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Device Associated Infections Among Neonates in Intensive Neonatal Care Units: A Single Unit Survey Study in Cairo, Egypt

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Abstract

Device associated Infection (DAI) namely Ventilator Associated Pneumonia (VAP) and Central Line Blood Stream Infection (CLBSI) is one of the challenges for both neonatal nurses and doctors. Aims: 1)Assess the rate of DAI occurrence among neonates, 2) explore the relationship between DAI rates and certain risk factors such as nurse patient ratio, hand hygiene practice, GA, weight, and length of hospital stay among neonates. Design: descriptive correlational survey research design w. Sample: All neonates admitted in twelve month were included in the study (total number of 1090). Nurses and doctors were observed for compliance to adequate hand hygiene technique. Tools: 1) (CDC) criteria to calculate DAI rates, 2) Hand hygiene five point checklist, 3) Review of neonates charts to collect data as weight, GA., 4) Ballard score and 5) nurse patient ratio. Results: 24 neonate developed DAI in the Unit, there was a high significant negative correlation between DAI and neonatal weight, GA, nurse/patient ratio and overall compliance to hand hygiene technique (P. value≤0.05). Length of hospital stay, inadequate hand hygiene technique had strong positive correlation with DAI rate (p. value ≤0.05). Conclusion: Factors that affect DAI are: weight, GA, length of hospital stay, inadequate hand hygiene technique and nurse patient ratio. Recommendation: implementation of infection control programs to raise nurses as well as physicians compliance to adequate hand hygiene technique and increase number of nurses in the NICU per shift to be similar to the world ratio which is one to one.

Keywords: DAI, Neonatal Nursing, Adequate hand hygiene, Nurse patient ratio

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Introduction and literature review

Neonates hospitalized in NICUs and subjected to invasive procedures; namely assisted ventilation devices (ventilators) and venous/central catheters are more prone to Device-Associated Infections (DAI)[1].Ventilator Associated Pneumonia (VAP) is defined as new and persistent radiographic infiltrates and worsening gas exchange in infants who are ventilated for at least 48 h, and who exhibit at least 3 of the following criteria: temperature instability with no other recognized cause, leukopenia, change in the characteristic of respiratory secretions, respiratory distress and bradycardia or tachycardia[2].

VAP is a serious complication in neonates on mechanical ventilation and accounts for 6.8 - 32.2 % of health-care associated infections among neonates. It has a large impact on neonatal morbidity, survival, hospital costs, and duration of NICU stay[3]. In a study by Talaat et al, VAP constituted 92% of the overall hospital-acquired pneumonia, hence, all participating hospital Infection Prevention & Control (IPC) teams formed prevention collaborative to reduce the rate of VAP in all ICUs[4]. Central Line Associated Blood Stream Infection (CLABSI), is a primary blood stream infection that has no association with infection at other sites in patients who have had a central line within 48 hours of symptom onset.[5,6,7].

Neonatal nurses are responsible for the care of the first period of an infant's life, usually the initial 28 days, although this can be extend-

ed in some cases. They care for all infants, including those who are healthy, those who have some complications, and those who are critically ill and require intensive care. These first few weeks of an infant's life carry significant changes, transitions, and challenges for the infant. A neonatal nurse may perform several tasks as implement treatment, monitor vital signs, administer medications, assist with diagnostic testing, operate medical equipment as ventilators, incubators, and phototherapy. To prevent neonatal infection nurses are the key element in the process[8].

Although DAI is one of the primary causes of neonatal morbidity and mortality in NICUs, they are essentially preventable. Even though it is preventable simply by application of infection control measures by personnel especially nurses VAP and CLBSI are still a challenge for neonates[4,9]. The care and maintenance of these devices is primarily the bedside nurse's responsibility, whose knowledge, beliefs, and practices influence the health and outcome of NICU patients. Critical care nurses play an important role in identification of risk factors and prevention of VAP and CLABSI. Knowledge built on evidence-based practices should give the necessary confidence to PICU nurses to make appropriate decisions and prevent poor outcomes in the recovery of patients[10]

Study significance

DAI (VAP and CLABSI), are associated with high morbidity and significant mortality among neonates in NICUs. In Egypt, the need to shed light on the factors associated with DAI is of high priority. However, in the literature there are not many extended period studies highlighting the occurrence of DAIs in NICUs and correlating them with these factors (Nurse/patient ratio, hand hygiene practice, gestational age, neonatal weight, and length of hospital stay)

The study Methods

Aim of the study

In the present study, our aim was to:

1- Assess the rate of DAI occurrence among neonates admitted to Cairo University Specialized Pediatric Hospital (CUSPH) NICU for the duration of 12 months (April 2018-March 2019).

2- Explore the relationship between DAI rates and certain risk factors (Nurse patient ratio, hand hygiene practice, gestational age, weight, and length of hospital stay) among neonates admitted to CUSPH, NICU for the duration of 12 months (April 2018-March 2019).

Research questions

1- What is the rate of DAI occurrence among neonates admitted to Cairo University Specialized Pediatric Hospital (CUSPH) NICU for the duration of 12 months (April 2018-March 2019)?

2- What is the relationship between DAI rate and certain risk factors (Nurse patient ratio, hand hygiene practice, gestational age, weight, and length of hospital stay) among neonates admitted to CUSPH, NICU for the duration of 12 months (April 2018-March 2019)?

Research design

A descriptive correlational survey design was adopted to fulfill the aims of the current study. A non-experimental design is one type of effective research design that is very helpful to the true experimental design except there is one lost criteria; which is randomization[11].

Sample and sampling technique

A total number of 1090 of neonates admitted during a 12 months period (April 2018-March 2019) were included in the study. All Nurses and doctors were included for the adequate hand hygiene technique without telling them.

Tools of data collection

The following tools were used to collect the study data:

1- Neonates' information data sheet (15 item): developed by the researcher after extensive literature review to include the factors that might affect rate of DAI. The sheet included items as gestational age (GA), sex, weight, admission age, length of hospital stay … etc.

2- GA was assessed based on a) Ballard score if subjects were admitted within 48 hours of birth, or on birth, b) patient records if admission was after 48 hours of birth[12].

3- A five-point checklist of adequate hand hygiene technique adopted and used by the infection control unit in Kasr Al-Aini Cairo University Hospitals was used to asses nurses and doctors compliance to it on each contact with each neonate during the twelve months.

4- VAP and CLABSI were prospectively surveyed and diagnosed as per the Center of Disease Control and Prevention criteria of diagnosing and reporting[2,13] and subsequently DAI rates per 1000 device days were calculated and recorded according to the following equation:

Device Associated Infection Rate

DAI rate is to be calculated according to the equation[14]

$$\frac{\text{Number of DAI for an infection site during a certain duration x 1000}}{\text{Number of Device days during the same duration}}$$

Device days

A count of the number of patients with a specific device in the patient care location. To calculate device days, for each day of the month, at the same time each day, the number of patients who have the specific device was recorded (e.g., central line or ventilator)[15].

5- Nurse patient ratio: every shift the number of nurses was divided by the number of patients to calculate the nurse patient ratio, more over the ratio was established daily by getting the mean of the three shifts ratio for each day during the twelve months of data collection.

Operational Definitions: for the purpose of this study; the following terms are defined as follow:

1- DAI rate is limited to VAP infection and CLBSI as being calculated by the CDC criteria mentioned above.

2-Nurse patient ratio= nurse number divided by patients number

Setting: The data was collected from the Neonatal Intensive Care Unit (NICU) present in the Cairo University Specialized Pediatric Hospital (CUSPH).

Ethical consideration: An informed consent was obtained from the guardian (father or mother) of the neonate to be included in the study after brief clear description of the study aim and assuring them that: a) the information pertaining to the neonate is confidential and not to be disclosed unless they approve to, b) refusal of being included is not affect the medical as well as nursing care needed to the neonate, c) they have the right to withdraw at any point from the study without the neonate medical or nursing care is affected.

Tool validity and Reliability

Neonatal data sheet was submitted to five experts (three from neonatal medicine and two from pediatric nursing field) to test the content validity. Modifications of the tool was done according to the experts' judgment on clarity and appropriateness of content. Tool reliability was tested by the reliability coefficients' alpha test and found to be (73 %(..

Ethical Considerations

The tools and the research was submitted for approval from Ethical Committee of CUSPH, and was approved. Informed written consent was recruited from fathers/mothers of the neonates included in the research after full concise description of the aim of the research and after assuring them that their innate data will be confidential and in case of reusing to share this will not affect the care provided to their children. Parents also were assured that they can request their children withdrawal from the research at any point with no consequences related to this.

Data Collection Procedures

Before conducting the study an official permission was obtained from the directors of CUSPH, and permission from the head of NICU also was obtained after explaining the nature of the study. The researchers introduced self to the mothers or fathers of the neonates ,clear and simple explanations about the aim and nature of the study were discussed by the researchers with them. For each subject data sheet the researchers filled gestational age was calculated as per Ballard score for those neonates who are admitted on birth or during the first 48 hours of age, for neonates admitted after 48 hours of age gestational age on referral sheet to the unit was accepted and recorded.

CDC criteria was used to calculate the DAI rate as described earlier. All medical staff and nursing staff who were in contact with these neonates during the inclusion period of 12 months were also included in the study for the assessment of hand hygiene performance as a part of the routine of hand wash checklist done in the unit. Hand hygiene compliance was surveyed for doctors and nurses during each contact with patients using the five-point checklist of hand hygiene procedures adopted and used by the infection control unit in Kasr Al-Aini Cairo University Hospitals. When NICU staff complied with the WHO five moments of hand washing, we marked that as 'Overall compliance". However, we also surveyed the step by step process of hand washing. Those who fulfilled the hand hygiene procedure and did not miss any of the 5 steps hygiene checklist including appropriate contact-time, were marked as "Adequate"; while those who missed any point of the checklist including contact-time were marked as "Inadequate"[16]. Nurse/patient ratio was calculated through nursing records of CUSPH, NICU.

Statistical methods

Data were statistically described in terms of mean±SD, median and range, or frequencies and percentages where appropriate. Comparing categorical data, Correlation between various variables was done using Pearson moment correlation equation for linear relation in normally distributed variables and Spearman rank correlation equation for non-normal distributed variables. Probability (p) values of less than 0.05 were considered statistically significant. All statistical calculations were done using a computer program SPSS (Statistical Package for the Social Science; SPSS Inc., Chicago, IL, USA) version 15 for Microsoft Windows

Item	
Sex* Male Female	 56% 44%
GA of Full Term (n=927)	37.81±0.95
GA of Preterm in weeks (n=163)	30.85±1.9
Weight in Kilograms**	(1.03-5.27)3.15±2.12
Length of Stay in Days**	(1-147)10.08±3.6
DAI, (n=24)*	2%
Total Mortality outcome (n=112)*	10%

Table 1: Descriptive Statistics of all neonates (n=1090)
*Values reflected as percent distribution ,** Value expressed as range and mean±SD, all other values are expressed as Mean± SD

Sex				WT (kg)	GA(weeks)	Admission Age (days)	Length Of Stay (days)
Male		Female		Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
N	%	N	%				
11	45.8	13	54.2	1.150±1.5	32.75±3.7	14.12±4.3	42.5±4.5

Table 2: Sex, Weight(kg), Gestational Age, Admission age, and Length of stay Among Neonates Whom Developed DAI (N=24)We

Table (2) displayed that 54.2% of neonates with DAI were female while 45.8% are male. Weight mean was 1.150 Kg , GA mean was 32.75 weeks, admission age mean was 14.12 days, and length of hospital stay mean was 42.5 days in NICU.

	VAP*	Ventilator device days	VAP* rate/1000 DD**	CLABSI***	Central line device days	CLABSI*** rate/1000 DD**
April 2018	3	133	14.5	2	37	90.9
May 2018	0	62	0	0	26	0
June 2018	0	84	0	4	48	83.3
July 2018	1	117	8.5	0	23	0
August 2018	0	148	0	2	38	52.6
September 2018	0	100	0	2	51	39
October 2018	1	157	6.3	1	30	33
November 2018	0	171	0	0	39	0
December 2018	1	183	5.5	1	69	14.5
January 2019	3	225	13.3	2	100	20
February 2019	1	164	6.1	0	59	0
March 2019	0	193	0	0	89	0
Total	10	1737	5.7	14	609	22.9

Table 3: Device associated infections rates (VAP, CLABSI Device days and rates)
*VAP: Ventilator Associated Pneumonia, ** DD: Device days, *** CLABSI: Central Line Associated Blood Stream Infections

Table (3) clarified that, (89%) of VAP cases were diagnosed clinically and radiologically and only (11%) were diagnosed clinically, radiologically and microbiologically due to difficult microbiological sampling. That is why microbiological data regarding VAP causative agents could not be provided. Whereas 100% of our CLABSI cases met the CDC (b,2019) criteria for laboratory confirmed blood stream infections.

Month/ Year	Overall compliance for Doctors	Inadequate technique for Doctors	Overall compliance for Nurses	Inadequate technique for Nurses	Nurse/ Patient Ratio	VAP* Rate/1000 DD***	CLABSI** Rate/1000 DD***
April 18	100%	33%	83%	40%	1/3	14.5	90.9
May 18	100%	100%	100%	33%	1/2	0	0
June 18	100%	67%	83%	60%	1/3	0	83.3
July 18	100%	100%	86%	71%	1/3	8.5	0
August 18	100%	100%	100%	43%	1/3	0	52.6
Sep 18	100%	100%	83%	80%	1/2	0	39
Oct 18	100%	50%	100%	57%	1/2	6.3	33
Nov 18	100%	0%	75%	43%	1/4	0	0
Dec 18	33%	0%	83%	20%	1/4	5.5	14.5
Jan 19	100%	100%	86%	83%	1/3	13.3	20
Feb 19	50%	100%	71%	40%	1/3	6.1	0
March 19	100%	50%	86%	67%	1/2	0	0

Table 4: Descriptive Statistics of (Overall Compliance For Hand Hygiene, Inadequate Hand Hygiene Technique for Nurses and Doctors), Nurse/ Patient Ratio, VAP and CLABSI Rate Among Neonates with DAI by Month
*VAP: Ventilator Associated Pneumonia, ** CLABSI: Central Line Associated Blood Stream Infections, ***DD: Device days

It appears from table (4) that the overall compliance to hand hygiene ranged between (33-100%) for doctors and (71-100%) for nurses. The inadequate technique of hand hygiene among doctors ranged between (0-100%) while in nurses it ranged between (20-83%) which reflected better overall compliance to, as well as performance of adequate hand hygiene of nurses more than doctors. The nurse patient ratio ranged between one nurse to two neonates to one nurse to four neonates. The highest VAP rate was in April,2018 (14.5/1000DD) while the highest rates of CLBSI were in April, June, August and December (2018) (90, 83.3,& 52.6/1000DD respectively).

Prognosis				DAI				Causative Agent of CLABSI							
Improved		Died		VAP		CLABSI		*S. aureus* (MRSA)		*Klebsiella*		*CONS*		*Acinetobacter*	
N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
18	75	6	25	10	41.7	14	58.3	5	35	4	29	4	29	1	7

Table 5: Prognosis and Causative Agent Among Neonates Whom Developed DAI (N=24)

DAI diagnosis was subcategorized into VAP and CLABSI based on the causative device. CLABSI was shown to be the more prevalent infection in our unit. The most common organism cultured in neonates with CLABSI was Staphylococcus aureus (MRSA), followed by Coagulase negative staphylococci (CONS), and Klebsiella spp. As for outcome, most of our neonates with DAI recovered and were discharged (75%) leaving us with a DAI mortality rate of 25% as shown in table (5).

Item	Gestational Age (Mean± SD)		Weight (Mean± SD)	
	R. Test	P value	R. Test	P value
VAP rate	0.438	**0.0005**	0.731	**0.000**
CLABSI rate	0.097	**0.001**	0.278	**0.001**
Outcome (mortality)	0.129	**0.000**	0.329	**0.000**

Table 6: Correlation of VAP, CLABSI and outcome with gestational age and weight among neonates who developed DAI (n=24)

As per table (6),VAP and CLABSI rate as well as patient outcome had a highly significant positive correlation with both GA (P. Value 0.0005, 0.001, and 0.000 respectively) and weight (P. Value 0.000, 0.001 and 0.000) respectively among neonates with DAI. Lower gestational ages and weights in neonates were associated with higher incidence of DAI.

DAI/month/year	Length of stay in days	
	R	P
April, 2018	0.84	**0.01**
May, 2018	0.32	**0.01**
June, 2018	0.34	**0.001**
July, 2018	0.66	0.4
August, 2018	0.15	**0.001**
Sept.,2018	0.34	0.2
Oct., 2018	0.59	**0.005**
Nov.,2018	0.97	0.4
Dece.,2018	0.88	**0.05**
Jan., 2019	0.5	0.4
Feb., 2019	0.53	**0.005**
March,2019	0.27	0.2

Table 7: Correlation between DAI and Length of Stay(days) in the NICU

Regarding the relationship between DAI rate per month and the length of stay in the NICU it was found that there was either a highly significant positive correlation in all the months with a P. value ≤ than (0.05) except for July, September, and November (2018) and January and March (2019).

Item	Patient outcome (Mean± SD)	
	R. Test	P value
Nurse patient ratio	**-0.102**	**0.000**
CLABSI rate	0.32	0.162
VAP rate	0.418	0.612

Table 8: Correlation of Patient Outcome with CLABSI, VAP, and Nurse/patient ratio in Neonates with DAI (n=24)

Table (8) highlights the strong negative correlation we found between nurse/patient ratio and patient outcome. Decreased nurse/patient ratio reflected a significant increase in mortality outcome (P=0.000). However, we showed no significant correlation between CLABSI and VAP rates with patient outcome.

Month/Year	DAI/Nurse Patient ratio	
	R	P. Value
April, 2018	0.438	0.58
May, 2018	0.080	0.94
June, 2018	0.129	0.22
July, 2018	0.438	1.0
August, 2018	0.097	0.91
Sept.,2018	0.129	1.1
Oct., 2018	0.438	0.54
Nov.,2018	**0.701**	**0.000**
Dece.,2018	**0.459**	**0.000**
Jan., 2019	0.438	0.09
Feb., 2019	0.097	0.63
March,2019	0.162	0.63

Table 9: Correlation Between DAI and Nurse/Patient Patio Among Neonates with DAI (n=24)

Unsurprisingly table (9) highlighted that nurse/patient ratio showed a strong significant correlation with development of DAI in the months that had the lowest nurse/patient ratio (November, December 2018) with P. value ≤0.000 in both months. This result means that the less nurses' number to neonates the more the incidence of DAI.

DAI monthly	Overall compliance for Doctors		Inadequate hand hygiene for doctors		Overall compliance for nurses		Inadequate hand hygiene for nurses	
	R	P	R	P	R	P	R	P
April, 18	**-0.24**	**0.01**	0.331	0.7	**-0.143**	**0.01**	0.31	0.5
May, 18	**-0.72**	**0.03**	**0.61**	**0.0000**	-0.82	0.4	0.34	0.6
June, 18	**-0.91**	**0.01**	**0.58**	**0.0000**	**-0.27**	**0.01**	**0.58**	**0.0000**
July, 18	-0.31	0.91	**0.61**	**0.0005**	0.55	0.9	**0.66**	**0.0005**
August, 18	-0.35	0.07	**0.24**	**0.0000**	-.035	0.7	0.24	0.5
Sept.,18	-0.48	0.09	**0.62**	**0.0000**	-0.48	0.09	**0.62**	**0.0000**
Oct., 18	-0.19	0.35	0.67	0.6	-0.49	0.2	**0.67**	**0.000**
Nov.,18	**-0.87**	**0.01**	0.35	0.2	**-.07**	**0.0001**	0.35	0.2
Dece.,18	**-0.79**	**0.0001**	0.45	0.6	-0.79	0.5	0.45	0.6
Jan., 19	-0.142	0.35	**0.41**	**0.0000**	-0.612	0.5	**0.91**	**0.0000**
Feb., 19	**-0.22**	**0.0001**	**0.81**	**0.0000**	**-0.2**	**0.0001**	0.27	0.9
Mar.,19	-0.19	0.34	0.34	0.61	-0.109	0.7	**0.64**	**0.0000**

Table 10: Correlation Between DAI and Hand Hygiene for Doctors and Nurses (overall compliance, adequate and in adequate Technique) Among Neonates with DAI (n=24)

Table (10) displayed that there is a negative correlation with high significance between overall compliance to hand hygiene of doctors and nurses in six and four months of the whole 12 months of the data collection with p. value ≤0.05. In the same table it was clear that there was a strong positive correlation between the inadequate hand hygiene in both doctors and nurses in seven months for doctors and six month for nurses with a p. value≤0.05.

Discussion:

The current study found a VAP incidence of 5.7/1000 ventilator days in our NICU, which is concomitant with neonatal VAP incidence in the US (4-6.5/1000 DD)[17] and in other countries like Rio de Niro[18] and lower than the neonatal VAP incidence in the International Healthcare-associated Infection Control Consortium (INICC) report which was 8.95/1000 DD[19] and much lower than another Egyptian study which showed 34.2 episodes/1000 ventilator days. This low incidence we have is attributed to by the routine implementation of VAP prevention bundle in CUSPH, NICU unit[20].

The at hand study found that mortality rate was (25%), this finding goes in harmony with Kasim etal,[21] who studies nosocomial infections in neonatal intensive care units, the authors found that mortality was significantly higher among infected neonates with VAP and CLABSI. As neonates are exposed to various therapeutic intervention such as intubation and central venous catheters that provide a portal of entry for pathogens, this render these neonates more susceptible to infections[22].

However, CLABSI was the most common DAI in the study owing to the fact that it is the most common cause of HAIs in NICU[23]. However, CLABSI rate in the study was 22.9/1000 central line days which is consistent with the range of CLABSI in limited resource countries like Egypt from 2.6 to 60 per 1000 central line days[24]. Nevertheless, lower rates are present in Europe ranging from 10.6 to 12.3[25] and the US ranging from 1.8 to 5.2[24].

As for the causative organisms the study at hand findings was that, Gram positive bacteria comprised more than half the causative agents in the form of MRSA 35% and CoNs 29% were the most prevalent organisms this compares to other studies which found CoNS 51% and S.aureus 23%[25].

An important fact to note was that DAI rates in the study did not affect patient outcome in terms of mortality; we showed no correlation between patient outcome and CLABSI and VAP rates. The reason for

that may be that early diagnosis and strict adherence to medical protocol of treatment and care of nosocomial infection may have averted an unfavorable outcome. Also, the setting (CUSPH, NICU) has recently adopted an oral care technique developed by Ragab et al,[9] using maternal breast milk, this might have reflected a reduction of DAI as well as its squeal. Breast milk contains secretory IgA, lysozymes, white blood cells, and lactoferrin and has been shown to encourage the growth of healthy lactobacilli and reduce the growth pathogenic bacteria[26] which may have led to more favorable outcomes.

The correlation found to be significant with DAI rates in the study with GA and neonatal weight. Prematurity is known to be a risk factor for increased morbidity and mortality. Current study reflected this theory by showing a significant increase in VAP and CLABSI rates with lower gestational ages and neonatal weights. As the second leading cause of death in children under five years old, prematurity remains a global health problem[27]. Patient outcome also correlated positively with neonatal gestational age and weight showing increased mortality in neonates who had lower gestational ages and weights. Infant mortality increases sharply with decreasing GA, from 175.94 per 1,000 live births at <32 weeks to 2.39 per 1,000 live births at 37–41 weeks[28]. Another study done by Sengupta, et al[29] on catheter duration and risk of CLABSI in neonates with PICCs reported no relationship between the development of CLABSI and weight nor gestational age.

The results showed a strong negative correlative relationship between nurse/patient ratio, and patient prognosis. As it is deeply rooted in the literature, nursing is the heart and back bone of neonatal care; the effects of a one-to-one nurse-to-patient ratio on the mortality rate in neonatal intensive care was studied by Watson et al.,[30] and researchers found a strong reduction of mortality rates in NICUS when the nurse patient ratio was decreased. In addition to our results showing a correlation between outcome and nurse/patient ratio, it also shows a correlation between DAI and nurse/patient ratio evidenced by the fact that the two months (November, December 2018) that had the lowest nurse/patient ratio are the same two months that showed a significant positive correlation with DAI rates.

Nevertheless, in a systematic review conducted by Sherenia net al., [31] to study nurse-to-patient ratios and neonatal outcomes, seven out of seven analyzed studies reported higher mortality due to decreased nurse-to-patient ratios. These findings build on the crucial role that is played by the neonatal nurses in the prevention of health associated infections as well as the care of the neonates whom developed it[31]. Jung Cho, and Cho[32] also studied CLABSI in neonates and concluded that it should also be ensured that appropriate patient-to-nurse ratios are maintained within the NICU, as decreased nurse/patient ratios are associated with increased CLABSI incidence.

The at hand study results displayed a highly strong positive correlation between performing hand hygiene inadequately and the development of DAI during all but 2 months of our study period with a P. value that ranged between ≤0.005 and 0.000. These finding sheds light on the importance of adapting the meticulous WHO steps and contact time of hand wash in healthcare settings and that monitoring "adequate" rather than mere comlience to hand hygiene is more essential. In a study conducted by Yalaz et al., (1); to evaluate device-associated infections in neonatal intensive care units the researchers concluded that clinicians should aim to decrease the incidence of DAI and its complications by adhering to strict hand hygiene protocols. Pessoa-Silva et al demonstrated the success of this plan; after training personnel on adequate hand hygiene technique in a study of a total of 5325 neonates, improved compliance was independently associated with infection risk reduction among very low birth weight neonates; bacteremia markedly decreased after implementation of hygiene protocols.

Conclusion

The current study found that DAI is condition that affects neonates in NICU of CUSPH; among the factors that seem to affect it strongly : weight, gestational age, length of hospital stay, inadequate hand hygiene technique of nurses and doctors and nurse patient ratio.

Recommendations: The current study recommends:

- Implementation of infection control programs to raise nurses as well as physicians compliance to adequate hand hygiene technique.
- Increase number of nurses in the NICU per shift to be similar to the world ratio which is one to one.

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