Critical Care Nursing
Iran J Crit Care Nurs 2013;5(4):228-237
Journal home page: www.inhc.ir

Assessing physical structure of Neonatal Intensive Care Unit from the perspective of nosocomial infection control

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ARTICLE INFO

Article type:
Original article

Article history:
Received: 5 Nov 2011
Revised: 9 sep 2012
Accepted: 23 sep 2012

Key words:
Nicu
Physical structure
Nosocomial infection control

ABSTRACT

Aims: Nowadays nosocomial Infection control is one of the important management issues in neonatal intensive care unit that in this context, the NICU's physical structure can improve infection control processes or interfere it. The aim of the present study is assessing physical environment of neonatal intensive care unit from the perspective of nosocomial infection control indicators.

Methods: This study is a descriptive cross sectional study in 2011with statistical population of 11 neonatal intensive care units and research environment of all includes 10 public hospitals of Tehran Medical Sciences University. The study tools had been taken from the7thandlatest report of the "Recommended standards for the NICU design" proposed by consensus committee. The researchers completed check list by observation method and analyzed data by using descriptive statistic and spss software of version 14.

Results: The findings of this study suggested that there have been observed lack of compliance with all the recommended standards in all the studied sections about air conditioning, features of NICU section levels, sink, neonates care space, isolated room and the features of contaminated instruments storage space, which are indicators of infection control.

Conclusion: According to the existence conditions of the physical environment of NICU, it has been suggested to observe recommended standards of designing NICU in constructions that are building or are being renovated for providing suitable implementation in order to activate infection control programs.

Please cite this paper as:
Nayeblouie E, A Farahani M, Khalesi N, Aghahosseini F, Darabi M. Assessing physical structure of Neonatal Intensive Care Unit from the perspective of nosocomial infection control. Iran J Crit Care Nurs 2013;5(4):228–237.

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1. Introduction

Nowadays prevalence of damages that happen because of hospitalization of the neonates with

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the age of 27 weeks gestations have been 57% and it is a lot more than term neonates (3%) [1] and one of the most known of these damages in NIC U is acquired infections[2] because preterm neonates because of shortage of Imnogolobin , skin surfaces and immature intestinal mucosal barriers are naturally susceptible to infection[3] and nosocomial infection is counted as one of the main reasons of Mortality and Morbidity in infants[4] and is related with increasing of hospitalization time in units and because of this, human and funding cost due to the neonates suffering from these infections is high[5] and despite this half of the nosocomial infections are resistant to usual Antibiotics and are not cured simply[6] because of this special attention and prevention measures in NICU is necessary that in this context physical environment of these units can play an important role[4] factors such as inappropriate situation of sink and shortage of air filtration and crowdedness of the unit can be effective in prevalence of these infections[7] it means in NICU nonstandard features of physical environment can cause acquired infections and one of the issues that nowadays is attended specifically and is counted among things that is preventable in this context is the effect of physical environment on prevalence of acquired infections in infants[2] for example in NICU units if a neonate suffered from a continuous infection he/she had to be cared in an isolated room [8] and although isolated room provides a supportive room for the neonates, if this space has not been designed correctly it can encounter treatment team with problem[7] according to pregnancy guidelines of America's children academy observing 2.4 meters distant between beds, availability of the sinks, existence of a sink for every two beds, air conditioning with positive pressure that replace air 6to 15 times per hour, 90% effect of air filtration and existence of at least one isolated room that its air conditioning is with negative pressure are among things that have to be observed in physical structure of NICU units[9]. In these units crowdedness has been related to increase of prevalence of acquired infections[10] and because of staff's hasty for attending other patients they had to decrease number of the times of washing hands or its quality [3] and although washing hands is the simplest strategy for decreasing acquired Sepsis in NICU units, achieving the most level of washing hands is the most difficult problem[5] because several factors such as factors related to physical structure of the unit is in this issue and things like crowdedness of the unit, inappropriate place of sink, inadequate equipment and increase of patients in compare with the bed can have negative effect on the level of washing hands which had to be overcome[11] and it is while treatment-health Ministry and medical education has entered possibility of easy access to every bed, presence of separated rooms of holding clean and contaminated instruments, also presence of at least one isolated room for separating the infected neonates and possibility of observing hands health has entered into assessing these units because nowadays nosocomial infection control has been counted as one of the indicators for quality improvement because of effectiveness and reduction of treatment cost and it is in priority in every country and so necessity of more attending to the factors related to nosocomial infection control has been felt [12]. One of the main duties of the nurse in NICU in management role is improvement of process of providing nursing services for neonates and using management tools in order to improve factors that effect on nursing care of the neonate and his/her family and a nurse causes increase of quality of providing nursing cares and decrease level of death and side effects in neonate by using management methods[13] and in this context a nurse can monitor structure factors related to nosocomial infection control by using "Structure Audit" method and observes space and the set that care is provided there and according to the present standards he/she tries to find the problems in health-care system in order to take steps to correct them with a correct planning [14]

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because giving consultation to the managers and policy makers of health system about decision makings related to intensive units or preterm or unwell neonate are counted as the nurses' duties of intensive care of the neonate[13] researchers of this study decided to assess present conditions of physical structure of NICU's units about infection control by attending to the importance of physical environment in NICU and its role in nosocomial infection control and with attending to that there have been little studies in this subject in the country and the researcher compared it with the suggested recommends that are about this subject.

2. Methods

This study is a descriptive cross sectional study that its research society is all the11 Units of NICU in 10 public hospitals of Tehran Medical University that have NICU unit. The researcher after getting written permission from stakeholders and introducing himself/herself to the related authorities in the hospitals, presented necessary explanations about study aims for them and after achieving informed consent from the authorities and ensuring them about reporting the results without name started to complete checklist by referring to study environment. This checklist has been completed during one month by researcher's observation and in some special cases like type of air conditioning system of the unit and material of the levels from the wash ability point of view with helping of an experienced civil consulting engineer of hospital building, then data had been collected and then the data had been analyzed. Tools of this study were from seventh and the last report version of "Recommended standards for the newborn ICU design" proposed by consensus committee that had been established in 2007 and is confirmed by APP. At firs the origin of the tools had been forward translated to Persian and in the next step by two experts of English had been back translated ,version of back translation with the origin of the questionnaire was given to 10 people of faculty members of school of nursing-midwifery of Tehran Medical University and ShahidBeheshti University, neonates subspecialties and pundits of developmental care for neonates and experts of baby health department and ministry of health, treatment and medical teaching and civil engineers and installations of some treatment centers that are involved in making in NICU in order to determine scientific validity with content validity method and then it has been proceeded for clarification and solving the present problems. About durability of tools for collecting data simultaneous observing method had been used, it means that in 5 hospitals the researcher referred to the units related to the study along with one experienced nurse and the checklist had been completed simultaneously by two people and the correlation coefficient had been counted (r=0.93). This checklist has got totally 157 suggestions about physical structure of NICU units that in this study it achieved information from comparing physical condition with recommended standards related to processes of infection control in NICU units that includes things such as; type of air conditioning, floor features, wall and the ceiling of NICU units, sink features and its distant with the beds, measure of space of taking care of the infant, features of isolated room and features of holding space of contaminated instruments of NICU. After data collection by using descriptive statistical method that includes; calculation of central indicators, dispersion, tables of relative frequency distribution and diagrams, present condition of physical structure of units from approach of having suggested standards about structure factors related to nosocomial infections control has been explained in the form of percent. All the calculations of this study had been done by computer and by using SPSS14.

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Table 1: Features of taking care of the neonate in NICU units of public hospitals of Tehran Medical University

	To have standard situation:	Yes		No		Total	
	neonate's care space:	No.	%	No.	%	No.	%
1	The least space of every neonate's bed is 11.2 square meter	0	0	157	100	157	100
2	The least distant between beds is 2.4 meters	21	13.4	136	86.6	157	100
3	The most distant of every neonate from the sink is 6 meters	102	65	55	35	157	100
4	The least distant of every neonate's bed from the sink is 90 cm	136	86.6	21	13.4	157	100

Table 2: Features of air conditioning and heat of NICU units of public hospitals dependent on Tehran Medical Science University.

	To have standard features	To have ventilation				*to not have ventilation system		Total	
		Yes		No					
	NICU air conditioning	No.	%	No.	%	No.	%	No.	%
1	Adjustability of the unit temperature between 22-26 degree	5	45.5	2	18.2	4	36.4	11	100
2	Adjustability of the unit humidity between 30-60 percent	2	18.2	5	45.5	4	36.4	11	100
3	Unit conditioning with speed of 6 times air changing per hour	0	0	7	63.6	4	36.4	11	100
4	Two times of air changing per hour with the outside air	0	0	7	63.6	4	36.4	11	100
5	Unit Filtered air	7	63.3	0	0	4	36.4	11	100
6	Air filtration out of neonate's care space	6	54.5	1	9.1	4	36.4	11	100
7	Ability to change air filtration	7	63.6	0	0	4	36.4	11	100

∗Among 11 units 36.4% did not have air conditioning system totally.

3. Results

Results showed that from 11 units of the study, 36.4%(4units) were in children's specialized hospital, 36.4%(4units) were in public hospital and 27.3% (3units) were in women's hospital Maternity and the average age of building age

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Table 3: Features of floor substance, wall and ceiling of NICU units of public hospitals dependent on Tehran Medical University.

	To have standard situation / Features of floor, wall and ceiling of NICU	Yes		No		Total	
		No.	%	No.	%	N0.	%
1	Wash ability of cover of unit's floor	11	100	0	0	11	100
2	Type of cover of the floor substance for preventing growth	11	100	0	0	11	100
3	Wash ability of walls cover	8	72.7	3	27.3	11	100
4	Wash ability of cover of the ceiling	9	81.8	2	18.2	11	100

Table 4: Features of sinks of NICU units in public hospitals dependent on Tehran Medical University.

	To have standard situation / Features of sink	Yes		No		Total	
		No.	%	No.	%	No.	%
1	Lack of discharge of water from the sink	36	100	0	0	36	100
2	The least length of sink is 61 cm	17	47.2	19	52.8	36	100
3	The least width of sink is 41 cm	23	63.9	13	36.1	36	100
4	The least depth of sink is 25 cm	13	36.1	23	63.9	36	100
5	Appropriate slope of sink (no static)	30	83.3	6	16.7	36	100
6	Existence of video guide of washing the hands correctly	19	52.8	17	47.2	36	100
7	Sealed wall around the sink	35	97.2	1	2.8	36	100
8	Existence of space alongside the sink for liquid soap	36	100	0	0	36	100
9	Existence of space alongside the sink for tissueق	19	52.8	17	47.2	36	100
10	A sink at an appropriate level for people in	0	0	36	100	36	100
11	Trash bin for infectious waste alongside of the sink	25	69.4	11	30.6	36	100
12	Trash bin for disinfections waste alongside of the sink	8	22.2	28	77.8	36	100
13	At least 90 cm distance of sink from the	35	97.2	1	2.8	36	100
14	Lack of dryer above the tap	35	97.2	1	2.8	36	100

of the hospitals that have NICU was 36.6 (7-54 years) and the average age of NICU units was 6.3 (1-18). In tables 1, 2,3,4,5 and 6 features of physical structure about nosocomial infection

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Table 5: Features of contaminated instruments room in NICU units of public hospitals of Tehran Medical University.

	To have standard situation	Existence of Contaminated tools room				* To not have *Contaminated tools room		TOTAL	
		YES		NO					
	Holding contaminated instruments	No	%	No.	%	No.	%	NO.	%
1	Existence of space of holding the	6	54.5	-	-	5	45.5	11	100
2	Existence of space with counter	0	0	6	54.5	5	45.5	11	100
3	Sink with cold water	3	27.3	3	27.3	5	45.5	11	100
4	Sink with auto system	1	9.1	5	45.5	5	45.5	11	100
5	Liquid soap alongside the sink	1	9.1	5	45.5	5	45.5	11	100
6	Tissue alongside the sink	0	0	6	54.5	5	45.5	11	100
7	Pedal trash bin alongside the sink	0	0	6	54.5	5	45.5	11	100
8	100% system negative pressure of	0	0	6	54.5	5	45.5	11	100
9	Lack of people's passing from care place in order to take contaminated instrument out	5	45.5	1	9.1	5	45.5	11	100

*Among 11 units totally 45.5% didn't have contaminated instruments room.

Table 6: Features of isolated room in NICU Units of public hospitals of Tehran Medical University.

	To have standard situation	To have isolated room				*To not have isolated room		total	
	Isolated room	YES		NO					
		No.	%	No.	%	NO	%	NO.	%
1	There is an isolated room inside the unit	7	63.6	-	-	4	36.4	11	100
2	Existence of the sink near the entrance	5	45.5	2	18.2	4	36.4	11	100
3	Sink has auto system	1	9.1	6	54.5	4	36.4	11	100
4	A place for wearing gown and holdingtheinstryment the	4	36.4	3	27.3	4	36.4	11	100
5	Appropriate seals for ceilings and floor	0	0	7	63.6	4	36.4	11	100
6	Air conditioning system with negative pressure	0	0	7	63.6	4	36.4	11	100
7	A device for monitoring air pressure situation	0	0	7	63.6	4	36.4	11	100
8	Monitoring device with showing air direcrsion	0	0	7	63.6	4	36.4	11	100

*Among 11 Units totally 36.4% didn't have isolated room.

control, in the form of space of taking care of the infants, providing heat, humidity and air conditioning, features of floor, wall and ceiling, features of sink, space of holding contaminated

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instruments and tools, and features of isolated rooms in NICU units dependent on Tehran Medical University have been shown consecutively.

4. Discussion

Among 11 units of the study, 3 units of NICU were reconstructed that its average was 2/3 of the last year and the rest has been made with this aim initially (7 hospitals) or they were not reconstructed at all (1 hospital). From the last assess it had been cleared that from 157 beds of NICU of this research (except isolated room beds) the specialized space for every bed of NICU is 3.56 square meter that has a range between 0.9 to 10.6 square meter and 11.2 square meter space that has been recommended in standards were not observed for any bed. The average space between beds had been measured too and this distant has been 1.30 meter that has a range between 0.15 to 6.20 meter that in 136 cases (86.6%) distant between beds was less than recommended 2.4 meter and only in (13.4%)it means 21 cases this distance had been observed that it needs to be thought about. The present standards suggest that the least space for every bed in care level three is 11.2 square meter [15] in one study in Australia in 2005 the average space for care level three has been reported 11.1 [16] that has been almost according to the standards but their findings are a lot far from the results of this study (the average space in this study is 3.56 meter that it shows the necessity of paying attention to this study. In study of Ghotbi et.al (2002) prevalence level of acquired infection in hospitalized neonates had been measured in 2001 (in old place) and in 2002 (in new place). Basic changes in new place were;increasing space, installing army taps, using disposable endotracheal tube and emphasis on washing the hands with principles. Among 285 hospitalized neonates in 2001, 45 cases (14.3%) and in 2002 from 298 cases 24 neonates(8%) suffered from acquired infection that shows decrease of infection that researchers reported one of the reasons of this change annually space increase of every infant's bed from 1.5 to 2.5 square meter [17]. In engineering design and building of NICU units there should be attention to presence of enough spaces for staffs' attending to the patients and for preventing cross transmission of infection from patients. Dolinger de Bertio et.al in 2007 AD with omission of simultaneous changes and focus on characteristics of environment reported effect of space of NICU on prevalence of acquired infection in hospitalized neonates very well. In time range of four years at first in 2003 one NICU of a temporary local has been transferred and until 2005 it has been transferred from there to a new constructed unit and observing has been done in three time ranges and in three places. Proportion of sink to bed in old building was 0.2, in temporary building 0.1 and in renovation building it was 0.4. Prevalence of acquired infections after transmission to temporary building was increased from almost 13% to 18.6%, because proportion of bed to sink and number of hospitalizations was more in them and vice versa prevalence of Stafilokoki Bacteria after transmission to buildings that are renovated. This study showed that with improvement of physical situation of NICU processes of infection control specially washing the hands has been done better[4] in the present study the average of proportion of sink to bed is 0.25 that shows necessity of more attention to this issue.

Also in this study beds distant from the nearest sink had been 5.01 in the average that had a range between 0.2 to 14.1 meter and about the most distant of every infant's bed from the sink that had been considered 6 meters in standards in 35% cases (55 beds) distance has been reported more than the recommended one that can be effective in times of staffs' hands washing. Putting sink in inappropriate places that are far from staffs' traffic or behind the doors is effective in times of washing hands.

From the other side features of sink can be effective in nosocomial infection control too. According to table 4, there were some contradictions between the average of length,

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width and depth of present 36 sinks in these 11 units with recommended standards that this issue can be effective in bursting water around. In study of Houta 6 et.al (2009) prevalence level of acquired infection from 2004 to 2006 was 36 cases that from this number 12 cases (71%) were resistant to being colonized by Soudomonai that researchers reported that the cause of prevalence of this infection is bursting water from around the sink that was next to medicine preparation space that with changing defective sink and preventing water bursting around sudden prevalence of this disease was finished. These researchers announced at the end that appropriate number of sink, replacing new sink and sink features are main factors of infection control in Intensive units [19].

For washing hands it is important to have soap, sink and suitable detergent in access. Written instructions of correct washing of hands should be installed above every sink that correct technique had to be performed by treatment team and families [20] and according to committee of disease control (CDC) being assure of correct way of washing people in hospital is one way of solutions of nosocomial infection control [21] that in this study it has been cleared that there wasn't any video guide of correct washing hands above 17 sinks (47.2%) that it is not only important for sensitization and reminding importance of washing hands for the staffs but also it is a good guide for the members of a family.

Floor, walls and ceiling in a NICU should have specific characteristics and although in this study flooring material of all the units has been washable, in three units (27.3%) because of using plastic color on the walls, there was no possibility of washing the unit completely and ceiling of two units (18.2%) was not washable that in this case it can interfere in infection control processes. One of the general precautions of infection control in NICU units is washing the walls and ceiling at least four times a year [22] also air system features of these units have been studied and it has been cleared that among 11 units 36.4% (4 units) did not have any air conditioning system and there was no control on airflow inside the unit and among units that had air conditioning system, none of them (100%) had possibility of air conditioning speed of 6 times per hour that 2 times of that are with outside air and only in 2 units (27.6%) there were possibility of humidity control of unit's environment between 30-60% that shows considerable deficiency in this issue. In this regard White (2007) indicated that: " Air conditioning system in NICU should be able to hold temperatures between 22-26˚ C and humidity between 30-60 ˚ C. according to susceptibility of preterm infant to acquired infection, air conditioning of NICU should have possibility of setting the air speed 6 times per hour that its 2 times are with outside air." There have been some studies which show that there is relationship between airflow inside the unit and acquired infection prevalence that airflow is dependent on the kind of air filtration, direction and airflow pressure, times of air changing per hour, humidity and holding method and cleaning air system[23-24] there were some studies which showed that putting patients in single rooms in NICU is effective in decreasing infection prevalence[25] presence of at least one isolated room inside NICU for taking care of unwell infants is necessary[15] what had been clear in this study indicates that among 11 units of the study , 4 units (36.4%) did not have isolated room totally and 7 units had isolated room that the average size of them were 8.98 square meters that among its important points it can be indicated to lack of air conditioning with 100% negative pressure and monitoring device of air pressure that shows airflow direction in the form of visual signs and faulty seals of ceilings and floor in all the isolated rooms, so that air of these rooms could be entered in the care space of taking care of other infants. In the study which has been done in 2005 in Australia on NICU units, there were isolated room in 22 cases of 26 ICU units of the study that the average of them was 9.2 square meters that from this approach it was almost in compliance

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with the present study and also in that study it was clear that just 10 isolated rooms had specific facilities like air conditioning with negative pressure [16]. Also among all the units of the study just 6 hospitals (54.5%)had holding space of contaminated tools and instruments in all NICU units that according to hospital accreditation process, presence of this room in NICU is one of the basic essentials.

5. Conclusion

Although according to limitations of this research, it can be indicated to lack of possibility of generalizing the assessing results of the units in the study with the present condition of the units structure of NICU of other universities , public and private hospitals, social security, army and other public and private hospitals in other cities of the country but this study according to its new approach gave important information to the pundits and researchers by producing scientific evidences about care challenges of hospitalized infants in NICU units in the country and it clarified that physical structure of the units of the study has got some deficiencies about infection control processes and it had been recommended that in units that are constructing or are being renovated there should be more attention to effect of physical structure in nosocomial infection control and with using appropriate design and structural standards about this issue it should be tried improve programs of infection control[5] because nowadays in NICU units there is special attention to reduction of Iatrogenic effects on hospitalized infants [22]. A nurse of special care of the infants in the health should also consider structural factors that effect on taking care of the infant with comprehensive view and tries to find problems of taking care with quality, because giving consultation to managers and policymakers of health system about decision makings related to intensive units of preterm or unwell infants is among duties of every nurse in NICU that efforts should be taken in that [13].

6. Acknowledgement

Writers would like to thank and appreciate all the people who made doing this research possible and especially all the head nurses of NICU of the study for helped in performing this research. This article had been written by using one Master's thesis in Tehran Medical University.

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