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

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4 1 **How often will midwives and obstetricians experience obstetric emergencies or high-risk**
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6 2 **deliveries: a national cross-sectional study**
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10
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50 21 **Running title**
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53 22 Obtaining skills in managing obstetric emergencies
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23 **Abstract**

24 **Objective**

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

27 **Design**

28 A national cross-sectional study.

29 **Setting**

30 All hospital labour wards in Denmark.

31 **Participants**

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

34 **Methods**

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

42 **Outcome measures**

43 The time interval between attending a specific obstetric event.

44 **Results**

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

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4 47 midwives, every nine days for specialty trainees, and every 17 days by specialist doctors. On average,
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6 48 rare events like eclampsia were experienced by midwives only every 42 years, every six years by
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9 49 specialty trainees, and every 11 years by specialist doctors.

11 50 **Conclusions**

12
13 51 Some obstetric events occur extremely rarely, hindering the ability to obtain and maintain the clinical
14
15 52 skills to manage them through clinical practice alone. By assessing the frequency of a healthcare
16
17 53 professionals attending an obstetric emergency our study contributes to assessing the need for
18
19 54 supplementary educational initiatives and interventions to learn and maintain clinical skills.
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23 55

25 56 **Strengths and limitations of this study**

- 27 57 • The first study to calculate how often healthcare professionals can expect to attend specific
28
29 58 obstetric emergencies or high-risk deliveries in clinical real life.
- 31
32 59 • The incidence of the obstetric events was based on a large data source comprising 465,919
33
34 60 deliveries.
- 35
36 61 • Even though the number of healthcare professionals working in labour wards are constantly
37
38 62 changing, our study results are assumed to be the most valid estimates obtainable as minor
39
40 63 variations in the number of healthcare professionals do not change the estimates substantially.
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44 64

48 65 **Keywords**

49
50 66 Obstetrics, pregnancy outcome, obstetric emergencies, obstetric nursing/education, emergency
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52 67 treatment
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57 68 **Disclosure of interest**

58
59 69 The authors have no conflicts of interests to disclose.
60

71 **Introduction**

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

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

81 Healthcare professionals must be qualified to manage these emergencies and high-risk deliveries
82 (obstetric events) to ensure patient safety. However, audit based studies have shown how these events
83 are not always managed according to well-known, evidence-based standards of obstetric care.^{5, 6, 11-}

84 ¹⁵ An analysis of 127 cases of peripartum hypoxic brain injuries in claims registered by the Danish
85 Patient Insurance Association concluded that all of the injuries were potentially avoidable if standard
86 obstetric care had been applied.¹¹ Substandard care was also found in 42% of deliveries with low
87 Apgar scores in Sweden,¹² and in the United Kingdom in nearly half of intrapartum stillbirths and in
88 half of the intrapartum-related neonatal deaths.¹³ Studies of maternal deaths in the United Kingdom
89 found that substandard care during pregnancy or delivery had occurred in 29% of cases.¹⁶

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

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4 95 negligence often entail high litigation and future healthcare costs.^{22, 23} Hence, to safeguard the women
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6 96 and prevent avoidable harm due to substandard obstetric care, and subsequent litigation and
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9 97 healthcare costs, the level of quality of managing obstetric events must be improved. The low
10
11 98 incidence rate of certain obstetric events, however, challenge healthcare professionals' opportunities
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14 99 to obtain and maintain the necessary clinical skills through daily clinical practice alone is a well-
15
16 100 known issue that needs addressing. However, no study has previously quantified this challenge.
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18 101
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20 102 To gauge the average number of opportunities, healthcare professionals have to obtain and maintain
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23 103 their proficiency in managing obstetric events, this study aimed to estimate how often midwives,
24
25 104 specialty trainees, and doctors specialised in obstetrics and gynaecology can expect to attend to and
26
27 105 get involved in obstetric emergencies and high-risk deliveries.
28

31 32 107 **Methods**

33 34 35 108 **Study design and setting**

36
37 109 We conducted a national cross-sectional study that included midwives, specialty trainees, and doctors
38
39 110 specialised in obstetrics and gynaecology (specialist doctors) working clinically in hospital-based
40
41
42 111 labour wards in Denmark in 2018. There are approximately 60,000 deliveries in Denmark annually,
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44 112 with 96-98% occurring at public hospitals and 2-3% as home births.²⁴
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46 113 In 2018 Denmark had 21 labour wards, all of them staffed with in-house, on-call specialist doctors in
47
48 114 obstetrics and gynaecology as well as anaesthesiology specialist doctors. The wards vary in size and
49
50
51 115 specialty level from highly specialised tertiary referral centres (the largest with about 7000 deliveries
52
53 116 per year) to small departments with only 600–1000 deliveries per year. All low-risk deliveries are
54
55 117 attended by midwives often accompanied by midwifery students, during the active phase of labour.
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58 118 Specialist doctors and specialty trainees are only involved when complications arise.²⁵ In high-risk
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4 119 deliveries, specialist doctors and specialty trainees are always involved, and managing the delivery
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6
7 120 is a collaborative team effort between the midwife, specialty trainee, and specialist doctor.
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11 122 **Population**

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13 123 **Eligible for inclusion**

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16 124 Midwives, specialty trainees, and specialist doctors in obstetrics and gynaecology working clinically
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18 125 in a Danish labour ward in 2018 were eligible.
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23 127 *Midwives*

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25 128 In Denmark midwives must earn a bachelor's degree in midwifery. During the 3.5-year programme
26
27 129 students spend half of their time in clinical placements, e.g. midwifery centres, labour wards,
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29
30 130 antenatal wards and postnatal wards. Most midwives work in shifts. When caring for women giving
31
32 131 birth, midwives are qualified and authorised to work independently, though in collaboration with a
33
34 132 doctor when complications arise. This study collected data on midwives working predominantly on
35
36 133 labour wards. All the midwives were included as if they were working full-time.
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41 135 *Specialty trainees*

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43 136 In this study, specialty trainee refers to doctors in their five-year postgraduate medical specialist
44
45
46 137 training programme in obstetrics and gynaecology. Mandatory general courses, specialty-specific
47
48 138 courses, and research training are also part of the curriculum. Upon graduation they are qualified to
49
50 139 examine and treat 90% of the conditions in the specialty.²⁶
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55 141 *Specialist doctors*

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4 142 In this study specialist doctors refers to individuals who have completed their specialty training in
5
6 143 obstetrics and gynaecology. A relatively large proportion of specialist doctors are subspecialised in
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8
9 144 either obstetrics or gynaecology, however with both groups participating in night shifts on the labour
10
11 145 wards. Specialist doctors on call have full responsibility for the labour ward and supervise specialty
12
13 146 trainees. According to the Danish Health Association labour wards must, as a minimum, always have
14
15
16 147 a specialist doctor or a last year specialty trainee on duty. We included only specialist doctors,
17
18 148 working in hospitals, who also did night shifts on the labour wards.
19

20 149
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22
23 150 The average work week for full-time healthcare professionals is 37 hours in Denmark. All healthcare
24
25 151 professionals included in this study participated in obstetric night shifts.
26

27 152 28 29 153 **Data collection**

30 154 **Healthcare professionals**

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32 155 Data on the number of obstetric healthcare professionals were collected in 2018 to obtain more valid
33
34 156 data than would be possible had data been collected for previous years. Data on healthcare
35
36 157 professionals were retrieved in various ways.
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41 158 42 43 159 *Midwives*

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45 160 The heads of midwifery in maternity units across Denmark were contacted by email in October 2018
46
47
48 161 and asked to provide data on the number of midwives employed in their labour wards.
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50 162 51 52 163 *Specialty trainees*

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54 164 Data on the number of specialty trainees was obtained through the Danish Health Authority, which
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57 165 regulates the number of specialty trainees.^{27, 28}
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167 *Specialist doctors*

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

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

173

174 **Obstetric events**

175 In this study the term obstetric events refers to both obstetric emergencies and high-risk deliveries,
176 the former defined as serious, unexpected, and potentially life-threatening conditions that may occur
177 in pregnancy, during labour, or after delivery, and which require immediate action by healthcare
178 professionals,^{2, 3} while the latter involve actual or potential hazards to the health or well-being of the
179 mother or foetus. The incidence of obstetric events used in this study was calculated based on data
180 from 465,919 deliveries from 2008–2015 and are reported in another paper.¹ Data were retrieved
181 from the Danish Medical Birth Registry, which was established in 1973 and contains information on
182 all deliveries in Denmark, including data on the mother, child, pregnancy, and delivery.³⁰ Diagnoses
183 are registered using International Classification of Diseases codes (ICD), 10th revision³¹ and surgery
184 is coded by the Danish version of the NOMESCO Classification of Surgical Procedures (NCSP).³²
185 In Denmark, all individuals have a unique personal identification number, making it possible to
186 conduct valid registry-based studies. Diagnoses in the Danish Medical Birth Registry have been
187 validated, and the authors found that the more severe the condition, the higher the validity of the
188 coding.³³

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4 189 The obstetric events included in our study were: Apgar score <7/5 min (ICD-10: DVA00-DVA06),
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6 190 eclampsia (ICD-10: O151, O152, O159), emergency caesarean section (NCSP: KMCA10A,
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9 191 KMCA10D, KMCA10E), severe postpartum haemorrhage (≥ 1000 ml) (ICD-10: O072, only ≥ 1000
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11 192 ml), shoulder dystocia (ICD-10: O660, NCSP: KMAH15), umbilical cord prolapse (ICD-10: O690),
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13 193 vaginal breech delivery (NCSP: DUP07-DUP11, DUP16 without caesarean sections, NCSP:
14
15
16 194 KMCA10), vaginal twin delivery (ICD-10: O300, without caesarean sections, NCSP: KMCA10), and
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18 195 instrumental delivery by vacuum extraction (NCSP: KMAE00, KMAE03, KMAE96). These critical
19
20 196 events may result in maternal and neonatal mortality and morbidity, are often subjects of clinical
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23 197 training.^{4, 5, 7, 11, 15} Moreover, obstetric healthcare professionals are expected to safely and expertly
24
25 198 manage these events.
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32 201 **Statistical analysis**

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34 202 The outcome of interest was the estimated average time interval between the expected acquaintance
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36 203 with one obstetric event to the next similar obstetric event divided across the number of midwives,
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39 204 specialty trainees, and specialist doctors. We calculated the average time interval between the events
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41 205 by dividing the occurrence of events per year (incidence times total number of deliveries in 2018)
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43 206 with the number of healthcare professionals in the study. The result was divided by 12 to calculate
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46 207 the number of months between a potentially experienced event. We based the analysis on the
47
48 208 assumption that all healthcare professionals can learn from an event if they are either participating
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50 209 hands-on or are present in the delivery room as an observer or assistant.
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52 210 The data was also analysed based on the alternative assumption that clinical skills can only be learned
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55 211 by playing an active role in managing the event. We only included specialty trainees and specialist
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4 212 doctors in these calculations, since they have ultimate responsibility for delivered care and clinical
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6 213 management of the respective obstetric events.
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9 214 Since the estimates constitute average numbers, they are presented as means. The average time
10
11 215 interval in years is presented on a logarithmic scale to illustrate the differences between the different
12
13 216 obstetric events and between different healthcare professionals. Probabilities of experiencing an
14
15 217 obstetric emergency were calculated using Microsoft Excel (Microsoft Cooperation version 14.6.6).
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20 219 **Patient or public involvement**

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23 220 There was no direct patient or public involvement in this study.
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28 222 **Results**

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30 223 Denmark had 61 273 deliveries in 2018.²⁴ Table 1 presents data on the number of midwives, specialty
31
32 224 trainees, and specialist doctors working at one of the 21 hospital labour wards. The number of
33
34 225 midwives per labour ward ranged from 13 to 135.
35

36 226

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38

39 227 Table 2 shows the incidences of the obstetric events and the average time interval between
40
41 228 experiencing each of the studied obstetric event as midwives, specialty trainees, and specialist doctors
42
43 229 in obstetrics and gynaecology. These estimates were calculated under the assumption that all
44
45 230 healthcare professionals learn from an event if they either participate hands-on, observe the event, or
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48 231 act as an assistant.
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53 233 Six of the obstetric events (eclampsia, Apgar score <7/5 min, umbilical cord prolapse, singleton
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55 234 vaginal breech delivery, shoulder dystocia, and vaginal twin delivery) occurred at a low incidence of
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57 235 0.05–1.00%. Three of the events (severe postpartum haemorrhage, delivery by vacuum extraction,
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236 and emergency caesarean section) occurred relatively often, with an incidence of 6.4–12.2%. The
237 time interval between the events differed depending on the incidence of the event and the group of
238 healthcare professionals. Midwives experienced eclampsia only every 42 years on average, specialty
239 trainees every six years, and specialist doctors every 11 years.

240
241 The events with relatively high incidence were hence experienced relatively more often. Emergency
242 caesarean section, with an incidence of 12.2%, were experienced, on average, every other month for
243 midwives, every nine days for specialty trainees, and every 17 days for specialist doctors.

244 Instrumental delivery with vacuum extraction and severe postpartum haemorrhage, with an incidence
245 of 7.0% and 6.4%, respectively, were, on average, experienced by midwives every four months, by
246 specialty trainees every 16 days, and by specialist doctors once a month (Table 2).

247
248 Table 3 depicts the time between events for doctors based on the assumption that only the healthcare
249 professional providing the first-line care can learn from the event. The time between experiencing
250 eclampsia increased from 6 to 17 years when performed independently by a specialty trainee, and
251 from 11 to 17 years when performed independently by a specialist doctor. The time interval between
252 experiencing an emergency caesarean section increased from 9 to 25 days and from 16 to 25 days for
253 a trainee and specialist doctor, respectively.

254

255 Discussion

256 *Main findings*

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

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

263

264 *Strengths and limitations*

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

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

276 We used data on specific obstetric events from existing research, obtained for 2008–2015.¹ Data on
277 the number of obstetric healthcare professionals were collected for 2018 since data from this year is
278 assumed to be more valid compared to data for previous years due to the possibility of recall bias.

279 Nationally, incidences of obstetric events are fairly consistent over the years. Therefore, we have
280 reason to believe that the different time periods used may have compromised the validity of our study
281 results.¹

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4 282 Danish labour wards differ in size and level of specialisation. Consequently, healthcare professionals
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6 283 at large departments with a high level of specialisation will experience the events more often than
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9 284 healthcare professionals at smaller departments, and more frequently than our results suggest.
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11 285 Our analysis assumed that the healthcare professionals may learn from a specific obstetric event if
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13 286 they are either providing care hands-on, are present in the delivery room either as an observer or as
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16 287 an assistant. However, if we base our findings on the assumption that each obstetric event only allow
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18 288 one from each healthcare worker profession, i.e., only one midwife, one specialty trainee, and one
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20 289 specialist doctor to learn from each event, then the frequency with which each of the attendants may
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22
23 290 potentially learn from these relative rare obstetric events fall significantly.
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25 291 26 27 292 *Interpretation* 28

29
30 293 Our results demonstrated that midwives and specialist doctors can have a lifelong working life and
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32 294 only experience certain severe obstetric emergencies once or twice, if at all. When emergencies occur,
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34 295 however, healthcare professionals are expected to have the skills to manage the event according to
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36 296 well-known, evidence-based standards of obstetric care. As a result, healthcare professionals must
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39 297 always be prepared for obstetric emergencies to occur. Our findings show that it is unrealistic for
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41 298 healthcare professionals to obtain and maintain the competences required to manage rare obstetric
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43 299 events through clinical experience alone. A common feature of the events studied is that the time
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46 300 interval between emergencies or high-risk deliveries depends on the healthcare professional group to
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48 301 which you belong, indicating that some groups can acquire the skills based primarily on clinical
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50 302 experience alone. However, alternative educational pathways must be provided for other groups. To
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53 303 improve patient safety, minimise litigation, and ameliorate the consequences for the healthcare
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55 304 professionals involved, ensuring that they have the necessary skills to manage obstetric events must
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57 305 be prioritised.²²
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4 306 Simulation-based education, which is a valuable supplement to traditional ways of learning through
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6 307 clinical practices and mentorship, represent one way of ensuring acquisition of clinical skills and
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9 308 maintenance hereof.³⁴ Simulation-based training can identify and correct common clinical errors
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11 309 made during emergencies, and has been recommended as a valuable standard supplementary to
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13 310 clinical practice in order to improve care provided.^{23, 35, 36} Obstetric emergency simulation-based
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16 311 training has been shown to impact the knowledge, skills, and attitudes of healthcare professionals.
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18 312 Moreover, some studies have found that this type of training reduces maternal and neonatal morbidity
19
20 313 and mortality, though other studies have failed to show an effect on clinical outcomes.³⁷⁻⁴¹
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22
23 314 Knowledge and skills deteriorate over time and must be maintained.^{38, 42, 43} Studies show that the
24
25 315 level of knowledge falls within 9–15 months after obstetric skills training,^{38, 41, 44} and some studies
26
27 316 suggest that annual obstetric skills training is necessary to combat this decline.^{42, 45} Our findings allow
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29
30 317 us to differentiate between the obstetric events that require frequent simulation based training and the
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32 318 ones that can generally be maintained at a certain level based on daily clinical practice alone.
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34 319 Moreover, our results indicate which healthcare professionals can rely on maintaining their skills
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36 320 primarily through clinical practice and who needs additional obstetric skills training. However, some
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39 321 argue that training individual groups of healthcare professionals is inadequate, highlighting the
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41 322 importance of including all team members in a multidisciplinary team when training due to the
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43 323 complexity of the skills and the rarity of certain obstetric events.^{38, 46}
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46 324 Our results may be transferred to other clinical specialties in which rare clinical emergencies occur
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48 325 that require prompt and professional action by healthcare professionals, e.g. abdominal aortic
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50 326 aneurisms in cardiology⁴⁷ and paediatric emergency medicine.⁴⁸ Rare events in these medical
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53 327 specialties also represent a challenge in terms of learning the required skills via the traditional
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55 328 apprenticeship model and ongoing clinical work, which is why simulation based skills training is
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57 329 necessary.⁴⁹
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331 **Conclusion**

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

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341 with data on the number of midwives employed in their units. We would like to express our deepest
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343 registry data from the Danish Medical Birth Registry.

345 **Contributorship statement**

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

352 **Details of ethics approval**

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

356 **Disclosure of interest**

357 The authors have no conflicts of interests to disclose.

359 **Funding**

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362 **Data sharing statement**

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

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4 514 **Table Caption List**

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6 515 **Table 1.** Approximate number of obstetric healthcare professionals working in Danish labour wards
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9 516 in 2018

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11 517 **Table 2.** Estimated time between obstetric emergency or high-risk delivery divided across midwives,
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13 518 specialty trainees, and doctors specialised in obstetrics and gynaecology.

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16 519 **Table 3.** Estimated time between expected obstetric emergency or high-risk delivery managed by
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18 520 either a specialty trainee or doctor specialised in obstetrics and gynaecology.

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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

For peer review only

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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.

BMJ Open

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

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Secondary Subject Heading:	Emergency medicine, Epidemiology, Medical education and training, Obstetrics and gynaecology
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4 1 **How often will midwives and obstetricians experience obstetric emergencies or high-risk**
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11 4 **Authors**
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50 21 **Running title**
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53 22 Obtaining skills in managing obstetric emergencies
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23 **Abstract**

24 **Objective**

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

27 **Design**

28 A national cross-sectional study.

29 **Setting**

30 All hospital labour wards in Denmark.

31 **Participants**

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

34 **Methods**

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

42 **Outcome measures**

43 The time interval between attending a specific obstetric event.

44 **Results**

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

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4 47 midwives, every nine days for specialty trainees, and every 17 days by specialist doctors. On average,
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6 48 rare events like eclampsia were experienced by midwives only every 42 years, every six years by
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9 49 specialty trainees, and every 11 years by specialist doctors.
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11 50 **Conclusions**

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13 51 Some obstetric events occur extremely rarely, hindering the ability to obtain and maintain the clinical
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15 52 skills to manage them through clinical practice alone. By assessing the frequency of a healthcare
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17 53 professionals attending an obstetric emergency our study contributes to assessing the need for
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19 54 supplementary educational initiatives and interventions to learn and maintain clinical skills.
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24 25 56 **Strengths and limitations of this study**

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27 57
- 28 • The first study to calculate how often healthcare professionals can expect to attend specific
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30 58 obstetric emergencies or high-risk deliveries in clinical real life.
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32 59 • The incidence of the obstetric events was based on a large data source comprising 465,919
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34 60 deliveries during an eight-year period.
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36 61 • The study comprised medical doctors and midwives working at all the labour wards
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38 62 throughout Denmark.
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40 63 • Our findings are based on average estimates, and results may be skewed by national variation
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42 64 in clinical experience and interest as well as regional clinical practice.
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44 65 • Differences in the size and level of specialisation in the labour wards may influence the
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46 66 frequency of experiencing the events.
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68 **Keywords**

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

71 **Disclosure of interest**

72 The authors have no conflicts of interests to disclose.

For peer review only

74 **Introduction**

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

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

84 Healthcare professionals must be qualified to manage these emergencies and high-risk deliveries
85 (obstetric events) to ensure patient safety. However, audit based studies have shown how these events
86 are not always managed according to well-known, evidence-based standards of obstetric care.^{5, 6, 11-}

87 ¹⁵ An analysis of 127 cases of peripartum hypoxic brain injuries in claims registered by the Danish
88 Patient Insurance Association concluded that all of the injuries were potentially avoidable if standard
89 obstetric care had been applied.¹¹ Substandard care was also found in 42% of deliveries with low
90 Apgar scores in Sweden,¹² and in the United Kingdom in nearly half of intrapartum stillbirths and in
91 half of the intrapartum-related neonatal deaths.¹³ Studies of maternal deaths in the United Kingdom
92 found that substandard care during pregnancy or delivery had occurred in 29% of cases.¹⁶

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

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4 98 negligence often entail high litigation and future healthcare costs.^{22, 23} Hence, to safeguard the women
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6 99 and prevent avoidable harm due to substandard obstetric care, and subsequent litigation and
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9 100 healthcare costs, the level of quality of managing obstetric events must be improved. It is well-known
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11 101 that we are challenged in obtaining and maintaining the necessary clinical skills to manage rare
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13 102 obstetric events in “real work-life”. However, no study has previously quantified this challenge.
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18 104 This study aimed to estimate how often midwives, specialty trainees, and doctors specialised in
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20 105 obstetrics and gynaecology on average can expect to attend and get involved in obstetric emergencies
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23 106 and high-risk deliveries.
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27 108 **Methods**

30 109 **Study design and setting**

32 110 We conducted a national cross-sectional study that included midwives, specialty trainees, and doctors
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34 111 specialised in obstetrics and gynaecology (specialist doctors) working clinically in hospital-based
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37 112 labour wards in Denmark in 2018. There are approximately 60,000 deliveries in Denmark annually,
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39 113 with 96-98% occurring at public hospitals and 2-3% as home births.²⁴
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41 114 In 2018 Denmark had 21 labour wards, all of them staffed with in-house, on-call specialist doctors in
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44 115 obstetrics and gynaecology as well as anaesthesiology specialist doctors. The wards vary in size and
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46 116 specialty level from highly specialised tertiary referral centres (the largest with about 7000 deliveries
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48 117 per year) to small departments with only 600–1000 deliveries per year. All low-risk deliveries are
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51 118 attended by midwives often accompanied by midwifery students, during the active phase of labour.
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53 119 Specialist doctors and specialty trainees are only involved when complications arise.²⁵ In high-risk
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55 120 deliveries, specialist doctors and specialty trainees are always involved, and managing the delivery
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58 121 is a collaborative team effort between the midwife, specialty trainee, and specialist doctor.
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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

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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

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4 169 The Danish Society of Obstetricians and Gynaecologists furnished data on the number of specialist
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7 170 doctors.

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11 172 The data on the number of healthcare professionals working in labour wards were validated with data
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14 173 from a national quality assurance project called Safe Deliveries.²⁹

15 16 174 17 18 175 **Obstetric events**

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20 176 In this study the term obstetric events refers to both obstetric emergencies and high-risk deliveries,
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23 177 the former defined as serious, unexpected, and potentially life-threatening conditions that may occur
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25 178 in pregnancy, during labour, or after delivery, and which require immediate action by healthcare
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27 179 professionals,^{2, 3} while the latter involve actual or potential hazards to the health or well-being of the
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30 180 mother or foetus. The incidence of obstetric events used in this study was calculated based on data
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32 181 from 465,919 deliveries from 2008–2015 and are reported in another paper.¹ Data were retrieved
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34 182 from the Danish Medical Birth Registry, which was established in 1973 and contains information on
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37 183 all deliveries in Denmark, including data on the mother, child, pregnancy, and delivery.³⁰ Diagnoses
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39 184 are registered using International Classification of Diseases codes (ICD), 10th revision³¹ and surgery
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41 185 is coded by the Danish version of the NOMESCO Classification of Surgical Procedures (NCSP).³²
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43 186 In Denmark, all individuals have a unique personal identification number, making it possible to
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46 187 conduct valid registry-based studies. Diagnoses in the Danish Medical Birth Registry have been
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48 188 validated, and the authors found that the more severe the condition, the higher the validity of the
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50 189 coding.³³

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53 190 The obstetric events included in our study were: Apgar score <7/5 min (ICD-10: DVA00-DVA06),
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55 191 eclampsia (ICD-10: O151, O152, O159), emergency caesarean section (NCSP: KMCA10A,
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57 192 KMCA10D, KMCA10E), severe postpartum haemorrhage (≥ 1000 ml) (ICD-10: O072, only ≥ 1000
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4 193 ml), shoulder dystocia (ICD-10: O660, NCSP: KMAH15), umbilical cord prolapse (ICD-10: O690),
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6 194 vaginal breech delivery (NCSP: DUP07-DUP11, DUP16 without caesarean sections, NCSP:
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9 195 KMCA10), vaginal twin delivery (ICD-10: O300, without caesarean sections, NCSP: KMCA10), and
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11 196 instrumental delivery by vacuum extraction (NCSP: KMAE00, KMAE03, KMAE96). These critical
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13 197 events may result in maternal and neonatal mortality and morbidity, are often subjects of clinical
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16 198 training.^{4, 5, 7, 11, 15} Moreover, obstetric healthcare professionals are expected to safely and expertly
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18 199 manage these events.
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22 202 **Statistical analysis**

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25 203 The outcome of interest was the estimated average time interval between the expected acquaintance
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27 204 with one obstetric event to the next similar obstetric event divided across the number of midwives,
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30 205 specialty trainees, and specialist doctors. We calculated the average time interval between the events
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32 206 by dividing the number of events per year (incidence times the total number of deliveries in 2018)
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34 207 with the number of healthcare professionals in the study (midwives, specialty trainees, and specialist
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37 208 doctors, respectively). The result was divided by 12 to calculate the number of months between a
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39 209 potentially experienced event. We based the analysis on the assumption that all healthcare
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41 210 professionals can learn from an event if they are either participating hands-on or are present in the
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44 211 delivery room as an observer or assistant. We, therefore, assumed that one event had a midwife, a
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47 212 specialty trainee, and a specialist doctor involved. Statistically the three groups of healthcare
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50 213 professionals therefore share an event.
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52 214 Since the estimates constitute average numbers, they are presented as means. Probabilities of
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55 215 experiencing an obstetric emergency were calculated using Microsoft Excel (Microsoft Cooperation
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57 216 version 14.6.6).
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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.

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240 The events with relatively high incidence were hence experienced relatively more often. Emergency
241 caesarean section, with an incidence of 12.2%, were experienced, on average, every other month for
242 midwives, every nine days for specialty trainees, and every 17 days for specialist doctors.

243 Instrumental delivery with vacuum extraction and severe postpartum haemorrhage, with an incidence
244 of 7.0% and 6.4%, respectively, were, on average, experienced by midwives every four months, by
245 specialty trainees every 16 days, and by specialist doctors once a month (Table 2).

247 Discussion

248 *Main findings*

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

255 *Strengths and limitations*

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

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

267 We used data on specific obstetric events from existing research, obtained for 2008–2015.¹ Data on
268 the number of obstetric healthcare professionals were collected for 2018 since data from this year is
269 assumed to be more valid compared to data for previous years due to the possibility of recall bias.
270 Nationally, incidences of obstetric events are fairly consistent over the years. Therefore, we have no
271 reason to believe that the different time periods used may have compromised the validity of our study
272 results.¹

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

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

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4 287 *Interpretation*

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6 288 Our results suggest that midwives and specialist doctors can have a lifelong working life and only
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9 289 experience certain severe obstetric emergencies once or twice, if at all. When emergencies occur,
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11 290 however, healthcare professionals are expected to have the skills to manage the event according to
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13 291 well-known, evidence-based standards of obstetric care. As a result, healthcare professionals must
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16 292 always be prepared for obstetric emergencies to occur. Our findings show that it is unrealistic for
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18 293 healthcare professionals to obtain and maintain the competences required to manage rare obstetric
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20 294 events through clinical experience alone. Studies on trainee doctors' experience and confidence in
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23 295 managing vaginal breech deliveries and vaginal twin deliveries show that the confidence increased
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25 296 with increasing number of deliveries attended.^{34, 35} Further, among trainees who did not intend to
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27 297 offer vaginal breech deliveries and vaginal twin deliveries, in 46% and 67%, the argument was that
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30 298 they did not have sufficient experience to manage these complex vaginal deliveries.³⁵

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32 299 A common feature of the events studied was that the time interval between emergencies or high-risk
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34 300 deliveries depended on the healthcare professional group, indicating that some groups can acquire
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36 301 the skills based primarily on clinical experience alone. However, alternative educational pathways
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39 302 should be provided for other groups. To improve patient safety, minimise litigation, and ameliorate
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41 303 the consequences for the healthcare professionals involved ensuring that they have the necessary
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43 304 skills to manage obstetric events must be prioritised.²²

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45 305 Educational approaches could be video-cases, E-learning, case-based interprofessional learning or
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48 306 simulation-based education.³⁶ Simulation-based education, which is a valuable supplement to
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50 307 traditional ways of learning through clinical practices and mentorship, represent one way of ensuring
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53 308 acquisition of clinical skills and maintenance hereof.³⁷ Simulation-based training can identify and
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55 309 correct common clinical errors made during emergencies, and has been recommended as a valuable
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57 310 standard supplementary to clinical practice in order to improve care provided.^{23, 38, 39} Obstetric
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4 311 emergency simulation-based training has been shown to impact the knowledge, skills, and attitudes
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6 312 of healthcare professionals. Moreover, some studies have found that this type of training reduces
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9 313 maternal and neonatal morbidity and mortality, though other studies have failed to show an effect on
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11 314 clinical outcomes.⁴⁰⁻⁴⁴

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13 315 Knowledge and skills deteriorate over time and must be maintained.^{41, 45, 46} Studies show that the
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15 316 level of knowledge falls within 9–15 months after obstetric skills training,^{41, 44, 47} and some studies
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18 317 suggest that annual obstetric skills training is necessary to combat this decline.^{45, 48} Our findings allow
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20 318 us to differentiate between the obstetric events that require frequent simulation based training and the
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23 319 ones that can generally be maintained at a certain level based on daily clinical practice alone.
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25 320 Moreover, our results may indicate which healthcare professionals can rely on maintaining their skills
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27 321 primarily through clinical practice and who needs additional obstetric skills training. However, some
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30 322 argue that training individual groups of healthcare professionals is inadequate, highlighting the
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32 323 importance of including all team members in a multidisciplinary team when training due to the
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34 324 complexity of the skills and the rarity of certain obstetric events.^{41, 49}

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36 325 Our results may be relevant in other clinical specialties in which rare clinical emergencies occur that
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39 326 require prompt and professional action by healthcare professionals, e.g., abdominal aortic aneurysms
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41 327 in vascular surgery⁵⁰ and paediatric emergency medicine.⁵¹ Rare events in these medical specialties
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43 328 also represent a challenge in terms of learning the required skills via the traditional apprenticeship
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46 329 model and ongoing clinical work, which is why simulation-based skills training is necessary.⁵²

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48 330 Finally, the results from this study only provide a part of the overall picture of training and
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50 331 maintaining the competences in managing rare complications.

51 52 53 332 54 55 333 **Conclusion**

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4 334 We found that some obstetric emergencies and high-risk deliveries were experienced so infrequently
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6 335 that the clinical skills required to competently manage the events is deemed to be impossible to obtain
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9 336 and maintain in clinical practice alone. Consequently, to enhance patient safety, reduce burnout in
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11 337 healthcare professionals, and minimise litigation costs, investing in supplementary training activities
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13 338 is the way forward to improving patient care. In this regard, our study contributes to assessing the
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16 339 need for supplementary educational initiatives.

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20 341 **Acknowledgments**

22
23 342 We would like to thank the heads of midwifery from all maternity units in Denmark for providing us
24
25 343 with data on the number of midwives employed in their units. We would like to express our deepest
26
27 344 gratitude to senior advisor Steen Rasmussen, MSc, MPH, Rigshospitalet for managing the national
28
29 345 registry data from the Danish Medical Birth Registry.

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34 347 **Contributorship statement**

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37 348 JLS created the idea. SH, LT, TB, ALR, MJ, and JLS participated in creating the study design. SH
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39 349 was responsible for collecting the data. SH and LT performed the analysis and drafted the initial
40
41 350 manuscript. TB, ALR, MJ, and JLS reviewed and revised the manuscript for interpretation of data
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43 351 and critical revision of important intellectual content. All authors reviewed and approved the final
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46 352 manuscript as submitted.

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50 354 **Details of ethics approval**

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53 355 Approval was obtained from the Danish Data Protection Agency (file no.: 2012-58-0004). As this is
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55 356 a registry-based study it is not legally required to obtain ethics approval from the Danish National
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57 357 Research Ethics Committee.

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358 Disclosure of interest

359 The authors have no conflicts of interests to disclose.

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364 Data sharing statement

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

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4 522 **Table Caption List**

6 523 **Table 1.** Number of obstetric healthcare professionals working in Danish labour wards in 2018

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9 524 **Table 2.** Estimated time between obstetric emergency or high-risk delivery divided across midwives,
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11 525 specialty trainees, and doctors specialised in obstetrics and gynaecology.

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528**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

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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.