Predictors of Omphalitis among Spontaneous Vertex Delivery Neonates in Nakuru County Hospital, Kenya

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Abstract

Background: Omphalitis (umbilical cord infection) among new-borns is common and a major cause of neonatal deaths in developing countries. Annually, about 4 million neonatal deaths occur around the world. Of these, >30% are caused by infections that mainly from umbilical cord. Cord care practices may directly contribute neonatal infections; largely contributing tothis was part data from a larger randomized trial among 540 participant's neonatal deaths. Cord infections are more prevalent in developing countries because of the high rates of poverty and unhygienic practices.

Objective: To determine the predictors of omphalitis among neonates in Nakuru County Hospital, Kenya. Methodology This was part data from a larger randomized trial among 540 participants.

Findings: The prevalence of Omphalitis was 23.1. Babies whose mothers' did not wash hands when eating had 2.14 times risk of developing cord infection compared to those babies whose mothers' indicated otherwise [AOR=2.14; 95%CI=1.28 - 3.57; p=0.004]. Likewise, babies whose mothers' never folded diapers backwards were twice likely over those who did to develop cord infection [AOR=1.88; 95%CI=1.03 - 3.44; p=0.039]. Babies whose mothers' stayed in different rooms had 7.35 times risk of developing cord infection [AOR=7.35; 95%CI=3.40 - 15.91; p<0.001] over those roomed in.

Conclusion and recommendation: Maternal and caretakers hand hygiene, folding back of diapers and rooming in are critical in cord infection prevention. Health education to mothers and care takers on the importance of hand hygiene, diaper application and importance of rooming in is recommended to minimise omphalitis and consequential morbidity.

Keywords: Diaper application, Hand hygiene, Rooming-in, Omphalitis.

Introduction

Newborns are a vulnerable group needing more attention and care. Globally, two thirds of total infant deaths comprise newborns and 99% of these deaths are concentrated in Sub-Saharan Africa and the South East Asian region (Mullany et al., 2009). Worldwide, 2.6 million neonatal deaths occurred in 2016, translating to approximately 7,000 deaths daily (UNICEF, 2019). Infections are a major contributor to newborn deaths in developing countries with majority of them starting as umbilical cord infection then becoming systemic. Omphalitis, the infection of the umbilical cord and defined as pus discharge, redness with or without pus and swelling of umbilical cord, has remained a public health problem in developing and resource-poor countries where it causes neonatal illnesses and deaths (Imdad et al., 2013). For this reason, Umbilical Cord Care (UCC) continues to be an active subject in scientific research.

Currently, there is substantial disagreement in the recommendations made by health providers to caregivers for UCC. These recommendations are often based on custom or personal beliefs and not supported by evidence (Zupan et al., 2004). Harmful traditional practices during cord cutting, tying, application of different substances to the fresh umbilical stump and unhygienic handling of the neonate by the care takers may contribute to the entrance of infectious micro-organisms (Shariff et al., 2016) leading to consequent morbidity and mortality.

Thus, understanding the proximal, intermediate and distal determinants of omphalitis is critical in prevention of the same. For the current study, we sought to understand the intermediate determinants of omphalitis

which include hygiene-related practices that contribute to infections and mortality mainly after discharge from the health facility. These include type of infant-bathing practices, manner diapers are folded, attendants' hand-washing practices, Rooming in which leads to skin to skin between mother and newborn, and thermal care of the newborn (Mullany et al., 2009). Proper hand hygiene is documented as the single most important, simplest, and least expensive means of reducing the spread of infections (Mathur et al., 2011).

Methods

Setting: The study was conducted in Nakuru County Hospital, a level 5 facility in Kenya. The hospital averages 1000 spontaneous vertex deliveries (SVD) and 300 caesarean sections a month. This facility had the highest early neonatal mortality rate in 2014 in Kenya (36%), with neonatal sepsis a great contributor (KDHS, 2014)

Study design and participants: The larger study from which this data was drawn was a randomized controlled trial comprising 540 participants systematically drawn. Participants were healthy term SVD new-borns (38-42 weeks gestation). They had to be within twelve hours post-delivery, free from congenital anomalies, and weigh 2500-4000 grams, and Apgar score ≥8 at first minute. Participants had to have nothing applied to the umbilical cord stump yet, roomed-in with their mothers, and breast fed within one hour. Informed consent was gotten from care takers. Neonates requiring immediate neonatal intensive care, born before arrival to hospital, with malformations, or referred from other hospitals with labour complications or other medical conditions were exempted.Demographic information and history relevant to the study were collected from the care-taker, other family members and from obstetrics record using a structured questionnaire. The tool further collected information on cord care practices, initiation of breastfeeding, thermal care, any substance application on the cord, methods used to care for the cord, appropriate application of diaper and washing hands. Additionally, umbilical cord-swab were taken from the base of the umbilical cord within twelve hours of delivery before any other cord care commencement and later on the seventh. The specimens were collected by a trained laboratory technologist using a dry sterile swab soaked in Amies transport medium (Oxiod, England), labelled with baby's code and delivery date. They were transported in Stuart's medium (Merck - Germany) and sent to bacteriology laboratory within one hour of collection. All specimens were cultured in the blood agar and MacConkey agar plates (Merck Germany) and incubated for 24-48 hours at 37°C. Bacterial growth was monitored to identify omphalitis causing organisms in the infected samples.

New-borns were followed up at day 3, 14, 21 and 28 for any signs of umbilical cord infection and features of sepsis during the total neonatal period. On day seven all the neonates were brought back to the facility for a follow-up umbilical cord swab and examination of the umbilical cord stump. During and immediately after the hospital stay, mothers were given health messages on how to care for the cord stump and how to note signs of umbilical infection at home which included redness, foul smell, or pass discharge and were asked to report to the researcher if any such signs were noticed. Objective identification of omphalitis in this study was defined as pathogenic bacterial culture in the umbilical cord swab within twenty four hours and /or on the follow up on the seventh day showing single isolates or predominantly single isolates with or without any physical signs on the skin.

Data analysis: Raw data from Kobo Collect were coded and entered into Microsoft Excel and transported exported into Statistical Package for Social Sciences (SPSS) version 22 for analysis. Descriptive statistics using frequency and proportions were computed to describe the basic attributes of the respondents as well as the occurrence of omphalitis. Chi-square tests and logistic regressions were performed to determine whether there were significant associations between the factors studied and occurrence of omphalitis The effectiveness of the regimens were determined using multiple logistic regression by considering the variables revealed significant difference at *p<0.05* during the descriptive comparison analysis. Accordingly, the model include the following factors: the intervention group, number of children and how to clean the umbilical cord. *Backward conditional* method was specified with removal at *p<0.05*.

Further, Odds ratios with corresponding 95% confidence interval were also calculated for the variables. Level of significance was set at a P value <0.05.

Ethical considerations: The study was approved by the Institutional Review Board and permission granted by both Nakuru county and the facility administration. Informed consent was obtained from the participants' care takers. Participants who had omphalitis or those whose caretakers requested were reviewed and treated by a neonatal clinician.

Results

Omphalitis in relation to socio-demographic characteristics of mothers and neonates

There was an attrition rate of 10% from the 540 neonates to 485 atfollow-up. The prevalence of cord infection was 23.1%. The highest percentage (41.6%) of mothers were aged between 19-24 years. Most were married (77.9%), attained secondary education (55.1%) and were Christians (95.3%). Highest percentage of households (30.7%) had one child. Studied neonates were majority female (51.8% versus 48.2% for male). All the neonates had normal Apgar score and birth weight, with majority (70.3%) having an Apgar score of ≥ 8 in the first one minute. About half (49.3%) weighed 3.01 to 3.50 Kgs. Almost all (99.4%) initiated breast feeding within one hour. However, there was no significant association between demographic characteristics of the mothers or neonates and cord infection among neonates (*p>0.05*) as shown in Table 1.

Table 1: Demographic characteristics of the mothers and neonates stratified by cord infection status

Variables	Total		Infected		Not infected		χ^2 value	p value
	n	%	N	%	n	%		
Age in years								
19-24	202	41.	50	24.8	152	75.2	0.68	0.877
25-29	141	29.	32	22.7	109	77.3		
30-34	97	20.	21	21.6	76	78.4		
35 and above	45	9.3	9	20.0	36	80.0		
Marital Status								
Married	378	77.	87	23.0	291	77.0	0.01	0.940
Single/divorced	107	22.	25	23.4	82	76.6		
Level of Education								
Primary	142	29.	31	21.8	111	78.2	0.54	0.763
Secondary	267	55.	65	24.3	202	75.7		
College	76	15.	16	21.1	60	78.9		
Religion								
Christian	462	95.	106	22.9	356	77.1	0.12	0.727
Muslim	23	4.7	6	26.1	17	73.9		
Number of children								
One	149	30.	30	20.1	119	79.9	3.12	0.538
Two	130	26.	32	24.6	98	75.4		
Three	138	28.	37	26.8	101	73.2		
Four	38	7.8	6	15.8	32	84.2		
Five and above	30	6.2	7	23.3	23	76.7		
Baby's gender								
Male	234	48.	50	21.4	184	78.6	0.76	0.384
Female	251	51.	62	24.7	189	75.3		
Birth weight								

2.50-3.00 Kgs	130	26.8	35	26.9	95	73.1	3.39	0.184
3.01-3.50 Kgs	239	49.2	57	23.8	182	76.2		
3.51-4.00 Kgs	116	23.9	20	17.2	96	82.8		
APGAR score in the first one minute								
8	138	28.5	34	24.6	104	75.4	0.38	0.829
9	341	70.3	77	22.6	264	77.4		
10	6	1.2	1	16.7	5	83.3		
Initiation of Breast Feeding								
< 1 hour	482	99.4	112	23.2	370	76.8	0.91	0.341
> 1 hour	3	0.6	0	0.0	3	100.0		
* Significance at p<0.05								

Omphalitis in relation to socio-economic factors

More than half (53.6%) of the mothers were unemployed and 90.5% earned <Kshs15000 per month. This, however, had no statistical association with cord infection (*p>0.05*). Although majority (66.4%) of the mothers had permanent housing, 82.5% were rental. Still, this had no significant association with cord infection among the neonates (*p>0.05*). Sixty two (61.6%) percent used pit latrines but proportions of cord infection were higher (*p=0.026*) among those using flash toilet. This and other socio-economic factors studies are presented in Table 2.

Omphalitis in relation to obstetric factors

All the mothers attended antenatal care (ANC) and 56.7% attended four times and above, but there was no significant association with cord infection (*p=0.680*). Similarly, all had normal gestational age during delivery with the highest percentage of 37-38 weeks (43.1%) but this too did not associate with cord infection (*p=0.460*). All other obstetric factors had no association with cord infection as shown in Table 3.

Table 2: Omphalitis in relation to socio-economic factors

Variables	Total (N=485)		Infected (N=112)		Not infected (N=373)		χ^2 value	p value
	n	%	n	%	N	%		
Occupation								
Permanent employment	37	7.6	7	18.9	30	81.1	1.19	0.551
Self/causal employment	188	38.8	48	25.5	140	74.5		
Not employed	260	53.6	57	21.9	203	78.1		
Monthly income in Shillings								
15,000 and less	439	90.5	103	23.5	336	76.5	0.48	0.786
20,000	13	2.7	3	23.1	10	76.9		
30,000 and above	33	6.8	6	18.2	27	81.8		
Nature of your house								
Permanent	322	66.4	82	25.5	240	74.5	3.46	0.178
Semi-permanent	112	23.1	19	17.0	93	83.0		
Temporary	51	10.5	11	21.6	40	78.4		
House ownership								
Self-owned	85	17.5	16	18.8	69	81.2	1.06	0.304
Rented	400	82.5	96	24.0	304	76.0		

Source of water								
Piped	378	77.9	84	22.2	294	77.8	3.25	0.197
Buying	48	9.9	16	33.3	32	66.7		
Others (rain water and borehole)	59	12.2	12	20.3	47	79.7		
Type of toilet								
Flash	186	38.4	53	28.5	133	71.5	4.96	**0.026**
Pit	299	61.6	59	19.7	240	80.3		
* Significance at p<0.05 bolded								

Table 3: Obstetric factors stratified by umbilical cord infection

Variables	Total		Infected		Not infected		χ^2 value	p value
	n	%	n	%	N	%		
Number of ANC visits								
Once	15	3.1	5	33.3	10	66.7	1.51	0.680
Twice	55	11.3	12	21.8	43	78.2		
Thrice	140	28.9	29	20.7	111	79.3		
Four times and above	275	56.7	66	24.0	209	76.0		
Gestation during delivery								
37 to 38 weeks	209	43.1	43	20.6	166	79.4	1.55	0.460
29 to 40 weeks	206	42.5	50	24.3	156	75.7		
41 to 42 weeks	70	14.4	19	27.1	51	72.9		
Duration of labour								
< 8 hours	44	9.1	9	20.5	35	79.5	0.53	0.912
8-10 hours	117	24.1	27	23.1	90	76.9		
11-14 hours	174	35.9	43	24.7	131	75.3		
15 hours and above	150	30.9	33	22.0	117	78.0		
Duration of membrane rupture								
One hour	79	16.3	19	24.1	60	75.9	0.12	0.989
Two hours	171	35.3	39	22.8	132	77.2		
Three hours	211	43.5	49	23.2	162	76.8		
Four hours	24	4.9	5	20.8	19	79.2		
Mode of delivery								
SVD(normal)	484	99.8	112	23.1	372	76.9	0.30	0.583
Caesarian	1	0.2	0	0.0	1	100.0		
Maternal HIV status								
Negative	427	88.0	99	23.2	328	76.8	0.02	0.896
Positive	58	12.0	13	22.4	45	77.6		

* Significance at p<0.05					

Omphalitis in relation to umbilical cord care practices

Majority (89.5%) of the mothers always washed hands after visiting toilet. Cord infections were more among those who did not, but this was not significant (*p=0.138*). A large percentage (96.3%) reported washed hands after changing the baby but this too was not significant (*p=0.631*). However, they were not statistically significant with cord infection (*p>0.05*). Of the total, 69.1% were not washing hands when eating and this was significantly more among neonates with cord infection (*p=0.003*). Most (86.6%) of the babies had their diaper folded backwards and cord infection was significantly higher among babies whose diaper was not folded backwards (*p=0.012*). Even though a large number (93.2%) of the mothers roomed in with the baby, cord infections were still significantly more among babies whose mothers were not always staying in the same room (*p<0.001*). Table 4 summarizes the practices that could influence cord infections.

Predictors of omphalitis among neonates

After considering eight factors with *p<0.2* altogether using binary logistic regression by specifying 'backward LR'method with removal at *p<0.05*, three factors remained in the last model (Table 5). Babies whose mothers' were not washing hands when eating had 2.14 times higher risk of developing cord infection compared to those whose mothers' indicated otherwise [AOR=2.14; 95%CI=1.28 - 3.57; *p=0.004*]. Likewise, babies whose mothers' did not fold the diaper backwards were twice likely to have cord infection [AOR=1.88; 95%CI=1.03 - 3.44; *p=0.039*] compared to those whose mothers' folded diapers backwards. On roomed-in babies had 7.35 times higher risk of developing cord infection [AOR=7.35; 95%CI=3.40 - 15.91; *p<0.001*] compared to roomed-in babies.

Table 4: Umbilical cord care practices based on cord infection status

Variables	Total (N=485)		Infected (N=112)		Not infected		χ^2 value	p value
	n	%	n	%	n	%		
Washing hands after visiting toilet								
No	51	10.5	16	31.4	35	68.6	2.20	0.138
Yes	434	89.5	96	22.1	338	77.9		
Washing hands after changing the baby								
No	18	3.7	5	27.8	13	72.2	0.23	0.631
Yes	467	96.3	107	22.9	360	77.1		
Washing hands when eating								
No	335	69.1	90	26.9	245	73.1	8.68	**0.003**
Yes	150	30.9	22	14.7	128	85.3		
Washing hands when cooking								
No	288	59.4	62	21.5	226	78.5	0.98	0.323
Yes	197	40.6	50	25.4	147	74.6		
Methods/ways of washing hands								
On a basin	428	88.2	100	23.4	328	76.6	2.49	0.288
On basin and tap	35	7.2	5	14.3	30	85.7		
Tap	22	4.5	7	31.8	15	68.2		
How to clean the umbilical cord								
Clean with	275	56.7	59	21.5	216	78.5	1.11	0.573
Clean with boiled	63	13.0	17	27.0	46	73.0		

Clean with wet/dry	147	30.3	36	24.5	111	75.5		
Application of diaper folded backwards on the baby (observe)								
No	65	13.4	23	35.4	42	64.6	6.39	**0.012**
Yes	420	86.6	89	21.2	331	78.8		
Always staying with the in the same room								
No	33	6.8	21	63.6	12	36.4	32.77	**<0.001**
Yes	452	93.2	91	20.1	361	79.9		
* Significance at p<0.05 bolded								

Table 5: Multivariable analysis for factors associated with the occurrence of cord infection

Variables	COR	95%CI		P value*	AOR	95%CI		P value*
		Lower	Upper			Lower	Upper	
Birth weight								
2.50-3.00 Kgs	1.77	0.95	3.28	0.071	1.97	0.89	3.88	0.069
3.01-3.50 Kgs	1.5	0.85	2.65	0.158	1.66	0.90	3.07	0.108
3.51-4.00 Kgs	Ref				Ref			
Nature of the house								
Permanent	1.24	0.61	2.53	0.551	0.98	0.42	2.29	0.963
Semi-permanent	0.74	0.32	1.7	0.483	0.53	0.21	1.34	0.180
Temporary	Ref				Ref			
Source of water								
Piped	1.12	0.57	2.21	0.745	0.71	0.31	1.60	0.404
Buying	1.96	0.82	4.69	0.131	2.19	0.84	5.68	0.108
Others (rain water and	Ref				Ref			
Type of toilet								
Flash	1.62	1.06	2.49	**0.027**	1.61	0.93	2.80	0.091
Pit	Ref				Ref			
Washing hands after visiting toilet								
No	1.61	0.85	3.03	0.141	1.13	0.55	2.33	0.743
Yes	Ref				Ref			
Washing hands when eating								
No	2.14	1.28	3.57	**0.004**	2.14	1.25	3.66	**0.006**
Yes	Ref				Ref			
Application of diaper folded backwards on the baby (observe)								
No	2.04	1.16	3.56	**0.013**	1.88	1.03	3.44	**0.039**
Yes	Ref				Ref			
Always staying with the in the same room								
No	6.94	3.29	14.63	**<0.001**	7.35	3.40	15.91	**<0.001**

Yes	Ref			Ref			
* Significance at p<0.05 bolded; AOR= Adjusted Odds Ratio; COR= Crude Odds Ratio CI=							

Discussion

From our study, differing socio-demographic characteristics such as age, marital status and religion of mothers and neonates factors such as sex, Apgar score or duration to initiation of breastfeeding do not appear to relate to occurrence of omphalitis. It is noteworthy however, that high majority of mothers, for instance, were married and almost all neonates were breastfed within the first hour making comparisons with those outside this possible. Breast milk encourages growth of healthy lactobacilli and lactoferrin. It further has been found to have immunoglobulins like IgA, lysozymes and white blood cells and reduces growth of E. coli and other pathogenic bacteria, (Edmond et al., 2010). Early initiation and breast-feeding frequently provides antibodies that fight infections to the newborn (WHO 2015) hence greatly encouraged. Similarly, this study found that relates socio-economic factors, employment, level of income or even housing type and ownership do not affect umbilical cord infection for neonates. While previous studies have shown that social economic factors influence the quality of cord care and consequent outcomes (kinanu et al, 2015; Sobita et al., 2010; Ogonlesi et al., 2010), our current outcomes could have been influenced by fact that we freely supplied the materials needed for cord care among our study participants so that they did not have to use their resources for this.We however found that the fecal waste disposal methods used had effect on cord infections, where use of pit latrines appeared protective against contracting omphalitis. It is likely that when diapers are disposed off into the pit latrine there is total discard of fecal wastes that would harbor bacterial organisms unlike where family members use flush toilets and therefore may have challenges in the total disposal of diapers, causing undue contaminations in the process.

The current study demonstrates that babies whose mothers' do not wash hands when eating have 2.14 times higher risk of developing omphalitis compared to those babies whose mothers' do. Need for care takers' hand hygiene can never be over emphasized in prevention of infections. The link between hand washing and infection was established over two centuries ago (global hand washing partnership, 2015). The purpose of hand washing mainly is to prevent the spread of pathogens through physical contact. Usually two types of microbes colonize hands: the resident flora, which consists of microorganisms residing under the superficial cells of the stratum corneum and the transient flora, which colonizes the superficial layers of the skin, and is removable by routine hand hygiene. Transient microorganisms survive, but do not usually multiply on the skin. They are often acquired and transferred during direct contact with contaminated environmental surfaces and are the organisms most frequently associated with infections. Our findings are in agreement to (Blencowe et al. 2011) who indicated that maternal handwashing during the postnatal period reduced cord infections, which would translate to a reduction in all-cause neonatal mortality. Multiple literature shows that this inexpensive way of preventing neonatal infections at home and in the hospitals, and that, further reduces related mortalities, is practicable in resource-limited settings such as ours (Daniels et al, 1999; Kuti et al., 2019; WHO, 2009).

From the current work, it appears there is no association between whether mothers attended ANC and how many times they did, and the occurrence of cord infection. It is likely however that this finding may have been affected by the fact that participants' caretakers were given health messages on cord-care after delivery, so that any direct influence from what was taught or not during ANC was masked. This may have affected contribution of factors such as gestation, delivery, duration of labour, time-period since rupture of delivery, mode of delivery and maternal HIV status all which are known to influence cord infection were not significant in this study. We demonstrate that factors otherwise known to contribute to omphalitis can be reversed by health messages relating to cord care as was received by our participants, which caused our findings to differ from published works.

For predictors of omphalitis among neonates, our current findings show that neonates whose mothers' were not washing hands when eating had more than twice higher risk of developing cord infection compared to those whose mothers' washed hands. This is in agreement with existing literature that shows hand hygiene is associated with reduced infections otherwise contacted from dirt. (Mathur et al., 2011) stated "There is now undisputed evidence that strict adherence to hand hygiene reduces the risk of cross-transmission of

infections" which further agrees with WHO "Clean Care is Safer Care" initiative. (Mullany et al., 2007) further indicated that simple, low-cost interventions like hand washing reduce neonatal infections. Other predictors from the current study included whether or not the diapers were folded backwards, with those infants whose diapers were not folded backwards twice likely to have cord infectionas far as we are aware, this is novel finding and no previous study has looked at this. Our study additionally found that non-roomed-in babies had more than seven times higher risk of developing cord infection compared to roomed-in babies, providing an additional predictor of omphalitis in our population. Many studies have emphasized the importance and great need for rooming-in with benefits such as making breastfeeding easier. Several studies suggest that mothers who room-in with their babies make more milk, much sooner, breastfeed longer, and are more likely to breastfeed exclusively compared with mothers who have limited contact with their babies (Bystrova, Matthiesen, et al., 2007; Daglas et al., 2005; Declercq, Sakala, Corry and Applebaum, 2006; Fairbank et al., 2000; Flores-Huerta & Cisneros-Silva, 1997; Mikiel-Kostyra, Mazur and Wojdan-Godek, 2005;). Furthermore babies who room-in with their mothers take in more breast milk (Bystrova, Matthiesen, et al., 2007), gain more weight per day (Yamauchi and Yamanouchi, 1990), and are less likely to develop jaundice, and other infections including omphalitis (Syafruddin et al., 1988).

There are several biological mechanisms thought to account for the relationship between exclusive breastfeeding and umbilical cord infection. Breast milk contains secretory IgA, lysozymes, white blood cells, and lactoferrin. It has been shown to promote the growth of healthy Lactobacilli and reduce the growth of E. coli and other gram-negative pathogenic bacteria (Levi et al., 2007). Early initiation and exclusive breastfeeding is associated with significant reductions in diarrhea and acute respiratory infections in neonates while other observational studies have demonstrated impact on infection specific mortality rates during the neonatal period (Edimond et al., 2006; Mullany et al., 2008). In addition, initiating breastfeeding in the first hour of life is also recognized by the WHO as an important component of protection and should be implemented as routine hospital practice in all countries in order to reduce all cause neonatal mortality. When a mother and her baby are continuously together (rooming in), the baby is exposed to the normal flora on the mother's skin, which offer great protection to the baby from becoming exposed to harmful bacteria which can predispose the baby to infection and disease (WHO, 1998), which reflects our current finding.

Conclusion
Socio-demographic and socio-economic factors do predispose to omphalitis among neonates in Nakuru-Kenya. The type of family toilet however associates with development of omphalitis, perhaps because this affects how diapers are disposed off. Predictors of cord infections development in our set up include whether or not caretakers wash hands before eating, whether neonates are roomed-in, and how the diapers are folded.

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