Exploring frequencies of sleep and sleep-wake states in neonates admitted to the Neonatal Intensive Care Unit (NICU).

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ABSTRACT

Background: There is increasing evidence about the influence of sleep on neonatal brain development. Sleep deprivation in the neonatal period has short- and long-term negative impact on breathing patterns, brain development and behaviour. So far, no instrument for measuring sleep unobtrusive turned out to be valid and reliable in neonates. However, in the Neonatal Intensive Care Unit (NICU) it is possible to determine sleep states by observations. This can lead to valuable insights and direct performance of developmental care.
Aims: To explore frequencies of sleep and sleep-wake states in neonates using clinical observations. Furthermore we aimed to explore disturbances in sleep and associations between sleeping time and patient characteristics.
Methods: An observational longitudinal cohort design was used. An observational tool was developed to record sleep, characteristics and disturbances influencing sleep. Descriptive statistics were used to present these outcomes. A Pearson's correlation determined associations between sleep, disturbances and patient characteristics.
Results: A total of 43 neonates was included in this study. Mean sleeping time was 117.67 minutes, average percentage sleep was 65.68 (range 15-100). All infants were disturbed in their sleep. On average infants were disturbed 4.60 times in three hours. A significant correlation was found between sleep and number of disturbances (-0.39, p=0.01). Related to the number of disturbances, time in active sleep decreases (-0.47, p=0.001), while time awake increases (0.33, p=0.03). Furthermore, analysis showed significant correlations between age and states of active sleep (-0.44, p=0.003) and quiet sleep (0.33, p=0.03).
Conclusion and implications of key findings: The main finding of this study is the fact that none of the infants was able to complete sleep cycles without being disturbed. This is affecting sleep and thereby negatively influences brain development. Important implications for practice are awareness of the importance of sleep, prevent unnecessary disturbances and focus on sleep promoting interventions.

Keywords: unobtrusive measurement, sleep, neonates

SAMENVATTING

Achtergrond: Wetenschappelijk onderzoek toont aan dat slaap een essentiële rol speelt in de hersenontwikkeling bij pasgeborenen. Verstoring van slaap heeft op korte en lange termijn negatieve effecten op ademhalingspatronen, hersenontwikkeling en gedrag. Er is nog geen valide en betrouwbaar instrument om slaap te meten op een manier die niet belastend is voor het kind. Het is echter wel mogelijk om op een Neonatale Intensive Care Unit(NICU) slaapstadia vast te stellen door middel van observatie. Dit kan waardevolle inzichten geven en impact hebben op ontwikkelingsgerichte zorg.
Doel: Exploreren van slaap en slaapstadia bij pasgeborenen door middel van klinische observaties. Daarnaast het exploreren van verstoringen in slaap en associaties tussen slaaptijd en patiëntkarakteristieken.
Methode: Er is een observationeel longitudinaal cohort design gebruikt. Er is een tool ontwikkeld om slaap, slaap verstoringen en patiëntkarakteristieken te observeren. Uitkomsten werden geanalyseerd door middel van beschrijvende statistiek. Om associaties tussen slaap, verstoringen en patiëntkarakteristieken vast te stellen werd een Pearsons correlatie berekend.
Resultaten: In totaal werden 43 kinderen geïncludeerd. De gemiddelde slaaptijd was 117,67 minuten, het percentage slaap was gemiddeld 65,68 (range 5-100). Alle kinderen werden gestoord in hun slaap, gemiddeld werden kinderen 4,60 keer gestoord in drie uur. Er werd een significante correlatie gevonden tussen slaap en het aantal verstoringen (-0,39, p=0,01). Met het aantal verstoringen nam tijd in actieve slaap af (-0,47, p=0,001) en wakker toe (0,33, p=0,03). Daarnaast werden significante correlaties tussen leeftijd en actieve slaap (-0,44, p=0,003) en diepe slaap (0.33, p=0,03) vastgesteld.
Conclusie en implicatie van belangrijkste bevindingen: Belangrijkste bevinding in deze studie is dat geen enkel kind een slaapcyclus kon voltooien zonder gestoord te worden. Dit is van invloed op slaap en daarmee op hersenontwikkeling. Belangrijke implicaties voor de praktijk zijn het creëren van bewustzijn in het belang van slaap, voorkomen van onnodige verstoringen en focus op slaap bevorderende interventies.

INTRODUCTION

There is increasing evidence about the influence of sleep on development of neural pathways in the neonatal brain[1–3]. Sleep is essential for neonates to enable the growth of five sense and neural systems as well as the structural development of hippocampus, pons, brainstem and midbrain. Preserving sleep and complete sleep cycles results in creation of memory and long-term memory, as well as maintenance of brain plasticity[2,3]. Brain plasticity is the capacity of the brain to change, adapt and learn responding on their environment.

Sleep patterns first appear between approximately 28 and 30 weeks gestational age[2–4].
In preterm infants (born <37 weeks gestational age), five states of sleep are differentiated: active sleep (also called Rapid Eye Movement (REM) sleep), quiet sleep (non REM sleep), transitional sleep (between sleep and awake), arousal and the non-sleep state of wake[4–7].
In preterm infants between 28 and 30 weeks gestational age, around 80% of their sleep is active sleep. In active sleep, brain activity is high. Active sleep is associated with development of sensory systems as touch, motion, position, smell and taste, hearing, vision, emotion, social learning and memory[2].

Infants at 40 weeks gestational age have sleep cycles with equal REM and non REM sleep states. While 8- 9 months of age, the sleep cycle is 80% and 20% respectivily[2,3,5].
Preterm infants spend around 70% of their time sleeping, while term infants spend time sleeping approximately 60%[5]. A change in sleep state organization over time is seen and gives an indication for development process of the brain[5].

Disturbances in sleep occur when professionals or parents interact with the infant or environment of the infant while sleeping. Also noise or alterations in light can disturb an infant's sleep[8,9]. Sleep deprivation in the neonatal period has short- and long-term negative impact on breathing patterns, brain development and behavior[1–3,6]. Deprivation of active sleep results in disturbed development of all sensory systems as mentioned earlier[2].
This explains the importance of protecting sleep and sleep cycles of infants admitted to the Neonatal Intensive Care Unit (NICU). The NICU environment has the potential to affect sleep quality and quantity, for example due to planning of (medical) interventions or minimalizing noise and light. Neonatal care should strive for a restful, nurturing non-invasive environment[2].
Therefore caregivers should be able to identify whether infants are available for interaction, based on monitoring and observations of behaviour. Several studies have suggested evidence-based approaches to improve sleep in infants admitted to the NICU, also called Neonatal developmental care[1,6]. Methods that have been proposed to reduce sleep

disruption include protocols for clustering of care and the Newborn Individualized Developmental Care and Assessment Program (NIDCAP). It helps nurses and other allied health care workers to provide neonates with the best care based on the behaviour of neonates in order to improve their sleep[1].

To provide the best developmental care, identification of sleep states is crucial[10]. Polysomnography (PSG) is the golden standard and most frequently used instrument to identify different sleep states[5,11]. However, this method is not reliable to use in preterm infants because electroencephalography (EEG) patterns are different compared to older children and adults[3]. Thereby, it could disturb the infants' sleep by the necessary use of adhesive electrodes and cables. These adhesive electrodes also lead to skin injury which affects the skin barrier function of neonates[12]. Therefore more unobtrusive methods without disturbing the infant are required.

So far, no instrument to measure sleep which is unobtrusive turned out to be valid and reliable in neonates. However, at the NICU or a neonatal ward it is possible to determine sleep states through observation of behaviour combined with interpretation of heartrate and respiratory monitoring[5,13].

Observation and registration of sleep in neonatal care might provide valuable insights and could have major impact on the performance of developmental care.
Therefore this study aimed to explore the frequency of sleep and sleep-wake states in neonates using clinical observations. Furthermore, second aim of this study was to explore the number of disturbances in sleep and associations between sleeping time, disturbances and patient characteristics.

METHODS

Design

An observational longitudinal cohort design was used to explore sleeping time and sleep-wake states of neonates admitted to the NICU of an academic hospital. Sleep was measured during admission at the NICU in periods of three hours. This study purposed to observe, describe and document sleep of infants as it naturally occurs[14]. Routine care data from medical records and interpretation of monitor values and behaviour was used.
Exploring associations, also called correlation research, could produce a large amount of data about a problem[14]. Studying sleep and sleep states using clinical observations led to very rich data associated to sleep. This first exploration could lead to identification of possible inferences regarding sleep was performed. The 'Strengthening the Reporting of Observational Studies in Epidemiology (STROBE)' checklist was used to report this study[15].

Population

The study population consisted of infants admitted to the NICU of an academic hospital in the Netherlands. This NICU consists of three units, with eight beds each. In order to be eligible to participate in this study infants needed to have an post menstrual age of 28 weeks or older. Furthermore they needed to be electrocardiography (ECG) and respiration monitored. Infants with major congenital deviations which are known to affect sleep were excluded in this study. During the data collection period all these infants admitted to the selected NICU, were eligible to be included, which is also called consecutive sampling[14]. This sampling method is considered to be the best possible recruitment strategy to minimize the risk of bias. Because this study is a first exploration of measurement in sleep at the NICU, no proper sample size calculation based on a power analysis was appropriate. Literature indicated to use a large sample as possible as the safest procedure to obtain data in a explorative study[14]. Therefore, as many neonates as feasible were included in the study. Because every included infant was observed for three hours, this led to a comprehensive set of data about sleep.

Data collection

Patient characteristics were obtained from medical records. Structured observations were used to record sleep behaviour and characteristics, sleeping time and disturbances influencing sleeping time. For pre-term born infants there is no instrument to measure sleep based on scientific evidence yet. To produce numeric information about operationalization of sleep an observational tool (APPENDIX 1) was developed based on rules, terminology and technical specifications to score sleep in full-term infants to two months of age developed by the American Academy of Sleep Medicine (AASM) and other relevant literature[5,13,16].

Scoring sleep initiates with assessing if eyes are open or closed[13]. In determining if an infant is awake, this is the most important behavioural determinant. Wakefulness is characterized by agitation or by bright, wide open eyes[16]. Together with information about breathing patterns, heart rate (HR), heart rate variability (HRV) it is possible to determine whether infants are awake and available for interaction. HR of preterm infants is normally between 120-160/minute[5]. During different stages of sleep, HR and HRV changes. For example, HR decreases during quiet sleep and increases during active sleep. Breathing Rate (BR) of preterm infants is around 40-80/minute[5]. In scoring sleep-wake states, regularity of respiration is most important[13]. Respiration is perceived regular if the variability between the slowest and fastest breath is less than 20 breaths/minute. When variability is above 20 breaths/minute, respiration is stated irregular. During quiet sleep, BR is low and relatively regular, in active sleep the BR is more irregular. In addition, it is possible to assess different states of sleep in behavioural assessment. This leads to more complete sleep analysis and is therefore recommended[5]. Behavioural classification of sleep is divided in general body movements and specific body movements. General body movements are ranging from low to high activity in different states of sleep.

Development of the observational tool, testing, training observers and interrater reliability assessment were performed carefully to minimize bias due to human perceptual error[14]. Development and testing of the observational tool, as well as translation of items of the tool in Dutch language was an iterative process. The first step was conceptualizing concepts. In the process, adaptation of the tool took place based on feasibility in practice and comprehensibility. This contributed to construct validity of the tool[14]. Experts in neonatal sleep and brain development were consulted during the process to review the items of observational tool, which ensured content validity[14]. For use of the tool by others, this is an important aspect of developing instruments.

The observational tool is used to determine different sleep states. For three hours, different sleep states were described. The observation time of three hours was chosen based on literature and testing of the observational tool[13]. This is called time sampling[14]. Furthermore, because of the number and kind of disturbances in sleep that has been observed, event sampling took place as well. In addition, during observation of sleep states other field observations were taken into account and described in the results section of this study.

Procedures

In February researchers were trained in behavioural observations and the relation of heartrate and respiration rate to sleep. Furthermore the reliability assessment took place. Data-collection took place from March until May 2018, at the NICU of an academic hospital in the Netherlands. Infants were included using broad consent. Although broad consent is regulated by institutional agreements, parents of included infants received written information about this study (APPENDIX 2). Optional they could also be debriefed about general study results. Researchers distributed the written information about the study during de data collection period to all eligible infants. All observations were noted in a digital Case Report Form. Data analysis and writing took place in May.

Analysis

All quantitative data was extracted from case report forms in IBM SPSS Statistics version 25 (IBM Armork, New York, USA), which was used for analysis.

In this study two observers collected data. Both observers were trained in theories about sleep and different sleep states in neonates before observing infants. To increase reliability, interrater reliability is essential[14]. In this study, observer scores from two researchers were compared using a weighted Cohen's kappa, because it is important to distinguish deviations between the two researchers with more than one category. A linear weighted kappa was calculated using a syntax.

Patient characteristics were analysed using descriptive statistics. All data was tested for Normality. Due to skewed data, for continuous parameters a median and interquartile range (IQR) were used to describe the population. For categorical parameters, frequencies and percentages were calculated.

In order to answer the question how much infants admitted to the NICU were sleeping, the mean sleeping time for every three hour period was calculated. To measure variability of these data, also the standard deviation was reported[14]. Furthermore different sleep states were analysed using descriptive statistics as well. Due to skewed data, a median and IQR were used to describe different sleep states. Additionally the total number of disturbances could be determined. Information about sleeping state of the infant and whether the infant awakens when disturbing is displayed in frequencies and percentages. An association between sleeping time and frequency of disturbances was determined by calculating a Pearson's correlation and performing a linear regression. To determine associations between sleeping time or different sleep states with patient characteristics, Pearson's correlations were calculated as well.

Ethical Issues

This study was approved by the Medical Research Ethics Committee (METC) of University Medical Centre Utrecht (UMCU)(18/070) and Division 'Woman and Baby' of UMCU. The study was conducted according to the principles of Good Clinical Practice and the Declaration of Helsinki[17,18]. Additionally the Act on Medical Treatment Agreement (WGBO) and Personal Data Protection Act (WBP) were be applicable on patients included in this study[19,20]. Data was handled confidentially and stored in a secured environment. Data from medical records was coded to make sure the data is not traceable to the included infants individually.

RESULTS

Interrater reliability of the observational tool

A total of 333 minutes was used to perform interrater reliability assessment in observation of sleep states. The calculated linear weighted kappa was 0.85.

Participants

A total of 43 neonates admitted to a NICU was included in this study and observed for a period of three hours each (180 minutes). Because of an necessary unplanned MRI, one of the observations could not be completed for the total of three hours. In total 7706 minutes sleep were observed, which led to almost 129 hours of sleep data. There was no missing data.

General characteristics of the population are summarized in Table 1. Percentage male was a little higher than female (53.49%). Median gestational age of included infants was 30 weeks and four days (ranging from 24 weeks and two days to 41 weeks and five days). Median post menstrual age was 31 weeks and five days (ranging from 28 weeks and two days to 42 weeks and two days).

Median birthweight was 1470 gram. Most of the included infants were admitted to the NICU because of prematurity or dysmaturity (72.10%). A few infants were given morphine or sedatives, medication affecting consciousness (6.98%). In the included population, invasive mechanical ventilation was not common (9.30%).

[Table 1]

Sleeping time

To observe sleep in infants admitted to the NICU, the mean sleeping time was calculated (quiet and active sleep together). The mean sleeping time was 117.67 minutes per 180 minutes (SD 35.97, ranging between 27-180 minutes). Average percentage sleep was 65.68 (SD 19.93, ranging between 15-100).

Median and IQR for all different sleep states were calculated. Infants admitted to the NICU showed less quiet sleep (median=12), when asleep they were mainly in the active sleep state (median=97). Clinical observations showed mostly short periods of quiet sleep, between two active sleep states. Minimal and maximal time for each sleep state showed a wide range in time (quiet sleep 0-76 minutes, active sleep 0-168 minutes, transitional sleep 0-86 minutes, awake 0-118 minutes), as presented in table 2.

[Table 2]

Disturbances

None of the infants was able to complete a sleep cycle without being disturbed. All infants included in this study were disturbed during the observation period of three hours.

In total the 43 infants were disturbed a 198 times, on average this is 4.60 disturbances/infant per three-hour observation. In 23 cases, reason for interaction with the infant was comforting when crying or during arousal.

During 123 disturbances the infants were sleeping, in 59 of these cases the infant awakened (47.97%). Additionally in 21 cases the infant was in a transitional sleep state, between sleep and awake. Infants were sometimes disturbed several times in a row for different reasons. For example, in one of the clinical observations the infant was in quiet sleep when disturbed for a blood sample, thereafter the infant was in the transitional sleep state, almost sleeping and disturbed again for medical examination.

Infants were disturbed a 157 times by healthcare professionals, 31 times by parents and ten times by external influences in the environment of the infant. Infants were mostly disturbed by nurses (131 times) for nurturing, medication and tube feeding. Physicians disturbed infants in their sleep for medical examination and other professionals for blood tests and radiology, respectively 20 and six times. An overview is presented in table 3.

[Table 3]

Clinical observations showed infants were usually not awakened by regular monitor alarms. However, noises arising on a less regular base were disturbing the infants. Examples of disturbing environmental factors were the sound of other medical devices or a telephone, loud voices, crying of other infants and noise arising from activities such as rustle with plastics.

Pearson's correlation showed a weak, but significant negative correlation between sleeping time and the number of disturbances(-0.39, r-square= 0.15, p=0.01). Linear regression analysis showed a 5.59 minutes decrease in sleeping time per disturbance.

Also a weak negative correlation was shown between time in active sleep state and the number of disturbances (-0.47, p=0.001). Furthermore Pearson's correlation showed a weak positive correlation between time awake and the number of disturbances (0.33, p=0.03). Significant associations between number of disturbances and sleep are also presented in table 4.

[Table 4]

Association between sleeping time and different patient characteristics

Analysis showed a correlation between post menstrual age and minutes of quiet sleep (0.33, p=0.03) and active sleep (-0.44, p=0.003). An overview of these associations is presented in table 5.

[Table 5]

Statistical analysis in other subgroups in patient characteristics was not appropriate due to the small cohort. However, clinical observations showed a tendency in phototherapy. Infants with phototherapy (n=10) were more restless than other infants. Furthermore type of bed suggested to influence sleeping time. Infants were more amenable for sleep deprivation in an open incubator or cradle, but this could not be supported with statistical evidence.

DISCUSSION

Most important result of this study is the fact that all infants were disturbed in their sleep. On average every infant was disturbed almost five times in three hours. Not one infant was able to complete a sleep cycle without being disturbed. Levy et al(2017) published an article about disturbances of sleep earlier[21]. They studied sleep disturbances in a small group of 25 term and late pre-term infants (GA > 35 weeks) admitted to the NICU. Their study resulted in arousals or awakenings occurring in 57% of contacts with a sleeping infant, which is even more than in this study (48%). We can conclude that disturbances affect sleeping time and thereby negatively influencing brain development. Long-term effects of sleep deprivation are not studied thoroughly yet, but evidence showed a relation between neonatal sleep and attention orienting and distractibility later[22].

Our findings in percentage of sleeping time are comparable to findings in the literature that preterm infants sleep around 70% of their time, while term infants sleep around 60% of their time[5]. Infants admitted to the NICU in this study showed less quiet sleep. When asleep, they were mainly in the active sleep state, because the majority of the included infants was born preterm and as shown they spend most of the time in active sleep[4–7]. Studies showed that infants between 28-30 gestational age spend 80% of their time in active sleep. Infants at 40 weeks gestational age have sleep cycles with equal active and quiet sleep states[2,3,5,23,24].The significant associations between post menstrual age and states of active and quiet sleep found in this study are therefore consistent with these earlier findings.

Furthermore clinical observations showed a tendency in an association between restlessness and phototherapy, which could possibly lead to sleep deprivations as well. Although a small cohort study among premature infants showed no significant difference between phototherapy and sleep, there is literature supporting this tendency[25]. As an aspect of developmental care, infants admitted to a NICU receive supportive positioning[26]. Supportive positioning with nestles and swaddling has proven to improve different outcomes, including neonatal sleep[26,27]. Due to phototherapy, there are limited possibilities to support the infant in their position and this could therefore influence sleep.
Conclusively, it is possible that type of bed influenced sleep as well. This could be explained by the fact there are differences in exposure to environmental noise. Being inside the incubator protects infants from the background noise, although the incubator does not protect for other noise sources and produces noises itself[28]. Awareness of the levels of noise is therefore important. Besides, use of sound absorbing panels could be helpful to decrease noise levels affecting sleep.

One strength of this study was the good interrater reliability. Infants with different admission indications were included in this study, which made results of this study generalizable to a general NICU population. Furthermore, clinical observations led to very rich data which can be used for several questions regarding neonatal sleep. Determining states of sleep and awake is a combination of interpretation of behaviour, heartrate and respiratory monitoring. Behaviour seemed most important in determining states of sleep above monitor values. It must be noted that determining sleep states in infants receiving phototherapy was difficult, because eyes were covered. This is a limitation in behavioural assessment of sleep states. Another limitation of this study was the observation of infants in daytime only. Performing observations during evening and night additionally could give more accurate estimates of the distributions of sleeping time and sleep cycles. Twenty-four hour sleep registration would be eligible, but is currently technically not possible. Therefore, data of this study are more valuable than using technical resources or just interpreting respiration rate and heartrate, which turned out to be not valid and reliable in preterm infants[5,11,23,29]. This also supported the choice for clinical observations as data collection, regarding the fact that these observations could lead to some bias. Health care professionals may show different behaviours than they would usually do because of the awareness being observed or from what they think is socially desirable, which is a risk to be taken in to account[14].

Most important implication for practice is the awareness of the importance of sleep and long term effects of preserving sleep, to prevent unnecessary disturbances of sleeping infants and cluster care. Professionals should enlarge their knowledge about neonatal sleep and adapt their behaviour towards an infants' needs, which can be achieved by training and continuously practicing[1,7]. In this study we did not aim to address sleep promoting interventions. Although, to achieve improved sleep conditions for neonates it is recommended to pay attention to sleep promoting interventions and defining regulations in postponing care during sleep[7]. The observational tool developed in this study could also be used in clinical practice to determine whether an infant is available for interaction. It could therefore be helpful in planning of care. A validation study would be necessary to test validity and reliability of the tool by nurses in daily practice, nurses should be involved in the process. Another question still remaining after this study is which independent variables are influencing neonatal sleep. In this study disturbances explained 15% of variance in sleep, therefore there might be other factors influencing sleep as well. A multi-centred cohort study in neonatal sleep could give valuable insights and thereby lead to improvement of neonatal care. Furthermore research in unobtrusive sleep measurement is necessary to collect data about sleep in the future, regarding the time-consuming methods used in this study. Items of the observational tool determining sleep states should be integrated in a database and automatic signalizing of different sleep states should be studied.

Conclusion

On average, neonates spend approximately 66 percent of their time sleeping. When asleep, they were mainly in the active sleep state. Significant associations between age and states of active and quiet sleep were seen. Main finding in this study is the fact that all infants were disturbed in their sleep. This affects sleeping time and thereby negatively influences brain development. Important implications for practice are awareness of the importance of sleep, prevent unnecessary disturbances and focus on sleep promoting interventions.

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TABLES

Table 1
Baseline Characteristics of included infants

	n (%)	*median (IQR)*	*min - max*
Gender			
Male	23 (53.49)		
Female	20 (46.51)		
Gestational age birth* *in weeks+ days*		30+4 (7+0)	24+2 - 41+5
Post menstrual age** *in weeks+ days*		31+5 (5+6)	28+2 - 42+2
Birthweight *in grams*		1470 (850)	680 - 3800
Indication admission			
Prematurity/dysmaturity	31 (72.10)		
Respiratory insufficiency	2 (4.70)		
Neurological	4 (9.30)		
NEC***	2 (4.70)		
Chirurgical	4 (9.30)		
Use of medication and sedation	41 (95.30)		
Coffeine	29 (67.40)		
Doxapram	2 (4.70)		
Morphine	2 (4.70)		
Sedatives	1 (2.30)		
Mechanical ventilation or respiratory support	27 (65.10)		
Invasive: *SIM-V, HFO*	4 (14.80)		
Non-invasive: *CPAP, nCPAP, nIPPV, Optiflow, Lowflow*	23 (85.20)		
Phototherapy	10 (23.30)		
Type of bed			
Incubator	33 (76.70)		
Open incubator	9 (20.90)		
Cradle	1 (2.30)		
Sleeping position****			
Prone	7 (16.30)		
Lateral	11 (25.60)		
Supine	25 (58.10)		

* Gestational Age(GA): is the time elapsed between the first day of the mother's last menstrual period and the day of delivery expressed in completed weeks and days[13].
** Post menstrual age (PMA): is the GA at birth plus the number of weeks and days postpartum[13].
*** NEC: Necrotizing Enterocolitis
**** When an infant had different sleeping positions during observations, main sleeping position was noted.

Table 2 *Sleeping time during three-hour observations, in minutes*		
	median (IQR)	*min - max*
Quiet Sleep	12 (26)	0 - 76
Active Sleep	97 (39)	0 - 168
Transitional Sleep	27 (29)	0 - 86
Awake	25 (24)	0 -118

Table 3 *Distribution of disturbances*		
	n (%)	*n/infant**
Healthcare professionals	157 (79.30)	3.65
- Nurses	*131 (66.15)*	*3.05*
- Physicians	*20 (10.10)*	*0.47*
- Other professionals	*6 (3.03)*	*0.14*
Parents	31 (15.70)	0.72
External environment	10 (5.0)	0.23
Total amount of disturbances	198 (100)	4.60

* n/infant: the average number of disturbances per infant in a three hour observation period.

Table 4 *Associations between sleep and the number of disturbances*		
Association	*Pearson's correlation*	*P-value*
Total sleeping time	-0.39	0.01
Active sleep	-0.47	0.001
Awake	0.33	0.03

Table 5 *Associations between sleep and post menstrual age*		
Association	*Pearson's correlation*	*P-value*
Active sleep	-0.44	0.003
Quiet sleep	0.33	0.03

APPENDIX 1: OBSERVATIONAL TOOL

<u>Observatie Slaap Neonaat</u>

Stap 1: Beoordelen of de ogen open of dicht zijn.

Stap 2: Kijk naar de bewegingen van de baby: de armen, benen, kin, kaak.

Stap 3: Kijk naar de monitor: is de hartactie en ademhaling regelmatig of erg wisselend?

Stap 4: Bekijk de kenmerken beschreven in de 3 tabellen: (1) van wakker zijn, (2) typische slaap (REM en Non-REM) en een (3) intermediaire fase (tussen wakker en slaap in).

Stap 5: het stadium met de meeste kenmerken is het stadium waar we het kind in scoren.

- Niet alle kenmerken hoeven aanwezig te zijn.
- Soms verschil tussen REM en NREM niet duidelijk: dan is “slaap” voldoende.

Kenmerken Wakker: hoe meer kenmerken hoe duidelijker wakker stadium
Ogen duidelijk open
Bewegingen van de open ogen
Duidelijke bewegingen van kaak en kin
Duidelijke bewegingen van armen en benen
Snellere en onregelmatigere hartactie dan gemiddeld bij het kind
Snellere en onregelmatigere ademhaling dan gemiddeld bij het kind
Spontane bewegingen
Huilen of jammeren

Regulariteit van de ademhaling meest betrouwbare parameter om slaapstadia REM en non REM te onderscheiden. Gemiddelde hartactie en ademhalingsfrequentie bij het kind kun je beoordelen door middel van het observeren van trends op de monitor.

Kenmerken fasen van slaap	
REM- slaap: Actieve slaap	*non REM- slaap: Diepe slaap*
Ogen dicht	Ogen dicht
Kleine bewegingen van het gezicht	Kaak en kin bewegingen
Onregelmatige en snelle(re) ademhaling Ademhalingsfrequentie varieert met >20/minuut	**Regelmatige en rustige(re) ademhaling** Ademhalingsfrequentie varieert met <20/minuut
Zuchten en/of zuigen	Regulaire hartactie
Kleine bewegingen (schokken) of juist langzame bewegingen van de ledematen	Weinig tot geen beweging van ledematen
Grimassen van het gezicht	

Intermediaire fase
Meestal in de fase van wakker naar slapen of net voordat ze wakker worden. Wanneer kinderen gedurende een periode van ten minste 30 seconden niet duidelijk aan de criteria van een andere fase van slaap voldoen.
Afwezigheid van aandacht, relatief minder bewegingen en het intermitterend openen en sluiten van de ogen. Deze fase wordt ook wel slaperigheid genoemd.

APPENDIX 2: PARENTS INFORMATION

Wilhelmina Kinderziekenhuis

Informatie brief ouders geïncludeerde kinderen

Beste Ouders,

Deze brief ontvangt u omdat uw kind is opgenomen op de Neonatale Intensive Care Unit (NICU) van het UMC Utrecht. Op de NICU wordt op kind bewaakt door middel van een monitor. Deze registreert onder andere ademhaling en hartactie terwijl de verpleegkundigen ook de slaap van uw kind in kaart brengen. We weten dat slaap erg belangrijk is voor ontwikkeling van kinderen op korte en lange termijn. Om inzicht te krijgen hoeveel en wanneer kinderen slapen en hoe we daar het beste de zorg op af kunnen stemmen worden er in de periode van februari - april 2018 verschillende gegevens, die opgeslagen zijn in de monitor, gebruikt om antwoord te geven op deze vragen.

Deze gegevens worden uiteindelijk bij elkaar gebracht in een onderzoeksverslag.
Wanneer u wenst kunnen wij u daar ook van op de hoogte houden, u kunt dit kenbaar maken door dit aan te geven op onderstaande antwoordstrook.

Wanneer u verder nog vragen heeft over dit onderzoek, of niet wil dat we de gegevens van uw kind gebruiken, kunt u dit aangeven bij de verpleegkundigen en wordt er contact met u opgenomen. U heeft ook de mogelijkheid om direct per mail contact op te nemen:
j.m.d.versantvoort@students.uu.nl of ahoogen@umcutrecht.nl

Met vriendelijke groeten,

Jorien Versantvoort, student Master Verplegingswetenschap, UMC Utrecht

Dr. Agnes van den Hoogen, senior onderzoeker WKZ, UMC Utrecht

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- o Ik ontvang na afloop van dit onderzoek graag het onderzoeksverslag met de algemene resultaten over slaap bij kinderen opgenomen op de NICU.

E-mailadres:____