Preventing The Human Factor: Organisational Aspects Linked to Foetal Asphyxia.

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Abstract

Background: the aim of this study was to identify prepartum, intrapartum and organisational risk factors for foetal asphyxia. We focused on modifiable factors such as organisational factors, maternal Body Mass Index, Assisted Reproductive Technology pregnancies, smoking and number of clinical checks.

Methods: This is a retrospective analytical observational study. It was carried out in a teaching hospital in Northern Italy. The data for this study was obtained from maternal and neonatal medical records, obstetric and neonatal hospital discharge summaries and birth assistance certificates. 162 cases of mothers whose children experienced foetal asphyxia were compared to 162 controls where this condition did not occur. The different variables were analysed using the Fisher test, the Mann Whitney U test and logistic regression. The association probability was estimated by the odds ratio with a confidence interval of 95%. The alpha level of 0,05 was considered significant.

Results: giving birth at night ($p < 0.001$), lack of one to one assistance during labour ($p < 0.001$), birth on a day of high volume activity ($p < 0.001$), Assisted Reproductive Technology obtained pregnancies ($p < 0.001$), number of clinical checks during pregnancy ($p < 0.001$), smoking during pregnancy ($p < 0.001$), high maternal body mass index ($p < 0.001$), as well as other traditionally associated risk factors like shoulder dystocia ($p < 0.001$) or age > 35 ($p < 0.001$) all increased the risk in a statistically significant way.

Conclusions: giving birth on a high activity day, at night or without one-to one care are organisational factors that statistically increase the risk of foetal asphyxia.

Our paper proposes strategies to try and modify these risk factors and therefore limit the incidence of foetal asphyxia and of its life changing consequences like cerebral palsy.

Background

Foetal asphyxia is a clinical condition caused by an acute or chronic decrease of maternal and fetal placental gas exchanges, characterized by hypoxemia and hypercapnia, which can induce hypoxic-ischaemic encephalopathy, cerebral palsy or death of the newborn.

Perinatal (birth) asphyxia is a general term referring to neonatal encephalopathy related to events during birth. It is often used interchangeably with terms describing the neonatal sequelae such as hypoxic-ischemic encephalopathy and cerebral palsy. Neonatal encephalopathy is a clinical syndrome of neurologic dysfunction manifested by an abnormal level of consciousness or seizures, difficulty maintaining respiration, and depression of tone and reflexes (1).

Neonatal encephalopathy occurs in 1–6 of every 1000 live full term births and is a major cause of neurodevelopmental disability: 15–20% of affected infants will die during the postnatal period, and an additional 25% will sustain permanent clinical deficits (2).

Cerebral palsy has a prevalence of 2–3 live births per 1000 (3). It is a static neuromuscular disorder characterized by an abnormal control of movement or posture appearing early in life that is not the result of a recognized progressive disease. It is the most common physical disability for children. It is also often accompanied by impairments of intellect, vision, speech, hearing, and epilepsy (4, 5).

Cerebral palsy is a life changing condition affecting not only the patient but also the child's family which has to cope with extensive rehabilitation, often economically demanding treatments and has to also face the emotional burden of a disabled child.

Cerebral palsy affects some four million neonates worldwide per year, causing the death of one million subjects (6) therefore many branches of research have sprung up to try and describe this clinical condition with a more precise and objective approach.

The consequences of such clinical conditions may be very severe so research is very active to try and standardize therapeutic protocols but the most common approach in high income countries is, whenever possible, prevention.

Although it has been clearly stated that most of these neurological adverse events are due to chronic intrauterine agents that affect the foetus during the pregnancy, there is a small portion of cases that has an acute onset, probably at labour or at birth. In order to prevent the birth of predictable, and thus preventable asphyxiated children as well as to manage other major neonatal problems such as very preterm newborns, children with severe malformations or virtually critical births, the current health organisation in one of the most populated regions of Northern Italy is structured so that most births occur in hospitals with a high volume of care (number of deliveries/year) and with readily available advanced neonatal care (7).

Cerebral palsy is still a great challenge from the therapeutic and rehabilitation point of view, and although most cases are not preventable as they are caused by chronic insults, there is a minor portion where the "human factor" may play a considerable part. The only way to try and limit peripartum adverse events is to identify, recognize and prevent potentially at risk situations

Most cases of neonatal encephalopathy are associated with metabolic acidemia at birth. Sub-optimal intra-partum care contributes in more than one-third of moderate to severe encephalopathy (8). Therefore these newborns represent an important group in which to explore issues of quality of care.

The aim of the study was to identify maternal-foetal or organisational risk factors that could contribute to foetal asphyxia.

Methods

A retrospective, observational, analytical study was carried out at the Maggiore Hospital in Novara.

It consisted of a case group which included 162 cases of foetal asphyxia registered between 1st January 2019 and 31st October 2019 at the Maggiore Hospital and a control group composed of the same number of births in which foetal asphyxia did not occur, this group was obtained through randomised sampling.

Foetal asphyxia was identified using the Cerebral Palsy Task Force criteria (4,9): Apgar score < 4 at 5th minute, pH < 7, base excess >12 mMol/L dosed on the funicular artery at birth.

Inclusive criteria for the two groups:

- single pregnancy
- foetus in vertex presentation
- gestational age between 37 and 41 weeks and 3 days , calculated according to the first day of the last menstrual period.
- spontaneous or induced labour
- spontaneous or operative vaginal birth or caesarean section
- normal admission test (according to the International Federation of Gynecology and Obstetrics 2015 guideline criteria.)

Exclusion criteria include:

- foetuses afflicted with malformations, genetic and chromosomal abnormalities diagnosed during pregnancy or during the hospitalisation of the newborn child.
- Caesarean sections performed without labour
- administration of general anesthesia or opioids to the mother before giving birth.

The data that was used as the source for this study was obtained from maternal and neonatal medical records,obstetric and neonatal hospital discharge summaries and birth assistance certificates.

Prepartum, intrapartum and organisational clinical variables were considered and analysed.The different variables were analysed using the Fisher test, the Mann Whitney U test and logistic regression. The association probability was estimated by the odds ratio with a confidence interval of 95%. An alpha level of 0,05 was considered significant.

When considering the midwife's qualification, it must be noted that in Italy the education system has changed in the last 20 years: the older midwives' qualification was a diploma, not a university course. Later midwifery became a three year university course and there was the possibility for those who had obtained the diploma to "convert" it to a university degree by taking a number of supplementary university

exams but not having to repeat the entire course. This explains why there are qualifications such as: diploma in midwifery, diploma converted to a university degree and a three year degree.

Considering that about 1800 children per year are born in this hospital, approximately 5 births per day, we considered high volume of activity over 9 births/day.

Multivariate analysis drew attention to the simultaneous influence of: pathological cardiotocographic trace, lacked attendance in one to one modality, urinary and vaginal infections, >12 hours duration of labour, birth during the night.

Results

The average age of the mothers who had children with asphyxia was 31.97+/- 4.64 years and 29+/- 6.07 years for the women in the control group.

The mean gestational age was 39.11 weeks for the newborns with neonatal asphyxia and 38.75 for the neonates in the control group. There was no statistically significant difference (p 0.39)

Table 1
prepartum variables.

VARIABLE	CATHEGORY	ASPHYXIA	NO ASPHYXIA	OR	IC	P-VALUE
Age	< 34	104 (64.19%)	139 (85.8%)	3.37	1.95–5.81	< 0,001
	> 35	58 (35.8%)	23 (14.20%)			
Ethnicity	European	121 (74.69%)	136(83.95%)	1.77	1.02–3.06	0.041
	North Africa	13 (8.02%)	16 (9,88%)			
	Sub Saharan Africa	14 (8.64%)	1 (8.64%)			
	South -East Asia	6 (3.7%)	4 (3.7%)			
	Oriental Asia	2 (1.23%)	0 (0.00%)			
	South America	6 (3.7%)	5 (3.09%)			
	Other vs European					
Citizenship	Italian	113(69.75)	122 (75.31)	1.32	0.81-2,15	0.263
	Foreign	49 (30.25)	40 (24.69)			
	Italian vs foreign					
marital status	Single	10(6.17%)	2 (1,23%)	1.66	0.73–3.78	0.224
	Married-cohabiting	89(54.94%)	110 (67,9%)			
	Separated-divorced	57(35.19%)	42 (25.92%)			
	widowed	6(3,7%)	8 (4.93%)			
	1,3,4 vs 2					
Education	No education	4(2.47%)	0 (0.00%)			
	Primary education	6(3.7%)	1(0.62%)			
	Middle school	51(31.48%)	61(37.65%)			
	High school	64(39.51%	65(40.12%			

VARIABLE	CATHEGORY	ASPHYXIA	NO ASPHYXIA	OR	IC	P-VALUE
	3 year degree	19(11.73%)	21(12.96%)			
	Masters degree	17(10.49%)	14(8.64%)			
	PhD	0(0.00%)	0(000%)			
	<high school vs > high school			0.98	0.62– 1.54	0.943
Work	in-work	92(56.79%)	103(63.58%)			
	unemployed	53(32.72)	37(22.64%)			
	housewife	17(10.49%)	21(12.96%)			
	student	0 (0.00%)	1(0.62%)			
	in-work vs others			1.32	0.85– 2.07	0.212
Type of work	Freelance professional	10 (6.17%)	14 (8.64%)			
	manager	20(12.3%)	16 (9.87%)			
	Office worker	50 (30.86%)	43 (26.54%)			
	Factory worker	51 (31.38%)	60 (37.03%)			
	self-employed	31 (19.13%)	29 (17.9%)			
	1,2,5 vs 3,4	61(37.65%)	59 (36.42%)	1.256	0,62– 2,51	0,520
parity	nulliparous	110 (67.9%)	93(57.41%)	1.56	1.99– 2.47	0.05
	Multiparous	52(32.10%)	69(42.59%)			
Body Mass Index	< 18.5	1(0.62%)	0(0.00%)			
	18.5–24.9	24(14.81%	46(28.4%)			
	25-29.9	50(30.86%)	77(47.53%)			
	30-34.9	47(29.01%)	20(12.35%)			
	35-39.9	26(16.05%)	12(7.41%)			
	> 40	10(6.17%)	2(1.23%)			
	> 35 vs < 35			4.03	2.46– 6.59	< 0.001

VARIABLE	CATHEGORY	ASPHYXIA	NO ASPHYXIA	OR	IC	P-VALUE
Smoking	absent	137(84.57%)	158(97.53%)			
	1– 5 cigarettes	6 (3.7%)	2 (1.23%)			
	6– 10 cigarettes	15 (9.26%)	2 (1.23%)	9.61	2.83– 32.52	< 0.001
	> 10 cigarettes	4 (2.47%)	0 (0.00%)			
Assisted reproductive technology	None	138 (85.19%)	160 (98.77%)			
	Pharmacological ovulation	3 (1.85%)	1 (0.62%)			
	IUI	1 (0.62%)	0 (0.00%)			
	FIVET	3 (1.85%)	0 (0.00%)			
	ICSI	8 (4.94%)	1 (0.62%)			
	Ovo donation or embryo-donation	9 (5.56%)	0 (0.00%)			
	2,3,4,5,6 vs1			13.91	3.22– 59.93	< 0.001
pre-existing diabetes	absent	153(94.44%)	160(98.77%)			
	present	9 (5.56%)	2 (1.23%)	4,7	1.00- 22.12	0.05
pre-existing Thyroid disease	absent	143(88.27%)	147(90.74%)			
	present	19 (11.73%)	15 (9.26%)	0.76	0.37– 1.56	0.469
Pre-existing vascular disease	Absent	154(95.06%)	162 (100.00%)			
	Present	8 (4.32%)	0 (0.00%)	17	1- 31.2	0.048
Pre-existing anaemia	Absent	153(94.44%)	159(98.15%)			
	Present	9 (5.56%)	3 (1.85%)	3.11	0.82– 11.73	0.093
Thrombophilia	Absent	147(90.74%)	156(93.3%)			
	present	15 (9.26%)	5 (3.09%)	3.20	1.13– 9.03	0.028
Prenatal assistance	Free clinic	40 (24.69%)	30(18.529%)	1.37	0.81– 2.32	0.232

VARIABLE	CATHEGORY	ASPHYXIA	NO ASPHYXIA	OR	IC	P-VALUE
	Private practice	49 (30.25%)	83 (51.23%)			
	Low risk surgery	35 (21.6%)	28 (17.28%)			
	High risk surgery	36 (22.22%)	17 (10.49%)	2.43	1.3–4.54	0.01
	Midwife	2 (1.23%)	4 (2.47%)			
No of clinical checks	0	7 (4.32%)	3 (1.85%)			
	1–4	83 (51.23%)	31 (19.14%)			
	5–9	47 (29.01%)	125(77.16%)			
	> 10	25 (15.43%)	2 (1.85%)			
	< 4 vs > 5			4.7	2.88–7.67	< 0.001
Preeclampsia	Absent	135(83.33%)	162(100.00%)			
	present	27 (16.67%)	0 (0.00%)	65.95	3.98–91.45	0.0034
Gestational Diabetes Mellitus	Absent	138(85.19%)	145 (89.15%)			
	Present	24 (14.81%)	17 (10.49%)	1.48	0.76–2.88	0.224
Gestational anaemia	absent	153 (94.44%)	159(98.15%)			
	present	9 (5.56%)	3 (1.85%)	4.67	1.99–21.99	0.056
Pregnancy related thyroid disease	Absent	147 (90.74%)	153 (94.44%)			
	Present	15 (9.26%)	9 (5.56%)	1.73	0.73–4.08	0.208
Obstetric cholestasis	Absent	157(96.91%)	161(99.38)			
	Present	5 (3.09%)	1 (0.62%)	5.12	0.59–44.38	0.138
Amniotic Liquid index	Normal	116 (71.61%)	152(93.83%)			
	oligohydramnios	40(24.69%)	8 (4.94%)			
	Anidramnios	2 (1.23%)	2 (1.23%)			

VARIABLE	CATHEGORY	ASPHYXIA	NO ASPHYXIA	OR	IC	P-VALUE
	polyhydramnios	4 (2.47%)	0 (0.99%)			
	2,3 vs 1,4			6.12	3.01–12.81	< 0.001
Foetal growth	10°-90° centile	130(80.25%)	160(98.77%)			
	< 10° centile	28 (17.28%)	2(1.23%)	17.23	4.02–73.08	< 0.001
	> 10° centie	4 (2.47%)	0 (0.00%)			
Streptococcus Agalactiae type B positive vaginal swab	Absent	105(64.81%)	143(88.27%)			
	Present	54(33.33%)	19(11.73%)	4.34	2.41–7.8	< 0.001
urinary infection	absent	128(79.01%)	156 (96.3%)			
	present	34(20.99%)	6 (3.7%)	6.9	2.81–16.96	< 0.001
chorioamnionitis	absent	153 (94.44%)	161 (99.38%)			
	present	9(5.56%)	1(0.62%)	9.47	1.18–75.64	0.034

Table 1 illustrates the prepartum characteristics of mothers with newborns affected and not affected by asphyxia. Age > 35 increases the risk by about 3 times (OR 3.37, p 0.00, IC: 1.95–5.81), ethnicity also appears to play a role as European ethnicity seems to have a protective effect (OR: 1,77; p: 0,041, IC: 1,02–3,06), to be nulliparous raises the risk (OR 1.56, p 0,05; IC: 1.99–2.47). Increased BMI (OR 4.03; p 0.000; IC: 2.83–32.52) and smoking (OR 9.61; P 0.000; IC: 2.83–32.52) are associated to a 4 and 10 fold increased risk of experiencing this outcome. Assisted reproductive technology (ART) (OR 13.91; p: 0.000; IC: 3.22–59.93) and pre-existing vascular disease (p: 0.048 ; OR :17, IC: 1-312) greatly increase the risk of foetal asphyxia as well as pre-existing diabetes which increases the risk nearly 5 times (OR: 4.7; p 0.005; IC: 1.00-22.12). Thrombophilia (OR: 3.20; p: 0.028; IC: 1.13–9.03) also is associated to an increased risk of developing neonatal asphyxia.

16.67% of mothers who experienced foetal asphyxia were also affected by preeclampsia compared to 0 mothers who didn't (OR: 65.95, IC:3.98–91.45; p 0.0034). Urinary infections (OR:6.9 ;p < 0.001; IC: 2.81–16.96), Streptococcus Agalactiae type B positive vaginal swab (OR: 4.34 ;p < 0.001; IC: 2.41–7.8) and chorioamnionitis (OR: 9.47 ;p: 0.034; IC: 1.18–75.64) are statistically associated to an increased risk of developing neonatal asphyxia respectively : 7, 4.34 and 9.5 times compared to not having these conditions.

Low levels of amniotic fluid seem to cause a 6 fold increased risk (OR 6.21, p 0.000; IC: 3.01–12.81). Small for gestational age children have largely increased risk of foetal asphyxia (17 times) (OR 17.23, p < 0.001; IC: 4.02–73.08).

The number of clinical check-ups during the pregnancy is another factor that influences the risk of developing foetal asphyxia. To have less than 4 check-ups during pregnancy raises the risk by almost 5 times (OR 4.7; p 0.000; IC: 2.88–7.67) .

Whereas, citizenship, marital status, education, being employed, the type of work, pre-existing thyroid diseases, pre-existing anaemia do not increase the risk of experiencing neonatal asphyxia.

Also gestational diabetes mellitus (GDM), pregnancy related anaemia, pregnancy related thyroid disease and obstetric cholestasis do not seem to be statistically related to this outcome.

Table 2
intrapartum variables.

VARIABLE	CATHEGORY	ASPHYXIA N(%)	NO ASPHYXIA N(%)	OR	IC 95%	P- VALUE
Type of labour	spontaneous	61 (37.65%)	111(68.5%)			
	Induced with prostaglandin	23 (14.19%)	7 (4.3%)	3.01	1.88–5.79	< 0.001
	Spontaneous + oxitoxin	51 (31.48%)	32 (19.75%)	3.45	2.09–5.68	< 0.001
	Induction + oxitoxin	27 (16.66%)	12 (7.4%)	4.09	1.93–8.65	< 0.001
labour	normal	105(64.81%)	146(90.12%)			
	dystocic	35(21.61%)	10(6.17%)	4.67	2.23–9.99	< 0.001
	precipitous	22(13.58%)	6(3.7%⁹	5.09	1.99–13.01	< 0.001
Epidural intra partum analgesia	absent	68(41.98%)	94(58.02%)			
	Present	94(58.02%)	68 (41.98%)	1.91	1.22–2.97	0.004
Cardiothocography	normal	30(18.52%)	141(87.04%)			
	Not reassuring	66(40.74%)	16(9.88%)			
	pathological	66(40.74%)	5 (3.09%)	30.79	16.73–56.64	< 0.001
Type of birth	spontaneous	84 (51.85%)	138(85.19%)			
	VAC for FHR*	22 (13.58%)	3 (1,85%)	6.57	2.58–16.73	< 0.001
	VAC for distocia	2 (1.23%)	3 (1.85%)			
	Urgent caesarean	44 (27.16%)	2 (1.23%)	4.92	2.7–8.96	< 0.001
	Not urgent caesarean	10 (6.17%)	16 (9.88%)			
Duration of expulsive period	30 min- 2 hours	62(57.41%)	139(96.53%)			
	> 2 hours	11(10.19%)	4(2.78%)	6.16	1.8-20.12	0.003

*Table 2: VAC for FHR: Vacuum assisted for fetal heart rate.

VARIABLE	CATHEGORY	ASPHYXIA N(%)	NO ASPHYXIA N(%)	OR	IC 95%	P- VALUE
	< 30 min	35(32.41%)	1(0.69%)	4.25	10.5– 58.7	< 0.001
Maternal positi on at birth	semi-recumbent	61(56.48%)	15(10.42%)	33.88	12.2– 93.7	< 0.001
	semi-sitting	94 (12.96%)	4(2.78%)			
	sitting (on stool)	6 (5.56%)	11 (87.64%)			
	squatting	17 (15.74%)	61(42.36%)			
	kneeling	3 (2.78%)	6 (4.17%)			
	standing up	1 (0.93%)	3 (2.08%)			
	lateral position	6 (5.55%)	44 (30.55%)			
Neonatal weigh at birth (gr)	< 2500	29(17.9%)	2 (1.23%)	1.88	1.78– 2.44	0.005
	2500–2999	32 (19.75%)	35(21.6%)			
	3000–3499	67(41.36%)	99(61.11%)			
	3500–3999	22(1.58%)	26(16.05%)			
	> 4000	12(7.41%)	0(0.00%)			
Shoulder distocia	absent	102(62.96%)	143(88.27%)			
	present	60(37.03%)	19(11.73%)	4.42	2.49– 7.86	< 0.001
Abnormal cord	absent	115	125			
	present	47	37	1.38	0.83– 2.27	0.206
Amniotic fluid	clear	118(72.84%)	153(94.44%)			
	meconium	44 (27.16%)	9(5.56%)	6.33	2.97– 13.5	< 0.001
Fever during labor	absent	153(94.44%)	159(98.15%)			
	Present	8(4.94%)	1(0.62%)	2.77	0.72– 10.6	0.138
*Table 2: VAC for FHR: Vacuum assisted for fetal heart rate.						

Table 2 shows the intrapartum variables that have been taken into account.

Induced labour is associated to a 3 fold increased risk of neonatal asphyxia (OR 3.01; IC 1.88–5.79; $p < 0,001$), and not surprisingly, induction + oxitoxin further increases that risk (OR 4.09; IC 1.93–8.65; $p < 0,001$). Intrapartum peridural analgesia seems to nearly double the risk (OR: 1.91; p 0.000; IC: 1.22–2.97).

Operative vaginal birth for abnormal foetal heart rate increases 7 times the risk (OR 6.57 ; $p < 0.001$; IC: 2.58–16.73)., while emergency caesarean section for abnormal cardiotocography (CTG) increases the risk 5 times (OR 4.92; p 0.000; IC: 2.7–8.96).

The time of the expulsive period is also an important factor: an expulsive period that lasts for more than 2 hours is associated to an increased risk of foetal asphyxia (OR 6.16; p 0.003; IC: 1.88–20.12), also a very quick birth increases the risk by about 4 times (less than 30 minutes) (OR 4.25; $p < 0.001$; IC: 10.5–58.7).

Meconium stained liquid increases the risk by about 6 times ($p < 0.001$; OR: 6.33 ; IC: 2.97–13.5). Newborns that have altered CTG traces have a 30 times increased risk of having foetal asphyxia ($p < 0.001$; OR: 30.79 ; IC: 16.73–56.64).

Shoulder distocia is associated to greatly increased risk ($p < 0.001$; OR:4.42 ; IC: 2.49–7.86).

The semi-recumbent position at birth compared to the kneeling position, standing up or lateral position increases the risk by about 30 times (OR 33.88; p 0.000; IC 12.24–93.78).

However fever during labour and having an abnormal umbilical cord do not increase the risk.

Table 3
organisational variables.

VARIABLE	CATHEGORY	ASPHYXIA N(%)	NO ASPHYXIA N(%)	OR	IC 95%	P- VALUE
One to one care	Absent	66 (40%)	39 (24%)	4.58	2.84– 7.39	< 0.001
	present	96 (59%)	123 (76%)			
Time of birth	Day time	77 (48%)	109 (67%)	2.27	1.44– 3.56	< 0.001
	Night time	85 (52%)	53 (33%)			
Day of birth	Weekday	116 (72%)	91 (56.17%)	0.106	0.31– 0.36	< 0.001
	Weekend	43 (26%)	49 (30,24%)			
	Bank holiday	3 (2%)	22 (13,5%)			
Volume of activity	Medium activity	104 (64,19%)	134 (82.7%)	2.62	1.55– 4.41	< 0.001
	High activity	58 (35,8%)	28 (17,28%)			
midwife's work experience (years)	< 5	10(6.17%)	5 (3.09%)	1.94	1.20– 3.13	< 0.001
	5–9	49 (30.25%)	41 (25.31%)			
	10–14	39 (24.97%)	73 (45.06%)			
	15–19	19 (11.73%)	40 (24.69%)			
	> 20	45 (27.78%)	3 (1.85%)			
	> 15 vs < 14					
midwife's qualification	Diploma in midwifery	42 (25.93%)	27(16.67%)	1.94	1.20– 3.13	< 0.001
	Diploma converted to university degree.	21 (12.96%)	8 (4.94%)			
	Three year university degree	87 (53.7%)	91 (56.17%)			

VARIABLE	CATHEGORY	ASPHYXIA N(%)	NO ASPHYXIA N(%)	OR	IC 95%	P- VALUE
	Three year degree + two years specialization	8 (4.94%)	29 (17.9%)			
	3 years + post degree qualification	3 (1.85%)	1 (0.62)			
	3 + 2 years + post degree qualification	1 (0.62)	6 (3.7%)			
	1 vs 2,3,4,5			1.78	0.51– 6.21	0.363
doctor's work experience	< 5	28 (17.28%)	6 (3.7%)			
	5–9	49 (30.25%)	16 (9.88%)			
	10–14	33 (20.37%)	12 (7.41%)			
	15–19	28 (17.28%)	9 (5.56%)			
	> 20	5 (3.09%)	2 (1.23%)			
	1vs 2,3,4,5			2.61	0.85– 8.04	0.093

Table 3 illustrates the organisational variables of births with newborns affected and not affected by asphyxia. The absence of one to one care increases the risk by about 4 and half times (OR 4.58; P 0.000; IC: 2.84–7.39); being born at night time doubles the risk (OR:2.27; p :0.000; IC: 1.44–3.56) as well as being born on a day with high volume of activity (OR:2.62; p 0.000; IC: 1.55–4.41). Giving birth on a bank holiday is protective for foetal asphyxia (OR: 0.16 ; p :0.000; IC: 0.31–0.36). Giving birth with a midwife with more than 15 years of work experience (OR:1.94; p : 0.000; IC: 1.20–3.13) apparently nearly doubles the risk.

Instead the midwife's qualification and the doctor's experience do not influence the risk of experiencing neonatal asphyxia.

Discussion

The aim of this paper is to discuss which situations and events could be prevented or changed to limit these kinds of adverse neonatal outcomes .

The organisational variables that were statistically associated with an increased risk of neonatal asphyxia were: lack of one-to-one attendance during labour, birth during the night and high volume of daily activity.

Other interesting factors that are significantly linked to foetal asphyxia and that could be somehow changed in their effect on births are: maternal BMI, smoking and Assisted Reproduction Technology (ART) obtained pregnancies.

Our findings are in line with previous ones (10) regarding one-to-one assistance as a protective factor against low Apgar score at birth.

One-to-one care is defined by NICE pathways as: “care provided for the woman throughout labour exclusively by a midwife solely dedicated to her care (not necessarily the same midwife for the whole of labour)”(11).

This kind of assistance should be offered to all women in all kinds of birth settings (12) because women who experience this kind of assistance are more likely to have a spontaneous vaginal birth and less likely to have intrapartum analgesia or to report dissatisfaction. In addition labours are shorter, they are less likely to have a caesarean or instrumental vaginal birth, regional analgesia, or a baby with a low five-minute Apgar score (10).

The risk of asphyxia was higher for births that occurred between 8.00 pm and 7.59 am. Instead births during weekends seemed to have lower risk of asphyxia. Being born during bank holidays seemed to have a protective effect in terms of perinatal asphyxia.

These results are similar to the findings of other works conducted in Europe. A retrospective cohort study carried out in the Netherlands showed that there is an increased risk of adverse events for night time births. Evening and night-time births that involved induction, augmentation of labour, or an emergency caesarean section, were associated to an increased risk of an adverse perinatal outcome when compared to similar daytime ones. As in our experience, they found that weekend births were not associated with an increased risk when compared to weekday ones. It was estimated that each year, between 126 and 141 cases with an adverse perinatal outcome could be attributed to this evening and night effect. Of these, 21 (15–16%) were intrapartum or early neonatal death (13).

In a completely different setting from the aforementioned work we observed similar results when discussing early neonatal deaths (ENND). In a teaching hospital in South East Nigeria ENND was twice and 1.3 times higher for evening and night hours respectively, while there was no difference between weekends and week days. There was also statistical difference in neonatal intensive care unit (NICU) admission between morning and evening hours but not between morning and night hours, so in this setting too there seemed to be some kind of association between “off hours” and perinatal outcomes but no association regarding weekdays and weekends (14).

The night time effect observed in our study could be due to various different factors; one of the main ones is the fatigue that hospital personnel has to undergo during particularly long shifts (for example: 12 hour shifts), the different volume of work during night and day, different people in the team at night time. The ready availability of expert professionals also at night time is guaranteed but, as there is only one doctor on duty, further assistance may have to be summoned from the doctor on call; also the ready access to the operating theatre is guaranteed but has to be organised on the spot.

As Abrams reports in his paper, obstetrics and gynecology is a field of medicine that leads to a high incidence of sleep deprivation and fatigue. Labour is typically unpredictable in its evolution and potential complications therefore leading to erratic work hours and impaired sleep (15).

Apart from having an impact on the staff's quality of life, fatigue from sleep deprivation has also been considered partially responsible for the increased number of neonatal deaths at night, along with structural variables such as the availability and quality of physicians, nurses, support personnel and accessibility of diagnostic tests and procedures (16).

In our study it seems that giving birth during high volume of activity days increases two fold the risk of suffering from foetal asphyxia. This finding is similar to other studies conducted in high income countries (17) although there are some interesting differences. In the study conducted by Snowden et al there is an association between high activity days and a large number of foetal and maternal complications, but the data suggests that there is definitely a weekend effect, in that most adverse perinatal outcomes occur mainly during weekends.

However, in the study conducted in Novara, this does not appear to happen, at least when considering the event that we focused on, neonatal asphyxia. Giving birth at weekends seems to be protective for this particular outcome. This might be partially explained by the great decrease in scheduled activity that enables the staff to focus on the various casualties that might occur. Another interesting aspect is that as the Maggiore Hospital is a teaching hospital, there is always extra medical trainee staff on the ward whereas non teaching hospitals often only have the doctor on duty. This means that there is always extra support available when it comes to emergency procedures or when dealing with abnormally increased workloads.

One rather interesting and apparently contradictory finding is to observe that giving birth with a midwife that has more than 15 years work experience is associated with an almost two fold increased risk of experiencing peripartum asphyxia.

When interpreting this finding it must be taken into account that the most complex deliveries and patients in need of experienced care and therefore those who are at higher risk of developing asphyxia are more often managed by senior midwives.

These findings are somewhat similar to those of Reif et al, who apparently found an inverse correlation between staff seniority and neonatal adverse events with more adverse outcomes with increasing

seniority; in this work senior staff were more likely to be involved in the management of high -risk births ab initio or in initially uneventful labours that needed further assistance (18).

Another risk factor that is still under debate is Assisted Reproductive Technology. In our study it increases the risk by about 13 times. This finding is consistent with those found in literature although the role of reproductive techniques is being reevaluated because many studies debate whether a large portion of cerebral palsy associated to assisted reproductive technology obtained pregnancies is more likely to be linked to the increased risk of preterm birth and multiple pregnancies (5, 19). In our study, the greatly increased risk is given not by preterm births or by multiple pregnancies because they were excluded from the study.

There is no unique regulation regarding which patients should undergo this kind of procedure and as there is a constant increase of ART obtained pregnancies, it would be fitting for the World Health Organisation to clearly state what peripartum risks are linked to these procedures, as we could expect a rise in the numbers of cerebral palsies with the increase of ART pregnancies.

This could encourage institutions to legislate and regulate more uniformly avoiding striking differences among various countries.

An audit is one of the most common tools used for evaluation, learning from past events and therefore preventing a recurrence.

Two commonly used perinatal process audits are topic audits and sentinel event audits: topic audits review a specific care activity for all patients. Sentinel event audits analyze the process of care in a case with a defined adverse outcome. Traditionally, maternal and perinatal deaths are used as sentinel events (20).

It has been proposed to include perinatal asphyxia as part of an extended perinatal audit because it can be considered a neonatal near miss and therefore an indicator of the quality of perinatal care (20, 21).

An audit of strategies employed to minimize obstetric liability within a maternity unit found that the percentage of cases with suboptimal care fell from 74–9% during an intervention period (22, 23).

Therefore performing regular audits and including these events as sentinel events could be useful to improve and implement changes in peripartum care by introducing new policies or even just for the staff to learn from difficult situations that have already occurred and been successfully managed (or not).

Another important preventive measure is to train staff to manage obstetric emergencies with a specific training program.

It has been shown that the introduction of obstetric emergencies training courses is associated with a significant reduction in low 5-minute Apgar scores and hypoxic–ischaemic encephalopathy (HIE) (24).

This could be an important opportunity to keep staff updated in new emergency procedures as well as improving the staff's confidence in dealing with severe complications.

When analyzing the previous literature regarding suboptimal care, among the most common events of malpractice in connection with births were : neglecting to supervise foetal wellbeing, neglecting signs of foetal asphyxia, incautious use of oxytocin and choosing a nonoptimal mode for the birth (25, 8).

Interpretation of foetal heart rate (FHR) monitoring remains a critical point in preventing intrapartum asphyxia. Unfortunately, interpretation of FHR monitoring is subject to intra- and inter-observer variability which impedes its interpretation and consequently the application of appropriate interventions (20).

Cardiotocography (CTG) reading is part of most training courses as it is still one of the main points of debate when later examining a birth or during legal litigation. It could be useful to routinely take arterial and venous blood samples from the umbilical cord at birth to have a more objective parameter not open to subjective interpretation.

Some hospitals keep the placenta refrigerated for some days and this allows later hystological examination of the placenta in the case of the child having any health issue that might be connected with the birth in the first days after being born (26, 27).

The most common prevention strategy for neonatal asphyxia is to routinely screen higher risk pregnancies with serial ultrasound scanning as well as organising elective birth (1).

An extra step forward could be screening to identify children that are at higher risk of experiencing neonatal asphyxia from a low risk population. Some studies have been conducted and have found that it is possible to predict infants that are at risk of severe adverse neonatal outcomes at term with moderate accuracy using an algorithm that combines maternal, intrapartum and ultrasound variables (28).

If applied regularly this could be useful so that more experienced staff could be selected to assist at risk patients and to have more strict intrapartum monitoring in these cases.

When dealing with night work which has been seen to increase the risk of adverse events, it is important to have shifts where the staff works only a limited number of nights as the impact on quality of life and on the quality of work can be dramatic. Regarding this, a study carried out by the University of Toronto showed how most of the residents in the study preferred shorter night shifts compared to a preexisting 24 hour call system and the nursing staff also found it easier to work with residents on shorter night shifts (29). One other organisational measure that could help reduce the work load at night is to start inductions of labour during the night hours so it is more probable that labour and birth will take place during day time with extra, more alert staff.

Many factors have been seen to be significantly linked to an increased risk of peripartum asphyxia. It is very difficult to change preexisting maternal conditions like medical issues such as diabetes but it could be useful to increase awareness toward some situations like the effect of maternal BMI on the risk of

foetal asphyxia. It has been proven that patients respond positively to health education and if correctly instructed limit their weight gain during pregnancy; therefore improving and implementing health educational programs could be very useful and for those patients who are at higher risk, (already overweight, with gestational diabetes) targeted counselling and follow up during the pregnancy should be offered (30).

Smoking is also significantly associated to an increased risk of foetal asphyxia, and although it is widely known that smoking is harmful not only for the mother but also for the child, there is a portion of women who do not quit smoking during pregnancy. A cohort study based in Romania shows that the women that are most likely to smoke during pregnancy meet the socio-demographic characteristics of the most vulnerable population groups: they live in rural areas, are single, and have a low education and socio-economic level, suggesting the presence of socio-economic disparities in smoking (31).

Ethnicity seems to have an effect on perinatal asphyxia. This could be caused by the more difficult access to health facilities that migrant women have. In our study it has been seen how perinatal asphyxia increases if less than 4 clinical check ups are performed during pregnancy. Often free clinics have difficulty explaining and giving instructions to some patients who don't speak the local language. Therefore it could be useful to implement translators and the presence of local free clinics that would perform accurate scans, not only clinical checks, and be a point of reference for patients that perhaps can't drive or that for cultural reasons wouldn't travel unaccompanied more than a certain distance from home (32).

These patients could be offered special support not only during pregnancy with more frequent check-ups and psychological assistance, but also after the birth of the child as these women often do not have the social network and support they need.

Cerebral palsy cannot always be prevented because it is a syndrome with a multitude of potential causes. The increase in numbers of ART obtained pregnancies, of mothers with increased BMI, and generally of pregnancies characterized by risk factors that cause diseases such as preeclampsia and GDM and, most importantly, the increase in preterm births make it impossible to completely prevent cerebral palsy

But a portion of cases is likely to be linked to acute intrapartum events that could be limited by changing organisational policies such as night-shifts, staff training and implementing team work and discussion. Our paper wants to highlight where there is space for improvement in obstetric health care. We would like to stress that improving staff training, audits and the organisation of the personnel are steps that can be taken by the individual ward and do not need large scale policies therefore they should be relatively easy and swift to put into practice.

Health institutions should try and modify those organisational and social situations that may increase the risk of developing peripartum adverse events such as birth asphyxia that can lead to the life changing disease known as cerebral palsy.

Abbreviations

OR: Odd's ratio

IC: interval confidence

ART: assisted reproductive technology

GDM: gestational diabetes mellitus

CTG: cardiotocography

BMI: body mass index

ENND : early neonatal deaths

NICU: neonatal intensive care unit

VAC for FHR: Vacuum assisted for fetal heart rate.

Declarations

Ethics approval and consent to participate: no ethical approval was obtained because this study did not involve a prospective evaluation, did not involve laboratory animals and only involved non-invasive procedures.

Our local ethics committee decided that no formal ethics approval was required in this specific case.

The hospital management gave permission to collect personal medical data from the medical records.

Consent for publication: not applicable.

Availability of data and materials: the datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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Author's contribution: AR designed the study , corrected the manuscript and did part of the statistical analysis, SG designed the study, created the database , EO wrote the original manuscript and created the database, CM did part of the statistical analysis, IA e did part of the data interpretation ,VS created the database and interpreted the data , RT did part of the statistical analysis, ADP interpreted the data , DS coordinatied and supervised the study.

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