BMJ Open

How often will midwives and obstetricians experience obstetric emergencies or high-risk deliveries: a national cross-sectional study

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2021-050790
Article Type:	Original research
Date Submitted by the Author:	06-Mar-2021
Complete List of Authors:	Høgh, Stinne; Rigshospitalet, Department of Obstetrics Thellessen, Line; Rigshospitalet University Hospital Bergholt, Thomas; Rigshospitalet, Dept. of Obstetrics and Gynecology Rom, Ane; Rigshospitalet, University of Copenhagen, Juliane Marie Centre for Children, Women and reproduction section 4074 Johansen, Marianne; Rigshospitalet, Department of obstetrics Sorensen, Jette Led; Rigshospitalet, University of Copenhagen, Juliane Marie Centre for Children, Women and reproduction section 4074; Jette Led Sorensen,
Keywords:	OBSTETRICS, MEDICAL EDUCATION & TRAINING, ACCIDENT & EMERGENCY MEDICINE

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

How often will midwives and obstetricians experience obstetric emergencies or high-risk deliveries: a national cross-sectional study

Authors

Stinne Høgh[1], Line Thellesen[1], Thomas Bergholt[1,2], Ane Lilleøre Rom[1], Marianne Johansen[1] & Jette Led Sørensen[1,2]

Author affiliations and addresses

[1]Department of Obstetrics, Juliane Marie Centre, Rigshospitalet, University of Copenhagen, Blegdamsvej 9, 2100 Copenhagen, Denmark

[2]Department of Clinical Medicine, University of Copenhagen, Blegdamsvej 3B, 2200 Copenhagen, Denmark

Corresponding author

Stinne Høgh

Department of Obstetrics, Juliane Marie Centre, Rigshospitalet University Hospital, University of Copenhagen, Blegdamsvej 9, 2100 Copenhagen, Denmark

Tel: +45 22973556

Email address: stinne.hoegh@regionh.dk

Running title

Obtaining skills in managing obstetric emergencies

Abstract

Objective

To estimate how often midwives, specialty trainees, and doctors specialised in obstetrics and gynaecology are attending to specific obstetric emergencies or high-risk deliveries (obstetric events).

Design

A national cross-sectional study.

Setting

All hospital labour wards in Denmark.

Participants

Midwives (n=1300), specialty trainees (n=180), and doctors specialised in obstetrics and gynaecology (n=340) working in hospital labour wards (n=21) in Denmark in 2018.

Methods

Categories of obstetric events comprised of Apgar score <7/5 min, eclampsia, emergency caesarean sections, severe postpartum haemorrhage, shoulder dystocia, umbilical cord prolapse, vaginal breech deliveries, vaginal twin deliveries, and vacuum extraction. Data on number of healthcare professionals were obtained through the Danish maternity wards, the Danish Health Authority and the Danish Society of Obstetricians and Gynaecologists. We calculated the time interval between attending each obstetric event by dividing the number of events occurred with the number of healthcare professionals.

Outcome measures

The time interval between attending a specific obstetric event.

Results

The average time between experiencing obstetric events was from nine days to 42 years. Emergency caesarean sections, which occur relatively frequent, were attended on average every other month by

midwives, every nine days for specialty trainees, and every 17 days by specialist doctors. On average, rare events like eclampsia were experienced by midwives only every 42 years, every six years by specialty trainees, and every 11 years by specialist doctors.

Conclusions

Some obstetric events occur extremely rarely, hindering the ability to obtain and maintain the clinical skills to manage them through clinical practice alone. By assessing the frequency of a healthcare professionals attending an obstetric emergency our study contributes to assessing the need for supplementary educational initiatives and interventions to learn and maintain clinical skills.

Strengths and limitations of this study

- The first study to calculate how often healthcare professionals can expect to attend specific obstetric emergencies or high-risk deliveries in clinical real life.
- The incidence of the obstetric events was based on a large data source comprising 465,919 deliveries.
- Even though the number of healthcare professionals working in labour wards are constantly changing, our study results are assumed to be the most valid estimates obtainable as minor variations in the number of healthcare professionals do not change the estimates substantially.

Keywords

Obstetrics, pregnancy outcome, obstetric emergencies, obstetric nursing/education, emergency treatment

Disclosure of interest

The authors have no conflicts of interests to disclose.

Introduction

In high-income countries most pregnancies have good outcomes. Obstetric emergencies like eclampsia, severe postpartum haemorrhage, shoulder dystocia, and umbilical cord prolapse are fortunately rare obstetric events.[1] These potentially life threatening emergencies often occur unexpectedly, and require immediate action by healthcare professionals[2, 3] and may entail tragic consequences such as death or serious morbidity in women and/or newborns.[4-6]

Obstetric emergencies often occur in extremely stressful settings that require highly professional communication and teamwork skills in order to take appropriate action. Similarly, high-risk deliveries, like vaginal twin or breech deliveries, also require highly specialised skills in healthcare professionals attending the event to ensure good outcomes.[7-10]

Healthcare professionals must be qualified to manage these emergencies and high-risk deliveries (obstetric events) to ensure patient safety. However, audit based studies have shown how these events are not always managed according to well-known, evidence-based standards of obstetric care.[5, 6, 11-15] An analysis of 127 cases of peripartum hypoxic brain injuries in claims registered by the Danish Patient Insurance Association concluded that all of the injuries were potentially avoidable if standard obstetric care had been applied.[11] Substandard care was also found in 42% of deliveries with low Apgar scores in Sweden,[12] and in the United Kingdom in nearly half of intrapartum stillbirths and in half of the intrapartum-related neonatal deaths.[13] Studies of maternal deaths in the United Kingdom found that substandard care during pregnancy or delivery had occurred in 29% of cases.[16]

Clinical negligence is devastating to the family involved, just as the healthcare professionals involved may experience emotional, behavioural, and cognitive consequences in terms of anxiety, depression symptoms,[17] post-traumatic stress disorder,[18] and loss of professional confidence, leading to self-doubt, isolation, practicing defensive medicine, and fear.[19, 20] Healthcare professionals involved in cases of clinical negligence are often referred to as second victims.[17, 18, 21] Moreover, cases of clinical

negligence often entail high litigation and future healthcare costs.[22, 23] Hence, to safeguard the women and prevent avoidable harm due to substandard obstetric care, and subsequent litigation and healthcare costs, the level of quality of managing obstetric events must be improved. The low incidence rate of certain obstetric events, however, challenge healthcare professionals' opportunities to obtain and maintain the necessary clinical skills through daily clinical practice alone is a well-known issue that needs addressing. However, no study has previously quantified this challenge.

To gauge the average number of opportunities, healthcare professionals have to obtain and maintain their proficiency in managing obstetric events, this study aimed to estimate how often midwives, specialty trainees, and doctors specialised in obstetrics and gynaecology can expect to attend to and get involved in obstetric emergencies and high-risk deliveries.

Methods

Study design and setting

We conducted a national cross-sectional study that included midwives, specialty trainees, and doctors specialised in obstetrics and gynaecology (specialist doctors) working clinically in hospital-based labour wards in Denmark in 2018. There are approximately 60,000 deliveries in Denmark annually, with 96-98% occurring at public hospitals and 2-3% as home births.[24]

In 2018 Denmark had 21 labour wards, all of them staffed with in-house, on-call specialist doctors in obstetrics and gynaecology as well as anaesthesiology specialist doctors. The wards vary in size and specialty level from highly specialised tertiary referral centres (the largest with about 7000 deliveries per year) to small departments with only 600–1000 deliveries per year. All low-risk deliveries are attended by midwives often accompanied by midwifery students, during the active phase of labour. Specialist doctors and specialty trainees are only involved when complications arise.[25] In high-risk

deliveries, specialist doctors and specialty trainees are always involved, and managing the delivery is a collaborative team effort between the midwife, specialty trainee, and specialist doctor.

Population

Eligible for inclusion

Midwives, specialty trainees, and specialist doctors in obstetrics and gynaecology working clinically in a Danish labour ward in 2018 were eligible.

Midwives

In Denmark midwives must earn a bachelor's degree in midwifery. During the 3.5-year programme students spend half of their time in clinical placements, e.g. midwifery centres, labour wards, antenatal wards and postnatal wards. Most midwives work in shifts. When caring for women giving birth, midwives are qualified and authorised to work independently, though in collaboration with a doctor when complications arise. This study collected data on midwives working predominantly on labour wards. All the midwives were included as if they were working full-time.

Specialty trainees

In this study, specialty trainee refers to doctors in their five-year postgraduate medical specialist training programme in obstetrics and gynaecology. Mandatory general courses, specialty-specific courses, and research training are also part of the curriculum. Upon graduation they are qualified to examine and treat 90% of the conditions in the specialty.[26]

Specialist doctors

In this study specialist doctors refers to individuals who have completed their specialty training in obstetrics and gynaecology. A relatively large proportion of specialist doctors are subspecialised in either obstetrics or gynaecology, however with both groups participating in night shifts on the labour wards. Specialist doctors on call have full responsibility for the labour ward and supervise specialty trainees. According to the Danish Health Association labour wards must, as a minimum, always have a specialist doctor or a last year specialty trainee on duty. We included only specialist doctors, working in hospitals, who also did night shifts on the labour wards.

The average work week for full-time healthcare professionals is 37 hours in Denmark. All healthcare professionals included in this study participated in obstetric night shifts.

Data collection

Healthcare professionals

Data on the number of obstetric healthcare professionals were collected in 2018 to obtain more valid data than would be possible had data been collected for previous years. Data on healthcare professionals were retrieved in various ways.

Midwives

The heads of midwifery in maternity units across Denmark were contacted by email in October 2018 and asked to provide data on the number of midwives employed in their labour wards.

Specialty trainees

Data on the number of specialty trainees was obtained through the Danish Health Authority, which regulates the number of specialty trainees.[27, 28]

Specialist doctors

The Danish Society of Obstetricians and Gynaecologists furnished data on the number of specialist doctors.

The data on the number of healthcare professionals working in labour wards were validated with data from a national quality assurance project called Safe Deliveries.[29]

Obstetric events

In this study the term obstetric events refers to both obstetric emergencies and high-risk deliveries, the former defined as serious, unexpected, and potentially life-threatening conditions that may occur in pregnancy, during labour, or after delivery, and which require immediate action by healthcare professionals,[2, 3] while the latter involve actual or potential hazards to the health or well-being of the mother or foetus. The incidence of obstetric events used in this study was calculated based on data from 465,919 deliveries from 2008–2015 and are reported in another paper.[1] Data were retrieved from the Danish Medical Birth Registry, which was established in 1973 and contains information on all deliveries in Denmark, including data on the mother, child, pregnancy, and delivery.[30] Diagnoses are registered using International Classification of Diseases codes (ICD), 10th revision [31] and surgery is coded by the Danish version of the NOMESCO Classification of Surgical Procedures (NCSP).[32] In Denmark, all individuals have a unique personal identification number, making it possible to conduct valid registry-based studies. Diagnoses in the Danish Medical Birth Registry have been validated, and the authors found that the more severe the condition, the higher the validity of the coding.[33]

The obstetric events included in our study were: Apgar score <7/5 min (ICD-10: DVA00-DVA06), eclampsia (ICD-10: O151, O152, O159), emergency caesarean section (NCSP: KMCA10A, KMCA10D, KMCA10E), severe postpartum haemorrhage (≥1000 ml) (ICD-10: O072, only ≥ 1000 ml), shoulder dystocia (ICD-10: O660, NCSP: KMAH15), umbilical cord prolapse (ICD-10: O690), vaginal breech delivery (NCSP: DUP07-DUP11, DUP16 without caesarean sections, NCSP: KMCA10), vaginal twin delivery (ICD-10: O300, without caesarean sections, NCSP: KMCA10), and instrumental delivery by vacuum extraction (NCSP: KMAE00, KMAE03, KMAE96). These critical events may result in maternal and neonatal mortality and morbidity, are often subjects of clinical training.[4, 5, 7, 11, 15] Moreover, obstetric healthcare professionals are expected to safely and expertly manage these events.

Statistical analysis

The outcome of interest was the estimated average time interval between the expected acquaintance with one obstetric event to the next similar obstetric event divided across the number of midwives, specialty trainees, and specialist doctors. We calculated the average time interval between the events by dividing the occurrence of events per year (incidence times total number of deliveries in 2018) with the number of healthcare professionals in the study. The result was divided by 12 to calculate the number of months between a potentially experienced event. We based the analysis on the assumption that all healthcare professionals can learn from an event if they are either participating hands-on or are present in the delivery room as an observer or assistant.

The data was also analysed based on the alternative assumption that clinical skills can only be learned by playing an active role in managing the event. We only included specialty trainees and specialist

doctors in these calculations, since they have ultimate responsibility for delivered care and clinical management of the respective obstetric events.

Since the estimates constitute average numbers, they are presented as means. The average time interval in years is presented on a logarithmic scale to illustrate the differences between the different obstetric events and between different healthcare professionals. Probabilities of experiencing an obstetric emergency were calculated using Microsoft Excel (Microsoft Cooperation version 14.6.6).

Patient or public involvement

There was no direct patient or public involvement in this study.

Results

Denmark had 61 273 deliveries in 2018.[24] Table 1 presents data on the number of midwives, specialty trainees, and specialist doctors working at one of the 21 hospital labour wards. The number of midwives per labour ward ranged from 13 to 135.

Table 2 shows the incidences of the obstetric events and the average time interval between experiencing each of the studied obstetric event as midwives, specialty trainees, and specialist doctors in obstetrics and gynaecology. These estimates were calculated under the assumption that all healthcare professionals learn from an event if they either participate hands-on, observe the event, or act as an assistant.

Six of the obstetric events (eclampsia, Apgar score <7/5 min, umbilical cord prolapse, singleton vaginal breech delivery, shoulder dystocia, and vaginal twin delivery) occurred at a low incidence of 0.05–1.00%. Three of the events (severe postpartum haemorrhage, delivery by vacuum extraction,

and emergency caesarean section) occurred relatively often, with an incidence of 6.4–12.2%. The time interval between the events differed depending on the incidence of the event and the group of healthcare professionals. Midwives experienced eclampsia only every 42 years on average, specialty trainees every six years, and specialist doctors every 11 years.

The events with relatively high incidence were hence experienced relatively more often. Emergency caesarean section, with an incidence of 12.2%, were experienced, on average, every other month for midwives, every nine days for specialty trainees, and every 17 days for specialist doctors. Instrumental delivery with vacuum extraction and severe postpartum haemorrhage, with an incidence of 7.0% and 6.4%, respectively, were, on average, experienced by midwives every four months, by specialty trainees every 16 days, and by specialist doctors once a month (Table 2).

Table 3 depicts the time between events for doctors based on the assumption that only the healthcare professional providing the first-line care can learn from the event. The time between experiencing eclampsia increased from 6 to 17 years when performed independently by a specialty trainee, and from 11 to 17 years when performed independently by a specialist doctor. The time interval between experiencing an emergency caesarean section increased from 9 to 25 days and from 16 to 25 days for a trainee and specialist doctor, respectively.

Discussion

Main findings

In this Danish national cross-sectional study examining how often an obstetric healthcare professional can expect to be involved in an obstetric emergency or a high-risk delivery, we found that the time interval between experiencing one of the obstetric events in focus per healthcare professional ranged

from nine days to 42 years. Our data shows that midwives experienced the studied events less frequently than did specialist doctors, and specialty trainees were found to experience the events most frequently.

Strengths and limitations

This study addressed a gap in the research literature by calculating how often healthcare professionals can expect to experience specific obstetric emergencies or high-risk deliveries in a Danish healthcare setting. A strength of our study is that the incidence of the obstetric events was based on a large data source comprising 465 919 deliveries during a eight year period. The exact number of midwives was difficult to obtain due to diversity in work tasks and work hours. To avoid this potential bias, we included midwives working both part- and full-time on labour wards, which suggests that our results are conservative estimates.

Even though the number of healthcare professionals working on labour wards changes over time due to various organisational, political, and economic factors, our results are assumed to be the most valid estimates obtainable as minor variations in the numbers do not change the overall estimates substantially.

We used data on specific obstetric events from existing research, obtained for 2008–2015.[1] Data on the number of obstetric healthcare professionals were collected for 2018 since data from this year is assumed to be more valid compared to data for previous years due to the possibility of recall bias. Nationally, incidences of obstetric events are fairly consistent over the years. Therefore, we have reason to believe that the different time periods used may have compromised the validity of our study results.[1]

Danish labour wards differ in size and level of specialisation. Consequently, healthcare professionals at large departments with a high level of specialisation will experience the events more often than healthcare professionals at smaller departments, and more frequently than our results suggest.

Our analysis assumed that the healthcare professionals may learn from a specific obstetric event if they are either providing care hands-on, are present in the delivery room either as an observer or as an assistant. However, if we base our findings on the assumption that each obstetric event only allow one from each healthcare worker profession, i.e., only one midwife, one specialty trainee, and one specialist doctor to learn from each event, then the frequency with which each of the attendants may potentially learn from these relative rare obstetric events fall significantly.

Interpretation

Our results demonstrated that midwives and specialist doctors can have a lifelong working life and only experience certain severe obstetric emergencies once or twice, if at all. When emergencies occur, however, healthcare professionals are expected to have the skills to manage the event according to well-known, evidence-based standards of obstetric care. As a result, healthcare professionals must always be prepared for obstetric emergencies to occur. Our findings show that it is unrealistic for healthcare professionals to obtain and maintain the competences required to manage rare obstetric events through clinical experience alone. A common feature of the events studied is that the time interval between emergencies or high-risk deliveries depends on the healthcare professional group to which you belong, indicating that some groups can acquire the skills based primarily on clinical experience alone. However, alternative educational pathways must be provided for other groups. To improve patient safety, minimise litigation, and ameliorate the consequences for the healthcare professionals involved, ensuring that they have the necessary skills to manage obstetric events must be prioritised.[22]

Simulation-based education, which is a valuable supplement to traditional ways of learning through clinical practices and mentorship, represent one way of ensuring acquisition of clinical skills and maintenance hereof.[34] Simulation-based training can identify and correct common clinical errors made during emergencies, and has been recommended as a valuable standard supplementary to clinical practice in order to improve care provided.[23, 35, 36] Obstetric emergency simulation-based training has been shown to impact the knowledge, skills, and attitudes of healthcare professionals. Moreover, some studies have found that this type of training reduces maternal and neonatal morbidity and mortality, though other studies have failed to show an effect on clinical outcomes.[37-41]

Knowledge and skills deteriorate over time and must be maintained.[38, 42, 43] Studies show that the level of knowledge falls within 9–15 months after obstetric skills training,[38, 41, 44] and some studies suggest that annual obstetric skills training is necessary to combat this decline.[42, 45] Our findings allow us to differentiate between the obstetric events that require frequent simulation based training and the ones that can generally be maintained at a certain level based on daily clinical practice alone. Moreover, our results indicate which healthcare professionals can rely on maintaining their skills primarily through clinical practice and who needs additional obstetric skills training. However, some argue that training individual groups of healthcare professionals is inadequate, highlighting the importance of including all team members in a multidisciplinary team when training due to the complexity of the skills and the rarity of certain obstetric events.[38, 46]

Our results may be transferred to other clinical specialties in which rare clinical emergencies occur that require prompt and professional action by healthcare professionals, e.g. abdominal aortic aneurisms in cardiology[47] and paediatric emergency medicine.[48] Rare events in these medical specialties also represent a challenge in terms of learning the required skills via the traditional apprenticeship model and ongoing clinical work, which is why simulation based skills training is necessary.[49]

Conclusion

We found that some obstetric emergencies and high-risk deliveries were experienced so infrequently that the clinical skills required to competently manage the events is deemed to be impossible to obtain and maintain in clinical practice alone. Consequently, to enhance patient safety, reduce burnout in healthcare professionals, and minimise litigation costs, investing in supplementary training activities is the way forward to improving patient care. In this regard, our study contributes to assessing the need for supplementary educational initiatives.

Acknowledgments

We would like to thank the heads of midwifery from all maternity units in Denmark for providing us with data on the number of midwives employed in their units. We would like to express our deepest gratitude to senior advisor Steen Rasmussen, MSc, MPH, Rigshospitalet for managing the national registry data from the Danish Medical Birth Registry.

Contributorship statement

JLS created the idea. SH, LT, TB, ALR, MJ, and JLS participated in creating the study design. SH was responsible for collecting the data. SH and LT performed the analysis and drafted the initial manuscript. TB, ALR, MJ, and JLS reviewed and revised the manuscript for interpretation of data and critical revision of important intellectual content. All authors reviewed and approved the final manuscript as submitted.

Details of ethics approval

Approval was obtained from the Danish Data Protection Agency (file no.: 2012-58-0004). As this is a registry-based study it is not legally required to obtain ethics approval from the Danish National Research Ethics Committee.[50]

Disclosure of interest

The authors have no conflicts of interests to disclose.

Funding

This work was supported by TrygFonden, grant number 105632.

Data sharing statement

The data that support the findings of this study are available on request from the corresponding author, (SH).

References

1. Hoegh S, Thellesen L, Christensen KB, et al. Incidences of obstetric outcomes and sample size calculations: A Danish national registry study based on all deliveries from 2008 to 2015. *Acta Obstet Gynecol Scand* 2019 2019/08/02. DOI: 10.1111/aogs.13700.
2. ACOG Committee. Committee opinion no. 590: preparing for clinical emergencies in obstetrics and gynecology. *Obstet Gynecol* 2014; 123: 722-725. DOI: 10.1097/01.AOG.0000444442.04111.c6.
3. Oxford Dictionaries. https://en.oxforddictionaries.com (2018, accessed October 18 2018).
4. Khan KS, Wojdyla D, Say L, et al. WHO analysis of causes of maternal death: a systematic review. *The Lancet* 2006; 367: 1066-1074.
5. Cantwell R, Clutton-Brock T, Cooper G, et al. Saving Mothers' Lives: Reviewing maternal deaths to make motherhood safer: 2006-2008. The Eighth Report of the Confidential Enquiries into Maternal Deaths in the United Kingdom. *BJOG* 2011; 118 Suppl 1: 1-203. DOI: 10.1111/j.1471-0528.2010.02847.x.
6. Ozimek JA, Eddins RM, Greene N, et al. Opportunities for improvement in care among women with severe maternal morbidity. *Am J Obstet Gynecol* 2016; 215: 509 e501-506. DOI: 10.1016/j.ajog.2016.05.022.

7. Berglund S, Grunewald C, Pettersson H, et al. Risk factors for asphyxia associated with substandard care during labor. *Acta Obstet Gynecol Scand* 2010; 89: 39-48. DOI: 10.3109/00016340903418751.
8. Milsom I, Ladfors L, Thiringer K, et al. Influence of maternal, obstetric and fetal risk factors on the prevalence of birth asphyxia at term in a Swedish urban population. *Acta Obstet Gynecol Scand* 2002; 81: 909-917.
9. Hannah ME, Hannah WJ, Hewson SA, et al. Planned caesarean section versus planned vaginal birth for breech presentation at term: a randomised multicentre trial. Term Breech Trial Collaborative Group. *Lancet* 2000; 356: 1375-1383.
10. Barrett JF, Hannah ME, Hutton EK, et al. A randomized trial of planned cesarean or vaginal delivery for twin pregnancy. *N Engl J Med* 2013; 369: 1295-1305. 2013/10/04. DOI: 10.1056/NEJMoa1214939.
11. Hove LD, Bock J, Christoffersen JK, et al. Analysis of 127 peripartum hypoxic brain injuries from closed claims registered by the Danish Patient Insurance Association. *Acta Obstet Gynecol Scand* 2008; 87: 72-75. DOI: 10.1080/00016340701797567.
12. Berglund S, Pettersson H, Cnattingius S, et al. How often is a low Apgar score the result of substandard care during labour? *BJOG* 2010; 117: 968-978. DOI: 10.1111/j.1471-0528.2010.02565.x.
13. MBRRACE-UK. *MBRRACE-UK 2017 Perinatal Confidential Enquiry: Term, singleton, intrapartum stillbirth and intrapartum-related neonatal death.* . 2017. Leicester: The Infant Mortality and Morbidity Studies, Department of Health Sciences, University of Leicester:.
14. MBRRACE-UK. *Saving Lives, Improving Mothers' Care - Lessons learned to inform maternity care from the UK and Ireland Confidential Enquiries into Maternal Deaths and Morbidity 2013–15.* 2017. Oxford: National Perinatal Epidemiology Unit, University of Oxford.
15. Berglund S, Grunewald C, Pettersson H, et al. Severe asphyxia due to delivery-related malpractice in Sweden 1990-2005. *BJOG* 2008; 115: 316-323. DOI: 10.1111/j.1471-0528.2007.01602.x.
16. Knight M, Bunch K, Tuffnell D, et al. *Saving Lives, Improving Mothers' Care. Lessons learned to inform maternity care from the UK and Ireland Confidential Enquiries into Maternal Deaths and Morbidity 2015-17*. 2019. Oxford: National Perinatal Epidemiology Unit, University of Oxford.
17. Seys D, Wu AW, Van Gerven E, et al. Health care professionals as second victims after adverse events: a systematic review. *Eval Health Prof* 2013; 36: 135-162. 2012/09/15. DOI: 10.1177/0163278712458918.
18. Wahlberg A, Andreen Sachs M, Johannesson K, et al. Post-traumatic stress symptoms in Swedish obstetricians and midwives after severe obstetric events: a cross-sectional retrospective survey. *BJOG* 2017; 124: 1264-1271. 2016/08/27. DOI: 10.1111/1471-0528.14259.
19. Robertson JH and Thomson AM. An exploration of the effects of clinical negligence litigation on the practice of midwives in England: A phenomenological study. *Midwifery* 2016; 33: 55-63. 2015/11/04. DOI: 10.1016/j.midw.2015.10.005.
20. Bourne T, Vanderhaegen J, Vranken R, et al. Doctors' experiences and their perception of the most stressful aspects of complaints processes in the UK: an analysis of qualitative survey data. *BMJ Open* 2016; 6: e011711. 2016/07/06. DOI: 10.1136/bmjopen-2016-011711.

21. Wu AW. Medical error: the second victim. The doctor who makes the mistake needs help too. *BMJ* 2000; 320: 726-727. 2000/03/17. DOI: 10.1136/bmj.320.7237.726.
22. Yau CWH, Leigh B, Liberati E, et al. Clinical negligence costs: taking action to safeguard NHS sustainability. *BMJ* 2020; 368: m552. 2020/03/04. DOI: 10.1136/bmj.m552.
23. NHS Litigation Authority. *Ten years of maternity claims. An analysis of nhs litigation authority data.* 2012. London: NHS LA.
24. National Health Data Authority. Medicinsk Fødselsregister, https://sundhedsdatastyrelsen.dk/da/registre-og-services/om-de-nationale-sundhedsregistre/graviditet-foedsler-og-boern/foedselsregisteret (accessed 11 April 2018).
25. Sundhedsstyrelsen. *Anbefalinger for svangreomsorgen*. 2013. Copenhagen.
26. National Board of Health. *Postgraduate medical training in Denmark – status and future perspectives. Summary in English*. 2012. Copenhagen: National Board of Health.
27. Danish Health Authority. *Lægeprognose 2015-2040 Udbuddet af læger og speciallæger*. 2016. Copenhagen: Sundhedsstyrelsen.
28. Danish Health Authority. *Opslåede og besatte hoveduddannelsesforløb i 2016*. 2017. Copenhagen.
29. Thellesen L, Sorensen JL, Hedegaard M, et al. Cardiotocography interpretation skills and the association with size of maternity unit, years of obstetric work experience and healthcare professional background: a national cross-sectional study. *Acta Obstet Gynecol Scand* 2017; 96: 1075-1083. DOI: 10.1111/aogs.13171.
30. Langhoff-Roos J, Krebs L, Klungsoyr K, et al. The Nordic medical birth registers--a potential goldmine for clinical research. *Acta Obstet Gynecol Scand* 2014; 93: 132-137.
31. World Health Organization. *International Classification of Diseases and Related Health Problems*. 2016.
32. Nordic Centre for Classification in Healthcare. NOMESCO Classification of Surgical Procedures (NSCP), https://medinfo.dk/sks/brows.php (2012, Version 1.16).
33. Bliddal M, Broe A, Pottegard A, et al. The Danish Medical Birth Register. *Eur J Epidemiol* 2018; 33: 27-36. 2018/01/20. DOI: 10.1007/s10654-018-0356-1.
34. Cook DA, Hatala R, Brydges R, et al. Technology-enhanced simulation for health professions education: a systematic review and meta-analysis. *JAMA* 2011; 306: 978-988. 2011/09/09. DOI: 10.1001/jama.2011.1234.
35. and ACoO and Gynecologists. Committee opinion no. 590: preparing for clinical emergencies in obstetrics and gynecology. *Obstet Gynecol* 2014; 123: 722-725. 2014/02/21. DOI: 10.1097/01.AOG.0000444442.04111.c6.
36. Gardner R and Raemer DB. Simulation in obstetrics and gynecology. *Obstet Gynecol Clin North Am* 2008; 35: 97-127, ix. 2008/03/06. DOI: 10.1016/j.ogc.2007.12.008.
37. Bergh AM, Baloyi S and Pattinson RC. What is the impact of multi-professional emergency obstetric and neonatal care training? *Best Pract Res Clin Obstet Gynaecol* 2015; 29: 1028-1043. DOI: 10.1016/j.bpobgyn.2015.03.017.
38. Merien AE, van de Ven J, Mol BW, et al. Multidisciplinary team training in a simulation setting for acute obstetric emergencies: a systematic review. *Obstet Gynecol* 2010; 115: 1021-1031. DOI: 10.1097/AOG.0b013e3181d9f4cd.
39. Draycott T, Sibanda T, Owen L, et al. Does training in obstetric emergencies improve neonatal outcome? *BJOG* 2006; 113: 177-182. 2006/01/18. DOI: 10.1111/j.1471-0528.2006.00800.x.
40. Lenguerrand E, Winter C, Siassakos D, et al. Effect of hands-on interprofessional simulation training for local emergencies in Scotland: the THISTLE stepped-wedge design

randomised controlled trial. *BMJ Qual Saf* 2020; 29: 122-134. 2019/07/16. DOI: 10.1136/bmjqs-2018-008625.
41. Sorensen JL, Lokkegaard E, Johansen M, et al. The implementation and evaluation of a mandatory multi-professional obstetric skills training program. *Acta Obstet Gynecol Scand* 2009; 88: 1107-1117. DOI: 10.1080/00016340903176834.
42. Crofts JF, Fox R, Draycott TJ, et al. Retention of factual knowledge after practical training for intrapartum emergencies. *Int J Gynaecol Obstet* 2013; 123: 81-85. DOI: 10.1016/j.ijgo.2013.04.015.
43. Crofts JF, Bartlett C, Ellis D, et al. Management of shoulder dystocia: skill retention 6 and 12 months after training. *Obstet Gynecol* 2007; 110: 1069-1074. 2007/11/06. DOI: 10.1097/01.AOG.0000286779.41037.38.
44. Nelissen E, Ersdal H, Mduma E, et al. Helping Mothers Survive Bleeding After Birth: retention of knowledge, skills, and confidence nine months after obstetric simulation-based training. *BMC Pregnancy Childbirth* 2015; 15: 190. 2015/08/26. DOI: 10.1186/s12884-015-0612-2.
45. Draycott TJ, Collins KJ, Crofts JF, et al. Myths and realities of training in obstetric emergencies. *Best Pract Res Clin Obstet Gynaecol* 2015; 29: 1067-1076. 2015/08/10. DOI: 10.1016/j.bpobgyn.2015.07.003.
46. Siassakos D, Fox R, Bristowe K, et al. What makes maternity teams effective and safe? Lessons from a series of research on teamwork, leadership and team training. *Acta Obstet Gynecol Scand* 2013; 92: 1239-1243. 2013/08/29. DOI: 10.1111/aogs.12248.
47. Lilja F, Mani K and Wanhainen A. Editor's Choice - Trend-break in Abdominal Aortic Aneurysm Repair With Decreasing Surgical Workload. *Eur J Vasc Endovasc Surg* 2017; 53: 811-819. 2017/04/11. DOI: 10.1016/j.ejvs.2017.02.031.
48. Meyer L, Stubbs B, Fahrenbruch C, et al. Incidence, causes, and survival trends from cardiovascular-related sudden cardiac arrest in children and young adults 0 to 35 years of age: a 30-year review. *Circulation* 2012; 126: 1363-1372. 2012/08/14. DOI: 10.1161/CIRCULATIONAHA.111.076810.
49. Nayahangan LJ, Lawaetz J, Strom M, et al. Ensuring Competency in Open Aortic Aneurysm Repair - Development and Validation of a New Assessment Tool. *Eur J Vasc Endovasc Surg* 2020; 59: 767-774. 2020/02/25. DOI: 10.1016/j.ejvs.2020.01.021.
50. The National Committee on Health Research Ethics. Act on Research Ethics Review of Health Research Projects: Part 4, section 14-2, http://www.nvk.dk/english/act-on-research (2013, accessed June 18 2018).

Table Caption List

Table 1. Approximate number of obstetric healthcare professionals working in Danish labour wards in 2018

Table 2. Estimated time between obstetric emergency or high-risk delivery divided across midwives, specialty trainees, and doctors specialised in obstetrics and gynaecology.

Table 3. Estimated time between expected obstetric emergency or high-risk delivery managed by either a specialty trainee or doctor specialised in obstetrics and gynaecology.

Table 1. Approximate numbers of obstetric healthcare professionals working in one of the 21 Danish hospital labour wards in 2018.

Obstetric healthcare professionals	Approximate number of healthcare professionals
Midwives	1300
Specialty trainees in obstetrics and gynaecology	180
Doctors specialising in obstetrics and gynaecology	340

Table 2. Estimated time between obstetric emergency or high-risk delivery divided across midwives, specialty trainees, and doctors specialised in obstetrics and gynaecology

Obstetric events[a,b]	Incidence (%)	Expected time between obstetric events[c] divided across healthcare professionals		
		Midwives	Specialty trainees	Specialist doctors
Eclampsia	0.05	42 years	6 years	11 years
Umbilical cord prolapse	0.10	21 years	3 years	5.5 years
Singleton vaginal breech delivery	0.50	4 years	7 months	1 year
Apgar score <7/5 min.	0.90	2.5 years	4 months	8 months
Shoulder dystocia	1.00	2 years	4 months	7 months
Vaginal twin delivery	1.00	2 years	4 months	7 months
Severe postpartum haemorrhage	6.40	4 months	17 days	1 month
Vacuum extraction	7.00	4 months	15 days	1 month
Emergency caesarean section	12.20	2 months	9 days	16 days

Calculations based on the assumption that all healthcare professionals can learn from an event if they participate hands-on, observe or assist at the event.

[a] One delivery can be represented more than once at the obstetric events.

[b] The obstetric event incidence is based on deliveries in Denmark from 2008–2015, with gestational age 20+0 to 45+0. In the event of multiple foetuses in one pregnancy, an event among one or more newborns counts.

[c] Number of events per year are calculated based on number of deliveries in Denmark in 2018 (61 273 deliveries). Numbers are rounded up or down to nearest 0.5 years or months.

Table 3. Estimated time between obstetric emergency or high-risk delivery managed by either a specialty trainee or a doctor specialising in obstetrics and gynaecology.

Obstetric events[a,b]	Incidence (%)	Time interval between events[c]
		Managed by either a specialty trainee or specialist doctor
Eclampsia	0.05	17 years
Umbilical cord prolapse	0.10	8.5 years
Singleton vaginal breech delivery	0.50	1.7 years
Apgar score <7/5 min.	0.90	11 months
Shoulder dystocia	1.00	10 months
Vaginal twin delivery	1.00	10 months
Severe postpartum haemorrhage	6.40	1.5 months
Vacuum extraction	7.00	1.5 months
Emergency caesarean section	12.20	25 days

The calculations are based on the assumption that only one healthcare professional can learn from the event (hands-on experience).

[b] The obstetric events included all deliveries in Denmark from 2008–2015, with gestational age 20+0 to 45+0. In the event of multiple foetuses in one pregnancy, an event among one or more of the newborns counts.

[c] Number of events are calculated based on the number of deliveries in 2018 in Denmark (61 273 deliveries). Numbers are rounded up or down to nearest 0.5 years or months.

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6-10
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	10
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	10
Bias	9	Describe any efforts to address potential sources of bias	9
Study size	10	Explain how the study size was arrived at	7-8
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	10-11
		(*b*) Describe any methods used to examine subgroups and interactions	10-11
		(*c*) Explain how missing data were addressed	N/A
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	N/A
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	11
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	N/A
		(b) Indicate number of participants with missing data for each variable of interest	N/A
Outcome data	15*	Report numbers of outcome events or summary measures	11-12
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	N/A
		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	12
Discussion			
Key results	18	Summarise key results with reference to study objectives	12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13-14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14-15
Generalisability	21	Discuss the generalisability (external validity) of the study results	15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	3

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

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

15

BMJ Open

How often will midwives and obstetricians experience obstetric emergencies or high-risk deliveries: a national cross-sectional study

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2021-050790.R1
Article Type:	Original research
Date Submitted by the Author:	03-Oct-2021
Complete List of Authors:	Høgh, Stinne; Rigshospitalet, Department of Obstetrics Thellessen, Line; Rigshospitalet University Hospital Bergholt, Thomas; Rigshospitalet, Dept. of Obstetrics and Gynecology Rom, Ane; Rigshospitalet, University of Copenhagen, Juliane Marie Centre for Children, Women and reproduction section 4074 Johansen, Marianne; Rigshospitalet, Department of obstetrics Sorensen, Jette Led; Rigshospitalet, University of Copenhagen, Juliane Marie Centre for Children, Women and reproduction section 4074; Jette Led Sorensen,
Primary Subject Heading:	Obstetrics and gynaecology
Secondary Subject Heading:	Emergency medicine, Epidemiology, Medical education and training, Obstetrics and gynaecology
Keywords:	OBSTETRICS, MEDICAL EDUCATION & TRAINING, ACCIDENT & EMERGENCY MEDICINE

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

How often will midwives and obstetricians experience obstetric emergencies or high-risk deliveries: a national cross-sectional study

Authors

Stinne Høgh[1], Line Thellesen[1], Thomas Bergholt[1,2], Ane Lilleøre Rom[1], Marianne Johansen[1] & Jette Led Sørensen[1,2]

Author affiliations and addresses

[1]Department of Obstetrics, Juliane Marie Centre, Rigshospitalet, University of Copenhagen, Blegdamsvej 9, 2100 Copenhagen, Denmark

[2]Department of Clinical Medicine, University of Copenhagen, Blegdamsvej 3B, 2200 Copenhagen, Denmark

Corresponding author

Stinne Høgh

Department of Obstetrics, Juliane Marie Centre, Rigshospitalet University Hospital, University of Copenhagen, Blegdamsvej 9, 2100 Copenhagen, Denmark

Tel: +45 22973556

Email address: stinne.hoegh@regionh.dk

Running title

Obtaining skills in managing obstetric emergencies

Abstract

Objective

To estimate how often midwives, specialty trainees, and doctors specialised in obstetrics and gynaecology are attending to specific obstetric emergencies or high-risk deliveries (obstetric events).

Design

A national cross-sectional study.

Setting

All hospital labour wards in Denmark.

Participants

Midwives (n=1303), specialty trainees (n=179), and doctors specialised in obstetrics and gynaecology (n=343) working in hospital labour wards (n=21) in Denmark in 2018.

Methods

Categories of obstetric events comprised of Apgar score <7/5 min, eclampsia, emergency caesarean sections, severe postpartum haemorrhage, shoulder dystocia, umbilical cord prolapse, vaginal breech deliveries, vaginal twin deliveries, and vacuum extraction. Data on number of healthcare professionals were obtained through the Danish maternity wards, the Danish Health Authority and the Danish Society of Obstetricians and Gynaecologists. We calculated the time interval between attending each obstetric event by dividing the number of events occurred with the number of healthcare professionals.

Outcome measures

The time interval between attending a specific obstetric event.

Results

The average time between experiencing obstetric events ranged from days to years. Emergency caesarean sections, which occur relatively frequent, were attended on average every other month by

midwives, every nine days for specialty trainees, and every 17 days by specialist doctors. On average, rare events like eclampsia were experienced by midwives only every 42 years, every six years by specialty trainees, and every 11 years by specialist doctors.

Conclusions

Some obstetric events occur extremely rarely, hindering the ability to obtain and maintain the clinical skills to manage them through clinical practice alone. By assessing the frequency of a healthcare professionals attending an obstetric emergency our study contributes to assessing the need for supplementary educational initiatives and interventions to learn and maintain clinical skills.

Strengths and limitations of this study

- The first study to calculate how often healthcare professionals can expect to attend specific obstetric emergencies or high-risk deliveries in clinical real life.
- The incidence of the obstetric events was based on a large data source comprising 465,919 deliveries during an eight-year period.
- The study comprised medical doctors and midwives working at all the labour wards throughout Denmark.
- Our findings are based on average estimates, and results may be skewed by national variation in clinical experience and interest as well as regional clinical practice.
- Differences in the size and level of specialisation in the labour wards may influence the frequency of experiencing the events.

Keywords

Obstetrics, pregnancy outcome, obstetric emergencies, obstetric nursing/education, emergency treatment

Disclosure of interest

The authors have no conflicts of interests to disclose.

Introduction

In high-income countries most pregnancies have good outcomes. Obstetric emergencies like eclampsia, severe postpartum haemorrhage, shoulder dystocia, and umbilical cord prolapse are fortunately rare obstetric events.[1] These potentially life threatening emergencies often occur unexpectedly, and require immediate action by healthcare professionals[2, 3] and may entail tragic consequences such as death or serious morbidity in women and/or newborns.[4-6]

Obstetric emergencies often occur in extremely stressful settings that require highly professional communication and teamwork skills in order to take appropriate action. Similarly, high-risk deliveries, like vaginal twin or breech deliveries, also require highly specialised skills in healthcare professionals attending the event to ensure good outcomes.[7-10]

Healthcare professionals must be qualified to manage these emergencies and high-risk deliveries (obstetric events) to ensure patient safety. However, audit based studies have shown how these events are not always managed according to well-known, evidence-based standards of obstetric care.[5, 6, 11-15] An analysis of 127 cases of peripartum hypoxic brain injuries in claims registered by the Danish Patient Insurance Association concluded that all of the injuries were potentially avoidable if standard obstetric care had been applied.[11] Substandard care was also found in 42% of deliveries with low Apgar scores in Sweden,[12] and in the United Kingdom in nearly half of intrapartum stillbirths and in half of the intrapartum-related neonatal deaths.[13] Studies of maternal deaths in the United Kingdom found that substandard care during pregnancy or delivery had occurred in 29% of cases.[16]

Clinical negligence is devastating to the family involved, just as the healthcare professionals involved may experience emotional, behavioural, and cognitive consequences in terms of anxiety, depression symptoms,[17] post-traumatic stress disorder,[18] and loss of professional confidence, leading to self-doubt, isolation, practicing defensive medicine, and fear.[19, 20] Healthcare professionals involved in cases of clinical negligence are often referred to as second victims.[17, 18, 21] Moreover, cases of clinical

negligence often entail high litigation and future healthcare costs.[22, 23] Hence, to safeguard the women and prevent avoidable harm due to substandard obstetric care, and subsequent litigation and healthcare costs, the level of quality of managing obstetric events must be improved. It is well-known that we are challenged in obtaining and maintaining the necessary clinical skills to manage rare obstetric events in "real work-life". However, no study has previously quantified this challenge.

This study aimed to estimate how often midwives, specialty trainees, and doctors specialised in obstetrics and gynaecology on average can expect to attend and get involved in obstetric emergencies and high-risk deliveries.

Methods

Study design and setting

We conducted a national cross-sectional study that included midwives, specialty trainees, and doctors specialised in obstetrics and gynaecology (specialist doctors) working clinically in hospital-based labour wards in Denmark in 2018. There are approximately 60,000 deliveries in Denmark annually, with 96-98% occurring at public hospitals and 2-3% as home births.[24]

In 2018 Denmark had 21 labour wards, all of them staffed with in-house, on-call specialist doctors in obstetrics and gynaecology as well as anaesthesiology specialist doctors. The wards vary in size and specialty level from highly specialised tertiary referral centres (the largest with about 7000 deliveries per year) to small departments with only 600–1000 deliveries per year. All low-risk deliveries are attended by midwives often accompanied by midwifery students, during the active phase of labour. Specialist doctors and specialty trainees are only involved when complications arise.[25] In high-risk deliveries, specialist doctors and specialty trainees are always involved, and managing the delivery is a collaborative team effort between the midwife, specialty trainee, and specialist doctor.

Population

Eligible for inclusion

Midwives, specialty trainees, and specialist doctors in obstetrics and gynaecology working clinically in a Danish labour ward in 2018 were eligible.

Midwives

In Denmark midwives must earn a bachelor's degree in midwifery. During the 3.5-year programme students spend half of their time in clinical placements, e.g. midwifery centres, labour wards, antenatal wards and postnatal wards. Most midwives work in shifts. When caring for women giving birth, midwives are qualified and authorised to work independently, though in collaboration with a doctor when complications arise. This study collected data on midwives working predominantly on labour wards. All the midwives were included as if they were working full-time.

Specialty trainees

In this study, specialty trainee refers to doctors in their five-year postgraduate medical specialist training programme in obstetrics and gynaecology. Mandatory general courses, specialty-specific courses, and research training are also part of the curriculum. Upon graduation they are qualified to examine and treat 90% of the conditions in the specialty.[26]

Specialist doctors

In this study specialist doctors refers to individuals who have completed their specialty training in obstetrics and gynaecology. A relatively large proportion of specialist doctors are subspecialised in either obstetrics or gynaecology, however with both groups participating in night shifts on the labour

wards. Specialist doctors on call have full responsibility for the labour ward and supervise specialty trainees. According to the Danish Health Association labour wards must, as a minimum, always have a specialist doctor or a last year specialty trainee on duty. We included only specialist doctors, working in hospitals, who also did night shifts on the labour wards.

The average work week for full-time healthcare professionals is 37 hours in Denmark. All healthcare professionals included in this study participated in obstetric night shifts.

Data collection

Healthcare professionals

Data on the number of obstetric healthcare professionals were collected in 2018 to obtain more valid data than would be possible had data been collected for previous years. Data on healthcare professionals were retrieved in various ways.

Midwives

The heads of midwifery in maternity units across Denmark were contacted by email in October 2018 and asked to provide data on the number of midwives employed in their labour wards.

Specialty trainees

Data on the number of specialty trainees was obtained through the Danish Health Authority, which regulates the number of specialty trainees.[27, 28]

Specialist doctors

The Danish Society of Obstetricians and Gynaecologists furnished data on the number of specialist doctors.

The data on the number of healthcare professionals working in labour wards were validated with data from a national quality assurance project called Safe Deliveries.[29]

Obstetric events

In this study the term obstetric events refers to both obstetric emergencies and high-risk deliveries, the former defined as serious, unexpected, and potentially life-threatening conditions that may occur in pregnancy, during labour, or after delivery, and which require immediate action by healthcare professionals,[2, 3] while the latter involve actual or potential hazards to the health or well-being of the mother or foetus. The incidence of obstetric events used in this study was calculated based on data from 465,919 deliveries from 2008–2015 and are reported in another paper.[1] Data were retrieved from the Danish Medical Birth Registry, which was established in 1973 and contains information on all deliveries in Denmark, including data on the mother, child, pregnancy, and delivery.[30] Diagnoses are registered using International Classification of Diseases codes (ICD), 10th revision [31] and surgery is coded by the Danish version of the NOMESCO Classification of Surgical Procedures (NCSP).[32] In Denmark, all individuals have a unique personal identification number, making it possible to conduct valid registry-based studies. Diagnoses in the Danish Medical Birth Registry have been validated, and the authors found that the more severe the condition, the higher the validity of the coding.[33]

The obstetric events included in our study were: Apgar score <7/5 min (ICD-10: DVA00-DVA06), eclampsia (ICD-10: O151, O152, O159), emergency caesarean section (NCSP: KMCA10A, KMCA10D, KMCA10E), severe postpartum haemorrhage (≥1000 ml) (ICD-10: O072, only ≥ 1000

ml), shoulder dystocia (ICD-10: O660, NCSP: KMAH15), umbilical cord prolapse (ICD-10: O690), vaginal breech delivery (NCSP: DUP07-DUP11, DUP16 without caesarean sections, NCSP: KMCA10), vaginal twin delivery (ICD-10: O300, without caesarean sections, NCSP: KMCA10), and instrumental delivery by vacuum extraction (NCSP: KMAE00, KMAE03, KMAE96). These critical events may result in maternal and neonatal mortality and morbidity, are often subjects of clinical training.[4, 5, 7, 11, 15] Moreover, obstetric healthcare professionals are expected to safely and expertly manage these events.

Statistical analysis

The outcome of interest was the estimated average time interval between the expected acquaintance with one obstetric event to the next similar obstetric event divided across the number of midwives, specialty trainees, and specialist doctors. We calculated the average time interval between the events by dividing the number of events per year (incidence times the total number of deliveries in 2018) with the number of healthcare professionals in the study (midwives, specialty trainees, and specialist doctors, respectively). The result was divided by 12 to calculate the number of months between a potentially experienced event. We based the analysis on the assumption that all healthcare professionals can learn from an event if they are either participating hands-on or are present in the delivery room as an observer or assistant. We, therefore, assumed that one event had a midwife, a specialty trainee, and a specialist doctor involved. Statistically the three groups of healthcare professionals therefore share an event.

Since the estimates constitute average numbers, they are presented as means. Probabilities of experiencing an obstetric emergency were calculated using Microsoft Excel (Microsoft Cooperation version 14.6.6).

Patient or public involvement

There was no direct patient or public involvement in this study.

Results

Denmark had 61,273 deliveries in 2018.[24] Table 1 presents data on the number of midwives, specialty trainees, and specialist doctors working at one of the 21 hospital labour wards. The number of midwives per labour ward ranged from 13 to 135.

Table 2 shows the incidences of the obstetric events and the average time interval between experiencing each of the studied obstetric event as midwives, specialty trainees, and specialist doctors in obstetrics and gynaecology. These estimates were calculated under the assumption that all healthcare professionals learn from an event if they either participate hands-on, observe the event, or act as an assistant.

Six of the obstetric events (eclampsia, Apgar score <7/5 min, umbilical cord prolapse, singleton vaginal breech delivery, shoulder dystocia, and vaginal twin delivery) occurred at a low incidence of 0.05–1.00%. Three of the events (severe postpartum haemorrhage, delivery by vacuum extraction, and emergency caesarean section) occurred relatively often, with an incidence of 6.4–12.2%. The time interval between the events differed depending on the incidence of the event and the group of healthcare professionals. Midwives experienced eclampsia only every 42 years on average, specialty trainees every six years, and specialist doctors every 11 years.

The events with relatively high incidence were hence experienced relatively more often. Emergency caesarean section, with an incidence of 12.2%, were experienced, on average, every other month for midwives, every nine days for specialty trainees, and every 17 days for specialist doctors. Instrumental delivery with vacuum extraction and severe postpartum haemorrhage, with an incidence of 7.0% and 6.4%, respectively, were, on average, experienced by midwives every four months, by specialty trainees every 16 days, and by specialist doctors once a month (Table 2).

Discussion

Main findings

In this Danish national cross-sectional study examining how often an obstetric healthcare professional can expect to be involved in an obstetric emergency or a high-risk delivery, we found that the average time interval between experiencing one of the obstetric events ranged from days to years. Our results show that midwives experienced the studied events less frequently than specialist doctors, and specialty trainees were found to experience the events most frequently.

Strengths and limitations

This study addressed a gap in the research literature by trying to estimate how often healthcare professionals can expect to experience specific obstetric emergencies or high-risk deliveries in a Danish healthcare setting. A strength of our study is that the incidence of the obstetric events was based on a large data source comprising 465,919 deliveries during an eight-year period. The exact number of midwives was difficult to obtain due to diversity in work tasks and work hours. Therefore, we included midwives working both part- and full-time on labour wards, which suggests that our results are conservative estimates.

Even though the number of healthcare professionals working on labour wards changes over time due to various organisational, political, and economic factors, our results are assumed to be the most valid estimates obtainable as minor variations in the numbers do not change the overall estimates substantially.

We used data on specific obstetric events from existing research, obtained for 2008–2015.[1] Data on the number of obstetric healthcare professionals were collected for 2018 since data from this year is assumed to be more valid compared to data for previous years due to the possibility of recall bias. Nationally, incidences of obstetric events are fairly consistent over the years. Therefore, we have no reason to believe that the different time periods used may have compromised the validity of our study results.[1]

Danish labour wards differ in size and level of specialisation. Consequently, healthcare professionals at large departments with a high level of specialisation will experience the events more often than healthcare professionals at smaller departments, and more frequently than our results suggest. Moreover, the time interval between attending the events may vary due to the variations in healthcare professionals' clinical preference as well as differences in regional clinical practice. Finally, data on incidences, e.g., vaginal breech deliveries, could be distributed unevenly between the labour wards due to different regional practices.

Our analysis assumed that the healthcare professionals may learn from a specific obstetric event if they are either providing care hands-on, are present in the delivery room either as an observer or as an assistant. However, if we base our findings on the assumption that each obstetric event only allow one from each healthcare worker profession, i.e., only one midwife, one specialty trainee, and one specialist doctor to learn from each event, then the frequency with which each of the attendants may potentially learn from these relative rare obstetric events fall significantly.

Interpretation

Our results suggest that midwives and specialist doctors can have a lifelong working life and only experience certain severe obstetric emergencies once or twice, if at all. When emergencies occur, however, healthcare professionals are expected to have the skills to manage the event according to well-known, evidence-based standards of obstetric care. As a result, healthcare professionals must always be prepared for obstetric emergencies to occur. Our findings show that it is unrealistic for healthcare professionals to obtain and maintain the competences required to manage rare obstetric events through clinical experience alone. Studies on trainee doctors' experience and confidence in managing vaginal breech deliveries and vaginal twin deliveries show that the confidence increased with increasing number of deliveries attended. [34, 35] Further, among trainees who did not intend to offer vaginal breech deliveries and vaginal twin deliveries, in 46% and 67%, the argument was that they did not have sufficient experience to manage these complex vaginal deliveries.[35]

A common feature of the events studied was that the time interval between emergencies or high-risk deliveries depended on the healthcare professional group, indicating that some groups can acquire the skills based primarily on clinical experience alone. However, alternative educational pathways should be provided for other groups. To improve patient safety, minimise litigation, and ameliorate the consequences for the healthcare professionals involved ensuring that they have the necessary skills to manage obstetric events must be prioritised.[22]

Educational approaches could be video-cases, E-learning, case-based interprofessional learning or simulation-based education.[36] Simulation-based education, which is a valuable supplement to traditional ways of learning through clinical practices and mentorship, represent one way of ensuring acquisition of clinical skills and maintenance hereof.[37] Simulation-based training can identify and correct common clinical errors made during emergencies, and has been recommended as a valuable standard supplementary to clinical practice in order to improve care provided.[23, 38, 39] Obstetric

emergency simulation-based training has been shown to impact the knowledge, skills, and attitudes of healthcare professionals. Moreover, some studies have found that this type of training reduces maternal and neonatal morbidity and mortality, though other studies have failed to show an effect on clinical outcomes.[40-44]

Knowledge and skills deteriorate over time and must be maintained.[41, 45, 46] Studies show that the level of knowledge falls within 9–15 months after obstetric skills training,[41, 44, 47] and some studies suggest that annual obstetric skills training is necessary to combat this decline.[45, 48] Our findings allow us to differentiate between the obstetric events that require frequent simulation based training and the ones that can generally be maintained at a certain level based on daily clinical practice alone. Moreover, our results may indicate which healthcare professionals can rely on maintaining their skills primarily through clinical practice and who needs additional obstetric skills training. However, some argue that training individual groups of healthcare professionals is inadequate, highlighting the importance of including all team members in a multidisciplinary team when training due to the complexity of the skills and the rarity of certain obstetric events.[41, 49]

Our results may be relevant in other clinical specialties in which rare clinical emergencies occur that require prompt and professional action by healthcare professionals, e.g., abdominal aortic aneurysms in vascular surgery [50] and paediatric emergency medicine.[51] Rare events in these medical specialties also represent a challenge in terms of learning the required skills via the traditional apprenticeship model and ongoing clinical work, which is why simulation-based skills training is necessary.[52]

Finally, the results from this study only provide a part of the overall picture of training and maintaining the competences in managing rare complications.

Conclusion

We found that some obstetric emergencies and high-risk deliveries were experienced so infrequently that the clinical skills required to competently manage the events is deemed to be impossible to obtain and maintain in clinical practice alone. Consequently, to enhance patient safety, reduce burnout in healthcare professionals, and minimise litigation costs, investing in supplementary training activities is the way forward to improving patient care. In this regard, our study contributes to assessing the need for supplementary educational initiatives.

Acknowledgments

We would like to thank the heads of midwifery from all maternity units in Denmark for providing us with data on the number of midwives employed in their units. We would like to express our deepest gratitude to senior advisor Steen Rasmussen, MSc, MPH, Rigshospitalet for managing the national registry data from the Danish Medical Birth Registry.

Contributorship statement

JLS created the idea. SH, LT, TB, ALR, MJ, and JLS participated in creating the study design. SH was responsible for collecting the data. SH and LT performed the analysis and drafted the initial manuscript. TB, ALR, MJ, and JLS reviewed and revised the manuscript for interpretation of data and critical revision of important intellectual content. All authors reviewed and approved the final manuscript as submitted.

Details of ethics approval

Approval was obtained from the Danish Data Protection Agency (file no.: 2012-58-0004). As this is a registry-based study it is not legally required to obtain ethics approval from the Danish National Research Ethics Committee.

Disclosure of interest

The authors have no conflicts of interests to disclose.

Funding

This work was supported by TrygFonden, grant number 105632.

Data sharing statement

The data that support the findings of this study are available on request from the corresponding author, (SH).

References

1. Hoegh S, Thellesen L, Christensen KB, et al. Incidences of obstetric outcomes and sample size calculations: A Danish national registry study based on all deliveries from 2008 to 2015. *Acta Obstet Gynecol Scand* 2019 2019/08/02. DOI: 10.1111/aogs.13700.
2. ACOG Committee. Committee opinion no. 590: preparing for clinical emergencies in obstetrics and gynecology. *Obstet Gynecol* 2014; 123: 722-725. DOI: 10.1097/01.AOG.0000444442.04111.c6.
3. Oxford Dictionaries. https://en.oxforddictionaries.com (2018, accessed October 18 2018).
4. Khan KS, Wojdyla D, Say L, et al. WHO analysis of causes of maternal death: a systematic review. *The Lancet* 2006; 367: 1066-1074.
5. Cantwell R, Clutton-Brock T, Cooper G, et al. Saving Mothers' Lives: Reviewing maternal deaths to make motherhood safer: 2006-2008. The Eighth Report of the Confidential Enquiries into Maternal Deaths in the United Kingdom. *BJOG* 2011; 118 Suppl 1: 1-203. DOI: 10.1111/j.1471-0528.2010.02847.x.
6. Ozimek JA, Eddins RM, Greene N, et al. Opportunities for improvement in care among women with severe maternal morbidity. *Am J Obstet Gynecol* 2016; 215: 509 e501-506. DOI: 10.1016/j.ajog.2016.05.022.
7. Berglund S, Grunewald C, Pettersson H, et al. Risk factors for asphyxia associated with substandard care during labor. *Acta Obstet Gynecol Scand* 2010; 89: 39-48. DOI: 10.3109/00016340903418751.
8. Milsom I, Ladfors L, Thiringer K, et al. Influence of maternal, obstetric and fetal risk factors on the prevalence of birth asphyxia at term in a Swedish urban population. *Acta Obstet Gynecol Scand* 2002; 81: 909-917.

9. Hannah ME, Hannah WJ, Hewson SA, et al. Planned caesarean section versus planned vaginal birth for breech presentation at term: a randomised multicentre trial. Term Breech Trial Collaborative Group. *Lancet* 2000; 356: 1375-1383.
10. Barrett JF, Hannah ME, Hutton EK, et al. A randomized trial of planned cesarean or vaginal delivery for twin pregnancy. *N Engl J Med* 2013; 369: 1295-1305. 2013/10/04. DOI: 10.1056/NEJMoa1214939.
11. Hove LD, Bock J, Christoffersen JK, et al. Analysis of 127 peripartum hypoxic brain injuries from closed claims registered by the Danish Patient Insurance Association. *Acta Obstet Gynecol Scand* 2008; 87: 72-75. DOI: 10.1080/00016340701797567.
12. Berglund S, Pettersson H, Cnattingius S, et al. How often is a low Apgar score the result of substandard care during labour? *BJOG* 2010; 117: 968-978. DOI: 10.1111/j.1471-0528.2010.02565.x.
13. MBRRACE-UK. *MBRRACE-UK 2017 Perinatal Confidential Enquiry: Term, singleton, intrapartum stillbirth and intrapartum-related neonatal death.* . 2017. Leicester: The Infant Mortality and Morbidity Studies, Department of Health Sciences, University of Leicester:.
14. MBRRACE-UK. *Saving Lives, Improving Mothers' Care - Lessons learned to inform maternity care from the UK and*
Ireland Confidential Enquiries into Maternal Deaths and Morbidity 2013–15. 2017. Oxford: National Perinatal
Epidemiology Unit, University of Oxford.
15. Berglund S, Grunewald C, Pettersson H, et al. Severe asphyxia due to delivery-related malpractice in Sweden 1990-2005. *BJOG* 2008; 115: 316-323. DOI: 10.1111/j.1471-0528.2007.01602.x.
16. Knight M, Bunch K, Tuffnell D, et al. *Saving Lives, Improving Mothers' Care. Lessons learned to inform maternity care from the UK and Ireland Confidential Enquiries into Maternal Deaths and Morbidity 2015-17*. 2019. Oxford: National Perinatal Epidemiology Unit, University of Oxford.
17. Seys D, Wu AW, Van Gerven E, et al. Health care professionals as second victims after adverse events: a systematic review. *Eval Health Prof* 2013; 36: 135-162. 2012/09/15. DOI: 10.1177/0163278712458918.
18. Wahlberg A, Andreen Sachs M, Johannesson K, et al. Post-traumatic stress symptoms in Swedish obstetricians and midwives after severe obstetric events: a cross-sectional retrospective survey. *BJOG* 2017; 124: 1264-1271. 2016/08/27. DOI: 10.1111/1471-0528.14259.
19. Robertson JH and Thomson AM. An exploration of the effects of clinical negligence litigation on the practice of midwives in England: A phenomenological study. *Midwifery* 2016; 33: 55-63. 2015/11/04. DOI: 10.1016/j.midw.2015.10.005.
20. Bourne T, Vanderhaegen J, Vranken R, et al. Doctors' experiences and their perception of the most stressful aspects of complaints processes in the UK: an analysis of qualitative survey data. *BMJ Open* 2016; 6: e011711. 2016/07/06. DOI: 10.1136/bmjopen-2016-011711.
21. Wu AW. Medical error: the second victim. The doctor who makes the mistake needs help too. *BMJ* 2000; 320: 726-727. 2000/03/17. DOI: 10.1136/bmj.320.7237.726.
22. Yau CWH, Leigh B, Liberati E, et al. Clinical negligence costs: taking action to safeguard NHS sustainability. *BMJ* 2020; 368: m552. 2020/03/04. DOI: 10.1136/bmj.m552.
23. NHS Litigation Authority. *Ten years of maternity claims. An analysis of nhs litigation authority data.* 2012. London: NHS LA.

24. National Health Data Authority. Medicinsk Fødselsregister, https://sundhedsdatastyrelsen.dk/da/registre-og-services/om-de-nationale-sundhedsregistre/graviditet-foedsler-og-boern/foedselsregisteret (accessed 11 April 2018).
25. Sundhedsstyrelsen. *Anbefalinger for svangreomsorgen*. 2013. Copenhagen.
26. National Board of Health. *Postgraduate medical training in Denmark – status and future perspectives. Summary in English*. 2012. Copenhagen: National Board of Health.
27. Danish Health Authority. *Lægeprognose 2015-2040 Udbuddet af læger og speciallæger*. 2016. Copenhagen: Sundhedsstyrelsen.
28. Danish Health Authority. *Opslåede og besatte hoveduddannelsesforløb i 2016*. 2017. Copenhagen.
29. Thellesen L, Sorensen JL, Hedegaard M, et al. Cardiotocography interpretation skills and the association with size of maternity unit, years of obstetric work experience and healthcare professional background: a national cross-sectional study. *Acta Obstet Gynecol Scand* 2017; 96: 1075-1083. DOI: 10.1111/aogs.13171.
30. Langhoff-Roos J, Krebs L, Klungsoyr K, et al. The Nordic medical birth registers--a potential goldmine for clinical research. *Acta Obstet Gynecol Scand* 2014; 93: 132-137.
31. World Health Organization. *International Classification of Diseases and Related Health Problems*. 2016.
32. Nordic Centre for Classification in Healthcare. NOMESCO Classification of Surgical Procedures (NSCP), https://medinfo.dk/sks/brows.php (2012, Version 1.16).
33. Bliddal M, Broe A, Pottegard A, et al. The Danish Medical Birth Register. *Eur J Epidemiol* 2018; 33: 27-36. 2018/01/20. DOI: 10.1007/s10654-018-0356-1.
34. Chinnock M and Robson S. Obstetric trainees' experience in vaginal breech delivery: implications for future practice. *Obstet Gynecol* 2007; 110: 900-903. 2007/10/02. DOI: 10.1097/01.AOG.0000267199.32847.c4.
35. Yeoh SGJ, Rolnik DL, Regan JA, et al. Experience and confidence in vaginal breech and twin deliveries among obstetric trainees and new specialists in Australia and New Zealand. *Aust N Z J Obstet Gynaecol* 2019; 59: 545-549. 2018/12/20. DOI: 10.1111/ajo.12931.
36. Topperzer MK, Roug LI, Andres-Jensen L, et al. Twelve tips for postgraduate interprofessional case-based learning. *Med Teach* 2021: 1-14. 2021/03/25. DOI: 10.1080/0142159X.2021.1896691.
37. Cook DA, Hatala R, Brydges R, et al. Technology-enhanced simulation for health professions education: a systematic review and meta-analysis. *JAMA* 2011; 306: 978-988. 2011/09/09. DOI: 10.1001/jama.2011.1234.
38. and ACoO and Gynecologists. Committee opinion no. 590: preparing for clinical emergencies in obstetrics and gynecology. *Obstet Gynecol* 2014; 123: 722-725. 2014/02/21. DOI: 10.1097/01.AOG.0000444442.04111.c6.
39. Gardner R and Raemer DB. Simulation in obstetrics and gynecology. *Obstet Gynecol Clin North Am* 2008; 35: 97-127, ix. 2008/03/06. DOI: 10.1016/j.ogc.2007.12.008.
40. Bergh AM, Baloyi S and Pattinson RC. What is the impact of multi-professional emergency obstetric and neonatal care training? *Best Pract Res Clin Obstet Gynaecol* 2015; 29: 1028-1043. DOI: 10.1016/j.bpobgyn.2015.03.017.
41. Merien AE, van de Ven J, Mol BW, et al. Multidisciplinary team training in a simulation setting for acute obstetric emergencies: a systematic review. *Obstet Gynecol* 2010; 115: 1021-1031. DOI: 10.1097/AOG.0b013e3181d9f4cd.

42. Draycott T, Sibanda T, Owen L, et al. Does training in obstetric emergencies improve neonatal outcome? *BJOG* 2006; 113: 177-182. 2006/01/18. DOI: 10.1111/j.1471-0528.2006.00800.x.
43. Lenguerrand E, Winter C, Siassakos D, et al. Effect of hands-on interprofessional simulation training for local emergencies in Scotland: the THISTLE stepped-wedge design randomised controlled trial. *BMJ Qual Saf* 2020; 29: 122-134. 2019/07/16. DOI: 10.1136/bmjqs-2018-008625.
44. Sorensen JL, Lokkegaard E, Johansen M, et al. The implementation and evaluation of a mandatory multi-professional obstetric skills training program. *Acta Obstet Gynecol Scand* 2009; 88: 1107-1117. DOI: 10.1080/00016340903176834.
45. Crofts JF, Fox R, Draycott TJ, et al. Retention of factual knowledge after practical training for intrapartum emergencies. *Int J Gynaecol Obstet* 2013; 123: 81-85. DOI: 10.1016/j.ijgo.2013.04.015.
46. Crofts JF, Bartlett C, Ellis D, et al. Management of shoulder dystocia: skill retention 6 and 12 months after training. *Obstet Gynecol* 2007; 110: 1069-1074. 2007/11/06. DOI: 10.1097/01.AOG.0000286779.41037.38.
47. Nelissen E, Ersdal H, Mduma E, et al. Helping Mothers Survive Bleeding After Birth: retention of knowledge, skills, and confidence nine months after obstetric simulation-based training. *BMC Pregnancy Childbirth* 2015; 15: 190. 2015/08/26. DOI: 10.1186/s12884-015-0612-2.
48. Draycott TJ, Collins KJ, Crofts JF, et al. Myths and realities of training in obstetric emergencies. *Best Pract Res Clin Obstet Gynaecol* 2015; 29: 1067-1076. 2015/08/10. DOI: 10.1016/j.bpobgyn.2015.07.003.
49. Siassakos D, Fox R, Bristowe K, et al. What makes maternity teams effective and safe? Lessons from a series of research on teamwork, leadership and team training. *Acta Obstet Gynecol Scand* 2013; 92: 1239-1243. 2013/08/29. DOI: 10.1111/aogs.12248.
50. Lilja F, Mani K and Wanhainen A. Editor's Choice - Trend-break in Abdominal Aortic Aneurysm Repair With Decreasing Surgical Workload. *Eur J Vasc Endovasc Surg* 2017; 53: 811-819. 2017/04/11. DOI: 10.1016/j.ejvs.2017.02.031.
51. Meyer L, Stubbs B, Fahrenbruch C, et al. Incidence, causes, and survival trends from cardiovascular-related sudden cardiac arrest in children and young adults 0 to 35 years of age: a 30-year review. *Circulation* 2012; 126: 1363-1372. 2012/08/14. DOI: 10.1161/CIRCULATIONAHA.111.076810.
52. Nayahangan LJ, Lawaetz J, Strom M, et al. Ensuring Competency in Open Aortic Aneurysm Repair - Development and Validation of a New Assessment Tool. *Eur J Vasc Endovasc Surg* 2020; 59: 767-774. 2020/02/25. DOI: 10.1016/j.ejvs.2020.01.021.

Table Caption List

Table 1. Number of obstetric healthcare professionals working in Danish labour wards in 2018

Table 2. Estimated time between obstetric emergency or high-risk delivery divided across midwives, specialty trainees, and doctors specialised in obstetrics and gynaecology.

Table 1. Approximate numbers of obstetric healthcare professionals working in one of the 21 Danish hospital labour wards in 2018.

Obstetric healthcare professionals	**Number of healthcare professionals**
Midwives	1303
Specialty trainees in obstetrics and gynaecology	179
Doctors specialised obstetrics and gynaecology	343

Table 2. Estimated time between obstetric emergency or high-risk delivery divided across midwives, specialty trainees, and doctors specialised in obstetrics and gynaecology

Obstetric events[a,b]	Incidence (%)	Expected time between obstetric events[c] divided across healthcare professionals		
		Midwives	Specialty trainees	Specialist doctors
Eclampsia	0.05	42 years	6 years	11 years
Umbilical cord prolapse	0.10	21 years	3 years	5.5 years
Singleton vaginal breech delivery	0.50	4 years	7 months	1 year
Apgar score <7/5 min.	0.90	2.5 years	4 months	8 months
Shoulder dystocia	1.00	2 years	4 months	7 months
Vaginal twin delivery	1.00	2 years	4 months	7 months
Severe postpartum haemorrhage	6.40	4 months	17 days	1 month
Vacuum extraction	7.00	4 months	15 days	1 month
Emergency caesarean section	12.20	2 months	9 days	16 days

Calculations based on the assumption that all healthcare professionals can learn from an event if they participate hands-on, observe or assist at the event.

[a] One delivery can be represented more than once at the obstetric events.

[b] The obstetric event incidence is based on deliveries in Denmark from 2008–2015, with gestational age 20+0 to 45+0. In the event of multiple foetuses in one pregnancy, an event among one or more newborns counts.

[c] Number of events per year are calculated based on number of deliveries in Denmark in 2018 (61 273 deliveries). Numbers are rounded up or down to nearest 0.5 years or months.

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6-10
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	10
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	10
Bias	9	Describe any efforts to address potential sources of bias	9
Study size	10	Explain how the study size was arrived at	7-8
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	10-11
		(*b*) Describe any methods used to examine subgroups and interactions	10-11
		(*c*) Explain how missing data were addressed	N/A
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	N/A
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	11
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	N/A
		(b) Indicate number of participants with missing data for each variable of interest	N/A
Outcome data	15*	Report numbers of outcome events or summary measures	11-12
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	N/A
		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	12
Discussion			
Key results	18	Summarise key results with reference to study objectives	12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13-14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14-15
Generalisability	21	Discuss the generalisability (external validity) of the study results	15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	3

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

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

15