lower-middle-income countries, causing potential perinatal harm. It is critical to understand the reasons for this overuse. Aim was to explore factors that shape practices around using oxytocin for labour augmentation in a high-volume labour ward in Dar es Salaam, Tanzania.

Methods:
Mixed-methods data collection was conducted from March 2021 to February 2022, including structured observations of 234 births, 220 hours of unstructured labour ward observations and 13 individual in-depth interviews with birth attendants. Thematic network analysis and descriptive statistics were used to analyse data. We used a time-lens to understand practices of oxytocin for labour augmentation in time-pressured labour wards.

Results:
Birth attendants constantly had to prioritise certain care practices over others in response to time pressure. This led to overuse of oxytocin for augmentation to ensure faster labour progression and decongestion of the, often overburdened, ward. Simultaneously, birth attendants had little time to monitor foetal and maternal condition. Surprisingly, while oxytocin was used in 146 out of 234 (62.4%) structured labour observations, only 9/234 (4.2%) women had prolonged labour (active labour lasting more than 12 hours). Correspondingly, 21/48 (43.8%) women who were augmented with oxytocin in the first stage of labour had uncomplicated labour progression at the start of augmentation. While the partograph was often not used for decision-making, timing of starting oxytocin often correlated with natural cycles of ward-rounds and shift-turnovers instead of individual women's labour progression. This resulted in co-existence of 'too early' and 'too late' use of oxytocin. Liberal use of oxytocin for labour augmentation was facilitated by an underlying fear of prolonged labour and low alertness of oxytocin-related risks.

Conclusions:
Time scarcity in the labour ward often made birth attendants deviate from clinical guidelines for labour augmentation with oxytocin. Efforts to navigate time pressure resulted in too many women with uncomplicated labour progression receiving oxytocin with little monitoring of labour. Fear of prolonged labour and low alertness to oxytocin-mediated risks were crucial drivers. These findings call for research into safety and benefits of oxytocin in low-resource settings and interventions to address congestion in labour wards and prevent using oxytocin as a time-management tool.

Key words: Oxytocin, prolonged labour, partograph, low-resource, augmentation, intrapartum, guidelines, PartoMa, time-pressure, urbanisation

Background

Oxytocin has been used since the 1950s to augment labour by stimulating contractions. Evidence, however, remains missing that oxytocin reduces caesarean section rates, although it has shown to reduce labour duration by two hours [1, 2]. In too high doses, oxytocin may cause harm to women and their foetuses [3, 4]. Potential complications of its use include uterine rupture and stillbirth [5]. The required dose of oxytocin differs per individual and correct dosing requires titrating oxytocin against the woman's contractions, whilst monitoring the foetal heart rate (FHR). Risks of oxytocin-related harm appear higher in low-resource settings with substandard monitoring [3]. Dosing in such settings often happens by visual drop count rather than electronic infusion, which is time-demanding and increases the risk of under- or overdosing. Availability of cardiotocography is rare in low-resource settings and replaced by intermittent auscultation of FHR.

It is troubling that the few studies conducted in low- and lower-middle-income countries (LLMIC) find that 89.5% of women receiving oxytocin for labour augmentation had uncomplicated labour progress, with some facilities using the drug in 80%-90% of women during birth [3]. This is much higher than the suggested 9-12% [6, 7]. Despite dangerously high rates of oxytocin for labour augmentation in some LLMICs, few studies have explored the underlying reasons.

Qualitative studies of labour augmentation with oxytocin have identified local demands among labouring women in Nepal, India and Uganda [8–11]. Studies from India, Nepal, Uganda and Sierra Leone suggest that birth attendants often underestimate the risks associated with oxytocin for labour augmentation and lack of skills in diagnosing prolonged labour and timing of oxytocin for labour augmentation [8–10, 12]. Finally, Khalil et al. explain how, in an Egyptian hospital, shortages of beds and hands were the main reasons for nearly universal oxytocin use for labour augmentation [13] while Van Hollen describes how oxytocin was used as "crowd control" [11]. These studies stop short of exploring such notions any further.

In alignment with previous studies suggesting that untimely and too frequent use of oxytocin to augment labour could be related to congestion, this mixed-methods study was conducted in an urban high-volume maternity unit, which historically has been among the most congested labour wards in Dar es Salaam, the largest urban centre of Tanzania and one of the fastest growing cities on the continent. The objective of this study was to investigate factors affecting practices around labour augmentation with oxytocin in a high-volume mega-maternity unit through the lens of time. Here, time refers to the duration of labour, birth attendant-to-women ratio, and frequency, duration and timing of care practices.

Methods

This mixed-methods study forms part of the PartoMa research project, aiming at co-creating contextualised intrapartum clinical guidelines and training [14, 15]. The study took place in a public urban maternity unit in a regional referral hospital in Dar es Salaam, Tanzania. Annual number of births was around 7,000, in 2021, much lower than the number of 16,000 in 2016 [16]. This reduction likely resulted from a policy promoting decongestion of the busiest referral facilities by re-distributing women more evenly among the facilities [16]. The Covid-19 pandemic may also have influenced the facility birth rate [17].

In the latent phase (until cervical dilatation of 4 cm), women are monitored in the antenatal ward where they often share beds with other women. In active phase (cervical dilatation 4 cm or above), they enter

the labour ward. The labour ward with 16 beds is managed by two to three nurse-midwives and a varying number of nurse-midwifery students, interns, registrar doctors and obstetric specialists. Nurse-midwives mostly practice on their own. They triage women on admission, monitor and manage labour, resuscitate neonates, prepare and escort women for caesarean section, provide immediate postnatal care and escort severely ill women to the national hospital. In addition, they are responsible for cleaning up beds after birth, keeping the ward clean, filling up equipment and medication storages and documenting information in multiple registers. All these extra tasks imply that generally, 1-2 nurse-midwives provide care to the women in the 16 beds with varying occupancy. Oxytocin is administered with manual infusion lines with 5 International Units in 500 ml saline. Contractions are measured manually over ten minutes and FHR assessed using intermitted auscultation with fetoscope or doppler. The context of high-volume Tanzanian maternity wards has also been described by others [16, 18–20].

Conceptual framework

To investigate the role of time, we draw on the concept of "Timescapes". This concept was developed by sociologist Barbara Adam to highlight the interdependency between space and time [21]. The 'Timescapes-concept' allows us to examine how the spatial context of a busy labour ward (the 'scapes' part) combined with the duration of labour and timing of labour interventions (the 'times' part) will affect the use of oxytocin for labour augmentation. Table 1 details the clinical guidance around frequency and timing of oxytocin administration, indicating the time spent on key practices. Aiming to provide the best possible care, birth attendants tinker with care practices to make them work in their time pressured and overstretched realities. By exploring how time manifests in such a congested environment we examined the relationship between time scarcity, efforts to manage time and the influence on oxytocin for labour augmentation. Exploration of these efforts included obtaining an in-depth understanding of how tasks are prioritised and planned in a busy and under-resourced labour ward.

Table 1: Routine monitoring and timing related to oxytocin use for labour augmentation

Action	Guideline	Minimum time spent per woman
Measuring contractions over 10 minutes	At initiation of oxytocin and every 30 minutes[a,b,c,d]	20 minutes/hour
Fetal Heart Rate (FHR) assessments	At initiation of oxytocin and every 30 minutes[a,c,d] Continuous cardiotocography (CTG)[b]	4 minutes/hour
Titration of oxytocin	Every 30 minutes[a,b,c,d]	6 minutes/hour
Timing of oxytocin according to dilatation	4 hours of cervical arrest[c] After crossing the Partograph action line[e] Cervical dilatation < 0.2 - 0.5 cm/hour[d] Cervical dilatation < 0.5 cm/hour[b]	

Labour progression is determined in relation to a scientifically derived "normal" length of labour, which is still widely debated. Cervical dilatation of 0.2 to 0.5 cm per hour is the slowest yet normal progression of active labour[b,d]. Depending on the guidelines, oxytocin for labour augmentation should be administered if labour progresses slower than this and contractions are inadequate[b,d], if there is complete arrest of labour for 4 hours[c] or if the partograph's action line is crossed[e]. To evaluate whether contractions are adequate, these must be counted over a ten-minute time frame. To avoid hyperstimulation and related risks oxytocin must be titrated by increasing the drop rate every 30 minutes until contractions are strong enough. FHR must be monitored to evaluate whether the fetus tolerates increased contractions. While electronic infusion, FHR and contractions monitoring are present in high-income settings, these are often not available in labour wards in LLMICs. As seen, routine monitoring of one woman on oxytocin (FHR, contractions, titration) will take at least 30 minutes per hour for one birth attendant when done manually.

a: Tanzanian National guideline and Managing complications of pregnancy and labour, WHO, 2017 [22, 23]
b. NICE guideline: Intrapartum care for healthy women and babies clinical guideline, 2022 [2]
c. Médecins Sans Frontiers (MSF): intrapartum guideline [24]
d. WHO: Labour care guide, 2019. Normal labour progression is said to be hyperbolic therefore included as 0.2-0.5 cm/hours [25]
e. WHO: Recommendations for augmentation of labour, 2014 [5]

Data collection

Data were collected between March 15th 2021 and February 15th 2022 (Table 2). We combined three methods: (i) 220 hours of unstructured observations and informal conversations with staff to explore labour ward practices; (ii) 13 in-depth individual semi-structured interviews (Additional file 1) to explore birth attendants' perceptions and (iii) 234 structured observations of labours by two research assistants to quantify oxytocin practices (timing, titration etc.).

Observations were conducted equally during days, evenings and nights over three months. Extensive field notes were written during and after observations. Although being a medical doctor, MLK had no license to practice clinically within this setting and did not make clinical decisions during observations. Structured observations were carried out by two Swahili-speaking research assistants with no obstetric experience. Observed care practices were noted in pre-piloted sheets (Additional file 2). Women were included in active labour and followed till birth. Inclusion happened consecutively during each observation period and was limited to singleton cephalic pregnancies at term with positive foetal heart rate on admission. Women who were referred and women with hypertensive disorders or previous caesarean section were excluded. We aimed to study oxytocin use among a low-risk population to avoid competing factors influencing the administration of oxytocin. MLK and a Swahili-speaking

research assistant conducted interviews through purposive sampling until no new topics appeared. The interview guide was adjusted after the first two interviews. Respondents included nurse-midwives (n=3), intern doctors (n=2), registrars (n=3) and obstetric specialists (n=3), all working in the labour ward at the time. Re-interviews with two respondents were conducted one year later to explore preliminary analytical findings. All interviews were conducted outside working hours and were audio-recorded, transcribed and translated ad verbatim to English by a trained translator. Translations were checked by two research assistants. To protect anonymity, staff members are referred to as respondents (R) or birth attendants throughout the text. In this manuscript, oxytocin refers to oxytocin for labour augmentation during active labour unless stated otherwise.

Table 2: Data collection methods

Data collection methods	Period
220 hours unstructured observations by MLK	15.03.2021 – 11.06.2021
234 structured observations by two research assistants	01.04.2021 – 31.06.2021
11 individual in-depth interviews by MLK and a research assistant	01.04.2021 – 11.06.2021
Two individual in-depth reinterviews by MLK	05.01.2022 – 15.02.2022

Analysis

A thematic network analysis was carried out using a combined deductive and inductive approach where time emerged as a central theme [26]. Text was coded using NVivo (release 1.6.2) and included predefined and emerging themes. Data from observations and interviews were triangulated and basic, organising and global themes were created within the frame of temporality (table 3). Descriptive statistics using IBM SPSS (version 28.0.0.0) were used to analyse data from structured observations. Rate of oxytocin for labour augmentation was based on all observed women, while a subgroup of women who received oxytocin during the first stage of labour were assessed for timing of oxytocin and monitoring of labour.

Table 3: Pre-defined and emerging themes based on NVivo coding

Global and organising themes	Basic themes
Time-pressure: realities of an urban congested labour ward	
Too many tasks and too little time	Disconnect between time availability and time demands Unrealistic guidelines for labour augmentation with oxytocin
Time-scarcity leading to congestion and prolonged labour	Clash between speed of labour and time-pressure in the busy labour ward Negative experiences and perceptions related to prolonged labour
Impractical partograph in the time-constraint labour ward	Difficult to adhere to requirements, e.g. four-hourly assessment Partograph used to protect against liability/accountability Partograph often completed after birth
Re-negotiating time: how birth attendants navigate in a busy urban labour ward	
Reducing frequencies of care practices	Prioritisation of care practices Substandard care
Speeding up labour leads to better outcomes	Oxytocin used as "crowd control" when labour ward fills up Positive experiences and perceptions related to faster labour Hospital policy on labour duration
Oxytocin is given in cycles of ward rounds and shifts	Women are mainly assessed during morning ward rounds by doctors and around change of shifts (morning and afternoon) Expectations to handover a decongested labour ward Less monitoring during the night
An "up-tempo" labour ward	
Oxytocin practices	Timing of oxytocin Low alertness towards risks of oxytocin Fear of prolonged labour

Findings

Three global, seven organising and 17 basic themes emerged from the analysis and all related to temporality (table 3). Our findings are structured around the three global themes. Figure 1 shows the conceptual framework, which was developed from the results of our analysis.

Time-pressure: the reality of an urban congested labour ward

"*It was busy, everyone was running around. Nobody kept an overview, it was impossible because the women were everywhere, constantly crying for help: "Nurse, nurse, nurse, come". It was stressful and overwhelming. Everyone did their best and all hands were in use. Two women were pushing with assistance from students, a woman had just given birth but there was no time to clean up and help her get settled with her newborn. A foetal head was crowning in bed three, but there was no birth attendant to assist. In another bed the drip with oxytocin was running, the woman unattended. An assistant was running with birth trays and medication for prevention of haemorrhage. There were not enough suturing sets, so the intern doctor struggled to repair bleeding tears. All hands were in use, care was limited to what was most necessary. After a few hours the labour ward became less chaotic. Exhaustion filled the room. Now the paperwork had to be filled, stocks recharged and curtains and floors cleaned for blood. Until the next wave of women filled the beds.*" (Observation notes 01.04.21).

This extract describes the extreme time scarcity in the labour ward, weighing heavily on the birth attendants, who often referred to the inability to do what was required. Time scarcity in the congested

labour ward was a dominating theme throughout the study and explained to cause neglect and harm: "*It often happened that women were here for days because there was no overview of the too many women. Then we had bad outcomes, it was always like that*" (Respondent (R) 2). Neglected prolonged labour appeared to have become a symbol of the dangerously congested and time-pressured labour ward. Thus, tackling prolonged labour had become a key strategy both at management levels and in day-to-day clinical work.

Time scarcity also influenced the ability to use the partograph. Although the partograph was viewed as a useful tool by birth attendants, it was rarely used for decision-making to time labour augmentation. For example, during observations, not all vaginal examinations were plotted on the partograph: "*The nurse did not record the vaginal examination. She explained that she was not supposed to do an examination before four hours, so therefore it would be wrong to write it on the partograph (since only two hours had passed)*" (observation notes 27.03.21). Correct filling of the partograph required four-hourly examinations and half-hourly monitoring, which was often impossible. Rather than using it for decision-making, staff filled the partograph so they could not be accused of mismanagement. It was, therefore, not unusual to see nurses meticulously filling it after the woman had given birth, with FHR and contractions that they never assessed.

As table 1 illustrates, safe and timely administration of oxytocin for labour augmentation would require one-to-one care. In this congested labour ward, one to three birth attendants had to look after up to 16 women simultaneously while also having many other tasks. Consequently, guidelines were largely unattainable and therefore constantly, either deliberately or subconsciously, negotiated and prioritised to manage in time.

Re-negotiating time: how birth attendants navigate in a busy urban labour ward

Birth attendants had found their own ways to deal with the time-pressured labour ward. This section details their time management strategies.

It was generally understood that oxytocin reduces labour duration and therefore resulted in a faster flow of labouring women through the ward. Use of oxytocin for labour augmentation was, therefore, a way to manage time by decongesting the labour ward. The necessity of applying oxytocin when the labour ward got busy and beds started to fill up, was the most frequently mentioned reason for applying oxytocin. As one birth attendant explained "*Oxytocin can be dangerous, but I believe that it is more dangerous if we have a congested labour ward where staff cannot monitor the women. We used to see much neglect at these times*" (R4). In this way, applying oxytocin was perceived as a tool to negotiate time to provide better care by shortening the duration of labour. As a response to the harmful congestion, the hospital had made an internal standard operating guideline by which nulliparous women in active labour should give birth within eight hours and multiparous women within six hours. This guideline was unanimously viewed as helpful by birth attendants. Even though limits were flexible, this practice shows that negotiation of time had become interwoven into hospital procedures, ensuring that birth attendants would keep a steady flow of birthing women.

Efforts to manage time also resulted in the dropping of several time-consuming clinical practices. For instance, structured observations showed that only 3/42 women (7.1%) had contractions and 5/42 (11.9%) had FHR measured when receiving oxytocin for augmentation (table 4). One birth attendant explained: "*How is it possible to monitor contractions for ten minutes when we have so many women in labour*" (R1). Also, titration of oxytocin was often neglected. Most birth attendants knew that oxytocin

had to be titrated and detailed titration plans were commonly observed in case-notes. Birth attendants had no explanation as to why it did not happen. As one doctor said "*I have never seen anyone titrating. You know it from school, but in hospitals, no, it doesn't happen…*" (R12). Noteworthy, some birth attendants claimed to titrate oxytocin, but were rarely observed to do so. Instead, unstructured observations showed that oxytocin drips were often almost blindly (without counting drops) increased or decreased without reference to contractions and FHR. Limited titration could reflect how cumbersome this practice was without electronic infusion pumps in a busy labour ward. These deviations from clinical guidelines illustrate how birth attendants tinkered with practices around oxytocin administration to navigate time-pressure.

Birth attendants also navigated the, at times, overwhelmingly busy and unpredictable environment by adhering to the 'natural labour ward cycles' instead of using time-demanding surveillance cycles of individual women with reference to their partograph. Hence, labour progression was assessed mainly during ward rounds (10-12 am) and around handovers between shifts (7-8 am and 2-3 pm) or on demand (e.g., a birthing woman starting to push or a filled labour ward). It was observed on several occasions that particularly doctors were action-oriented in their management during ward rounds. They often ordered obstetric interventions (e.g., oxytocin) to enhance labour despite uncomplicated progression. When asked, one doctor explained: "*Because it can become very busy as the day progresses, we never know when we are able to come back. So many hours can pass before someone is checking the woman. If I come in the morning and again in the afternoon, I know that the women who are still here have been there too long*" (R7). This illustrates how birth attendants had found a system to navigate time and avoid delaying care.

Too early interventions also happened, because birth attendants were encouraged to hand over a "clean" labour ward (referring to a less crowded ward) for the next shift: "*We always tell them to make sure the women in their shift give birth. That is their responsibility, these women. This is how we avoid women are there during one, two or three shifts*" (R12). According to the staff, this was a helpful division because it ensured that women would not stay during several shifts. These are examples of how attempts to manage time pressure were built into existing systems. On other occasions, these natural cycles were broken because it was too busy and women were at risk of delayed care. In the morning, it sometimes happened that women had been in labour overnight without receiving appropriate interventions. For example, one woman progressed 2 cm over 17 hours, without the membranes being ruptured or oxytocin given. The following day she gave birth two hours after augmentation with oxytocin was started. Surprisingly, delayed care also happened during calm moments, where care tended to be more passive and less action-oriented: "*There was only one woman in labour. The birth attendant was on his/her phone while another was sleeping. I knew that time for vaginal examination was overdue, but nobody seemed to notice*" (field notes, 28.3.21). This illustrates how the natural labour ward cycles had replaced structured timekeeping even when there was time.

An up-tempo labour ward

Table 4 presents data from 234 structured labour observations and includes background characteristics and birth outcomes. Data will be presented in this section to triangulate the qualitative findings on how oxytocin was used for labour augmentation.

Table 4: Structured observations of 234 consecutive women in active labour

All women	***234***
Age, mean, SD	25.5 (±5.1)
	n (%)
Parity	
Nulliparous	98 (41.9)
Multiparous	136 (58.1)
Mode of birth	
Spontaneous vaginal birth	224 (95.7)
Vacuum-assisted birth	8 (3.4)
Caesarean section	2 (0.9)
Oxytocin for labour augmentation	
No	88 (37.6)
Yes	146 (62.4)
Initiated during 1st stage	100 (68.5)
Initiated during 2nd stage	46 (31.5)
Duration of active labour[a]	
< 6 hours	166 (77.6)
6 – 12 hours	39 (18.2)
> 12 hours	9 (4.2)
Missing	20
Birth outcome	
Discharged home	214 (92.3)
Admitted into neonatal intensive care unit	13 (5.6)
Stillbirth	4 (1.7)
Neonatal death < 24 hours	1 (0.4)
Missing	2
Birth outcome in cases with oxytocin augmentation	146
Discharged home	132 (90.4)
Admitted into neonatal intensive care unit	8 (5.4)
Stillbirth	3 (2.1)
Neonatal death < 24 hours	1 (0.7)
Missing	2 (1.4)
Subgroup of women who received oxytocin during 1st stage of active labour	***58[b]***
	n (%)
Contractions measured	
Yes	3 (7.1)
No	39 (92.9)
Missing	16
Fetal heart rate (FHR) measured	
Yes	5 (11.9)
No	37 (88.1)
Missing	16
Oxytocin rate adjusted	
None	28 (48.3)
Once	24 (41.4)
≥ 2 times	6 (10.3)
Time between active labour[c] and initiation of oxytocin	
< 2 hours	15 (28.3)
2 – 4 hours	19 (35.8)
> 4 hours	19 (35.8)
Missing	5
Labour progression on initiation of oxytocin[d]	
≤ 0.5 cm/hour	27 (56.2)
>0.5 cm/hour	21 (43.8)
Missing	10

[a]Defined as first cervical dilatation of 4 cm and above until birth of the child.
[b]Only includes labours where time of oxytocin initiation was observed.
[c]Defined as cervical dilatation of 4 cm and above.
[d]Measured as dilatation/hour from first cervical dilatation of 4 cm and above to time of administration of oxytocin.

The urge to speed up labour resulted in 146/234 (62.4%) women in active labour receiving oxytocin for labour augmentation (table 4). Of a subgroup of women augmented in the first stage of labour, 21/48 (43.8%) had labour progressing faster than 0.5 cm per hour at the time oxytocin was applied and 5/48 (10.4%) faster than 1 cm per hour. International clinical guidelines recommend that vaginal examination should take place no more than four-hourly in uncomplicated labour. We observed, however, that 34/53 (64.1%) women received oxytocin within four hours of active labour and 15/53 (28.3%) even within two hours (table 4).

Exploring substandard monitoring of women on oxytocin revealed that birth attendants had little awareness of the risks associated with oxytocin. Birth attendants used expressions like "*Why not speed up labour, if you can*" (R4) and referred to oxytocin as a way of helping women give birth faster. One birth attendant described the events of a woman with a stillborn baby: "*He [the doctor] even added an extra bottle of oxytocin [to help the baby]*" (R5). This showed the perceived harmlessness of oxytocin, which is crucial in understanding why injudicious use had developed. In contrast, experiences related to delay in care seemed to have a strong impact on birth attendants. They had daunting memories from the past when the labour ward had been busier, with women presenting from home whilst having been in labour for several days and with a dead foetus in utero. When adverse outcomes happened, prolonged labour was seen as a determinant while oxytocin was considered helpful. These perceptions persisted even though experiences of such horrifying delays mostly belonged to the past. In fact, during the structured labour observations, prolonged labour was a rare event: only 9/214 (4.2%) women were in active labour for more than 12 hours, while 166/214 (77.6%) were in active labour for less than 6 hours (table 4). These findings crucially show how efforts to bring flow to the labour ward and avoid prolonged labour had been successful, but to an extent where oxytocin was given even in the absence of prolonged labour largely detached from individual women's needs. What remains to be explored is what the consequences of such "up-tempo" labour ward management are in terms of caesarean sections and foetal outcomes. Four of five perinatal deaths happened in the oxytocin group. It is, however, beyond the scope of this study to assess causal associations.

Discussion

In the study's high-volume, urban maternity ward with severe time scarcity and shortage of staff, birth attendants were forced to renegotiate care practices. Of the 234 women in active labour, 146 (62.4%) received oxytocin for labour augmentation, most often despite uncomplicated labour progress. Several time factors influenced oxytocin use (figure 1). The strongest driver was to fasten labour when the ward became too busy or to prevent overcrowding. In the absence of electronic monitoring devices, many women received oxytocin at unregulated doses with little monitoring. In many ways, birth attendants found augmentation of labour with oxytocin a preferred choice: it was perceived to prevent congestion and responded to the fear of prolonged labour, while there appeared to be little focus on potential oxytocin-mediated risks. Importantly, among the 234 observed women, only nine were in active labour for > 12 hours (4.2%) and prolonged labour was a rare complication. This illustrates how efforts to avoid dangerous congestion and delayed care had been successful, but consequently resulted in overuse of oxytocin with little reference to individual women's needs.

Figure 1: Conceptual framework on how time factors shape practices around oxytocin for labour augmentation

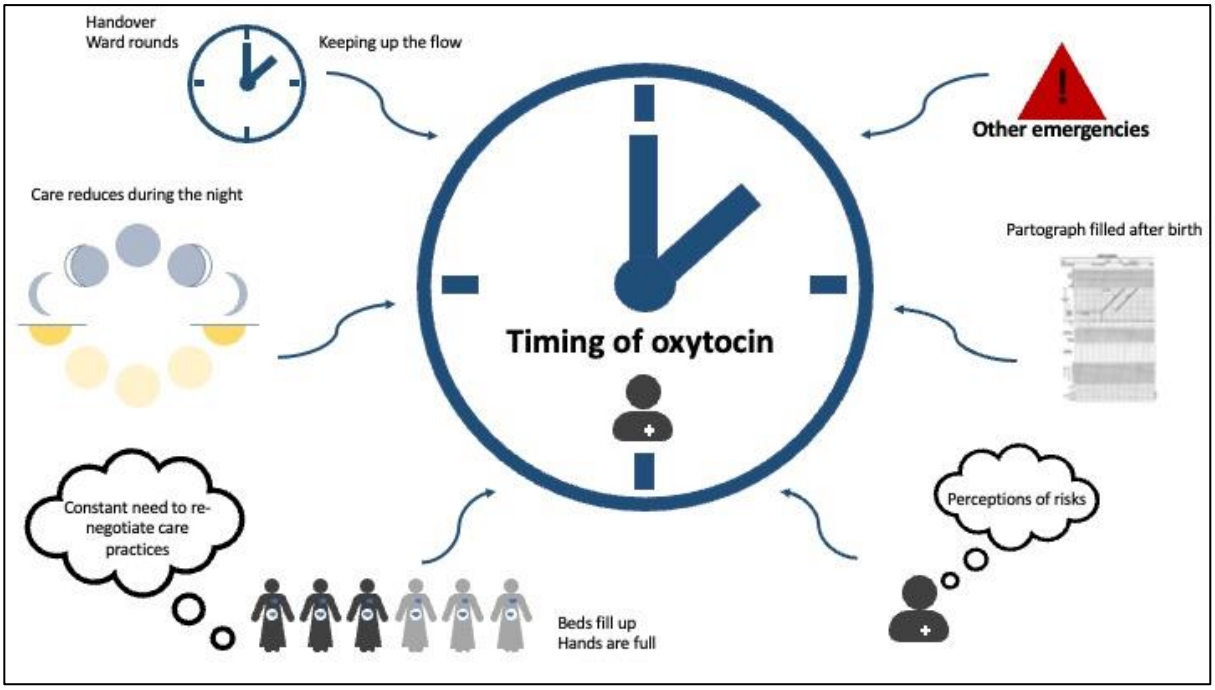

Figure legend: Use of oxytocin was often not based on labour progression or partograph. Number of women and staff, time of the day, ward-rounds and shifts turn-over created cycles with moments where oxytocin use accelerated, sometimes leaving all women on a drip, while at other times, when the ward was too busy or during nighttime, oxytocin was given too late. Perceptions related to risks of prolonged labour and oxytocin further facilitated its use.

Navigating time-pressure in maternity care globally

Time pressure is not unique to this labour ward. Hospital environments globally face increasing demands for providing constantly better care without a simultaneous increase in resources [27]. High-volume understaffed hospitals are increasingly common in cities of LLMIC as urbanisation continues, and communities increasingly respond to the push for facility births [16, 28]. As reported from Egypt and India, we argue that overburdened time-pressured mega maternity units are a crucial driver of the overuse of oxytocin and likely a driver of urban disadvantages in maternal health [28]. Reporting a 50% deficiency in health workforce, literature increasingly reports poor health outcomes in Dar es Salaam, one of the fastest-growing cities [29]. This emphasises, that simply training birth attendants better will not solve overmedicalisation caused by underfunded health care systems. Referring to “tricks of the trade”, Celine et al. emphasised how medical doctors in Switzerland avoided time-consuming practices, just as birth attendants did in our study [30]. They explain how everything that takes time was seen as ‘bumps on the road’. Although effective, if time management becomes the end goal, unintended, less obvious consequences may occur. Oxytocin use is an example of an unintended side effect of navigating time pressure. Oxytocin has been shown to reduce labour by two hours. While such a reduction in labour duration may not seem crucial for the individual, administering oxytocin to many women could save time for care and bed space (if not considering the increased need for monitoring). This explains why excess oxytocin can be used as a time management strategy [11, 13, 31]. Birth attendants in our study had been successful in managing congestion and avoiding delayed care, but at a price of overmedicalisation. Recognising that increasing staff-patient ratios must be seen as a central part of the solution in a human resource crisis is therefore important.

With increasing urbanisation and the formation of mega-cities, such as Dar es Salaam, the time lens could become a crucial tool to understand care provision in these settings more broadly. This requires investigating time scarcity including health provider-to-patient ratio and the gap between guidelines and reality, as well as strategies that health providers use to navigate time pressure.

Normalisation of deviance

While time pressure appeared to be a key driver of overusing oxytocin for labour augmentation, practices remained, even when the labour ward was calm. This emphasises the complexity of deviations from the clinical guidelines [32]. Drawing on previous literature which describes the process of normalisation of deviance, three factors appear central: 1) unrealistic clinical guidelines and structures requiring deviation, 2) low alertness to harmful effects and 3) limited accountability measures [33]. These factors are elaborated in the context of labour augmentation with oxytocin [34].

First, the current guidelines for oxytocin use are cumbersome and not made for settings with a shortage of staff and no electronic devices to dose or monitor oxytocin. Therefore, birth attendants have to find alternative ways that work for them. Adaptations happen all the time in complex, imperfect hospital settings, but as Freedman emphasises, more commonly in low-resource settings [35, 36]. The further away from reality clinical guidelines are, the harder they are to adapt, and adaptations may become unintentionally harmful [37]. When adapted, evidence from which the guidelines were originally based, may no longer be applicable. Deviant practices often start with small changes that move further away from the intended use [33]. It is likely that the current deviations in this labour ward are a result of many years of adjustment to meet continuous congestion with constantly fewer resources [16].

Second, the scarcity of evidence of adverse effects results in low alertness toward oxytocin [3]. Collectively, because of the bad experiences with prolonged labour, clinicians blamed labour duration rather than oxytocin when adverse events occurred. Behavioural scientist Soyer and psychologist Hogart unfold this well-known phenomenon in their article “Fooled by experience” [38]. Additionally, RCTs including oxytocin were small and not powered to investigate rare events which further downplays the risk of oxytocin [1, 39–44].

Finally, the low focus on substandard, unrestricted and unaudited use reflects the limited accountability for oxytocin. In contrast, birth attendants were held accountable for perfectly filled partographs, where prolonged labour was not accepted. Meanwhile, oxytocin was freely available and mostly in stock in the fridge next to the labour ward. While this may increase life-saving oxytocin for third stage of labour, it may have facilitated liberal use during labour. Establishing accountability measures that hold birth attendants accountable for *realistic* oxytocin guidelines based on the partograph as a decision, and not a liability tool, thus, seems crucial.

Improving the use of oxytocin in this labour ward requires de-normalising its use. Consequently, we recommend addressing the congestion of urban high-volume labour wards, as this fundamentally sustains excessive oxytocin use. We further emphasise the sensitisation of oxytocin as a high-alert medication, while global evidence is crucially needed to unfold the risk profile and long-term effects of oxytocin stratified in low-, middle- and high-income countries. Meanwhile, the development of realistic oxytocin guidelines for low-resource settings is crucial for providing safer use. The PartoMa project, which this study is part of, provides a model for co-creating clinical guidelines and training adapted to

the local setting. The results may show a promising way of navigating unrealistic guidelines in increasingly time-pressured realities [45].

Strengths and limitations

Our mixed-methods design allowed a deeper understanding of the mechanisms which shape practices around labour augmentation with oxytocin. The primary researcher's position as an "outsider" with obstetric experience from another setting and our diverse author group appeared crucial in recognizing and reflecting on deviant normalized practices. BSD, MA and DN have in-depth clinical experience from the study hospital ensuring findings were recognizable. Translated transcripts have limitations since nuances may have been missed in the translation process. Observations may be subject to the Hawthorne effect where birth attendants performed better than they would usually. Though assistants were not trained obstetricians and had no reason to over- or underestimate oxytocin observer's bias cannot be ruled out. We included only women with low-risk pregnancies and quantitative findings are therefore comparable to this population primarily. Underlying perceptions and culture are specific to this labour ward with limited generalizability. Our findings are of interest to other LLMICs where congestion is an issue. Rural hospitals may experience underuse of oxytocin due to absence of staff, lack of storage capacity, stock-outs of oxytocin or low quality of oxytocin. Findings, however, are of global health concern, as unindicated oxytocin use is also increasingly observed in HIC [43, 45–47].

Conclusion

In this labour ward, almost two out of three women in active labour received oxytocin for labour augmentation, most with uncomplicated labour progress and limited monitoring and titration. Overcrowding appeared to be the strongest driver, forcing birth attendants to keep up the flow in the busy labour ward by using oxytocin as a decongestion tool. Low alertness towards oxytocin-mediated risks, along with fear of prolonged labour, further facilitated liberal oxytocin use. Evidence-based, context-adjusted training and guidelines for prolonged labour management in time-pressured labour wards are required to avoid medically unindicated use of oxytocin. Further, myths and perceptions must be addressed to de-normalise its use. With increasing urbanisation, facility births and the formation of mega-cities, the time lens could become a crucial tool to understand the effect of time pressure and congestion on care practices in low-resource settings more broadly.

Abbreviations

LLMIC: Low- and lower-middle-income countries
LIC: Low-income countries
HIC: High-income countries
FHR: Fetal heart rate
WHO: World Health Organisation

Declarations

Ethics approval and consent to participate

All respondents for interview gave their written informed consent. Informed verbal consent was obtained from women and staff during observations. The research project, including verbal consent, received ethical approval from the Tanzanian National Institute for Medical Research (NIMR/HQ/R.8a/Vol. IX/3324) (approval of protocol) and NIMR/HQ/P.12VOLXXXV/111 (permission to publish). Methods were performed in accordance with the Declaration of Helsinki.

Consent for publication
Not applicable.

Availability of data and materials

The datasets are not publicly available due to privacy of respondents, but are available from the corresponding author on reasonable request.

Competing interests
The authors declare that they have no competing interests, apart from Jos van Roosmalen, who is a senior board member of BMC Pregnancy Childbirth.

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Authors contributions
MLK, JBS, MS, EP, NM, TvdA and FK contributed to the conception and design of the work;
MLK collected the data and developed figures and tables;
MLK, MS, JBS and DN contributed to the analysis and interpretation of data;
MLK drafted the manuscript;
All authors substantively revised the draft;
All authors have approved the submitted version (and any substantially modified version that involves the author's contribution to the study);
All authors have agreed both to be personally accountable for the author's own contributions and to ensure that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature.

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Supplementary files
Supplementary file 1: Interview guide.docx
Supplementary file 2: Template for structured observations.docx

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Supplementary file 1: Observation sheet for structured observations

Observation sheet: **NO** = Not Observed, **y**=yes **n**=no, **/**= not applicable

Referral (y/n):
Date of admission:
Time of admission:
Cx dilatation on admission:
Date of opening the Partograph:
Time of opening the Partograph:
Cx dilatation when Partograph opened:
Date and time of delivery, stillbirth or CS:

Name of the mother / Hospital ID	
Age of mother	
Risk factors: PIH, fever, APH, PROM, prev CS, cord, breech, multiple, shoulder dystocia, anemia, HIV…	
Parity	
Gestational age	
Induced (No/balloon/misoprostol/oxytocin)	
Time of oxytocin start: **Time of oxytocin stopped:**	**Changes of rate can be documented on the back.**
Oxytocin used in first stage (y/n) Cx dilatation (cm)	
Oxytocin used in second stage (y/n)	
Concentration used (units)**	Prescribed/labelled: Observed:
Starting drop rate per 15 sec (number)	
Maximum drop rate per 15 sec (number)	
Bolus i.v. (y/n), units and 19approx. time	
Oxytocin documented in the case file (y/n)	
Oxytocin documented in report book	
Oxytocin labeled (y/n)	
Fetal Heart rate monitored (time)**	
Contractions monitored (time)**	

Birth weight:

Apgar Score	**0**	**1**	**2**	**1 min**	**5 min**	**(10 min)**
Appearance	Blue/pale all over	Blue/pale extremities				
Pulse	Absent	< 100	>100			
Grimace on stimulation	No response	grimaces	Sneezes/coughs /pulls away			
Activity	Absent	Arms/legs flexed	Active			
Respiration	Absent	Weak/slow irregular breathing	Good cry			
Total Apgar Score						

Outcome of the newborn (Y/N)
Admission to neonatal unit(No. of days): Neonatal death(day): Transfer to Muhimbili (date):

Supplementary file 2: Questions for in-depth interviews

Presentation of interview to the participant

- I am a student/researcher and part of a Tanzanian and international team that looks into health care workers' and managers' experiences with working at the maternity wards at several hospitals in Dar es Salaam Region
- Thank you for taking the time to talk to me about your work and your experiences working in the maternity ward.
- With your permission, I would like to ask you about the work at the maternity ward.
- You have been asked to take part in this interview, because you have experience from working at the maternity ward at x- hospital.
- Your answers will be kept strictly confidential. Your name will not appear anywhere. If you are uncomfortable partaking in this interview, you are free to let me know and we will stop the interview. If you want to take a break and continue at another time, please let me know.
- Your experiences are very important to us. Keep in mind that we are interested in both negative and positive comments. We would like to learn from your sincere opinions and experiences, so please do not fear to give your honest answers.
- There is no right and wrong to the answers and the interview is not a test of your knowledge, but it is to understand how you think and act.
- There are no right or wrong answers – we are only interested in your personal experiences and views.
- The interview will take approximately one hour.
- Can I have your permission to interview you?
- [If yes] Can I have your permission to record our talk? In this way, I do not have to write down all your comments while we talk.
- Do you have any questions before we start the interview? [turn on recorder]

Questions	What we want toknow
Understanding the daily life and context of the participant	
1. Please tell me a little bit about yourself. - What is your professional background - How many years have you been a midwife/doctor? - How long time have you worked at Mwananyamala Hospital (MH)? - How long time have you worked with deliveries? - How many deliveries have you done? - What type of training in delivery care have you received?	Building rapport. The context about what it is like to work as a birth attendant in Dar es Salaam
Understanding the participant's perceptions and experiences of working at the labour ward	
2. Internationally, people are somehow in disagreement about how to define what prolonged labour is. How do you define prolonged labour? How fast is a normal labour progression according to you? 3. After how many hours of active labour do you start to get worried? *4.* I have been told that in this hospital a primiparous woman should not be in the labour ward more than 8 hours. - *Do you know why/how this rule was made? How was it before?* - *Do you like this rule?* - *What happens if a labour lasts for longer time?*	The participant's view on prolonged labour and natural labour progression.
5. What is good and supportive care in your experience, and do you use supportive care, why/why not? (empty bladder, ensure food and drink, ambulation, pain relief) 6. When would you typically choose to rupture the membranes? Can you give me an example?	Understanding of the use of supportive care and rupture of membranes
7. Let us talk a bit about the use of oxytocin here *a. In which situations do you apply oxytocin for augmentation? Can you give me some examples?(help with an example). What happens if you don't use oxytocin in these situations but wait and see?* *b. Do you think oxytocin works well? Can you give me an example?* *c. Have you experienced oxytocin being harmful? Can you give me an example? What are other harmful effects of oxytocin have you seen?* *d. Have you experienced giving too much oxytocin? What happened? Is there a maximum dose you would give? What is the maximum strength of contractions (length, number)?* *e. I have noticed that not many staffs measure contractions and count drips. What do you think is the reason for that? How is the right dose assured?* *f. How many patients do you think gets oxytocin for augmentation? (few/many/suggest a percentage). Why do you think so many women are given oxytocin for augmentation here? Has it always been like that?* *i. What is the role of number of patients?* *ii. What is the role of fear of prolonged labour?* *iii. Can you imagine using it less?*	Understanding the overuse of oxytocin to augment labour including why protocols are not being followed. Understand the perceptions of oxytocin as being good or harmful.
8. Can you tell me how second stage of labour is typically managed here? Do you have a passive and an active phase? What do you do if the baby is not coming? - *Why is the oxytocin drip sometimes being increased rapidly during second stage?*	Understanding why second 2nd stage labour is managed very active

- *Bolus oxytocin and fundal pressure is sometimes being applied? in which situations? What is your experience with these actions?* - *In Denmark (other places) many women are in second stage for 3 hours. What do you think about that? Could you imagine that happening here? What challenges do you see with this?*	Vacuum extractions
9. Can you explain your experience with vacuum extraction?	Perceived causes for problems in partograph use
10. What is your experience with using the partograph? Do you find it useful? In which situations is it useful? - *Do you use the partograph alert and action line? If yes, how do you use the alert and action line to guide you?* - *I have observed in the labour ward, that partographs are often filled in after delivery. Why do you think that happens?*	Understanding of causes of the lack of monitoring
11. How often do you assess labour progress? *What are the challenges in relation to assessing labour progress routinely here (to many/too few PV)?*	
12. Now I want to tell you about a fictive case from a hospital. A woman is in labour and was started on oxytocin at 2.30 am. At 10 o'clock she has the same dilatation. The Partograph shows that there had been no monitoring of her. *a. What are your thoughts on this case?* *b. Could this have happened here?* *c. Can you think of reasons why she was not monitored during the night?* *d. Does this happen often that women are not monitored over the night?* *e. I have seen that sometimes the ward is not very busy and still mothers would not be monitored adequately, do you know why that happens sometimes?* *f. Who is responsible in such case?*	Assess the understanding newborn care, low Apgar scores and oxytocin
13. What happens if the Apgar Score is low? Is it correct that there is a great fear of low "scores", can you explain something about that? I have noticed that Apgar Scores are often 8-10, even if I would tell it to be lower. Why do you think that is? *(i.e. could be fear of low scores, difficult to assess Apgar, assessing apgar too late?)*	
14. Why do you think are the reasons when there are low apgar scores here?	
Understanding of the responsibilities and the collaboration in the labour ward	
15. What do you think about the cooperation among nurse-midwives, orderlies, students and doctors in the ward? - *Can you give examples of good (or otherwise) cooperation between nurses, midwives and doctors? Do you feel supported (in the labour ward?) Do you feel supported by your colleagues*	The micro-political dimensions within the work group
Closing the interview	
These were all my questions. Thank you very much. Is there anything else of importance that you think I should have asked you? Do you have any questions about our research or final comments to the interview?	

Point-by-point response to the editor 29.05.23

Dear Editor,

Thank you for reviewing our paper. We are glad to see that both reviewers find the paper interesting, of good quality and relevant. Please see below our response to specific questions asked by the reviewers.

Reviewer 1
Thank you for allowing me to review this manuscript. These are my comments and questions that I request the authors to address:
Thank you for taking the time to review the paper and for the useful feedback to improve it.

The written English language could be improved as Grammarly detects multiple grammatical mistakes.
We have read through the manuscript carefully to improve the language. We also downloaded Grammarly and looked through suggestions made by this software. Please see corrections throughout the manuscript.

The problem is clearly stated and the reason to embark on this research. The objective of the study is clearly stated too.

Under the Method section: there was no mention of the mean occupancy of the labour ward because those 16 beds in the labour ward may not be fully occupied at all times.

Thank you for this observation. We mention instead the annual number of births as an indicator of volume. Unfortunately, like in most comparable settings, there are no numbers for mean occupancy. We have included the following:

All these extra tasks imply that generally 1-2 nurse-midwives provide care to the women in the 16 beds with varying occupancy.

In Table 1: Why does it take minimally 20 minutes to time contractions over 10 minutes? That goes for the rest of the actions too especially to titrate oxytocin.
We calculate the hourly time consumption and as these practices should be conducted every 30 minutes, we multiply by 2. E.g. 10 minutes x 2 are spent on calculating contractions every hour.

What are the exclusion criteria for this study apart from those are referred to the hospital? Why are those referred to the hospital excluded from participating in this study?
Thank you for this comment. We acknowledge that this was not clearly written, but added as a footnote in the table. Referred women in Tanzania have often been in labour for a long time and these cases are more complicated. Therefore, evaluating timing of oxytocin and labour length would be difficult to interpret. We wanted to assess care practices for a low-risk population to avoid too many competing explanations for why (prolonged) labour was managed as it was. We have included the following to clarify this:

Inclusion happened consecutively during each observation period and was limited to singleton cephalic pregnancies at term with positive foetal heart rate on admission. Women who were referred and women with hypertensive disorders or previous caesarean section were excluded. We aimed to study oxytocin use among a low-risk population to avoid competing factors influencing administration of oxytocin.

I am surprised to read about filling up the partogram post-delivery. It is dangerous and unethical to do so. Partogram is an integral tool for labour management. It is also dangerous not to monitor FHR and contractions once oxytocin augmentation is started. The incidence of operative deliveries, instrumental deliveries, PPH and uterine hyperstimulation is higher with oxytocin augmentation. In this study, are these complications not observed? The outcome of the deliveries seems good despite the poor monitoring of FHR and contractions during labour. Could the author address this matter?

We agree with the comments and concerns of reviewer 1. Low use of the partograph and low monitoring combined with excessive oxytocin use are crucial findings that call for interventions to reduce oxytocin use in overburdened urban labour wards. Our study was not designed to assess outcomes. An intrapartum stillbirth rate of 1.7% in a low-risk population does seem high and could very well be partly due to overuse of oxytocin. Upon

request from reviewer 2, we included outcomes for women who were augmented with oxytocin, where we, despite low numbers, do see overrepresentation of perinatal deaths in the oxytocin group. We have included the following:

Four of five perinatal deaths happened in the oxytocin group. It is, however, beyond the scope of this study to assess causal associations.

Reviewer 2
It is a very comprehensive and well-written paper. I have several comments as follows:
We thank reviewer 2 for assessing the manuscript and for providing advice that helped us improve the manuscript.

I understand that the authors would like to include all the study data but I think the overall manuscript is very lengthy (Word count approx 5660).
Thank you for pointing this out. The manuscript was lengthy and we have tried our best to cut down and prioritise our key messages. Our comprehensive qualitative component requires more words to facilitate an in-depth understanding of the complexity of underlying factors as compared to a classic quantitative study. Further, while we believe the mixed-methods design is partly what makes this manuscript unique and valuable, more words are needed to explain the different methods. We, therefore, hope the current word count, which has been reduced substantially to around 4.500 words, is acceptable.

What is the dosage of oxytocin used in the infusion, at the centre?
They use 5 IU in 500 ml. This is now included in the manuscript.

Oxytocin usage carries risks maternal and fetal risks. Is there any data on uterine rupture and PPH among the women? What about fetal distress/ meconium liquor? It would be interesting to see the data on stillbirth/ NICU admission among the women (augmented vs natural labour).
Thank you for this relevant comment. We have now included birth outcomes for labours augmented with oxytocin into table 4. The numbers are small and call for careful interpretation, but it seems like intrapartum and early neonatal deaths are primarily in the oxytocin group.
We did not focus much on outcomes, as there are other studies from low-resource settings that have established the potential risks (please see our systematic review: *Kujabi ML et al. Labor augmentation with oxytocin in low- and lower-middle-income countries: a systematic review and meta-analysis. AJOG Glob Rep. 2022 Oct 21;2(4):100123. doi: 10.1016/j.xagr.2022.100123.* Our study was designed to look at practices and understand how it is used in a low-resource setting (leading to potentially adverse outcomes) and causes of excessive use. Therefore, PPH was not systematically collected. Uterine rupture, being a rare complication, did not happen in our small sample. We do believe a study on outcomes in a low-resource setting is highly overdue since most robust trials on oxytocin are conducted in high-income countries. We hope the findings from this study crucially unfold the need for such research and give a unique insight into the underlying mechanisms of medically unindicated oxytocin that occurs in many places. Hopefully, this can lead to targeted interventions.

4) The conventional framework is interesting. Worth considering using keywords instead of phrases.

Thank you, we have adjusted the keywords. We also find the framework quite useful and believe it is worth investigating the role of time particularly in such overburdened low-resource hospitals. As we argue in the paper, the lack of time may be a crucial reason for the urban disadvantage we increasingly see for example in Dar es Salaam. Quality of care simply cannot keep up with the increasing demand without simultaneous increase in human resources.

We sincerely hope that our reply answers any questions or concerns. Please let us know if more revision is needed.

On behalf of the authors,

Monica Lauridsen Kujabi, MD
Global Health Section, Department of Public Health
University of Copenhagen, Denmark

Point-by-point response to the editor 09.01.2024

Dear Editor and reviewer,

Thank you for carefully peer-reviewing our manuscript and providing useful input. Your work is highly appreciated.

We are happy that the reviewer appreciated the manuscript with only minor revisions. We have amended the manuscript accordingly and hope it is satisfying. Please see below the response to the requested revision.

Reviewer 3
REQUESTED REVISIONS:
The study was well conducted, and the manuscript well written. Issues raised by previous reviewers led to appropriate changes to the manuscript.
My only suggestion would be to add a comment with references (if any are available) on the effectiveness of operator training interventions to improve the appropriate use of oxytocin in LLMICs.

The requested revision is highly relevant and we have added the text below to the discussion which explains with references interventions carried out to lower the use of oxytocin.

A few studies from LLMIC have succeeded in reducing oxytocin use. A Tanzanian study decreased labour augmentation with oxytocin from 22% to 12% after implementing context-adjusted guidelines developed with frontline health workers (the PartoMa intervention). The guideline restricted oxytocin to women crossing the partograph's action line. An Indian study reported a reduction in oxytocin from 78% to 32% after implementing the WHO childbirth checklist. Oxytocin increased to 48% 6 months after ending the intervention. Finally, a study from a Palestinian hospital reported a decrease in the use of oxytocin for augmentation from 32.1% to 10.9% after implementing a multifaceted intervention. The intervention consisted of on-the-job training 2-3 days a week, audit of practices, feedback during interactive audit meetings every 2–3 months, five training workshops and informal meetings with managers and midwives to understand barriers and providers' opinions of the intervention. Two years post-implementation the oxytocin rate, however, increased to 17%.

On behalf of the authors

Monica Lauridsen Kujabi
PhD student and OBGYN resident
University of Copenhagen
Denmark

Paper III

Unfolding potentially avoidable caesarean sections in five urban maternity units in Tanzania: A criteria-based clinical audit (a PartoMa sub-study).

Hansen S, Kujabi ML, Maimburg RD, Macha AN, Maembe L, Kabanda I, Housseine N, Hussein K, van den Akker T, Meyrowitsch DW, Maaløe N.

Manuscript not submitted.

Unfolding non-medically indicated caesarean sections in five high-volume urban maternity units in Tanzania: A criteria-based clinical audit (a PartoMa sub-study)

Authors

Sarah Hansen[1], Monica Lauridsen Kujabi[2,3], Rikke Damkjær Maimburg[1,4,5,6], Anna Macha[7], Luzango Maembe[8], Idrissa Kabanda[9], Hudson Manyanga[10], Rukia Juma Msumi[11], Sangalala Mtingele[12], Natasha Housseine[7], Brenda Sequeira Dmello[7], Kidanto Hussein[7], Thomas van den Akker[13,14], Dan Wolf Meyrowitsch[2], Nanna Maaløe [2,15]

Institutional affiliation

[1] Department of Clinical Medicine, Aarhus University, Denmark
[2] Global Health Section, Department of Public Health, University of Copenhagen, Denmark
[3] Department of Gynaecology and Obstetrics, Aarhus University Hospital Skejby, Denmark
[4] Department of Midwifery, University College of Northern Denmark, Denmark
[5] Department of Occupational Medicine, Danish Ramazzini Centre, Aarhus University Hospital, Denmark
[6] School of Nursing and Midwifery, Western Sydney University, Australia
[7] Medical College East Africa, Aga Khan University, Dar es Salaam, Tanzania
[8] Department of Gynaecology and Obstetrics, Mwanyanamala Regional Referral Hospital, Dar es Salaam, Tanzania
[9] Department of Gynaecology and Obstetrics, Sinza Regional Hospital, Dar es Salaam, Tanzania
[10] Department of Gynaecology and Obstetrics, Temeke Regional Referral Hospital, Dar es Salaam, Tanzania
[11] Department of Gynaecology and Obstetrics, Rangi Tatu Maternity Hospital, Dar es Salaam, Tanzania
[12] Department of Gynaecology and Obstetrics, Amana Regional Referral Hospital, Dar es Salaam, Tanzania
[13] Athena Institute, VU University Amsterdam, the Netherlands
[14] Department of Obstetrics and Gynaecology, Leiden University Medical Centre, Leiden, the Netherlands
[15] Department of Gynaecology and Obstetrics, Copenhagen University Hospital – Herlev Hospital, Denmark

Corresponding author

Sarah Hansen, Department of Clinical Medicine, Aarhus University, Denmark,
sarahhansen95@hotmail.com, +45 41 62 66 32

Short running title: Unfolding non-medically indicated caesarean sections

ABSTRACT

Objective: Assess to what extent caesarean section (CS) indications followed evidence-based and locally co-created guidelines and identify reasons contributing to non-medically indicated CSs.
Design: Retrospective cross-sectional study.
Setting: Five urban, high-volume maternity units (annually 60,000 births) in Dar es Salaam, Tanzania.
Population: Women undergoing CS during a three-month period at each maternity unit, between 1. October 2021 and 31. August 2022. Exclusion criteria: unavailable records or unknown indication.
Methods: Case files of CS were audited against pre-defined, localised criteria.
Main Outcome Measures: CS rate, indications and proportion of non-medically indicated CSs.
Results: Overall CS rate was 31% (2949/9364) and 2674/2949 (91%) CSs were included for analysis. Main indications were previous CS (1133/2674; 42%), prolonged labour (746/2674; 28%), and foetal distress (554/2674; 21%). Overall, 1068/2674 (40%) did not comply with audit criteria, most important reasons being: 1) one previous CS with no trial of labour (527/1068; 49%); 2) reported prolonged labour without actual slow labour progress (243/1068; 23%); 3) foetal distress with normal FHR (120-160 BPM) recorded at time of CS decision (226/1068; 21%).
Conclusion: Two in five CSs were categorised as non-medically indicated at time of decision. Defensive decision making appeared central. The need is crucial for conducive urban maternity units to ensure safe vaginal births, and for more research and clinical guidance to ensure best possible timely care for all with the limited resources available.
Funding: Danida Fellowship Centre, Ministry of Foreign Affairs of Denmark (18-08-KU) and Aarhus University Research Foundation, Denmark.
Keywords: Caesarean section, indications, urban-disadvantage, low-income countries, sub-standard care

INTRODUCTION

Globally, the caesarean section (CS) rate has increased dramatically, now reaching 21.1% and forecasted to be 28.5% in 2030.[1] While the option of CS is undoubtedly a key requirement for safe childbirth, the CS pandemic continues to accelerate, with CSs being performed on questionable medical indications in low-, middle- and high-income countries.[2] Meanwhile, other women in resource-constrained settings continue to have limited access to timely CS.[3-5]

Overuse of CSs is of particular concern in Sub-Saharan African (SSA) where associated risks are highest: 1% of women and 8% of babies are estimated to die during or after CS, which is 100- and 50-fold the rates in high-income countries (HICs).[6] In subsequent pregnancies, CSs predispose to repeated CSs, uterine ruptures and abnormal placentation.[7-9] Furthermore, non-medically indicated CSs are resource-draining and counteract hard-won improvements in maternal and perinatal health.[10-12]

Particularly in urban areas of SSA, the CS rate has increased rapidly. This potentially undermines the positive momentum of increased facility births and the "CS pandemic" may be a central contributor to a growing 'urban disadvantage' in maternal and perinatal health, which is observed in some cities.[2,13-15] Notably, by 2030 over half of global births will occur in urban settings, the vast majority in low- and middle-income countries.[20] 'Urbanicity' challenges the traditional rural-centric approach in maternal and newborn health programs, and it calls for a shift in health strategies.[18,19]

Dar es Salaam (DSM) in Tanzania is among the world's fastest-growing cities and the city is an example of an urban setting facing significant disadvantages for both giving birth and being born.[13-15,21] Despite 75% of the city's women attending at least four antenatal visits and 100% giving birth in facilities, current maternal and neonatal mortality rates in urban areas are significantly higher than those in the country's rural settings.[13-15,21] Simultanously, DSM's population-based CS rate is increasing fast, from 17% in 2015 to 26% in 2022.

We here present an in-depth, criteria-based audit of the quality of clinical management and decision-making preceding CSs in five of DSM's most congested maternity units.

METHODS

A retrospective criterion-based audit examined the clinical records of all women who gave birth by CS during a three-month period at each of five busy, public maternity units in DSM, Tanzania.[22,23] Data collection took place between October, 1st 2021 and August, 31st 2022 as part of a baseline situational analysis for the PartoMa Birth scale-up study (Figure 1).[24,25] Data on clinical management preceding the decision to perform CS were collected and compared to pre-selected, evidence-based, locally adapted criteria of best possible care (Table 1).

The audit criteria for the present study were based on the locally co-created PartoMa Birth Clinical Practice Guidelines. These guidelines were co-created with healthcare providers to assist them in arriving at realistic, evidence-based guidance on intrapartum care, including both routine and emergency management. The guidelines are based on existing national and international evidence-based guidelines and scientific evidence and they were externally peer-reviewed and approved by Tanzania's Ministry of Health for use in the included facilities. [24,26-30] Thereby, we aimed for audit criteria representing best possible clinical practice

when deciding on CS in the clinical contexts. Moreover, the audit criteria are similar to criteria that have previously been applied successfully in comparable low-resource settings.[4,31-34]

Setting

The five study hospitals are all government-owned maternity units in DSM, providing comprehensive obstetric and neonatal care. Mwananyamala Hospital, Amana Hospital and Temeke Hospital are regional referral hospitals, and Sinza Health Centre and Mbagala Rangi Tatu Health Centre serve as district hospitals (Table S1). In 2019, these hospitals' maternity units had been the most congested in DSM for more than a decade and provided service to nearly 60,000 annual births in total. Primarily, women of lower socioeconomic status make use of these facilities.[14]

Despite successful implementation of a complex and dynamic intervention to improve urban maternal and perinatal health in 22 facilities in DSM between 2010 and 2016, significant challenges still persist.[14] Due to shortage of staff, each birth attendant often attends three to six labouring women simultaneously, a number that may further increase when assistance is required for CS in the operating theater.

There are shortages of supplies, such as kits for vaginal birth, gloves, soap, essential medication (e.g. antihypertensives) and vacuum extractors. Also, during data collection for this study, the hospitals had no clinical guidelines regarding intrapartum management and when to perform CS. Foetal heart rate (FHR) monitoring during labour is usually assessed by a Pinard fetoscope and occasionally foetal doppler.

The maternity units are led by nurses in charge and births are attended by nurse-midwives, clinical officers, or medical doctors. CS is performed by either a clinical officer or medical doctor, and there is no apparent financial motivation observed at the facilities for performing CS. In the regional referral hospitals, specialised pediatricians lead neonatal intensive care units, while medical doctors attend sick newborns in district hospitals or refer them to more specialised hospitals.

Data collection and management

All women who gave birth by CS at the five study sites during the pre-specified three study months at each site were included. Women giving birth by CS were identified through the health management information system's birth register, known as MTUHA-12, in each facility and their identities were cross-checked with the hospitals' surgical registers. Case files were retrieved within a maximum of one month after childbirth. Women with an inaccessible case file, or a case file lacking recorded indications for CS, were excluded from analysis.

Data for included women were extracted from case files, partographs, birth registers and operating room records. The data were recorded in pre-tested case extraction forms using KoBoToolbox.[35] Data collection was done by SH and three research assistants, all of whom had a medical background. Preceding data collection, data collectors were trained to align interpretation of case files. In case of ambiguous documentation, staff members from the labour ward were consulted. To ensure the quality of data retrieval, 810/2674 (30%) of files were double-entered; all mismatches corrected, and data collectors trained continuously to avoid further errors. In case of discrepancies, MLK or NM was consulted as a tie breaker. If a procedure was not documented, it was assumed that it had not been performed.[36]

Variables

The audit form included background characteristics, intrapartum care, crucial time-points (e.g., admission, assessments, decision on CS, birth), status of labour at time of decision for CS, and perinatal and maternal outcomes. Sociodemographic indicators, such as economic and educational status of women, were not available.

Moreover, audit criteria were selected to categorise CS indications into: 1) medically indicated; 2) non-medically indicated; and 3) unclear if medically indicated (Table 1). Some CSs had more than one indication. The group *medically indicated* included CSs where at least one indication was considered medically indicated, e.g., placenta previa. The category *non-medically indicated* included indications that, according to the audit criteria, did not require a CS. For examples, see Table 1. The category *unclear if medically indicated* included CSs that could not be assessed due to incomplete record keeping. As cases of CS due to prolonged labour needed more complex analysis, these are reported elsewhere (unpublished paper).

We included all indications for CS as documented in the managing clinician's notes regarding the decision to perform CS as well as the managing surgeon's notes. Of indications representing prolonged labour, we included 'prolonged labour', 'poor progress of labour', 'failure of augmentation', 'cervical arrest', 'cervical dystocia', 'cephalopelvic disproportion (CPD)', 'obstructed labour' and 'big baby'. Of indications representing foetal distress, we included 'foetal distress', 'non-reassuring foetal status', 'reduced foetal kicks/movement' and 'meconium-stained liquor'. Women with unknown labour progress upon admission were defined as having been in labour.

For case files with no documentation of the time of birth, this time point was estimated by deducting 45 minutes from the time of reaching the postpartum ward after surgery. These interpretations were based on input from health providers from the hospitals.

Statistical analysis

The facility-based CS rates and the frequency of each indication for CS were calculated using descriptive statistics. An in-depth analysis to assess the quality of decision-making employing descriptive statistics was conducted for the commonest indications of CS. The proportions of CSs being 1) medically indicated; 2) non-medically indicated; and 3) unclear if medically indicated were calculated as proportions of the total number of CSs and of each of the commonest indications. Following data analysis, two meetings were held with senior obstetricians from the facilities to share and discuss preliminary findings locally and ensure contextual interpretation.

Ethical considerations

Ethical approval for The PartoMa Scale-Up Study was obtained from the Tanzanian National Institute of Medical Research (NIMR/HQ/ R.8a/Vol. IX/3324, NIMR/HQ/R.8c/Vol. I/1679, NIMR/HQ/R.8c/Vol. I/926). The PartoMa study is registered in clinicaltrials.gov (NCT04685668). Further permission to conduct the audit here presented was obtained from the Tanzania Commission of Science and Technology, regional and district medical officers in DSM and participating hospitals. A data management agreement has been signed by the partners involved in storing and analysing data, and all data are de-identified with codes having replaces names of participants.

RESULTS

In the five maternity units, 9364 women gave birth and 2949/9364 (31%) gave birth by CS. Facility-based CS rates ranged from 20% to 42% (Figure 1). Case files with a documented CS indication were available for 2674/2949 (91%). Amongst these, 688/2674 (26%) were referred from a lower level health facility, 790/2674 (30%) were nulliparous, 1157/2674 (43%) had had a previous CS.

Previous CS was the leading indication for CS (1133/2674, 42%), followed by prolonged labour (746/2674, 28%), foetal distress (554/2674, 21%), hypertensive disorders in pregnancy (216/2674, 8%), abnormal presentation (134/2674, 5%), breech (84/2674, 3%) and other indications (446/2674, 17%) (Figure 2, Table S2). More than one indication for CS was recorded in 661/2674 (25%) women.

On admission, 632/2674 (24%) women were not in labour, 1254/2674 (47%) in latent phase of labour (cervical dilatation <4 cm), 535/2674 (20%) in the first stage of active labour (cervical dilatation 4-<10 cm) and 16/2674 (1%) in the second stage (Table 2).

A written CS decision note was present in 2364/2674 (88%) files and FHR at the time of decision was recorded in 2149/2674 (80%) files. When deciding on CS, 2196/2674 (82%) were in labour, and their decision-to-birth interval was within 1 hour for 190/2196 (9%) and >3 hours for 891/2196 (41%).

One maternal death was reported and 84/2674 (3%) had maternal complications documented postpartum before discharge (e.g. sepsis, post-partum hemorrhage). Median time between birth and discharge was 2 days (IQR 1-2, missing information n=149). In total, 2601/2783 (93%) had an Apgar 8-10 after 5 min. Among newborns, 47/2783 (2%) were stillbirths, of which 25/47 (53%) had a positive FHR recorded at the time of deciding on CS. Another 93/2783 (3%) were transferred to a neonatal intensive care unit of which 6/93 (6%) died and 17/93 (18%) could not be traced.

Estimation of non-medically indicated CSs

In total, 1009/2576 (38%) of all CSs were audited as being medically indicated at the time when decided upon, 1068/2674 (40%) as non-medically indicated, and 597/2674 (22%) as unclear if medically indicated. The commonest indications are described below, the audit criteria are detailed in Table 1 and further details are available in Figure 2.

Among women having CS due to a previous CS (1133/2674, 43%), 472/1133 (39%) were categorised as “medically indicated CS”, 527/1133 (47%) were categorised as “non-medically indicated CS”, and 134/1133 (12%) were categorised as unclear. Among women with a previous CS, 350/1133 (31%) were not in labour on admission while 553/1133 (49%) were in the latent phase of labour, 140/1133 (13%) in the active first stage and 3/1133 (0.003%) in the second stage.

Among women having CS due to prolonged labour (746/2674, 28%), 213/746 (29%) were categorised as “medically indicated CS”, 243/746 (33%) were categorised as “non-medically indicated CS, and 290/746 (39%) were categorised as unclear. For more details, an in-depth analysis of prolonged labour cases is published elsewhere.

Among women having CS due to foetal distress (554/2674, 21%), 19/554 (3%) were categorised as “medically indicated CS”, 226/554 (41%) were categorised as “non-medically indicated CS”, and 309/554 (56%) were categorised as unclear. For CSs performed due to foetal distress, 428/564 (76%) babies were

born more than one hour after CS decision and scored Apgar 8-10 after 5 minutes. Among all foetal distress cases with a normal FHR when deciding on CS (n=270), 151/270 (56%) had meconium-stained liquor recorded and 34/270 (13%) reported reduced foetal movements (Table S3).

Among women having CS due to hypertensive disorders in pregnancy (216/2674, 8%), 22/216 (10%) were categorised as "medically indicated CS", 117/216 (54%) were categorised as "non-medically indicated CS", and 77/216 (36%) were categorised as unclear.

Among women having CS due to breech presentation (84/2674, 3%), 68/84 (81%) were categorised as "medically indicated CS", 7/84 (8%) were categorised as "non-medically indicated CS", and 9/84 (11%) were categorised as unclear. Of nulliparous women eligible for a trial of breech labour, 19/41 (46%) did not have a trial of labour.

DISCUSSION

Similar to other urban settings in LMICs, Tanzania's CS rate is rising fast in cities and it is concurrent with a growing urban disadvantage in maternal and perinatal health. Against this background, our in-depth review of clinical management preceding 2674 births provides a detailed illustration of the vicious cycle underlying the CS increase: prolonged labour and foetal distress are often over-diagnosed during first birth, and the first CS nearly always leads to repeated CSs.[3,21,37-40] With 74% of women coming directly from home, facility-based CS rates of 20-42% appear relatively high - especially as 40% of the CSs appeared non-medically indicated at time of decision. Main reasons for non-medically indicated CSs included no trial of labour after one previous CS (TOLAC), as well as non-substantiated diagnoses of prolonged labour and foetal distress. Notably, some of the CSs may, however, have been contextually indicated when considering lack of resources to ensure safe vaginal births. Also, some women would potentially have needed a CS later during birth.

Strengths and limitations

Criterion-based audit and feedback have shown potential to improve maternity care.[31,41] Prior to publication, two meetings with senior obstetricians from all five facilities were held to present and discuss preliminary findings and ensure contextual interpretation. Also, the results here presented are informing the content of local clinical guidelines and training (the PartoMa Birth intervention).

The validity of the study's findings is supported by triangulation with qualitative assessments at two of the sites: TOLAC is discouraged out of fear of uterine rupture, prolonged labour is overtreated to decongest labour wards.[42] Moreover, while findings are not universally applicable,[23,43] their consistency across the facilities, and similarity to other low-resource settings, support their broader relevance, particularly given the unusually detailed description of clinical management.[4,32,41,44] Notably, compared to the Robson classification, this study provides more detailed information as to why CSs are performed, which is crucial for informing how change may happen.[45] Additional strengths include a high proportion of assessed CS files (91%; Figure 1) and double-entry of 30% of cases to ensure continual data accuracy.

The study also has its limitations. First, it is retrospectively conducted, and the 'not documented, not performed' principle was applied as in most criterion-based audits.[23,36] Due to inadequate documentation, understanding clinical nuances around the decision to perform CS at times became challenging. Consequently, 208 CSs could not be evaluated due to missing information, and also in evaluated cases, there may have been additional factors influencing decisions that we don't know. In particular, while the audit criteria were co-created to represent best possible local management, sub-optimal access to

adequate monitoring during vaginal birth and timely CS may have influenced decision processes. Secondly, most women were discharged two days after CS and complications arising after discharge could not be included. Finally, the number of women undergoing vaginal birth who would have benefitted from a CS remains uncertain.

Clinical implications

To end the vicious circle of repeated CS, the first CS must be prevented by strengthening timely and safe diagnosis and management of prolonged labour and foetal distress. Prolonged labour was often diagnosed despite uncomplicated labour progress and foetal distress despite reassuring FHR. Discussions with the staff revealed difficulties in reassuring foetal well-being through intermittent auscultation due to low number of staff compared to women. In fear of poor outcomes and delays in accessing the operating theatre, health providers aimed to diagnose fetal distress by evaluating meconium-stained fluid and reduced foetal movements, both of which are poorly associated with fetal distress if FHR is normal.[49-52] Accordingly, 94% of CSs due to foetal distress had Apgar scores of ≥8 after 5 min. Meanwhile, a simultaneously conducted case-control study of perinatal deaths revealed 143 intra-facility perinatal deaths among vaginal births, which may have been prevented by timely surveillance and CSs. Likewise, eight stillbirths occurred between decision and CS. A similar tendency of overdiagnosis of foetal distress has been observed in an observational study in Nepal.[4] These challenges strongly highlight the need for better means to assess foetal well-being and tools to guide decision making in busy, resource-constrained settings.[53-55] Notably, clear, context-specific clinical guidelines are alarmingly lacking for these diagnoses, which may accelerate defensive decision making on CS.[4,17,65]

Based on a risk of uterine rupture of <0.005% in HICs, TOLAC is recommended globally.[56] Evidence regarding safety of TOLAC in low-resource settings is, however, scarce. In the study hospitals, close surveillance during vaginal birth and timely access to emergency CS were mostly not achievable (41% waited >3 hours from decision to CS). Thus, local obstetricians argued, a uterine rupture could be fatal, and TOLAC was perceived to be too dangerous and therefore not practiced.[61,62] While these concerns are similar to other low-resource setting,[57-5942] a 4-year observational study from Senegal and Mali reported promising results of TOLAC when compared to the risks of CS: the risk of uterine rupture related to TOLAC was 1.2% (n=95), maternal death 0.3% (n=24) and neonatal death 0.8% (n=67), while the likelihood of successful TOLAC was 45% (n=3616).[60] More research is crucial on how to provide and promote safe TOLAC in resource-constrained, busy maternity units[61,62 63] Notably, qualitative findings from Tanzania reveal how women with previous CS often intentionally arrive late at the facility out of fear of not being allowed TOLAC if arriving early in labour.[21,42] This further stresses the need for shared decision-making on mode of birth between health personnel and pregnant women.[69-71]

Urban health system implications

Our findings suggest how the decision-making on CS was primarily based on short-term safety for individual women and babies. The CS decision may have been further accelerated by the risk of blame and shame for a bad outcome and fear of litigation. Furthermore, emerging evidence indicates that overburdened, congested maternity units drive up CS rates to expedite and avoid unsafe vaginal birth, and in some settings an economic incentive for CS seems to influence.[17]

Meanwhile, defensive decision making neglects the collective need for resources and the costing cascades that strain already scarce human and financial resources in the health system.[10-12,66] While our analysis of 2674 CSs indicates reassuring short-term outcomes for most women and babies undergoing CS, high rates of

CS indirectly left other labouring women suboptimally attended during vaginal birth, which increased their obstetric risks.[15,19] This is particularly evident in a simultaneously conducted case-control study from the same study hospitals where CS did not appear to be a determinant for perinatal mortality.[66] Furthermore, though short-term risks after CS were relatively low at the study sites, potential long-term risks (e.g. uterine rupture, abnormal placentation) in future pregnancies must not be forgotten, particularly when considering the fertility rate of 3.6.[21]

Our study emphasises the need for a collective-oriented, structured and rights-based approach within urban health care systems in resource constrained settings that ensures best possible and timely care for all.[19] This shift in mental mindset is urgently needed, considering that the demand for facility births in many cities is increasing faster than the rate at which the health system is expanding.[13,15,18] Furthermore, to reach beyond too much and too soon use of CS, it is paramount to enable conducive maternity units that safely support and protect labour progression during vaginal birth.

CONCLUSION

We found that 40% of 2674 CSs were non-medically indicated at time of decision, main reasons being no trial of labour after one previous CS, and non-substantiated diagnoses of prolonged labour and foetal distress. However, some of the CSs may have been contextually indicated due to lack of resources to ensure safe vaginal births. Also, some women would potentially have needed a CS later during birth. Moreoever, our findings present defensive decisions on CS in unconducive urban maternity units, which rapidly drives up the CS rate. This calls for increased resources to: 1. Ensure safe maternity units for vaginal birth; 2. Prioritisation of research into TOLAC in resource-constrained settings, safe and timely diagnosis and management of prolonged labour and simple methods for foetal heart surveillance; and 3. Integrated clinical practice guidelines for intrapartum care and associated training that are adjusted to the targeted contexts and balance short- and long-term risks and benefits for all. Policy and practice must ensure urban healthcare systems that cover the entire population by using a collective-orientered, structured and rights-based approach in clinical decision-making.[19]

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Table 1: Evidence-based and locally agreed audit criteria grouping indications for CS into "medically indicated", "non-medically indicated" and "unclear if medically indicated" based on the PartoMa guideline [23,25-29]

Medically indicated CS (i.e. absolute indications for CS)	Non-medically indicated CS (i.e. indications that do not require CS)	Unclear if medically indicated (i.e. non-assessable indications due to suboptimal recording in case files)

- **Abnormal presentation:** Brow presentation, compound presentation, face mentoposterior, footling breech, oblique lie, transverse lie, shoulder presentation, twins if first is breech
- **Abruptio placenta**
- **Breech**[a]: Nulliparous or failed trial of labour in multiparous
- **Cord prolapse** with pulsating cord
- **Foetal distress:** Abnormal FHR at time of decision (<100;>180 bpm)
- **One previous CS:** Failed trial of labour
- **Placenta praevia**
- **Previous reconstructive vaginal surgery** (fistula repair etc.)
- **Prolonged labour/CPD**
- **Retained second twin**
- **Severe hypertensive disorders** in pregnancy with another absolute or non-assessable indication[b]
- **Two or more previous CS**
- **Uterine rupture** incl. severe scar pain/impending uterine rupture
- **Vacuum extraction failure**
- **Other absolute indications**[c]
	- **One previous CS**[d]: No trial of labour[e]
	- **Prolonged labour/CPD**[f]:
	  - CS in latent labour (cervical dilatation 0-3 cm): CS should not be performed unless the woman has a grossly abnormal pelvis or after minimum two days of labour.
	  - CS during first stage, active labour (cervical dilatation 4-<10 cm): CS should only be considered after crossing the partograph's action line.
	  - CS during second stage labour: Minimum 2 hours of second stage for multiparous women or 3 hours for nulliparous women and vacuum extraction attempted unless progressive signs of obstruction are described[g]
	- **Foetal distress**[h]: Normal FHR at time of decision (120-160 bpm)
	- **Hypertensive disorders in pregnancy:** Mild-moderate hypertensive disorders or severe hypertensive disorders as only indication[b]
	- **Breech**[a]**:** No trial of labour in multiparous with complete or frank breech[e]
	- **Other indications that alone do not require a CS**[i]
		- **Foetal distress**: Borderline FHR (100-119;161-180 bpm) or no FHR documented at time of decision
		- **Previous CS**: Unknown number of previous CS
		- CS with missing information to categorize whether "non-medically indicated" or "medically indicated"[d/e/j]

[a] Medically indicated (absolute): Breech presentation with previous CS or foetal weight >4 kg
[b] Severe hypertensive disorders: Severe pre-eclampsia or eclampsia documented in the case file. Mild hypertensive disorders: Hypertension or pre-eclampsia documented in the case file
[c] Other absolute indications: Bartholin's odema, cervical/uterine prolapse, cervical stenosis, obstructive tumor, transverse vaginal septum, pelvic injury, hip dislocation in previous labour, psychosis
[d] Medically indicated (absolute): One previous CS with non-cephalic presentation or multiple gestation
[e] Trial of labour is defined as being in labour for a minimum of 4 hours. If unknown status of labour on admission, women were defined to be in labour.
[f] Unclear if medically indicated: Referred women with cervical dilatation >6 cm upon admission or where referral diagnosis was prolonged labour, breech pregnancies, multiple pregnancies, intrauterine foetal deaths, failed induction, and women with a previous CS.
[g] Definition of progressive signs of obstruction: Head is >1/5 palpable above the pelvic brim per abdomen, station at level of ischial spine or above or severe caput and moulding (+3)).
[h] Definition of foetal distress: Foetal distress, non-reassuring foetal status and reduced-foetal movement documented as indication for CS
[i] Age below 16 years, bad obstetric history, elderly maternal age, endometriosis, grand multiparity, intrauterine contraceptive device (IUCD), intrauterine foetal death (IUFD), long interpregnancy interval, oligohydramnios with normal FHR, placenta calcification, polyhydramnios, post date, precious baby, PPROM/PROM, twins (not conjoined, no malpresentation).
[j] Unclear if medically indicated: Anemia, antepartum bleeding (no placenta abruptio, no placenta praevia), failure of induction, foetal malformation, genital warts/vaginal infection, HIV, intrauterine growth restriction (IUGR), prolonged PROM, uterine myoma.

Figure 1: The facility-based CS rates and the total number of women included in the study

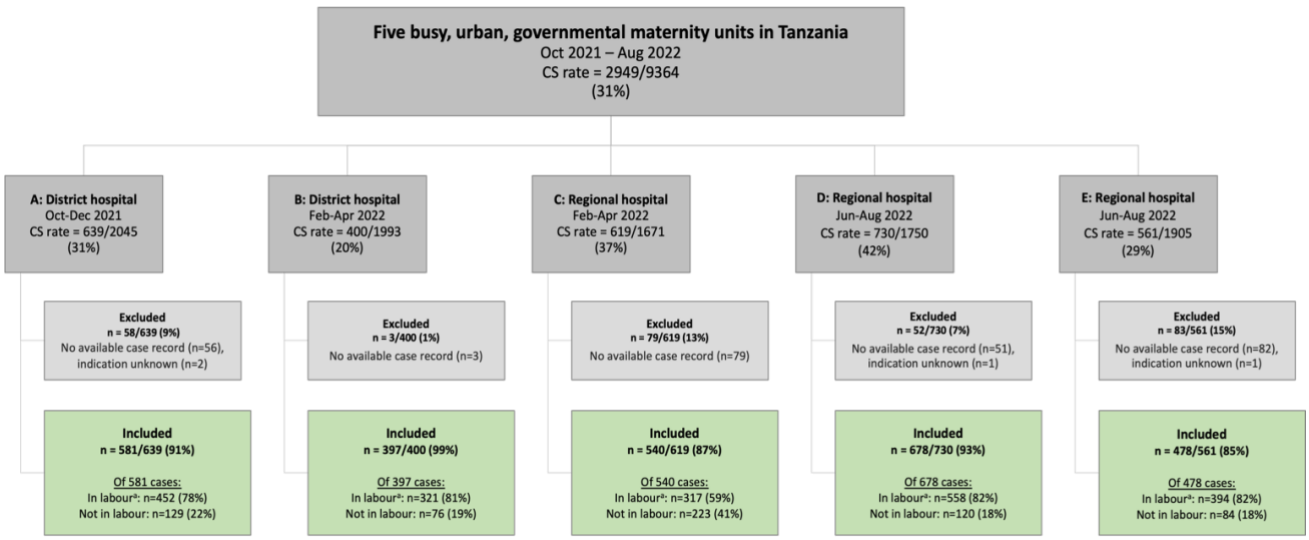
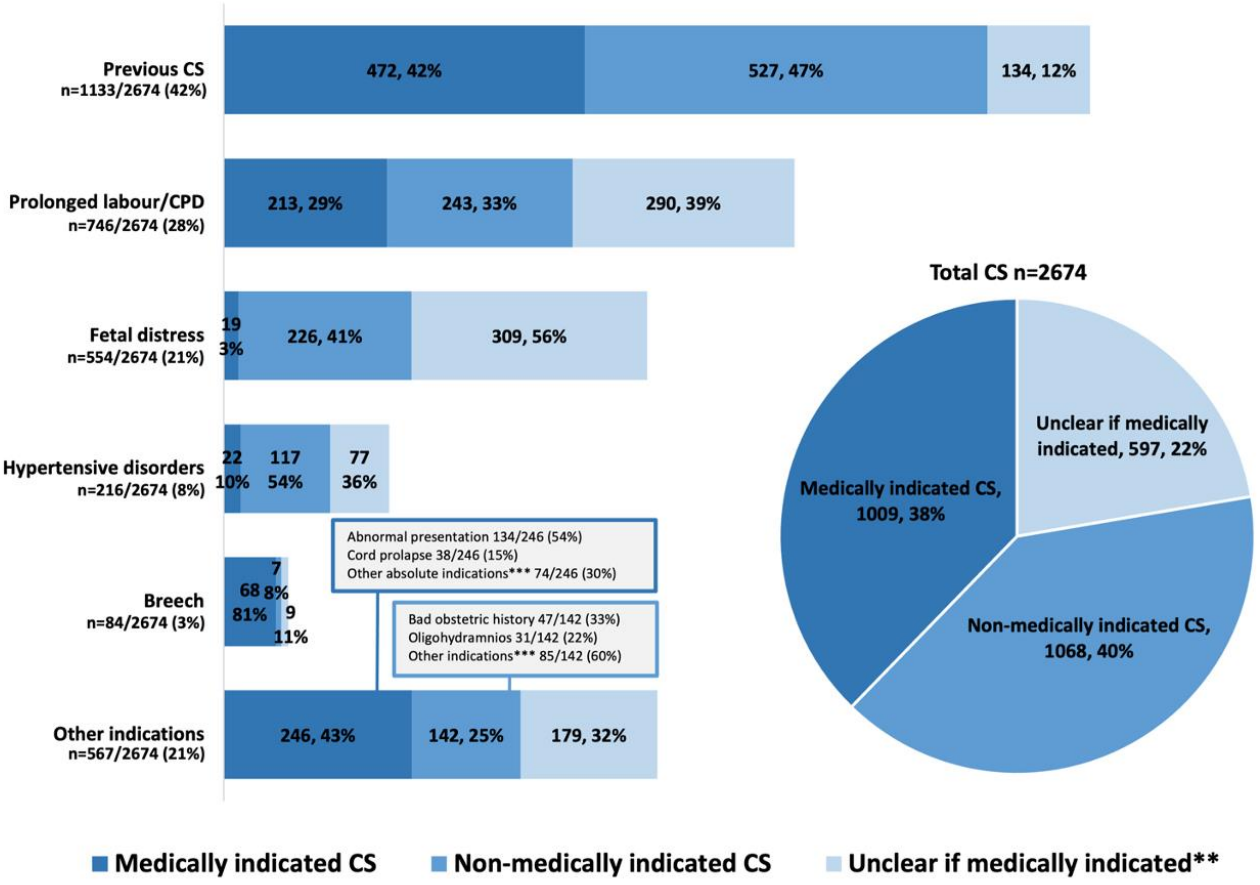


Table 2: Maternal characteristics, quality of care and clinical decisions during labour, and outcomes

		All five maternity units		A: District referral		B: District referral		C: Regional referral		D: Regional referral		E: Regional referral	
		n=2674	%	n=581	%	n=397	%	n=540	%	n=678	%	n=478	%
Admission	**Maternal age (n=2674)**												
	Maternal age, Md (IQR)	28 (24-32)		27 (23-31)		28 (24-32)		29 (24-33)		28 (24-33)		29 (24-32)	
	Missing	60	2%	35	6%	19	5%	6	1%	0	0%	0	0%
	Parity on admission (n=2674)												
	0	790	30%	173	30%	143	36%	154	29%	199	29%	121	25%
	1	763	29%	172	30%	113	28%	160	30%	177	26%	141	29%
	≥2	1027	38%	200	34%	121	30%	220	41%	302	45%	184	38%
	Missing information	94	4%	36	6%	20	5%	6	1%	0	0%	32	7%
	Previous caesarean section (n=2674)												
	0	1517	57%	391	67%	233	59%	283	52%	391	58%	219	46%
	1	785	29%	145	25%	116	29%	170	31%	172	25%	182	38%
	≥2	345	13%	39	7%	47	12%	82	15%	108	16%	69	14%
	Yes, unknown number	27	1%	6	1%	1	0%	5	1%	7	1%	8	2%
	Referral case (n=2674)												
	Yes	688	26%	51	9%	7	2%	323	60%	231	34%	76	16%
	No	1986	74%	530	91%	390	98%	217	40%	447	66%	402	84%
	Stage of labour on admission (n=2674)[a]												
	Not in labour	632	24%	129	22%	76	19%	223	41%	120	18%	84	18%
	In labour, stage unknown	237	9%	99	17%	4	1%	12	2%	49	7%	73	15%
	Latent phase, first stage (<4 cm)	1254	47%	228	39%	241	61%	194	36%	391	58%	200	42%
	Active phase, first stage (4-<10 cm)	535	20%	118	20%	74	19%	109	20%	114	17%	120	25%
	Second stage	16	1%	7	1%	2	1%	2	0%	4	1%	1	0%
Decision on CS	**Doctor's documentation of decision of CS (n=2674)**												
	Yes	2364	88%	561	97%	392	99%	517	96%	643	95%	251	53%
	No	310	12%	20	3%	5	1%	23	4%	35	5%	227	47%
	Stage of labour on decision of CS (n=2674)												
	Not in labour	464	17%	93	16%	59	15%	166	31%	80	12%	66	14%
	In labour, stage of labour unknown	115	4%	22	4%	2	1%	8	1%	18	3%	65	14%
	Latent phase of labour (<4 cm)	916	34%	154	27%	141	36%	155	29%	334	49%	132	28%
	First stage, active labour (4-<10 cm)	1103	41%	288	50%	183	46%	193	36%	235	35%	204	43%
	Second stage	62	2%	20	3%	12	3%	15	3%	10	1%	5	1%
	Unknown	14	1%	4	1%	0	0%	3	1%	1	0%	6	1%
	Decision-to-delivery interval ***Of women in labour on decision of CS (n=2196)***												
	<1 hour	190	9%	72	15%	35	10%	18	5%	32	5%	33	8%
	1-2 hours	493	22%	160	33%	87	26%	83	22%	103	17%	60	15%
	2-3 hours	387	18%	93	19%	53	16%	78	21%	104	17%	59	15%
	>3 hours	891	41%	107	22%	129	38%	154	42%	347	58%	154	38%
	Missing information	235	11%	52	11%	34	10%	38	10%	11	2%	100	25%
Outcomes	**Birth outcome (n=2783)**												
	Stillbirth	47	2%	5	1%	4	1%	13	2%	21	3%	4	1%
	Neonatal death before discharge	6	0%	1	0%	0	0%	0	0%	5	1%	0	0%
	Transferred to NICU, outcome unknown[b]	17	1%	1	0%	6	1%	2	0%	8	1%	0	0%
	Alive on discharge	2622	94%	549	92%	370	90%	555	96%	671	95%	477	97%
	Missing information[c]	91	3%	40	7%	30	7%	9	2%	3	0%	9	2%
	Apgar after 5 min (n=2783)												
	0-2	48	2%	5	1%	4	1%	13	2%	22	3%	4	1%
	3-7	40	1%	3	1%	1	0%	11	2%	14	2%	11	2%
	8-10	2601	93%	547	92%	374	91%	544	94%	670	95%	466	95%
	Missing information	94	3%	41	7%	31	8%	11	2%	2	0%	9	2%
	Birth weight (n=2783)												
	<2500 g	306	11%	29	5%	29	7%	106	18%	91	13%	51	10%
	≥2500 g	2395	86%	525	88%	361	88%	466	80%	616	87%	427	87%
	Missing information	82	3%	42	7%	20	5%	7	1%	1	0%	12	2%
	Maternal outcome (n=2674)												
	Death	1	0%	0	0%	0	0%	1	0.2%	0	0%	0	0%
	Alive	2673	100%	581	100%	397	100%	539	100%	678	100%	478	100%
	Maternal complications (n=2674)												
	No	2590	97%	581	100%	379	95%	507	94%	660	97%	463	97%
	Infection/sepsis	7	0.3%	0	0.0%	4	1.0%	1	0.2%	0	0.0%	2	0.4%
	Post partum hemorrhage[d]	51	1.9%	0	0.0%	11	2.8%	22	4.1%	9	1.3%	9	1.9%
	Re-surgery	2	0.1%	0	0.0%	0	0.0%	1	0.2%	1	0.1%	0	0.0%
	Hysterectomy	10	0.4%	0	0.0%	1	0.3%	2	0.4%	3	0.4%	4	0.8%
	Other	14	0.5%	0	0.0%	2	0.5%	7	1.3%	5	0.7%	0	0.0%

[a] If unknown status of labour on admission, women were defined to be in labour.
[b] Newborns were transferred to intensive care unit (ICU) and outcome could not be followed up.
[c] Newborns with unknown Apgar after 5 min or positive Apgar but were referred to higher level hospital.
[d] Defined by blood loss >1000 ml or documentation of severe anemia or PPH post partum.

Figure 2: Distribution of indications for CS and an overview of "medically indicated CS", "non-medically indicated CS" and "unclear if medically indicated"*. Each case may have more than one indication.



* If more than one indication for CS, both indications were reviewed. The group "medically indicated CS" included CSs where at least one indication was considered absolute, e.g. placenta praevia. The group "non-medically indicated CS" included indications that, according to the criteria, do not require a CS. The group "unclear if medically indicated" included CSs that could not be assessed. Within each of the most common indications "medically indicated CS" is defined as the indication being in accordance with audit criteria (absolute indication). "Non-medically indicated CS" is defined as the indication not being in accordance with audit criteria with no other non-assessable or absolute indication. "Non-medically indicated CS" is defined as the indication being non-assessable or not being in accordance with audit criteria but having another absolute or non-assessable indication for CS.

** The proportion in "unclear if medically indicated" that is medically indicated due to another absolute indication: Previous CS 7/134 (5%), prolonged labour/CPD 64/291 (22%), foetal distress 65/309 (21%), hypertensive disorders in pregnancy 28/77 (36%), breech 2/9 (22%) and other indications 36/179 (20%).

*** Other absolute indications in "medically indicated CS": Placenta abruptio n=23, placenta praevia n=23, uterine rupture n=7, retained twin n=5, oligohydramnios (not normal FHR) n=5, vacuum failure n=5, previous reconstructive vaginal surgery n=4, cervical stenosis n=3, obstetric tumor n=3, cervical prolapse n=2, bartholin's odema n=1, hip dislocation n=1, pelvic injury n=1, psychosis n=1, transverse vaginal septum n=1.

Other indications in "non-medically indicated CS": Placenta calcification n=18, PROM n=15, post date n=12, long interpregnancy interval n=12, grand multiparity n=5, elderly maternal age n=5, twins n=4, polyhydramnios n=3, precious baby n=2, IUFD n=2, below 16 years n=1, endometriosis n=1.

SUPPLEMENTARY MATERIAL

Table S1: Map of the five included maternity units in Dar es Salaam, Tanzania.

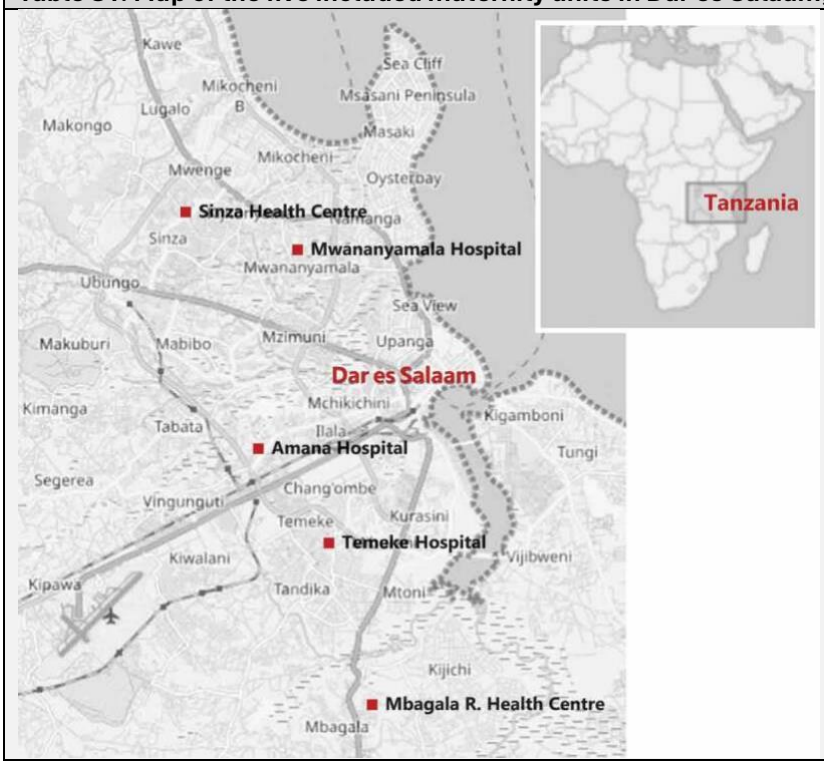


Table S2: Distribution of indications for caesarean section illustrating the proportion of each indication. Each case may have more than one indication.

	All five maternity units				A District referral		B District referral		C Regional referral		D Regional referral		E Regional referral	
	Distribution of indication(s)		Proportion of each indication											
	n=2674	%	n=2674	%	n=581	%	n=397	%	n=540	%	n=678	%	n=478	%
Previous CS	964	36%	1133	42%	179	31%	164	41%	253	47%	280	41%	257	54%
Prolonged labour[a]	465	17%	746	28%	258	44%	127	32%	110	20%	128	19%	123	26%
Foetal distress	268	10%	554	21%	97	17%	67	17%	99	18%	201	30%	90	19%
Hypertensive disorders in pregnancy	38	1%	216	8%	4	1%	5	1%	115	21%	67	10%	25	5%
Abnormal presentation	73	3%	134	5%	27	5%	14	4%	32	6%	40	6%	21	4%
Breech	42	2%	84	3%	24	4%	12	3%	15	3%	17	3%	16	3%
Other indication(s)[b]	163	6%	446[b]	17%	86	15%	70	18%	111	21%	121	18%	58	12%
≥2 indications	661	25%												

[a] Indications included: Prolonged labour, cephalopelvic disproportion, poor progress of labour, cervical arrest, failure of augmentation, obstructed labour, big baby.

[b] Includes the following:

Defined as medically indicated: Cord prolapse with pulsatin cord n=38, placenta abruptio n=23, placenta praevia n=23, uterine rupture n=7, retained second twin n=5, vacuum failure n=5, previous reconstructive vaginal surgery n=4, oligohydramnios (no normal FHR) n=4, cervical stenosis n=3, obstetric tumor n=3, cervical/uterine prolapse n=2, psychosis n=1, transverse vaginal septum n=1, hip dislocation in previous pregnancy n=1, pelvic injury n=1.

Defined as non-medically indicated: Bad obstetric history n=73, oligohydramnios n=38, placenta calcification n=26, long interpregnancy interval n=19, other rarely used indications n=93 (e.g. elderly maternal age, post date).

Defined as unclear if medically indicated: Failure of induction n=49, antepartum bleeding (no placenta abruptio, no placenta praevia) n=36, other rarely used indications n=46 (e.g. anemia, myoma). All indications are presented in audit criteria (Table 1).

Table S3: Possible characteristics to understand the complexity of why women undergo CS due to foetal distress with a normal FHR (120-160 bpm) on decision of CS (n=270)[a]. Each case may have more other indications or characteristics.

	n=270	%
Other characteristics on decision of CS		
Meconium-stained liquor	151	56%
Reduced foetal movement	34	13%
Irregular rhythm	15	6%
Other indications for CS		
Severe hypertensive disorders in pregnancy	24	9%
Bad obstetric history	9	3%
Oligohydramnios	6	2%
Failure of induction	4	1%
Rarely used indications (e.g. post date, polyhydramnios, anemia)	13	5%
Another absolute indication[b]	39	14%

[a] Among foetal distress with normal FHR on decision (n=270), 4/270 (1%) had Apgar 0-2 after 5 min, 4/270 (1%) had Apgar 3-7 after 5 min, 258/270 (96%) had Apgar 7-10 after 5 min and 4/270 (1%) had unknown Apgar after 5 min.
[b] Other absolute indications for CS: Prolonged labour n=22, 2 previous CS or 1 previous CS with failed trial of labour n=4, breech with failed trial of labour n=2 and other indications (e.g. cord prolapse, placenta abruptio, abnormal presentation) n=11.

Paper IV

Prolonged labour as a driver of the ”caesarean section pandemic” – A criterion-based audit of caesarean sections among women with prolonged labour in five urban maternity units in Tanzania. Submitted.

Kujabi ML, Housseine N, Kabanda I, Msumi R, Maembe L, Sangalala M, Hudson M, Hansen S, Nico A, Dmello BS, Meyrowitsch DW, Konradsen F, Hussein K, Maaløe N, van den Akker T.

Title:

Prolonged labour as a driver of the ”caesarean section pandemic” – A criterion-based audit of caesarean sections among women with prolonged labour in five urban maternity units in Tanzania

Authors:
Monica Lauridsen Kujabi[a,b], Natasha Housseine[a,c], Idrissa Kabanda[d], Rukia Msumi[d], Luzango Maembe[e], Mtingele Sangalala[e], Manyanga Hudson[e], Sarah Hansen[f], Anna Nico[c], Brenda Sequeira D'mello[a,c,g], Dan Wolf Meyrowitsch[a], Flemming Konradsen[a,h], Kidanto Hussein[c] , Nanna Maaløe[a,i], Thomas van den Akker[j,k]

[a] Global Health Section, Department of Public Health, University of Copenhagen, Denmark
[b] Department of Gynaecology and Obstetrics, Aarhus University Hospital Skejby, Denmark
[c] Medical College East Africa, Aga Khan University, Dar es Salaam, Tanzania
[d]Municipal Hospitals Ubungo (Sinza) and Temeke (Mbagala Rangitatu), Presidents Office, Regional and Local Government, Dar es Salaam, Tanzania
[e] Regional Referral hospital Dar es Salaam, (Temeke/Amana/Mwananyamala), Ministry of Health, Community Development, Gender, Elderly and Children
[f] Department of Clinical Medicine, Aarhus University, Denmark
[g] CCBRT Hospital, Dar es Salaam, Tanzania
[h] Novo Nordisk Foundation, Hellerup, Denmark
[i] Department of Obstetrics and Gynaecology, Copenhagen University Hospital - Herlev Hospital, Denmark
[j] Athena Institute, VU University Amsterdam, the Netherlands
[k] Department of Obstetrics and Gynaecology, Leiden University Medical Center, Leiden, the Netherlands

Corresponding author:
Monica Lauridsen Kujabi
Ringen 37, 2.1., Aarhus N, Denmark
Phone:+45 23862727
Email address: monica.kujabi@gmail.com

Short running title (60 ch): Audit of caesarean sections: prolonged labour as a driver

Abstract

Objective: To estimate the proportion of caesarean sections (CS) not meeting audit criteria for prolonged labour.

Design: Cross-sectional.

Setting: Five urban maternity units in Dar es Salaam, Tanzania.

Population: Women giving birth by CS with an indication of prolonged labour, from October 1st, 2021 to August 31st, 2022. Exclusion criteria: referral to the study sites because of prolonged labour or cervical dilatation >6 cm upon admission; non-cephalic presentation; multiple pregnancy; intrauterine fetal death; failed induction; previous CS; or other reasons for CS.

Methods: Criterion-based audit of CS case files with an indication of prolonged labour.

Main Outcome Measure: CSs in women with uncomplicated progress.

Results: Overall CS rate was 32% (2949/9364) and 746/1517 (47.9%) of first-time CSs were performed because of prolonged labour. Out of these, 456 met inclusion criteria and 243/456 (53.3%) CSs were in uncomplicated labour: 1) women not being given a trial of labour (78/243, 32.1%); 2) women in first stage of active labour not crossing the partograph action line (145/243, 59.7%); and 3) women in second stage <1 hour (20/243 8.2%).

Conclusion: Almost half of CS in the unscarred uterus were because of prolonged labour and many did not meet audit criteria for prolonged labour. Crowded hospitals and inadequate monitoring may have prompted defensive decision-making. Unconducive labour wards may, therefore, indirectly drive the CS epidemic.

Funding: Danida Fellowship Centre (18-08-KU). Laerdal Global Health (2021-0095 and 40662)

Keywords: Prolonged labour, dystocia, caesarean sections, low-resource, urban disadvantage, PartoMa.

INTRODUCTION

While caesarean sections (CSs) can be lifesaving, the latest decades' dramatic increase in CSs globally is not accompanied by a simultaneous decrease in adverse perinatal outcomes. This raises concern for dangerous overuse.[1,2] At current speed, the global CS rate is predicted to increase from 21.1% of all births today to 28.5% (38 million CSs) in 2030. Of these, 88% will occur in low- and middle-income countries where CS-related risks are highest and where cost-efficient healthcare is needed.[2,3]

Compared to vaginal birth, an avoidable CS is related to increased maternal and perinatal risks.[4] In Sub-Saharan Africa women face a 1% risk of maternal death in relation to CS, which is hundred-fold the risk for women in high-income countries.[2] In addition, the risk of uterine rupture and placenta accrete spectrum disorders in subsequent pregnancies may be fatal.[5] CSs are costly and the human and material resources spent on unnecessary CSs may indirectly cost lives elsewhere.[6–8] Meanwhile, many women in the poorest parts of the world still suffer from a delay in receiving an indicated CS.[3] Consequently, ending the current "CS pandemic", which harms women and children, must be a global health priority.

Prolonged labour is the leading cause of CS in the unscarred uteri and a crucial driver of the increasing CS rates.[3,9–11] Between one-third to one-fourth of all emergency CSs are done for prolonged labour.[12–16] A key contributor may be substandard diagnosis and management of prolonged labour, resulting in a dangerous co-existence of care that is 'too little, too late' and 'too much, too soon'.[17] For instance, conservative management strategies (one-to-one care, continuous support, free movement and pain relief) and second-stage vacuum extraction appear to be underutilized, while oxytocin and CSs are often overused.[12,13,17–20]

Notably, in Tanzania, data suggest a trend towards growing urban disadvantages in maternal and perinatal health.[21–23] While maternal and perinatal mortality have stagnated in Dar es Salaam, CSs have increased rapidly from 13% in 2013, 17% in 2015 and 26% today.[24–26] This indicates that maternal health programs in cities are not meeting the needs.[27] Consequently, as part of the PartoMa project for reaching locally useful clinical practice guidelines (CPGs) in five of the most congested governmental maternity units in Dar Es Salaam, Tanzania, we conducted an in-depth criteria-based audit to identify the proportion of CS because of prolonged labour not meeting specified audit criteria.

METHODS

The PartoMa scale-up study is conducted at five governmental maternity units in Dar Es Salaam, Tanzania with annual number of births ranging from 7,000 to 14,000.[28–30] These are referral sites providing comprehensive emergency obstetric care, including caesarean sections around the clock and access to blood banks. The hospitals receive low- and high-risk women. In Dar es Salaam, all women give birth at a health facility according to the latest demographic health survey.[26] Births are primarily attended by nurse-midwives, while CSs are decided by medical doctors. Foetal heart rate is monitored by intermittent Pinard auscultation or handheld doppler machine. Birth companions are not allowed and epidural analgesia is not available. Intravenous fluids, amniotomy, oxytocin augmentation by manual infusion-sets, and vacuum extraction are available in these facilities. The hospitals had no clinical guidelines on prolonged labour management available at the time of this study. The partograph paper sheet was used to document monitoring of labour. Each nurse-midwife usually cared for three-to-six labouring women simultaneously. More details about the study sites and the PartoMa project are published elsewhere.[28,29]

Development of locally achievable, evidence-based audit criteria

To define our audit criteria, we followed the World Health Organisation's (WHO) audit principles,[31] commencing by defining clear standards against which care is measured. The audit criteria were developed from the PartoMa CPGs for childbirth care. The PartoMa CPGs were based on global evidence-based recommendations, co-created with 107 health providers, peer-reviewed by an international panel of experts and approved by the Tanzanian Ministry of Health. This enabled audit criteria reflecting standards on best possible, evidence-informed obstetric care when taking local resources into account.[32] Hydration, urination, ambulation, and amniotomy were not included as audit criteria due to unreliable documentation in case-files. Oxytocin was recorded and analysed, but not included as audit criteria.

The audit criteria can be found in Figure 1. These criteria enable categorisation of women into three categories: those having a) CS during normally progressing labour, including women who were never given a trial of labour (green), b) CS during slow labour progression (yellow), and c) CS during prolonged labour (red). CSs decided in category a and b can be considered potentially avoidable. The PartoMa CPGs and background information are available online.[33]

Data collection

Data collection took place between 1st October 2021 and 31st August 2022, during a 3-month period at each of the five study sites.[28,29] The study population included all women who gave birth by CS due to the diagnosis of prolonged labour as written in the case-file.

As terms were used interchangeably, we use prolonged labour as an "umbrella indication" which includes the following terms: "prolonged labour", "poor progress of labour", "failure of augmentation", "cervical arrest", "cephalopelvic disproportion" (CPD), "big baby" and "obstructed labour" (supp table 1). CPD, big baby and obstructed labour are not synonyms for prolonged labour but are causes (CPD, big baby) or a particularly severe outcome (obstructed labour) and were therefore included.

We excluded referred women with cervical dilatation >6 cm upon admission or where referral diagnosis was prolonged labour, non-cephalic pregnancy, multiple pregnancy, intrauterine fetal death, failed induction, and previous CS. Furthermore, women were excluded if they had more than one indication for CS and the other indication, additional to the prolonged labour indication, was considered an absolute indication for CS, i.e. placental abruption, fetal distress, and chorioamnionitis (Figure S1). By using strict inclusion/exclusion criteria, we aimed to identify CSs that were not influenced by other factors than prolonged labour.

All case files were collected from the hospital storage after discharge. Case-files were cross-checked with birth registry books (MTUHA). All births were entered to provide an overall CS rate, and CSs due to other indications are analysed elsewhere (Manuscript co-submitted to BJOG by Hansen et al). CSs with prolonged labour as written indication in the case file were identified. For these, data from birth registries and case-files (including partographs) were reviewed and double-entered into pre-piloted forms using KoBoToolbox. Data were collected and entered by SH, AM and two additional research assistants with medical backgrounds. Data collectors did not make interpretations. In case of uncertainty (e.g. difficult handwriting), the hospital staff, MLK or NM was consulted. If a procedure was not documented, it was assumed not to have been performed.

Validation of the data in case files was carried out prior to the study and showed that concordance between performed practices and the medical charts was >95% for vaginal examinations, times and background

characteristics. For documenting contractions, concordance was only 55% and data on contractions were not used as audit criteria.

Variables, analysis and audit

Descriptive statistics were carried out using R version 4.1.2 (2021-11-01). Background characteristics included hospital, age, gestational age, parity, referral status, stage of labour, maternal complications, perinatal outcomes and birth weight. Intrapartum management included information on labour duration, labour progression and labour interventions (induction, status of membranes, oxytocin augmentation and vacuum extraction). CSs were evaluated based on labour stage: 1) before active labour (cervical dilatation <4 cm), 2) first stage of active labour (cervical dilatation of 4-9 cm), and 3) second stage (10 cm/full dilatation)). If the partograph was not used, data collectors plotted cervical measurements on a partograph to visualize labour progress. If time of birth was not recorded, time of reaching the post-operative ward minus 45 minutes was used. Active labour was defined as the time the partograph was started or at the first cervical dilatation of 4 cm or above. The audit was carried out by comparing the data entered against the audit criteria (Figure 1). This was carried out by MLK (PhD candidate and resident in obstetrics and gynaecology) after all data had been collected. CSs were categorised and proportions for CSs not meeting audit criteria in each phase of labour and in total were calculated. After analysis, findings were discussed with clinical representatives from the five study hospitals to include their perspectives.

RESULTS

The combined CS rate at the five hospitals was 31.5% (2949/9364). Of these, 788/2949 (26.7%) CSs were performed with prolonged labour as indication, accounting for 727/1517 (47.9%) CSs in unscarred uteri (flowchart in Figure S1). Findings did not differ significantly between hospitals and combined analyses are presented. After excluding women not meeting inclusion criteria, 456 women remained for analysis. Nulliparous women accounted for 277/456 (60.9%) (unknown = 1). From birth until discharge, 7/456 (1.5%) women had complications documented in relation to or after surgery, including bleeding >1 liter (5), infection (1) and cardiomyopathy (1). Median time between birth and discharge was 24 hours (IQR 13-34) and it was not possible to follow women after discharge. Fetal distress as an indication for CS and intrauterine deaths were excluded, and Apgar scores were between 8-10 at five minutes in 454/456 (99.6%).

On admission, 33/456 (7.2%) women were not in labour, 274/456 (60.1%) presented in the latent phase of labour, 130/456 (28.5%) in the first stage of active labour, and 2/456 (0.4%) in the second stage of labour. Almost half of the women had an admission-to-decision time ≤12 hours (189/431, 43.9%; unknown = 25). The decision-to-birth interval was >2 hours for 232/431 (53.8%, unknown = 25). Of these, 186/202 (92.1%, unknown = 30) did not have cervical dilatation re-examined before the CS was performed. Remaining background and labour characteristics are shown in Table 1.

Phase of labour at time of caesarean section decision

Women were divided into three groups: 1) before active labour (89/456, 19.5%), 2) first stage of active labour (346/456, 75.9%), and 3) second stage of labour (21/456, 4.6%) (Table 2).

Of the 89/456 (19.5%) women with a CS decision before active labour, 78/89 (87.6%) were not given a trial of labour or duration from admission-to-decision was less than two days with no grossly abnormal pelvis

described (Figure 2). Of other characteristics in this group, time from admission-to-decision for CS was less than 24 hours for 59/89 (66.3%) and birthweight was less than 4 kg in 76/88 (86.4%) women (unknown = 1). Induction was attempted in 10/89 (11.2%) and none of these women had labour augmented with oxytocin.

Of the 346/456 (75.9%) women with CS decided during first stage of active labour 145/346 (41.9%) were performed before crossing the partograph action line. Of these, 53/346 (15.3%) did not cross the alert line and 92/346 (26.6%) were between the alert and action lines (Figure 2). In addition, there was no progress between the last two vaginal examinations in 138/270 (51.1%) women, in 74/270 (27.4 %) progress was 0.1-0.5 cm/hour and in 58/270 (21.5%) progress was faster than 0.5 cm/hour (unknown = 76). In 79/346 (22.8%) women, labour had arrested completely for four hours. Oxytocin augmentation was provided to 132/346 (38.2%) women. Of those receiving oxytocin, it was applied before crossing the partograph alert line in 65/123 (52.8%), between the alert and action line in 36/123 (29.3%) and after crossing the action line in 22/123 (17.9%) (unknown = 9).

Of the 21/456 (4.6%) women with CS decided during the second stage of labour, 20/21 (95.2%) were performed when duration of the second stage had lasted less than one hour (Figure 2). Vacuum extraction was attempted in 1/21 (4.8%) woman (supp table 1).

CS in uncomplicated labour progression

In total, 243/456 (53.3%) of CS did not meet audit criteria because these were decided despite labour progression being uncomplicated (Figure 2). The biggest groups were CS in first stage of active labour (145/243, 59.7%) and CS before active labour (87/243, 35.8%). The proportion of CS that did not meet audit criteria was 20/21 (95.2%) for CS during second stage, 78/89 (87.6%) for CS before active labour and 145/346 (41.9%) for CS during first stage of active labour.

Use of diagnostic terms

As shown in Table S1, many different terms for prolonged labour were used (obstructed labour (160/456, 35.1%), big baby (119/456, 26.1%), prolonged labour/poor progress (118/456, 25.9%), cervical arrest (78/456, 17.1%) and CPD (63/456, 13.8%)). Some women had more than one diagnosis. For women with obstructed labour, associated descriptions included mostly caput succedaneum (+2) (60/160, 37.5%), cervical arrest between the last two vaginal examinations (51/160, 31.8%) and head 1/5 or more palpable above the pelvic brim (46/160, 28.8%), while 39/160 (24.4%) had nothing described. For women with big baby as the indication, 33/119 (27.7%) had a neonate with a birth weight ≥4 kg. Of women with an indication of prolonged labour/poor progress, 87/118 (73.7%) had a progression slower than 0.5 cm per hour. Of women with an indication of cervical arrest, 27/78 (34.6%) had cervical arrest for 4 hours. Finally, for women with an indication of CPD, 'inadequate pelvis' (9/63, 13.8%) was the commonest description, while 48/63 (76.2%) had no description at all.

DISCUSSION

Main findings

At five of the busiest, governmental maternity units in Dar es Salaam, Tanzania, prolonged labour accounted for 47.9% of CSs in unscarred uteri. At the time of decision 53.3% had uncomplicated labour progression, e.g. without a trial of labour, before crossing the partograph's action line, without arrested labour or during second stage lasting less than one hour. Unpublished conversations revealed inability to monitor labour

being a central cause of defensive decisions. Unconducive labour wards indirectly contribute to the CS increase in Dar es Salaam. Detailed multi-center enquiries into CSs at the frontline of congested, urban maternity units are extremely scarce, and the observed findings strongly call for action.

Strengths and limitations

Strengths include high data quality with double-entry of all case-files. Validation of case-files showed >95% accuracy for cervical assessments, which the audit criteria were based on. A limitation is that the study was retrospective and unwritten external factors possibly influencing care were not considered. Considering such factors is important since CS decision-making is complex, particularly in resource-constraint settings with limited access to an operating room and a high disease burden. Further, 8% of the women were referred and their progression preceding arrival at hospital was not assessed and could have influenced the decision. We excluded women whose referral diagnosis was prolonged labour and if cervical dilatation was more than 6 cm. We excluded women with conditions that could require CS. Conservative management was not included in audit criteria, which is also important in averting CS. While caution should be taken to generalize findings from clinical audits, our findings are relevant to similar low-resource, overburdened labour wards.

Interpretation

Health system implications

Historically, untreated prolonged labour has been a tragedy, particularly due to delays in seeking and receiving care.[34–36] This is important in understanding why our findings of too early diagnosis may represent fundamental health system challenges and coping strategies in constrained labour wards, rather than simply seeing this as substandard clinical judgements.[37] As obstructed labour is a feared complication, unpublished conversations find that health providers try to predict CPD early and many external factors such as long latent labour or previous intrauterine death could influence defensive decisions in the constrained setting. This may explain CSs decided on before "real" prolonged labour. Defensive management may rise in countries where maternal and neonatal deaths are highly politicized and where giving birth is fraught with risks.[37–39] While particularly long-term CS risks are difficult to count, immediate good outcomes of CS, as in this study, prevent blame and shame for health providers. While we, in the following discussion, focus on the clinical challenges of prolonged labour diagnoses, such external factors driving up the CS rates must be addressed.

Clinical implications

"Big baby" and "CPD" were commonly applied indications, which were defined as sub-categories of prolonged labour (Table S1). Some hospitals recommend elective CS for suspected macrosomia.[40,41] Clinical and sonographic methods, however, have limited power to predict macrosomia and result in increased CS rates without improved neonatal outcomes.[42–45] The combination of many "big baby" diagnoses and birth weights < 4 kg in our study supports that CSs are performed without clear medical indication, compounded by difficulties in weight estimation. Likewise, the WHO discourages pelvimetry to predict CPD.[46] Guidelines emphasizing that a diagnosis of CPD should be given only after a trial of labour are important in lowering CS rates. Clinical findings such as caput succedaneum and moulding were often described as signs of obstruction in the decision note. These are difficult to assess and misleading because both might also occur in physiological birth.

Women admitted in latent labour comprised more than half of the included women. It is well-studied that admission in latent labour results in more interventions compared to later admission.[47–50] A key strategy in

many low-resource settings has, however, been early admission for safe hospital birth, especially for women living in remote areas or facing heavy traffic jams.[51,52] Care for women in latent labour can be resource-draining if staff and beds are few, as is seen in urban high-flow labour wards. Latent phase of labour is poorly described and defined in the literature which may contribute to overcrowding and management challenges. As sending women home in latent labour may not be safe, strategies as maternity-waiting-homes and improved clinical guidelines for latent labour in busy hospitals appear crucial to avoid CSs performed during latent labour and reducing CSs in later labour.

Many CSs in first stage of active labour were performed before crossing the action line and 20.9% of women did not have cervical arrest at the time of CS decision. It appeared that clinicians included total length of labour above 12 hours into their consideration despite uncomplicated progression at the time of CS and that progression slower than 1 cm per hour was considered abnormal (unpublished observations). It is commonly recommended that CS should only be performed after four hours of complete arrest.[11] Newest evidence finds that labour progression is not linear and cervix may dilate 1 cm over several hours and only accelerate at 6-7 cm.[46,53] Consequently, the recent Labour Care Guide (LCG) by the WHO, replacing the partograph, defines active labour as ≥5cm cervical dilatation and include much longer thresholds for uncomplicated progression.[11,46] The early diagnosis seen in this study contradicts the much slower labour progression curve and patience in allowing physiological labour appears fundamental. This is challenged by a chronic shortage of staff where more women with longer labours mean less monitoring of each woman and increasingly over-crowded labour wards.

Most CSs in second stage were carried out within one hour. It appears that birth attendants are exceptionally worried during second stage due to increased risks exaggerated by the inability to monitor fetal heart rate frequently (unpublished observations).[54] While international standards allocate up to five hours for nulliparous women in second stage labour, there is little evidence on the safety of this strategy in urban, overburdened, low-resource settings where fetal heart rate cannot be monitored closely and without immediate access to a CS.[55] One woman had a trial of vacuum extraction. For twelve women without signs of obstruction, vacuum-assisted birth could potentially have safely prevented the second-stage CS.[56]

Finally, guidelines on *when* to intervene in labour remain absent in the latest WHO LCG and many guidelines fall short by simply stating what is normal/abnormal progression and not *how/when* to intervene and *when* to diagnose "failed" vaginal birth requiring a CS. [46,57] The many terms and descriptions used for prolonged labour and understanding of labour progression in this and other studies indicate a fundamental lack of clarity around prolonged labour definitions and management (supp table 1) .[12,13,16,18,58] Clarity on definitions along with guidelines and training in prolonged labour diagnosis and management is urgently and crucially needed, not only in the labour wards here studied.[12,13,16,18,58]

CONCLUSION

Many CSs were done because of prolonged labour, around half were performed in labour with uncomplicated progression. The complexity of urban, low-resource labour wards where timely management is hampered by few staff and a continuous flow of women allows little time for physiological labour. The inability to monitor women adequately may have prompted early defensive decisions. Indirectly, the unconducive labour ward, therefore, becomes a central, yet preventable driver of CSs.

Disclosure of interest

The authors have nothing to disclose.

Contribution

MLK, NM, NH and TvdA contributed to the conception of this study. MLK, NM, NH contributed to the planning. MLK, SH and AN carried out the study with support from NM and NH. MLK and SH analysed the results. MLK wrote the first draft with support from TvdA. All authors contributed to interpretation of results and substantially reviewed and revised the manuscript. All authors accepted the final manuscript for publication.

Ethical considerations

Ethical approval for The PartoMa Scale-Up Study was obtained from the Tanzanian National Institute of Medical Research (NIMR/HQ/ R.8a/Vol. IX/3324, NIMR/HQ/R.8c/Vol. I/1679, NIMR/HQ/R.8c/Vol. I/926). Further permission was obtained from the Tanzania Commission of Science and Technology, regional and district medical officers in DSM and participating hospitals. Women were given an anonymous ID, thus, the data collected is unidentifiable. The PartoMa study is registered in clinicaltrials.gov (NCT04685668).

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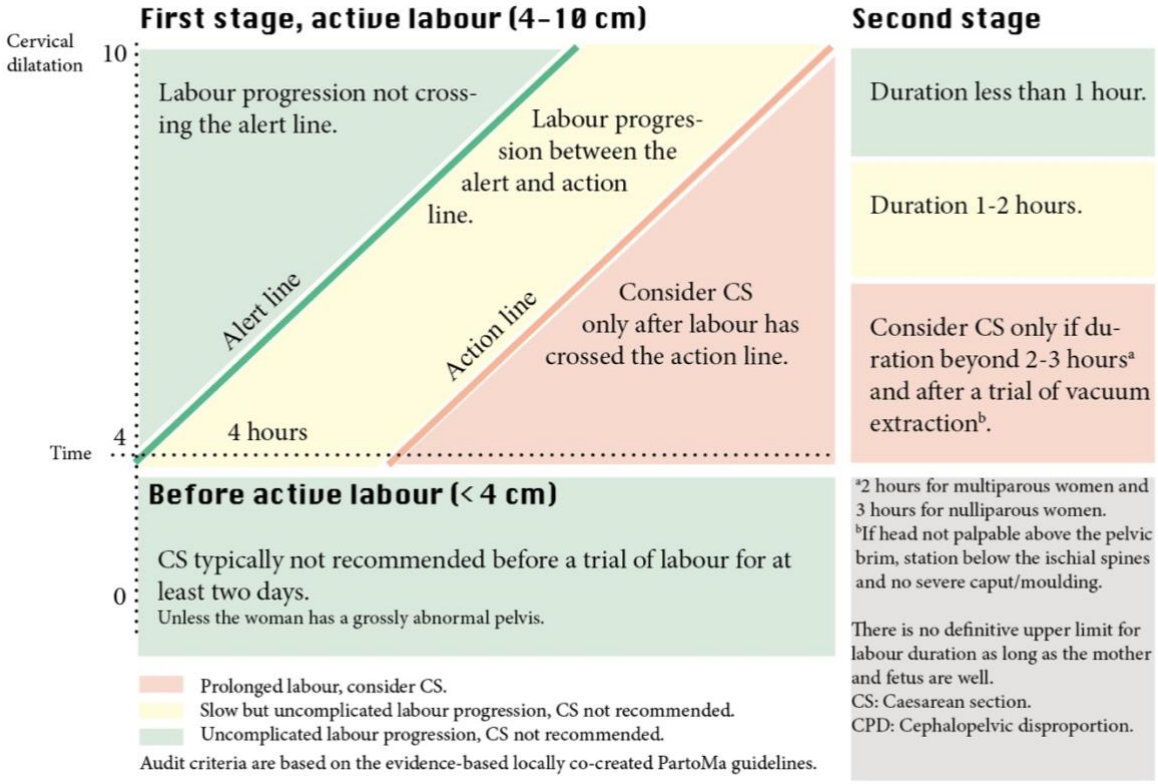
Figures and tables

- **Figure 1:** Audit criteria used to evaluate caesarean sections because of prolonged labour
- **Figure S1**: Flow chart
- **Table 1:** Caesarean section because of prolonged labour: Characteristics of women with cephalic, singleton pregnancies and no previous CS
- **Table 2:** Caesarean section because of prolonged labour: labour management according to stages of labour at time of caesarean section decision
- **Figure 2:** Criteria-based audit to identify potentially avoidable caesarean section because of prolonged labour in cephalic, singleton pregnancies with no previous caesarean section
- **Table S1:** Terms used to diagnose prolonged labour and associated clinical findings

Figure 1: Audit criteria used to evaluate CS because of prolonged labour/CPD



Flow chart Figure S1:

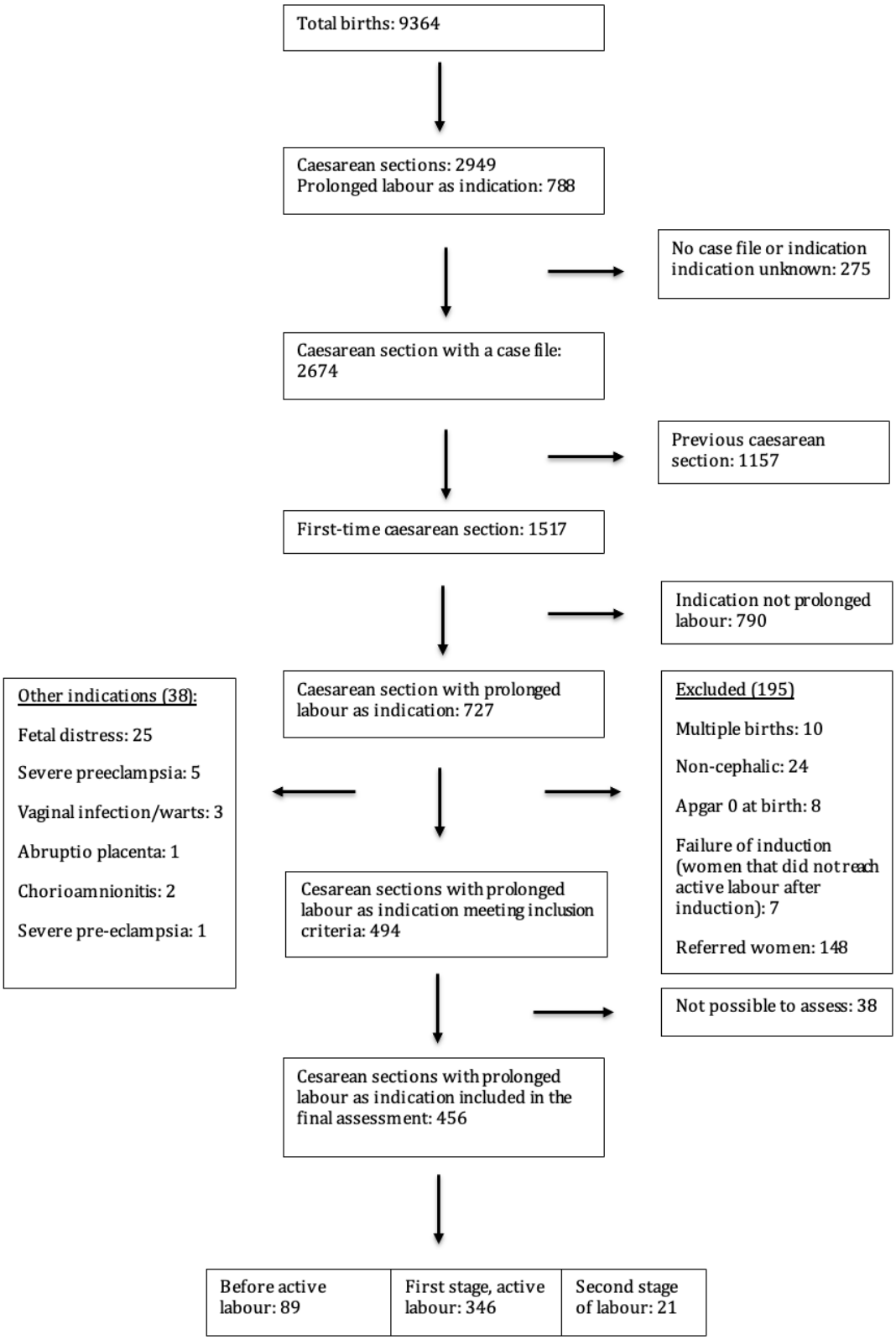


Table 1: Caesarean section because of prolonged labour: Characteristics of women with cephalic, singleton pregnancies and no previous CS

Background information	N = 456
Referred	40 (8.8%)
Age (Md, IQR)	25 (21-30)
Parity	
Nulliparous	277 (60.9%)
Multiparous without previous CS	178 (39.1%)
Unknown	1
Gestational age	
< 37 weeks	13 (3.0%)
≥ 37	425 (97.0%)
Unknown	18
Maternal complications (infection, cardiomyopathy, bleeding > 1000 ml)	7 (1.5%)
Apgar score	
4-7	2 (0.4%)
8-10	454 (99.6%)
Labour characteristics	
Labour interventions	
Induction	71 (15.6%)
Oxytocin augmentation	138 (30.3%)
Status of labour on admission	
Not in labour	33 (7.2%)
Latent phase	274 (60.1%)
First stage	130 (28.5%)
Second stage	2 (0.4%)
In labour, stage/phase unknown	17 (3.7%)
Time between admission and CS decision	
≤ 12 hours	189 (43.9%)
>12 hours	242 (56.1%)
Unknown	25
Time between decision and birth	
≤ 2 hours	199 (46.2%)
> 2 hours	232 (53.8%)
Vaginal examination between decision and birth	
Yes	16 (7.9%)
No	186 (92.1%)
Unknown	30
Unknown	25
Time between birth and discharge (Md, IQR) (hours)	24.0 (13.0-34.0)
CS decision note present	400 (87.7%)
Doctor's notes preceding CS	
None	118 (25.9%)
One	148 (32.5%)
≥Two	190 (41.7%)
Partograph use (of 367 women in active labour)	
No	39 (10.6%)
One time-point plotted	118 (32.2%)
≥ Two time-points plotted	210 (57.2%)

Table 2: Caesarean section because of prolonged labour: labour management according to stages of labour at time of caesarean section decision

Women who had not reached active labour	N = 89
Time between admission and decision	
0-23.9 hours	59 (66.3%)
24-47.9 hours	19 (21.3%)
48-96 hours	11 (12.4%)
Birthweight	
2.5-3.9 kg	76 (86.4%)
4-6 kg	12 (13.6%)
Unknown	1
Grossly abnormal pelvis (hip-joint deformity)	1 (1.1%)
Interventions	
Induction	10 (11.2%)
Membranes ruptured (spontaneously or artificially)	14 (16.8%)
Oxytocin augmentation	0 (0%)
Women who were in first stage of active labour	N = 346
Cervical dilatation at time of decision	
4-5 cm	96 (28.6%)
6-9 cm	240 (71.4%)
Unknown	10
Progress of labour at time of decision	
On or before crossing the alert line	53 (15.3%)
Between the alert and action line	92 (26.6%)
On or after crossing the action line	201 (58.1%)
Cervical progression between the last two vaginal examinations	
0 cm/hour	138 (51.1%)
0.1 - 0.5 cm/hour	74 (27.4%)
> 0.5 cm/hour	58 (21.5%)
Unknown	76
Four hours of labour arrest	79 (22.8%)
Interventions	
Membranes ruptured (spontaneously or artificially)	308 (89.0%)
Oxytocin augmentation	132 (38.2%)
Progress of labour at the time oxytocin was prescribed (of 132 augmented)	
On or before crossing the alert line	65 (52.8%)
Between the alert and action line	36 (29.3%)
On or after crossing the action line	22 (17.9%)
Unknown	9
Women who were in second stage of labour	N = 21
Duration of second stage	
<1 hour	20 (95.2%)
>2 hours (multiparous)	1 (4.8%)
Attempted vacuum-assisted birth	
Yes	1 (4.8%)
No[a]	20 (95.2%)
Progressive signs of obstruction described	7 (33.3%)

Figure 2: Evaluation of Caesarean Sections (CS) because of prolonged labour/cephalopelvic disproprotion (CPD) in 456 cephalic, singleton pregnancies with no previous CS.

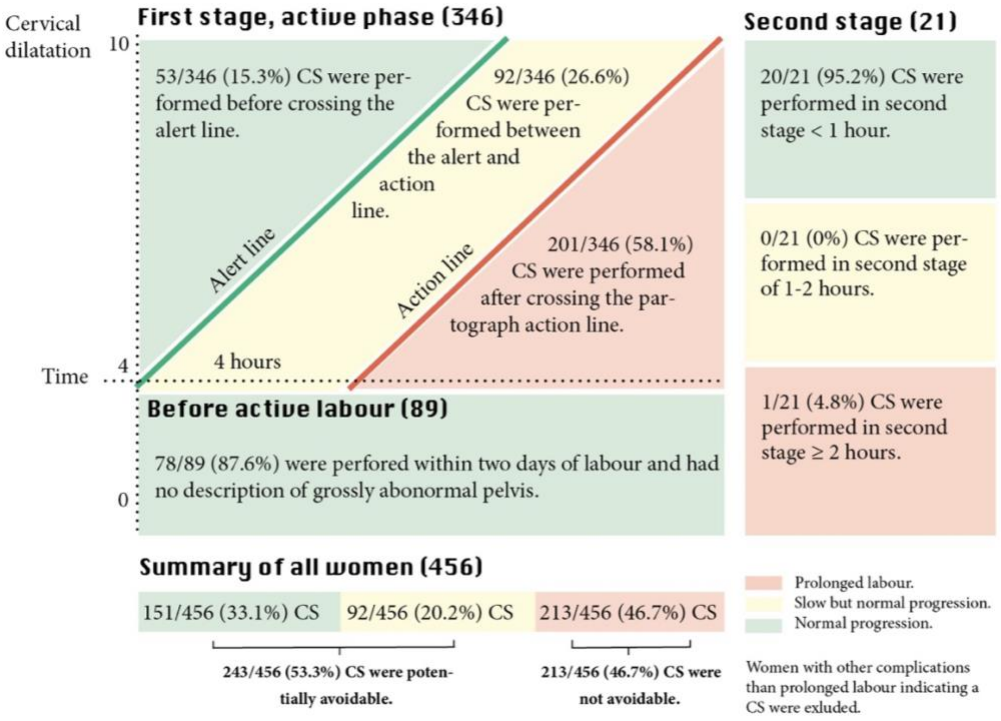


Table S1: Terms used to diagnose prolonged labour and associated clinical findings

Terms	N = 456 (%)
Obstructed labour	160 (35.1%)
Cervical arrest between last 2 vaginal examinations	51 (31.9%)
Head 1/5 or more palpable per abdomen 31 + 8 +1 +1+1+4	46 (28.8%)
Station above the ischial spines (-1, -2, -3) +1+1+2	4 (2.5%)
Severe caput succedaneum (+3)	10 (6.3%)
Caput succedaneum (+2)	60 (37.5%)
Severe moulding (+3)	1 (0.6%)
Moulding (+2)	15 (9.4%)
Others[a]	5 (3.1%)
No description	39 (24.4%)
Big baby	119 (26.1%)
Birthweight ≥ 4 kg	33 (27.7%)
Prolonged labour/poor progress	118 (25.9%)
Latest cervical progression slower than 0.5 cm/hours	87 (73.7%)
Cervical arrest	78 (17.1%)
No progression between last to vaginal examinations	39 (50.0%)
No progression within the last four hours	27 (34.6%)
CPD	63 (13.8%)
Borderline/inadequate pelvis	9 (14.3%)
Prominent pubic angle/unfavorable pelvimetry	2 (3.2%)
Others[b]	4 (6.3%)
No description	48 (76.2%)

[a] blood-stained urine and swollen cervix blood in catheter, head high, swollen cervix
[b] Cervix swollen, contracted pelvis, hip joint deformity, and maternal heigh 146 cm

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Paper V

Inconsistent definitions of labour progress and over-medicalisation cause unnecessary harm during birth. BMJ 2023;383:e076515

Maaløe N, Kujabi ML, Nathan NO, Skovdal M, Dmello, BS, Wray S, van den Akker T, Housseine N

Inconsistent definitions of labour progress and over-medicalisation cause unnecessary harm during birth

Nanna Maaløe and colleagues argue that resource challenges, unclear and outdated clinical practice guidelines, and lack of women's perspectives lead to overdiagnosis and overtreatment of prolonged labour

Nanna Maaløe, [1,2] Monica Lauridsen Kujabi, [1,3] Nina Olsén Nathan, [4] Morten Skovdal, [5] Brenda Sequeira Dmello, [1,6] Susan Wray, [7] Thomas van den Akker, [8,9] Natasha Housseine[1,10]

1 Global Health Section, Department of Public Health, University of Copenhagen, Denmark

2 Department of Obstetrics and Gynaecology, Copenhagen University Hospital—Herlev Hospital, Copenhagen, Denmark

3 Department of Obstetrics and Gynaecology, Aarhus University Hospital, Skejby, Denmark

4 Department of Obstetrics, Copenhagen University Hospital—Rigshospitalet, Copenhagen, Denmark

5 Section for Health Services Research, Department of Public Health, University of Copenhagen, Denmark

6 CCBRT Hospital, Dar es Salaam, Tanzania, East Africa

7 Women and Children's Health, University of Liverpool, Liverpool, UK

8 Department of Obstetrics and Gynaecology, Leiden University Medical Center, Leiden, Netherlands

9 Athena Institute, VU University, Amsterdam, Netherlands

10 Department of Obstetrics and Gynaecology, Aga Khan University, Tanzania, East Africa

Correspondence to: N Maaløe
nannam@sund.ku.dk

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Prolonged labour results in considerable morbidity and mortality globally in women and children, as well as risk of caesarean section, uterine rupture, and fetal adverse events.[1] In some instances, labour fails to progress because of fetal malposition or disproportion between the fetus and the woman's pelvis. However, the commonest cause of prolonged labour is inefficient uterine contractions (fig 1).[2] For women with weak uterine contractions, synthetic oxytocin may increase the power of contractions, but there are associated risks, including hyperstimulation, stillbirth, and neonatal complications.[4-10] Furthermore, caesarean section may still be required, and evidence that synthetic oxytocin reduces the risk of caesarean section is scarce.[5,6] Adding to the challenge, definitions of prolonged labour are inconsistent and tend to overestimate the speed of physiological labour.[11] Furthermore, overdiagnosis of prolonged labour may be caused by detrimental working conditions and routines among healthcare providers in overburdened maternity units.[12-14] Consequently, many women receive oxytocin or caesarean section with the indication of prolonged labour despite it being uncomplicated labour.[11,15-18]

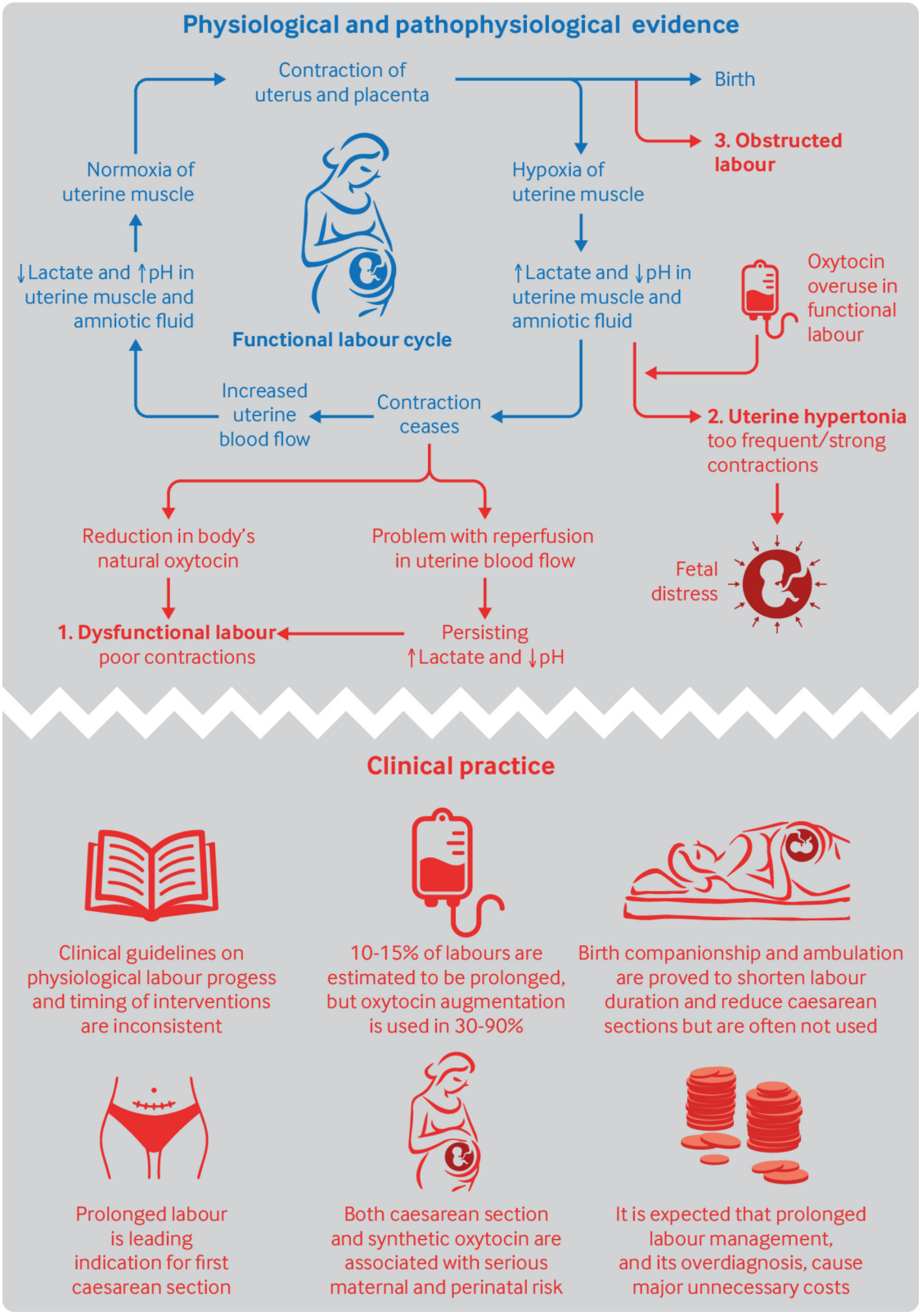

Fig 1 | Physiological and pathophysiological evidence on functional and dysfunctional labour, and discordance with clinical practice. In the functional labour cycle, contractions gradually increase in strength until the cervix is fully dilated and vaginal birth occurs. Relaxation of the uterine muscle between contractions allows for fetal and myometrial re-oxygenation. Possible problems with this natural contraction-relaxation cycle during labour are: (1) Women with true prolonged labour often have either reduced flow of the body's natural oxytocin (eg, because of pain, fear, or mental distress), or increased lactic acid in the capillaries of the uterine muscle. The acidity (lower pH) inhibits calcium ion channels, which in turn decreases contractile strength and limits oxytocin's effect; (2) Too powerful or too frequent contractions—resulting, for example, from

augmentation of labour with synthetic oxytocin—decrease placental perfusion and reduce oxygen flow to the fetus; and (3) In a smaller subgroup of women, progress of labour arrests because of mechanical disproportion between the fetal presenting part and the maternal pelvis despite a functional labour cycle[2-4]

According to synthesis of the evidence on physiological labour progression, prolonged labour occurs in 10-15% of births.[19 20] Yet, cross sectional and systematic review studies indicate that 30-90% of women in hospitals worldwide receive oxytocin to accelerate contractions.[6 16 17] Also, prolonged labour remains the indication for 35%-48% of first caesarean sections, and audits suggest that many of these women in fact had uncomplicated labour progression.[21-25] Prolonged labour, and particularly its overdiagnosis, thereby seems to contribute strongly to the rising global caesarean section rates, which are forecast to reach 28.5% of all births by 2030. This will incur substantial health system costs and add to maternal morbidity and mortality.[15 26-28]

We examine the evidence on defining and managing prolonged labour and propose concrete actions at both global and national levels to prioritise timely, effective, and safe management.

Conflicting definitions of prolonged labour

Management of labour has for decades been guided by information recorded on a partogram, which was adopted by the World Health Organization in the 1990s.[29] This paper sheet is used for recording labour progression and health status of the woman and baby, and it sets out thresholds for action. Active labour is defined to start at 4 cm cervical dilatation, and it assumes labour to be normal if dilatation progresses at a rate of 1 cm per hour or faster until full dilatation (the alert line). The action line is charted parallel to the alert line, but four hours later (fig 2).[30 31]

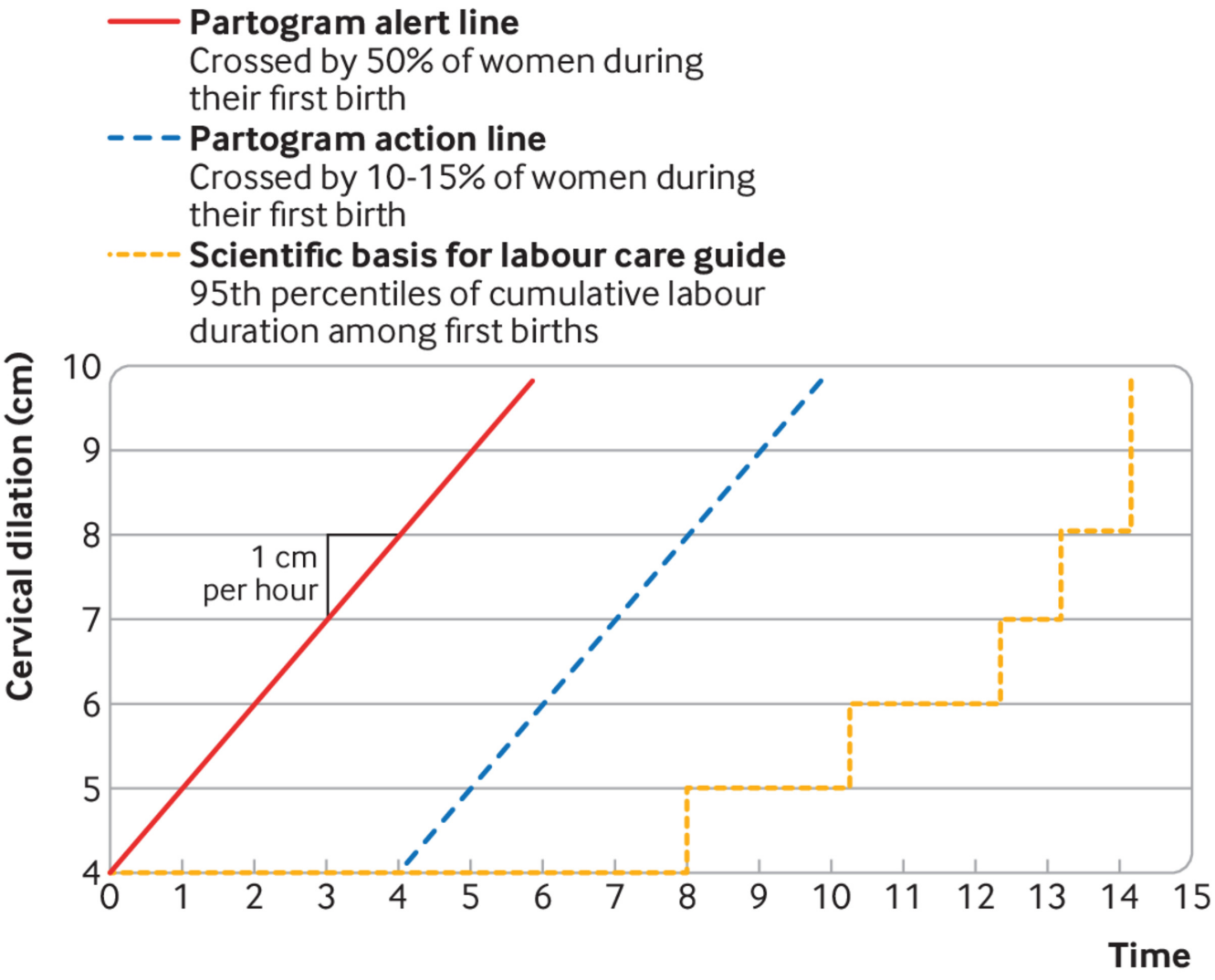

Fig 2 | WHO's thresholds for prolonged first stage of active labour using the partogram and labour care guide

The partogram is widely used. However, large studies from diverse settings over the past 20 years have shown that spontaneous first labours progress much more slowly than 1 cm/hour and that cervical dilatation is not linear.[19 20] For example, WHO conducted a cohort study of progression of spontaneous labour in Uganda and Nigeria. The study found that around half of 5606 women giving birth for

the first time had cervical dilatation rates slower than 1 cm/hour, while only 15% crossed the action line. Caesarean section was performed in 13.2% of these women.[32]

In 2020, WHO released the labour care guide to replace the partogram. It defines prolonged labour more cautiously with a specific threshold for action for each centimetre of cervical dilatation.[33] For example, labour is prolonged at 5 cm of dilatation if cervical dilatation has not progressed to 6 cm within 5 hours (fig 2), and a woman may be in active labour for more than 18 hours and still be considered to be progressing physiologically. Although use of this labour care guide reduces the risk of interventions being performed too soon, it does not provide guidance on recommended clinical management when a woman crosses the threshold for prolonged labour.[33 34] Furthermore, while WHO has pushed for its use since 2020, a randomised trial of its potential effects has not provided results yet. Evidence is lacking on the physical, mental, and health system consequences of potentially much extended labour durations.[34-36]

Moreover, global, national, and facility based clinical practice guidelines vary widely in terms of their recommendations for diagnosing and managing prolonged labour and, generally, a combination of positive perceptions and habitual use of oxytocin among staff may drive its continued overuse.[11 37 38 13 16 17 39] For instance, the 2021 International Classification of Diseases still defines prolonged labour as slower than 1 cm/hour,[40] which is in line with the partogram from the 1990s rather than evidence from the past 20 years of labour progression studies.[19 20] This has resulted in unclear thresholds for interventions with synthetic oxytocin.[16-18]

Unknowns regarding synthetic oxytocin for labour augmentation

Synthetic oxytocin gained regulatory approval for use in augmentation of labour in many high income countries in the 1950s—when severely prolonged labour was still a big contributor to maternal mortality. In addition to synthetic oxytocin's lifesaving role in treating postpartum haemorrhage, its capacity to boost contractions was welcomed.[41] Synthetic oxytocin was, and often still is, considered equivalent to the body's natural oxytocin, and it is still often perceived that faster labours are preferable. However, intravenous, synthetic oxytocin tends to be administered at higher levels than endogenous oxytocin and control of levels is less sensitive. A specific dose may therefore have no effect in some women and produce too frequent contractions in others.[41 42]

Concerning actual effects of augmenting labour with synthetic oxytocin, it has been shown to reduce length of labour by about two hours compared with no oxytocin or placebo in low risk women in the first stage of spontaneous labour at term.[5] However, augmentation with oxytocin has not been shown to reduce caesarean sections, which was its core purpose when first introduced.[5 6] On the contrary, two observational studies have indicated that reducing use of oxytocin may in fact reduce caesarean section rates. A 2015 Norwegian study assessed 20 227 women with singleton cephalic pregnancies ≥37 weeks' gestation in spontaneous or induced labour who had no previous caesarean section. After implementing a protocol recommending more judicious use of oxytocin, the study reported a reduction in use from 34.9% to 23.1% and caesarean sections reduced from 6.9% to 5.3%, including those for fetal distress, which fell from 3.2 to 2.0%. Simultaneously, the proportion of neonates with an umbilical cord pH<7 decreased from 4.7% to 3.2%, the proportion of women in active labour for more than 12 hours increased from 4.4% to 8.5%, and the rate of severe postpartum haemorrhage increased from 2.6% to 3.7%.[43] Similarly, a 2018 before and after study from a Tanzanian hospital evaluated an intervention where oxytocin was restricted to women crossing the partogram action line (fig 2) and found that overall oxytocin use for augmentation reduced from 22.3% to 12.1%. Caesarean rates did not change significantly and stillbirths reduced from 5.9% to 3.9%.[44]

The above studies are, however, all observational and not designed to assess the effect of oxytocin on perinatal outcomes. Oxytocin's effect on caesarean section rates remains unclear. A 2013 Cochrane meta-analysis identified only three randomised trials comparing synthetic oxytocin with no oxytocin or placebo in low risk pregnant women with slow progress during the first stage of spontaneous labour at term (37-42 weeks' gestation, singleton fetus in cephalic presentation). These trials were conducted in Thailand, Argentina, and the US during 1981-96 among a total of 239 women. They were underpowered, but found no difference in caesarean section rates among women with or without oxytocin for labour augmentation.[5] No similar trials have been done since then.[5 6] However, the Cochrane meta-analysis also included five studies among 1200 women assessing early versus delayed use of oxytocin for augmentation (differing definitions). In this group, no change was found in caesarean section rates when comparing early and late use, but there was a significant increase in fetal heart changes in the early use group.[5]

The Cochrane meta-analysis was underpowered to assess more severe neonatal outcomes. However, observational studies of both primiparous and multiparous women from high income countries have found associations between oxytocin and adverse neonatal outcomes, including low Apgar score, acidaemia, and neonatal encephalopathy.[7-9] For example, a systematic review and meta-analysis published in 2021 included a total of 24 208 women giving birth at or beyond 36 weeks of gestation and found oxytocin augmentation to be associated with a 2.19 higher odds of neonatal encephalopathy.[7] Furthermore, our 2022 systematic review and meta-analysis of studies from low and lower middle income countries found associations between oxytocin for labour augmentation and neonatal resuscitation, stillbirth, and day 1 neonatal mortality. We found few studies assessing associations between oxytocin augmentation and caesarean section or uterine rupture, and no randomised controlled trials.[6]

Thus, while oxytocin might help some women with prolonged labour, there are also serious drawbacks and harms associated with its use, which deserve more careful and critical evaluation. Global clinical practice guidelines not only lack clear indications for timely administration of oxytocin for augmentation, but they also provide insufficient information about possible adverse effects to guide clinical decision making and informed consent.[11 38 39]

Taking women's voices into account

Although some studies show that women who have longer labours tend to report more negative childbirth experiences, focusing solely on shorter labour overlooks that oxytocin augmentation itself may lead to negative childbirth experiences. A qualitative review was conducted of 25 studies from 14 middle and high income countries examining women's experiences with oxytocin augmentation. Here, women indicated that decisions to augment labour are often made without their involvement and that oxytocin is routinely administered without their informed consent.[45] This happens against a background of many women believing that oxytocin augmented labour is more painful. Notably, this is aligned with synthetic oxytocin's lack of analgesic effects, which differs from endogenous oxytocin.[45 42] Conversely, a 2013 qualitative study

among 140 community members in India's Karnataka state, including women who had recently given birth and health providers, reported that high value was placed on pain during labour. This fostered a demand for oxytocin augmentation, often despite awareness of risks.[46]

These contrasting perceptions show the importance of taking women's views into account, both through informed choices in the clinic and through co-creating clinical practice guidelines with the women.[38 45] For instance, UK guidelines on intrapartum care, by the National Institute for Health and Care Excellence, stress that it must be explained to labouring women that oxytocin augmentation "will bring forward the time of birth but will not influence the mode of birth or other outcomes."[47] The part about birth outcomes, however, contradicts the evidence on oxytocin's associations with adverse perinatal outcomes and may affect women's choices.[5 -9] Current WHO guidelines, on the other hand, set out the risks of adverse birth outcomes associated with oxytocin augmentation, but do not mention the lack of evidence regarding effect on mode of birth.[31 34]

Searching for new treatments for prolonged labour

Evidence is growing on how to promote the release and effectiveness of natural oxytocin during childbirth.[42] In particular, fear of childbirth and mental distress from pain, unfamiliar surroundings, and lack of support are associated with longer duration of labour. Meanwhile, continuous birth support, even by a person with modest training, and mobile, upright positions during the first stage of labour have each been shown to improve labour progress, decrease analgesia use, and reduce risks of caesarean section and adverse neonatal outcomes.[48 49] However, inside the world's hospitals, birth companionship remains far from universal, and most women still labour while lying in hospital beds.[49 36 50]

Additionally, recent studies have shown that women with prolonged labour often have considerably increased lactate levels in the uterine muscle. This lower pH reduces contractions and causes both natural and synthetic oxytocin to be less effective (fig 1).[51 52] Two independent randomised controlled trials from 2017 and 2021, one of 200 Swedish women and the other of 142 Egyptian women with prolonged labour, found that treating prolonged labour with oral bicarbonate followed by oxytocin significantly increased vaginal birth.[53 54] The use of such inexpensive, orally administered, well tolerated treatment to enhance the effectiveness of endogenous oxytocin and avoid intervention in labour could potentially improve health outcomes substantially and larger, and confirmatory, trials are needed.[27]

Towards timely, safe, and respectful care everywhere

Prolonged labour is not easy to diagnose, and oxytocin might help some women with prolonged labour but not others. However, it is evident that there is systemic overuse of synthetic oxytocin for augmenting labour and of caesarean sections. The risks of preventable caesarean sections and oxytocin augmentation are established,[5 6 26 -28 55] and so are the benefits of continuous support and mobility during labour and the fact that physiological labour takes time.[19 20 48 49] However, inconsistent and outdated guidelines and clinical practices show alarming delays in adapting to established evidence. Together with persistent gaps in research and research funding for women's health, this delay denies women their right to the highest attainable standard of health.[56] To address these urgent problems surrounding prolonged labour, three concurrent actions are essential (table 1).

Table 1 | Actions for timely, safe, and respectful treatment of prolonged labour

Goal	Global	National
Conducive maternity units	Allocate sufficient funding to support national childbirth programmes Invest in implementation research on how to close gap between evidence and practice Invest in research on women's preferences during childbirth	Strengthen resources in maternity units to allow for physiological, spontaneous labour progress Scale up proved interventions for prolonged labour such as birth companions and ambulation Invite women and frontline health providers to contribute to these actions
Safe and respectful clinical practice guidelines for labour progression	Harmonise definitions of prolonged labour Co-create and pilot clinical guidelines that take scientific evidence and women's voices into account Support adaptations for regional, national, and sub-national context	Prioritise resources for context sensitive adaption of clinical practice guidelines together with women and healthcare workers Co-create implementation strategies for clinical guidelines Conduct post-implementation evaluations of the effects, including potential adverse effects, of the guidelines
High quality research into causes and prevention of prolonged labour	Invest in basic and clinical research into biology and pathophysiology of labour, and the benefits and harms of potential interventions for prolonged labour (such as oxytocin and bicarbonate)	Ensure robust routine data on prolonged labour, use of synthetic oxytocin for augmentation, and rates of and indications for caesarean section

Firstly, resources must be prioritised to ensure safe birth environments that support and protect physiological labour progression. This low cost and low technology approach of giving women time to progress, while closely monitoring safety and wellbeing, must be possible in all maternity units. It is, however, increasingly challenged by hospital congestion and the crisis in human resources for healthcare. Historically, the morbidity toll of prolonged labour has been on women in rural, resource constrained settings receiving interventions "too little, too late."[30] Although this may still be true for some women living rurally, interventions now often happen "too much, too soon" in urban and overburdened maternity units lacking empathetic designs.[57 -59] For instance, a survey among 204 Swedish midwives found that excessive oxytocin use for augmentation was driven by congestion and high workload rather than individual women's needs.[12 13] Similar findings have been reported in urban studies in Egypt[60] and Tanzania (authors' unpublished data). For example, empathetic co-design of the architecture and structure of maternity units, which enables designers to view units from the viewpoint of women and healthcare providers, has potential to improve the quality and experience of childbirth. This was the approach in a childbirth project in Zanzibar resulting in the redesign of the space to maintain the privacy of women moving to the delivery room and the introduction of birthing stools.[61]

Secondly, the global health community must establish clear and standardised criteria for diagnosing prolonged labour. Also, they must provide well tested, precise guidance for its timely and safe management across different care contexts.[3,8] WHO's efforts are welcome,[3,4] but its guidelines, for example, lack clarity on indications for oxytocin augmentation, dosages, and risks. Furthermore, WHO's current guidelines have been disseminated globally before pilot testing or timely post-implementation evaluation of effects, including unintended harms.[3,8] Moreover, women and frontline healthcare providers must be sensitively included during creation and local adaptation of guidelines.[3,8,45]

Lastly, research must be intensified on the pathophysiology of prolonged labour, on promising new treatments, and on how to bridge the evidence-practice gap (fig 1).[5,6] Improved understanding of causes of prolonged labour may lead to effective, individualised management.[2,3] Also, after 70 years of use, a thorough understanding of the potential effects of oxytocin augmentation when administered restrictively, rather than near routinely, is long overdue.

Key messages

- Globally, prolonged labour is overdiagnosed and overtreated with oxytocin and caesarean section
- Consequently, many women are exposed to avoidable health risks, including uterine hyperstimulation, surgical risks, and adverse perinatal outcomes
- Clinical practice guidelines provide outdated, inconsistent, and unclear definitions of prolonged labour with an unbalanced view on treatment risks and benefits
- Maternity units are needed that enable physiological labour progression through caring, continual support, and ambulation
- Research and clinical practice guidelines that reflect latest evidence, context, and women's perspectives are also required to reduce unnecessary harms

Contributors and sources: This article results from deliberations between clinicians within obstetrics and midwifery as well as social and basic scientists, who collaborate on a large scale childbirth care project in Tanzania (the PartoMa project). Our research, coupled with our diverse backgrounds, has heightened our attention to attenuating gaps between emerging evidence and clinical practice related to labour progress, across countries of all income levels. Our analysis is based on scientific evidence, literature reviews, clinical experiences, and women's personal accounts. NM led conceptualisation and writing of the draft, with substantial involvement from MLK. All authors have critically reviewed, edited, and contributed. NM is the guarantor.

Public and patient involvement: Five of the authors have given birth and six work within maternity care in Tanzania, Denmark, and the Netherlands. We also included perspectives from qualitative studies on women's and healthcare providers' perceptions of prolonged labour and its clinical management.

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