

1 **Factors associated with adverse clinical outcomes among obstetric trainees**

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24 The authors have no conflicts of interest to declare.

25

26 **Author Contributions**

27 CA, AA and JB conceived of and designed the study. CA, AA, HP and AP collected
28 and analysed the data. CA, AA, JB, HP and AP wrote and edited the manuscript. All
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30

31 **Ethics Approval**

32 No patient-identifiable data were accessed in the course of this research, which was
33 performed as part of a provision-of-service study for the obstetrics centre. Individual
34 medical records were not accessed at any stage. The Institutional Review Board
35 confirmed that the work was exempt from expedited or full board review. The work
36 was carried out in accordance with the Declaration of Helsinki, including, but not
37 limited to there being no potential harm to participants and the anonymity of
38 participants is guaranteed.

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44 **Abstract (300)**

45 **Objective:** To determine whether UK obstetric trainees transitioning from directly to
46 indirectly-supervised practice have a higher likelihood of adverse patient outcomes
47 from operative deliveries compared to other indirectly supervised trainees and to
48 examine whether performing more procedures under direct supervision is associated
49 with fewer adverse outcomes in initial indirect practice.

50 **Methods:** We examined all deliveries (13,861) conducted by obstetricians at a single
51 centre over 5 years (2008-2013). Mixed-effects logistic regression models were used
52 to compare estimated blood loss, maternal trauma, umbilical arterial pH, delayed
53 neonatal respiration, failed instrumental delivery, and critical incidents for trainees in
54 their first indirectly-supervised year with trainees in all other years of indirect
55 practice. Outcomes for trainees in their first indirectly-supervised 3 months were
56 compared to their outcomes for the remainder of the year. Linear regression was used
57 to examine the relationship between number of procedures performed under direct
58 supervision and initial outcomes under indirect supervision.

59 **Results:** Trainees in their first indirectly-supervised year had a higher likelihood of
60 >2 litres estimated blood loss at any delivery (OR 1.32;CI(1.01-1.64) $p<0.05$) and of
61 failed instrumental delivery (OR 2.33;CI(1.37-3.29) $p<0.05$) compared with other
62 indirectly-supervised trainees. Other measured outcomes showed no significant
63 differences. Within the first three months of indirect supervision, the likelihood of
64 operative vaginal deliveries with >1litre estimated blood loss (OR 2.54;CI(1.88-3.20)
65 $p<0.05$) was higher compared to the remainder of the first year. Performing more
66 deliveries under direct supervision prior to beginning indirectly-supervised training
67 was associated with decreased risk of >1litre estimated blood loss ($p<0.05$).

68 **Conclusions:** Obstetric trainees in their first year of indirectly-supervised practice
69 have a higher likelihood of immediate adverse delivery outcomes, which are primarily
70 maternal rather than neonatal. Undertaking more directly supervised procedures prior
71 to transitioning to indirectly-supervised practice may reduce adverse outcomes,
72 suggesting that experience is a key consideration in obstetric training programme
73 design.

74

75

76

77 **Introduction**

78 The aim of obstetric training programs worldwide is to produce obstetricians who
79 achieve good fetal and maternal outcomes in independent practice. One of the key
80 steps in achieving independent practice in any operative skill is the transition between
81 performing a procedure under direct supervision to performing it with indirect
82 supervision, *i.e.* with help immediately available if required but without a senior
83 clinician present at all times (1). Determining the right time for trainees to embark
84 upon this transition involves a difficult balance between providing optimal
85 educational opportunities to advance surgical skills and ensuring patient safety (2, 3).
86

87 Transitioning to independent practice is a practical and psychological milestone and
88 according to transitional psychology trainees should move through the key stages of
89 preparation, encounter, adjustment and stabilization (4). Moreover, the principles of
90 proximal development and constructive friction suggest that the most effective
91 learning will occur when there is a gap between a trainee's current unaided
92 capabilities and the skill level required for full independence (5, 6). In theory, an
93 incremental model in which trainees progress through an individualized program of
94 stages, each involving various degrees of supervision, might provide an optimal
95 balance between skill development and safety. Yet as the traditional apprenticeship
96 model of medical education has been increasingly replaced by a more standardized
97 structure (7), there are fewer opportunities for supervisors to make repeated
98 observations of an individual trainee to gauge skill level and readiness (8). As a result,
99 standardized clinical training programmes are typically designed according to one of
100 three basic models: time-based training, competency-based training or experience-
101 based training (9, 10).

102

103 In the United Kingdom (UK), obstetric training is organized following competency-
104 based principles. Assessment of readiness for the transition from the final year of
105 directly supervised training to the first year of indirectly supervised training is based
106 upon completion of a certain number of workplace based assessments for operative
107 skills. Senior obstetricians assess skills such as Caesarean section and operative
108 instrumental vaginal delivery, aiming for the situation where ‘the majority of cases
109 are managed with no direct supervision or assistance...’ (11). Only once these
110 assessments are successfully completed can trainees transition to independent
111 practice.

112

113 There is little evidence, however, that assessment of basic competence is sufficient
114 either to optimally meet trainees’ learning needs (12) or to prevent increases in
115 operative obstetric complications. Although under a competency-based model it
116 might be expected that adverse procedure outcomes will decrease over time with
117 increasing experience—and thus that trainees in the initial period of indirect
118 supervision will likely have higher rates of complications compared with other
119 indirectly supervised trainees—gaining a greater degree of experience *before* making
120 the transition to indirectly supervised practice might limit patient harm further.

121 Ideally, although trainees will learn to perform procedures more quickly and
122 efficiently over time as they proceed through indirectly supervised training (13), there
123 should be no substantial differences in adverse patient outcomes over time or across
124 training groups. Moreover, gaining more supervised experience may confer further
125 educational benefits: reducing supervision before the trainee feels ready can have a
126 negative psychological impact on subsequent learning (12) and the experience of

127 making a significant medical error can have a devastating impact on trainees' self-
128 confidence (14).

129

130 The objectives of this study are firstly to determine whether trainees in the initial
131 stages of indirectly supervised practice have a significantly higher likelihood of
132 adverse operative outcomes compared to trainees at later stages of indirect training
133 and secondly to examine whether performing a higher number of cases in the directly
134 supervised period is associated with an improvement in patient outcomes in the initial
135 transition to indirectly supervised practice. We hypothesize that deliveries by trainees
136 in the initial phase of indirectly supervised practice will be associated with more
137 adverse events, and that such events could be reduced through greater experience
138 during directly supervised training.

139

140 **Methods**

141 We identified 13,861 deliveries performed by trainee and senior obstetricians over a
142 5-year period (January 2008 - December 2013) in a single tertiary obstetrics centre in
143 the UK. In this centre, most spontaneous vaginal deliveries are performed by
144 midwives, and hence all cases in the sample are elective or emergency Caesarean
145 sections, instrumented operative vaginal deliveries using forceps or vacuum
146 assistance, or complex spontaneous deliveries, for example in the breech position or
147 pre-term.

148

149 Following medical school graduation in the UK, new doctors first undertake two
150 years of general medical and surgical practice. Once this training is complete, they
151 become eligible for a seven-year specialty-training program in obstetrics and

152 gynecology, during which they change hospitals yearly. In our analysis, trainee
153 obstetricians are those in years one to five of specialty training, while senior
154 obstetricians are those with greater than five years of specialty training. Our sample
155 (n=100) is comprised of 11 senior obstetricians permanently employed at the study
156 centre, 25 senior obstetricians who worked at the centre for 1-2 years during the study
157 period, and 64 specialty trainees who worked at the centre during some or all of the
158 study period. Fifty-three obstetricians who had completed a year at the study centre
159 early in their training returned to work there in later training years (n=18) or as senior
160 obstetricians (n=27) or both (n=8). Doctors with fewer than 10 deliveries during the
161 study period were excluded from the analysis as they were most likely locums or
162 visiting fellows who may not have trained according to the UK standardized national
163 curriculum. Frequencies of each type of delivery carried out by trainees in each year
164 of specialty training pooled over the five-year study period are shown in Table 1.

165

166 Trainees in their first two years of specialty training perform obstetric procedures
167 under direct supervision. The final year of directly supervised practice thus
168 corresponds to the *second* year of specialty training. Trainees in years two to five of
169 specialty training typically perform procedures under indirect supervision. The first
170 year of indirectly supervised practice thus corresponds to the *third* year of specialty
171 training. Direct supervision is defined as having a senior clinician present in the
172 operating room who can guide as necessary all the steps performed during the
173 procedure. The trainee does not have to recognize a problem and ask for help – the
174 onus will be on the supervisor to identify issues and to take over as appropriate.
175 Complications are thus attributed to the supervising clinician. Indirect supervision is
176 defined as having a senior clinician responsible for attending in person at the trainee's

177 request immediately available within the hospital. The trainee carries the
178 responsibility of asking for assistance and thus complications are attributed to the
179 trainee. All of the trainees in our study were assessed during their training according
180 to standard competency-based principles by yearly review. All trainees passed these
181 assessments and progressed to subsequent training years.

182

183 On-duty midwives recorded data on each delivery undertaken during the study period
184 in the hospital's electronic system. The obstetrics center regularly performs audits to
185 check data accuracy by comparison to original patient notes. This study involved a
186 secondary analysis of de-identified data and no medical records were accessed. The
187 Institutional Review Board at our institution determined that the study was exempt
188 from full review. For each delivery, maternal and fetal complications were retrieved
189 from the electronic database. Delay in neonatal respiration was recorded where
190 spontaneous respiration was not achieved within 1 minute of delivery. Umbilical cord
191 blood was obtained immediately following delivery, and the arterial pH recorded.
192 Umbilical arterial pH was categorized as ≥ 7.1 or < 7.1 (15). A critical-incident form
193 was generated at delivery in the case of any obstetric or neonatal emergency
194 associated with delivery, including neonatal resuscitation, shoulder dystocia, maternal
195 visceral injury or any other event triggering an obstetric emergency call. Maternal
196 blood loss was measured immediately after delivery, using suction blood collection
197 and weighing of swabs and other pads. Blood loss was categorized as < 1 litre, 1-2
198 litres and > 2 litres. Severe maternal perineal trauma was defined as any disruption to
199 the anal sphincter complex.

200

201 We also obtained characteristics of the maternal-fetal dyad, including maternal age (at
202 time of delivery), BMI (at first trimester prenatal booking), parity (prior to delivery),
203 and the birth-weight of the infant from the electronic database. Birth-weight was
204 recorded to the nearest gram. Gestational age was determined from first trimester
205 ultrasound and recorded to the nearest week. Mode of delivery was identified as
206 elective Caesarean section, emergency Caesarean section, instrumental vaginal
207 delivery (sub-classified as forceps or ventouse, and hereafter referred to as
208 “instrumental delivery”) and unassisted vaginal delivery (sub-classified as either
209 breech or cephalic). All trainees undergo training in both non-rotational forceps and
210 ventouse delivery.

211

212 To examine whether deliveries conducted during the study period by trainees in their
213 first year of indirectly supervised training (third year of specialty training) have a
214 higher likelihood of maternal and fetal complications compared to those conducted by
215 other indirectly supervised trainees, we used a series of binary mixed-effects logistic
216 regression models with trainee-level random-effects. These models allow us to
217 account for individual differences between trainees and to produce standard errors
218 that are robust to the clustering of deliveries within trainees. Birth-weight, gestational
219 age, maternal age and maternal BMI were included as fixed-effects. We did not
220 compare rates of complications for trainees in their final year of direct practice *versus*
221 their first year of indirect practice because complications arising from cases
222 undertaken during direct practice are typically attributed to the supervising senior
223 doctor.

224

225 To further reduce inter-operator variability and investigate the relationship between
226 increasing trainee experience and procedure outcomes, we used a series of binary
227 mixed-effects logistic regression models with trainee-level random effects to compare
228 outcomes for deliveries performed within the first 3 months of indirectly supervised
229 practice *versus* deliveries performed in the subsequent 9 months of the same year by
230 the same group of trainees. Birth-weight, gestational age, maternal age and maternal
231 BMI were included as fixed effects.

232

233 We then assessed the association between performing a greater number of procedures
234 in the period of directly supervised practice and trainee complication rates in the
235 initial period of indirectly supervised practice. Only fifteen individual trainees met the
236 criteria of both spending their last year of directly supervised practice and their first
237 year of indirectly supervised practice within the same obstetrics unit and within the 5-
238 year study timeframe. For each individual, we plotted the percentage of adverse
239 outcomes from deliveries in the first indirectly supervised year against the number of
240 deliveries completed in the final directly supervised year. Adverse outcomes were
241 those demonstrated by the analyses described above to be significantly higher among
242 trainees in the first indirectly supervised year. We then used linear regression models
243 to find the line of best fit and the sum of least squares to determine the goodness-of-
244 fit. The small sample size prohibited multivariable modeling at the individual level,
245 but to check for systematic differences in the difficulty of deliveries performed
246 between trainees, we constructed an index variable using maternal age, maternal BMI,
247 birth-weight and gestation for all deliveries performed by individual trainees during
248 the first indirectly supervised year. Such differences were negligible and thus no
249 adjustment was made.

250

251 Finally, we investigated whether trainees' experience could be accurately assessed
252 using the number of workplace-based assessments they had completed. The procedure
253 described above was used to examine the correlation between the number of work-
254 placed based assessments obtained and the total number of directly supervised
255 procedures performed within the last year of directly supervised training.

256

257 All analyses were conducted using the R statistical software package version 2.14.1.
258 Findings were considered statistically significant at an alpha level of 0.05.

259

260 **Results**

261 Analysis of data pooled across all five years of the study period shows that trainees in
262 their final year of directly supervised practice performed 8.1% (1,119) of the total
263 deliveries compared to 20.5% (2,841) performed by trainees in their first year of
264 indirectly supervised practice (Table 1). Comparing those in their final year of
265 directly supervised training with those in their first year of indirectly supervised
266 training, the average number of emergency Caesarean section, forceps, and ventouse
267 deliveries per trainee increased 2.3, 3.8 and 2.6-fold respectively,.

268

269 Table 2 shows the comparison of delivery outcomes performed by trainees in their
270 first year of indirectly supervised practice *versus* trainees in their second or higher
271 years of indirectly supervised practice. Trainees in their first year of indirectly
272 supervised practice have a higher likelihood of estimated blood loss >2 litres at any
273 delivery (OR=1.32, $p<0.05$) and of estimated blood loss >1 litre at instrumental
274 delivery (OR =1.79, $p<0.05$). Estimated blood loss >1 litre at Caesarean section

275 (either elective or emergency) is not significantly different between the groups.
276 Trainees in their first indirectly supervised year also have a higher likelihood of failed
277 instrumental deliveries (OR=2.33, $p<0.05$). The likelihood of severe maternal perineal
278 trauma is also higher, although this association is not statistically significant
279 (OR=1.28, $p=0.09$). There is no difference between the groups with respect to
280 umbilical artery pH <7.1 , delay to neonatal respiration, or critical incidents occurring
281 at delivery.

282

283 Trainees have a higher likelihood of estimated blood loss >2 litres at any delivery
284 (OR=1.54, $p<0.01$) and of estimated blood loss >1 litre at instrumental delivery
285 (OR=2.54, $p<0.01$) during the first 3 months of indirectly supervised practice
286 compared to the following 9 months of the first year (Table 3). The likelihood of
287 severe maternal perineal trauma is also higher, although this association is not
288 statistically significant (OR=1.71, $p=0.07$). There are no significant differences in the
289 likelihood of other adverse maternal or fetal outcomes.

290

291 Among the fifteen trainees who completed both the final year of direct and the first
292 year of indirect training at the study centre, we observe a significant negative
293 correlation between the total number of deliveries performed in the final year of direct
294 supervision and the percentage of deliveries with an estimated blood loss of >1 litre in
295 the first year of indirectly supervised practice ($R^2 = 0.31$, $p<0.05$) (Figure 1A). We
296 also note a trend towards a lower incidence of severe maternal perineal trauma at
297 instrumental delivery in the first year of indirect supervision, although this association
298 was not statistically significant ($R^2 = 0.26$, $p=0.09$) (Figure 1C). A negative correlation
299 exists between the number of instrumental deliveries performed under direct

300 supervision and both rates of estimated blood loss >1 litre at instrumental delivery
301 and failed instrumental delivery, but neither association is statistically significant
302 (Figures 1B and D).

303

304 There is no correlation between the number of Caesarean sections performed by
305 trainees and the number of assessments completed (Figure 2A), but a significant
306 positive correlation ($p < 0.05$) is demonstrated for operative vaginal deliveries (Figure
307 2B).

308

309 **Discussion**

310 Our findings strongly suggest that trainees' operative skills improve as they gain more
311 experience over time during indirectly supervised training. We show that obstetric
312 trainees in their first year of indirectly supervised practice have higher rates of
313 maternal haemorrhage and failed instrumental delivery compared to trainees in
314 subsequent indirectly supervised years. Additionally, within their first 3 months of
315 indirectly supervised practice, trainees have higher rates of maternal haemorrhage
316 compared to the remainder of the first year. For other obstetric outcomes, including
317 compromised neonatal respiration, severe perineal trauma, and critical incidents, we
318 found no significant differences among trainees in their first indirectly supervised
319 year compared to their more experienced colleagues. While these findings suggest
320 that the competency-based training program at our center prepares trainees well for
321 some aspects of independent practice, they also raise the important question of
322 whether providing additional experience prior to the transition to indirectly supervised
323 practice could help reduce all types of adverse patient outcomes.

324

325 For the small number of trainees who undertook both directly and indirectly
326 supervised training at our centre, we show that having gained more experience prior
327 to transitioning to indirectly supervised practice is associated with lower rates of
328 maternal haemorrhage. In addition, there was a 3-fold increase in the number of
329 emergency operative deliveries performed by trainees in their first year of indirect
330 supervision compared to trainees in their final year of direct supervision. While a
331 major limitation is that we did not have a sufficiently large sample size (n=15) to
332 robustly assess these correlations, our findings (especially when taken together with
333 the improvements in outcomes seen over time during the indirectly supervised phase)
334 suggest possible benefits to trainees of gaining experience rather than simply
335 preparing for assessments of competency. While we were able to assess only
336 immediate delivery outcomes, maternal obstetric haemorrhage and failed instrumental
337 delivery are both strongly associated with maternal morbidity in the puerperium (16,
338 17). Failed instrumental delivery is also associated with neonatal morbidity (18),
339 although we did not find significant differences in other immediate neonatal outcomes
340 by training year.

341

342 Our findings raise intriguing questions about what factors account for the observed
343 differences in degree of trainee experience during the directly supervised training
344 period—the variability in the number of procedures undertaken by individual trainees
345 is striking. One possibility is that greater opportunities are given to trainees who are
346 perceived by their educators to show more surgical aptitude, enthusiasm or dedication
347 to training. If so, then experience *per se* might not be directly related to better
348 outcomes, but rather might serve as a surrogate for other aspects of trainee
349 performance or trainee characteristics. Conversely, those with the poorest skills may

350 be perceived by their trainers to require most training and may be pushed to perform
351 extra cases. Alternatively, there may be other individual attributes that determine the
352 number of cases a trainee will be perform. A better understanding of such influences
353 could shed further light on training program design and is a prime target for future
354 research.

355

356 Previous studies across a number of surgical disciplines have also identified the need
357 for increased operative experience in terms of total case numbers (19-21). Within
358 obstetrics, many trainees do not achieve adequate volumes of instrumental deliveries
359 during training overall, even within teaching hospitals (20) and despite the influence
360 of obstetrician experience on instrumental delivery success (17). Focusing specifically
361 on the transition from directly to indirectly supervised training, we have identified a
362 potential opportunity to modify the structure of the training programme to integrate
363 needed experience. The current competency-based model does not appear to provide
364 adequate training to prevent an increase in all adverse patient outcomes in the initial
365 phase of indirectly supervised practice, perhaps because assessments are often based
366 upon straightforward cases. On the basis of our findings, consideration of a more
367 experience-based model might not only ensure competence to perform a
368 straightforward procedure but also to allow trainees the opportunity to develop the
369 skills to avoid complications as they arise. These opportunities could include the use
370 of simulation-based training (22) or the requirement of a certain quota of procedures
371 and a test of peer-level competence before transitioning to the next training stage.
372 Workplace-based assessment numbers provide a faithful estimation of the total
373 numbers of procedures performed for operative vaginal delivery (but not for
374 Caesarean section) and may therefore be a useful tool in assessing training from an

375 experience point-of-view. Future research should examine not only the total number
376 of assessments completed but also the relationship between how well trainees
377 performed on these assessments and their subsequent clinical outcomes in
378 independent practice. These findings could illuminate whether it is possible to
379 prospectively identify trainees who are at risk of poor performance.

380

381 The use of patient outcomes to evaluate training programmes in obstetrics allows a
382 practical and patient-centred approach (23), which has also been used in other surgical
383 disciplines (24). We have focused primarily on operative outcomes but we also
384 recognize that increasing seniority demands simultaneous development of other
385 important skills (including communication and organizational skills) for which
386 trainees undergoing important career transitions may feel under-prepared (25).

387 Quality of surgical supervision and learning experience is also a key factor in
388 determining how valuable trainees consider their programs (26, 27), and this may
389 correlate better with surgical outcomes than the absolute number of cases performed.

390 Continuity of training within the same institution and surgical team may also be
391 important in developing surgical skills more efficiently, as communication and
392 relationship with supervising senior clinicians have often been identified as important
393 to surgical education (26, 28).

394

395 The main strengths of our study are the inclusion of trainees who had completed both
396 directly and indirectly supervised practice in the same setting, thus minimizing the
397 variability in training opportunities available during the study period and inter-
398 operator differences. Our study also has several limitations. Focusing on trainees
399 following the national RCOG curriculum for obstetrics training in a single centre

400 means that our findings may not be generalizable to other settings. Additionally,
401 while we were able to control for characteristics of the maternal-fetal dyad and for
402 variability between individual trainees, we were unable to control for factors such as
403 the urgency of each procedure and the management of the patient during labor and
404 prior to delivery. In particular, a potential source of bias is that more junior trainees
405 may have undertaken systematically less complicated deliveries involving lower-risk
406 women and infants, while more senior trainees may have undertaken higher-risk
407 deliveries. We cannot fully control for this possible selection bias in our models.

408

409 **Conclusion**

410 Transitioning to indirect supervision for operative procedures is a significant
411 milestone in the training pathway. All the trainees in our study passed competency-
412 based training. However, analysis of their operative outcomes suggests a need for
413 further operating experience to limit patient harm, particularly with respect to
414 maternal outcomes. Calculation of the number of directly supervised procedures
415 required to produce no difference in patient outcomes in the initial independent phase
416 is a potential target for future research. The need for increased opportunities to build
417 experience is relevant not only to obstetric training but could apply across other
418 surgical and procedural disciplines.

419

420

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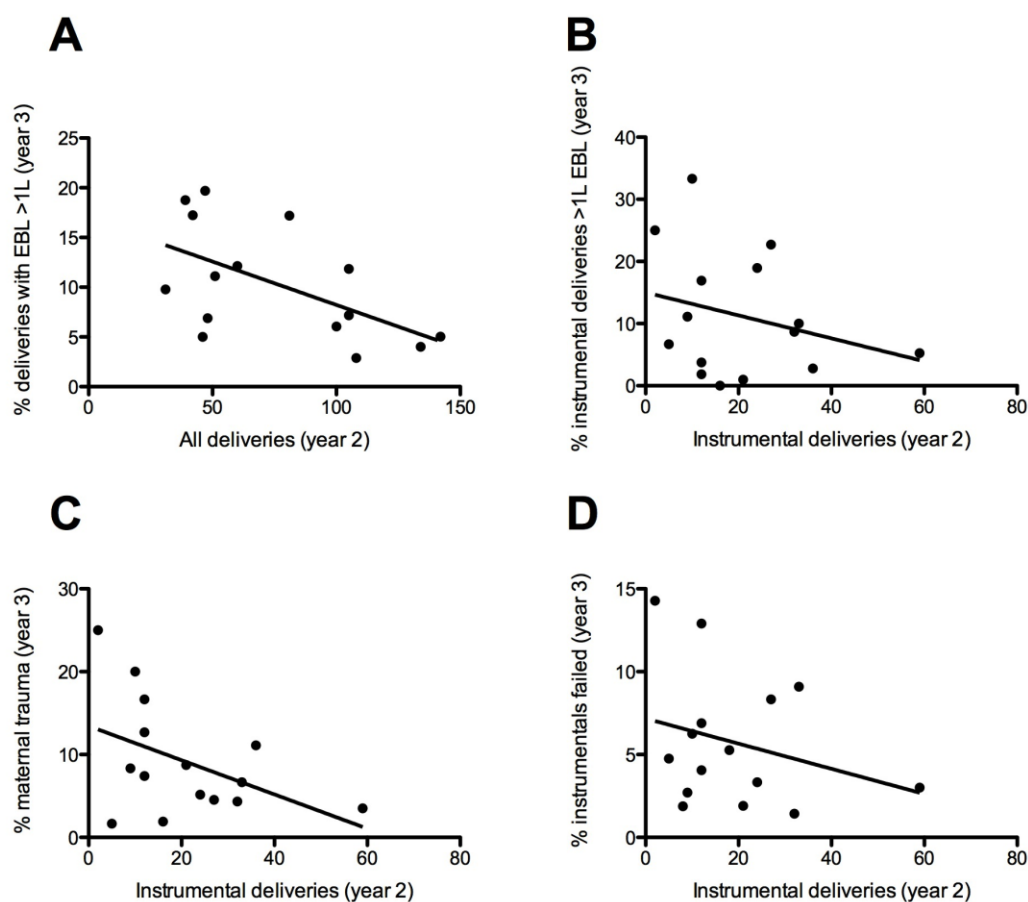
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498 **Figures and Tables**

499



500

501 **Figure 1** – Delivery outcomes during the third year of training plotted against number

502 of deliveries performed in second year of training. Each closed circle represents a

503 single trainee. **A)** Total number of deliveries of any type in second training year (year

504 2) v. percentage of deliveries in third training year (year 3) with estimated blood loss

505 of >1 litre. $R^2= 0.32$, $p<0.05$ **B)** Number of instrumental deliveries performed in year

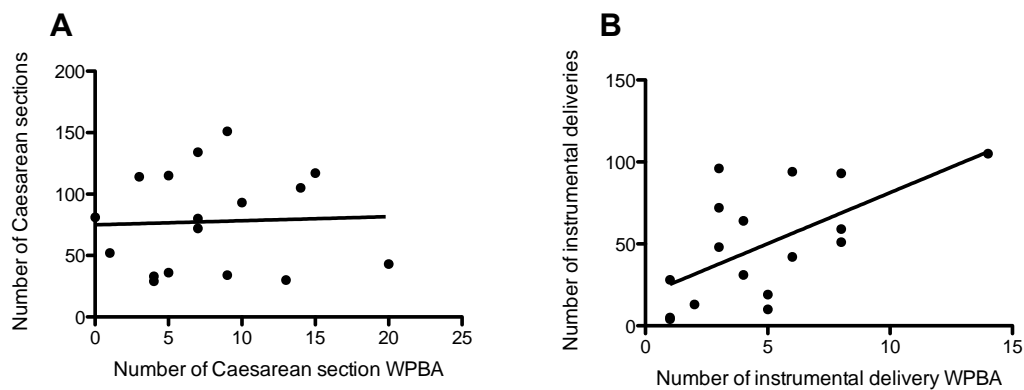
506 2 v. percentage of instrumental deliveries in year 3 with estimated blood loss of >1

507 litre. $R^2= 0.08$, $p=0.32$ **C)** Number of instrumental deliveries performed in year 2 v.

508 percentage of instrumental deliveries in year 3 sustaining severe maternal perineal

509 trauma. $R^2= 0.20$, $p=0.09$ **D)** Number of instrumental deliveries performed in year 2510 v. percentage of failed instrumental deliveries in year 3. $R^2= 0.08$, $p=0.31$

511



512

513 **Figure 2** – Number of work-placed based assessments (WPBA) confirming
514 competence obtained during the second year of training plotted against number of
515 deliveries performed in second year of training. Each closed circle represents a single
516 trainee.

517 A) Caesarean section ($R^2= 0.01$, $p=0.87$) B) Operative vaginal delivery ($R^2= 0.48$,
518 $p<0.05$)

519

Obstetrician grade (Year of specialty training)	Total n=13,861	Emergency Caesarean n=4619	Elective Caesarean n=4558	Forceps n=2489	Ventouse n=1599	Vaginal Breech n=129	Vaginal Cephalic n=462
Year 1 (8)	Total (1.4%) Av. per trainee 24.1 ± 2.1	55 (1.2%) 6.9 ± 3.5	86 (1.9%) 10.8 ± 3.7	20 (0.8%) 2.5 ± 1.1	20 (1.3%) 2.5 ± 0.9	0 (0%) 0	12 (2.6%) 1.5 ± 0.5
Year 2 (19)	Total (8.1%) Av. per trainee 58.9 ± 5.8	297 (6.4%) 15.6 ± 7.7	469 (10.3%) 24.7 ± 10.2	178 (7.2%) 9.4 ± 4.8	122 (7.6%) 6.4 ± 3.1	4 (3.1%) 0.2 ± 0.1	49 (10.6%) 2.6 ± 1.4
Year 3 (22)	Total (20.5%) Av. per trainee 129.1 ± 11.4	988 (21.4%) 44.9 ± 9.1	719 (15.8%) 32.7 ± 13.1	633 (25.4%) 28.8 ± 12.2	370 (23.1%) 16.8 ± 7.7	22 (17.0%) 1.0 ± 0.5	109 (23.6%) 4.9 ± 2.3
Year 4- 5 (37)	Total (25.9%) Av. per trainee 97.0 ± 15.2	1281 (27.7%) 34.6 ± 23.6	1009 (22.1%) 27.3 ± 21.1	652 (26.2%) 17.6 ± 5.1	488 (30.5%) 13.2 ± 10.2	26 (20.2%) 0.7 ± 0.7	134 (29.0%) 3.6 ± 2.1
Senior (71)	Total (44.1%) Av. per trainee 86.1 ± 19.2	1998 (43.3%) 28.1 ± 22.9	2275 (49.9%) 32.0 ± 15.26	1006 (40.4%) 14.2 ± 12.8	599 (37.5%) 8.4 ± 8.1	77 (59.7%) 1.1 ± 1.2	158 (34.2%) 2.2 ± 2.49

520

521 **Table 1** - Number of deliveries and type of deliveries performed by doctors between
522 Jan 2008 and December 2013. Data are displayed as n (percentage). ‘Total’ refers to
523 the number of deliveries performed by all the doctors at each level during the study
524 period. ‘% delivery’ refers to the % of each delivery type performed by doctors at
525 each level. ‘Av. per trainee’ refers to the mean number of each type of delivery
526 performed by trainees at each level ± 1 standard deviation. The category ‘senior
527 obstetrician’ includes both any trainee with >5 years of obstetric experience and
528 consultant obstetricians. The number in brackets after the category denotes the
529 number of doctors contributing data at each tier. Data from 100 doctors in total is
530 included in the study, with 53 contributing data at more than one tier over the study
531 period.

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535

Outcome	OR for delivery by first year indirectly supervised trainee	95% confidence interval
Arterial pH <7.1 any delivery	1.34	(0.98 – 1.68)
EBL>2L any delivery	1.32	(1.01 – 1.64) *
Critical incident any delivery	0.84	(0.59 – 1.10)
Delay to neonatal respiration any delivery	1.05	(0.79 – 1.31)
>1L EBL at elective LSCS	1.11	(0.53 – 1.69)
>1L EBL at emergency LSCS	1.11	(0.79 – 1.43)
>1L EBL at instrumental	1.79	(1.21 – 2.38) *
Severe perineal trauma at instrumental	1.28	(0.84 – 1.73)
Failed instrumental	2.33	(1.37 – 3.29) *

536

537 **Table 2**—Delivery outcomes for trainees in their first year of indirect supervision

538 compared to other indirectly supervised trainees. Delivery outcomes are adjusted for

539 birth-weight, gestational age, maternal age and maternal BMI as fixed effects, and

540 trainee as a random effect. N= 6341 total deliveries, by 56 trainees

541 Model coefficients are expressed as odds ratios and 95% confidence intervals (CI).

542 *p<_0.05

543

Outcome	OR for delivery by first 3m indirect supervision	95% confidence interval
Arterial pH <7.1 any delivery	0.79	(0.21 – 1.36)
EBL>1L any delivery	1.54	(1.22 – 1.87) **
Critical incident any delivery	0.89	(0.47 – 1.33)
Delay to neonatal respiration any delivery	1.20	(0.79 – 1.61)
>1L EBL at elective LSCS	1.03	(0.22 – 1.85)
>1L EBL at emergency LSCS	1.37	(0.89 – 1.84)
>1L EBL at instrumental	2.54	(1.88 – 3.20) **
Severe perineal trauma at instrumental	1.71	(1.13 – 2.29)
Failed instrumental	1.36	(0.11 – 2.62)

544

545 **Table 3**—Delivery outcomes for indirectly supervised trainees in their first 3 months

546 compared to the same group in the subsequent 9 months. Delivery outcomes are

547 adjusted for birth-weight, gestational age, maternal age and maternal BMI, as fixed

548 effects and trainee as a random effect. N=2841 total deliveries by 22 trainees

549 Model coefficients are expressed as odds ratios and 95% confidence intervals (CI).

550 **p<_0.01

551

552

553

554