Multiresistant bacterial colonization due to increased nurse workload in a neurology intensive care unit

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ABSTRACT

Objective: To determine the relationship between nurse workload and multiresistant bacteria colonization or infection (MRB+) in a neurology intensive care unit (ICU).

Methods: We studied the relationship between nurse workload and MRB+ development in patients who were hospitalized in Dicle University Neurology Department ICU, Turkey during a 6-month period from November 15, 2003 to April 15, 2004. The intensity of workload and procedures applied to the patients were scored with the Project de Recherché en Nursing (PRN) and the Omega scores.

Results: Of 138 patients followed, 71 (51.4%) were female and 67 (48.6%) were male. The mean age of females was 65.6±6.7 years, and of males was 62.2±15.8 years. The mean time of hospitalization in the ICU was 13±7.6 days. In 26 (18.8%) cultures taken from patients, multiresistant bacteria (MRB) were demonstrated. The development of MRB+ infection was correlated with length of stay (LOS), Omega 2, Omega 3, Total Omega, daily PRN, and total PRN ($p<0.05$). There was no correlation between development of MRB+ infection with gender, age, APACHE-II and Omega 1 scores ($p>0.05$). In the PRN system, when the workload of nurses was compared, it was seen that in the MRB colonized patient group, the workload of nurses was meaningfully higher than the MRB patient (-) group ($p<0.001$).

Conclusion: As a result, the risk of MRB+ development in the ICU is directly proportional to understaffing, increased nurse workload, LOS, and procedures applied to patients. In management of nosocomial infection, it is crucial to increase the number of nurses in the ICU, and thus, decrease the workload.

Neurosciences 2006; Vol. 11 (4): 265-270

High rates of nosocomial infections (NI) are observed in intensive care units (ICU). Recommended procedures to prevent and control the spread of NI have been published, including measures to manage multiresistant bacteria (MRB).[1,2] The NI have well-documented adverse effects on attributable mortality and morbidity, length of stay (LOS), and hospital costs. Fewer data are available on the effects of NI on the workload of nurses. Most studies of excess costs related to personal charges, based their cost estimates on the attributable excess of hospital LOS.[3-7] Although the increase in LOS associated with NI is an important source of excess costs, it fails to reflect the effects of NI on the daily workload of nurses, and consequently is inadequate for determining staffing requirements. An evaluation of the effects of NI on nurse workload is difficult, because the relationship between these 2 parameters is complex. Understaffing

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Received 25th April 2006. Accepted for publication in final form 24th May 2006.

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and a heavy nurse workload can be viewed as a risk factor for NI or as a consequence of NI. On one hand, excessive nurse workloads have been shown to contribute to recurrent NI outbreaks; moreover, in a given patient, a persistently high level of therapeutic activity may be a risk factor for NI.[8-10] On the other hand, NI can increase the severity of illness in the patient, and consequently the level of therapeutic activity, and require stepped-up infection control procedures, particularly when the causative organism is an MRB, both adding to the nurse workload.[10] These aspects of the daily workload should be considered when seeking to match staffing patterns to both the number of patients and the level of care for each patient. Scoring systems capable of measuring these aspects are needed. The aim of this study is to determine the possible association between the risk of development of NI and increased daily nurse workload due to understaffing in the ICU, and ascertain the risk factors in the development of MRB colonization in patients with and without MRB colonization using the Omega score[10] and PRN (Project de Recherché en Nursing (PRN) system) systems.[11]

Methods. A prospective study conducted in a 10-bed medical ICU in the Neurology Department of Dicle University Hospital in Diyarbakir, Turkey, from November 15, 2003, to April 15, 2004. All patients admitted to the ICU during the 6-month study period (138 patients [71 (51.4%) females, 67 (48.6%) males]) were included in the study. The patients were divided into 2 groups, based on MRB colonization or infection. The MRB colonization (MRB+ group) was defined as recovery from an MRB at any clinical site on admission or during the ICU stay. The criteria used for infections were those defined by the Centers for Disease Control. The MRB (+) were defined as any of the following: ceftazidime-resistant *Pseudomonas aeruginosa* and *Acinetobacter baumannii, methicillin-resistant Staphylococcus aureus, methicillin-resistant Staphylococcus spp., vancomycin-resistant Enterococcus,* and beta-lactam producing *Enterobacteriaceae*. Nosocomial infections were monitored by a NI control team. Periodic screening of cultures was performed on all patients on ICU admission and weekly thereafter. Consequently, it is unlikely that any episodes of MRB colonization or infection were missed. The patients who were admitted to the ICU during the study period, and who had negative tests for MRBs constituted the MRB (-) group. For each patient, the following data were recorded: socio-demographic data, primary diagnosis, and dates of ICU admission and discharge. The severity of illness was evaluated based on the APACHE II calculated during the first 24 hours of ICU stay. Nurses work in 2 shifts -night and day shifts- in the Neurology ICU. Two nurses' work during the daytime shift (between 8:00 AM-4:00 PM) and one during the night-time shift (4:00 PM-8:00 AM). Therapeutic and nursing activity during the entire ICU stay was estimated using the Omega score and the PRN system. Moreover, we performed a specific functional analysis of recommended procedures for managing MRB nosocomial colonization or infection. The Omega score is a therapeutic activity scale composed of 45 items scored 1 to 10 and divided into 3 categories, as follows: 1. Tasks recorded only the first time they are carried out; 2. Tasks recorded each time they are carried out; 3. Tasks recorded each day they are carried out. The total score is calculated by adding the points in the 3 categories at ICU discharge (**Table 1**). The simplified version for the ICU is a specific scale for nurse workload evaluation. It includes 8 categories of nursing procedures covering all technical, relational, and basic tasks (**Table 2**). In each category, nursing tasks are carefully individualized, described, and weighted. A fixed value is assigned to each task (one point is equal to 5 minutes). The time needed to complete each task correctly was determined by Delphi consensus. The times for routine infection control practices used in all patients are included in each task. Items are entered either daily or each time they are carried out.

Data management and analysis were carried out using SPSS software (SPSS, Chicago, IL). Results were expressed as means ± standard deviations. Continuous variables in the 2 unmatched groups were compared using the unpaired Student's t test. For data that was not normally distributed, the nonparametric Mann-Whitney test was used. *P*-values less than 0.05 were considered significant.

Results. Of 138 patients included in the study, 71 (51.4%) were female and 67 (48.6%) were male. The mean age of females was 65.6±6.7 years, and of males 62.2±15.8 years. The mean time of hospitalization period in the ICU was 13±7.6 days. The patient's primary diagnosis and indication for hospitalization are demonstrated in **Table 3**. For each patient, the screening tests and cultures of blood, urine, feces, and endotracheal tube were performed after admission to the ICU and each week thereafter. In 26 (18.8%) cultures taken from patients, MRB (+) was demonstrated. The mean time of LOS for MRB-colonized patients was 15.8±11.2 days, and for MRB (-) patients was 12.3±6.4 days. Thus, the development of MRB colonization was correlated with LOS

Table 1 - The Omega Scoring System.

Items	Points	Items	Points
Category 1		Neurological examination	1
Tracheotomy	6	Lumbar puncture	1
Chest tubes	6	Intracranial pressure monitoring	3
Training for home mechanical ventilation	6	Infusion of sedative drugs	6
Central venous catheter	3	Peritoneal lavage	3
Arterial line	3	***Category 2***	
Pulmonary artery catheter	6	Hemodialysis, extracorporeal circulation	10
Temporary cardiac pacing	3	Plasmapheresis	10
Nasotracheal or orotracheal intubation	6	Bronchoscopy	3
Cardioversion and defibrillation	3	Gastrointestinal endoscopy	3
Cardiac arrest	10	Ultrasonography	3
Vasoactive drug infusion	6	Angiography	10
Fibrinolysis	10	Scintigraphy	6
Intra-aortic balloon and counterpulsation	10	Intrahospital transport	3
Infusions of blood products	10	Preparation for out-of-hospital transport	1
Gastric lavage	1	Preparation for and transport to the operating room	6
Parenteral nutrition	6	***Category 3***	
Balloon tamponade of gastroesophageal varices	3	Continuous intensive care unit surveillance	4
Enteral nutrition	3	Mechanical ventilation	10
Ascites reinstallation	10	Continuous hemofiltration	10
Arteriovenous bypass	10	Peritoneal dialysis	10
Ureteral catheter	3	Digestive fluid reinstallation	6
Percutaneous cystostomy	1	Complex surgical dressings	6
Complex orthopedic traction	6	Isolation	10

Table 2 - The simplified PRN for intensive care unit patients.

Nursing categories	No. of tasks	No. of modalities
Mobilization	3	6
Elimination	3	8
Hygiene	2	4
Feeding	2	6
Communication	3	7
Respiration	3	8
Diagnosis	8	26
Treatments	11	22
Total	**35**	**87**

Modalities: in each nursing category, the weight of a given task may vary according to the number of times the task is performed each day, and the number of nurses needed to perform the task. PRN - Project de Recherché en Nursing

Table 3 - Primary diagnosis in the study population.

Diagnosis	Overall population	MRB (-)	MRB (+)
		No. (%)	
No. of patients	138	112 (81.2)	26 (18.8)
Cerebrovascular thromboembolus	79 (57.2)	65 (58)	14 (53.8)
Intracranial hemorrhage	44 (31.8)	36 (32.1)	8 (30.7)
Hemorrhagic infarct	15 (10.8)	11 (9.8)	4 (15.4)

MRB - Multiresistant bacterial colonization

Table 4 - Comparison between MRB (-) and MRB (+) groups.

Variable	MRB (-)	MRB (+)	*P-value*
No. of patients	111	27	
Age	63 ± 13.7	65 ± 6.5	0.097
APACHE II	19 ± 7.5	23 ± 8.7	0.074
LOS (days)	12.3 ± 6.4	15.9 ± 11	0.001*
Omega 1	3 ± 0.7	5 ± 2.3	0.098
Omega 2	5 ± 1.3	10 ± 5.9	0.001*
Omega 3	0.3 ± 0.7	4 ± 2.5	0.001*
Total Omega score	9 ± 1.9	20 ± 8.9	0.002*
Total PRN score	651 ± 52	1479 ± 87	0.001*
Daily PRN score	76 ± 5	115 ± 9.5	0.001*

LOS - length of stay, MRB - Multiresistant bacterial colonization, PRN - Project de Recherché en Nursing
*significant values

(p=0.001). The total Omega score was 20±8.9 in the MRB-colonized patient group, and 9±1.9 in the MRB (-) patient group (p=0.002). The total PRN score in the MRB-colonized group was 1479±87, and 651±52 in the MRB (-) patient group (p=0.001). The development of MRB (+) colonization or infection in patients was correlated with length of stay (LOS), Omega 2, Omega 3, total Omega, daily PRN, and total PRN ($p<0.05$). There were no correlations between development of MRB (+) infection with gender, age, and APACHE-II, and Omega 1 scores ($p>0.05$). In the PRN system, the comparison of the workload of nurses revealed that in the MRB colonized patient group, the workload of nurses was significantly higher than in the MRB patient (-) group ($p<0.001$) (**Table 4**). The PNR score consists of 4 parts: The nurse should practice: 1. Isolation of the patient. 2. Cleaning with antiseptic solution. 3. Changing bed covers. 4. Collection of blood, urine, and other specimens for culture. Overall, the functional analysis showed that the amount of time needed each day to carry out MRB (-) driven tasks was 95 minutes per patient. Most of the time was spent on isolation precautions and antiseptic baths. In our ICU, 3 nurses, 2 during the day and one at night, are on duty each day. The mean care time nurses spent for MRB (-) patients was 95 minutes, where it was 66 minutes for MRB-colonized patients.

Discussion. To prevent high rates of nosocomial colonization or infections with resistant bacteria observed in ICUs, the mechanism of infection development should be investigated. The eradication of infection development seems more reasonable than management of NI infections. Nosocomial infection development increases morbidity and mortality as well as LOS, and increases costs. Understaffing and increased workload of nurses is a factor that concomitantly increases NI.

In the literature, there are few studies on the relationship between nurse workload and NI development. Many studies have determined that inclined LOS, rather than staff salaries lay a heavy burden on countries economies. The appropriate number of nursing staff in the ICU would reduce NI development and the costs in the longer term. Increased intensity of workload of nurses and understaffing is also a risk factor for NI. Excess workload would cause delays in patient-care, which results in an increase in development of hospital infections. Haley[9] emphasized this topic, and determined that a staphylococcal epidemic in an infant ICU was related to staff insufficiency. In another study, Taunton et al[12] demonstrated a correlation between urinary tract and sepsis in the emergency room and ICU, with increased workload due to nurse's absenteeism without excuse.

Fridkin,[13] in his study, showed that in central venous catheter-associated bloodstream infection, risk is related to the patient/nurse ratio. In our study, 26 (18.8%) of 138 patients demonstrated MRB-colonization in the neurology ICU related to increased nurse workload. An increase in NI with MRB-colonization was related to the period of increased workload of nurses, elongated LOS, and increased number of interventions. Girou et al[14] determined a relation between NI development with LOS and inclined treatment activity. Treatment activity and treatment and interventions applied to patients were evaluated with the Therapeutic Intervention Scoring System (TISS) and Omega score. In a study conducted on 177 patients during an 8 month period,[15] interventions applied to these patients were evaluated with Omega 1, 2 and 3. As a result, the relationship between MRB (+) NI development, and Omega 2, 3 and total Omega scores were found to be statistically significant ($p<0.05$). In our study, we also used the Omega score to assess treatment and intervention applied to patients. We found that there was a statistically significant correlation between MRB (+) NI development, and Omega 2, 3 and total Omega ($p=0.001$). Interventions applied to patients were found to be a risk factor for NI development.

The PRN system is an effective activity in assessment of nurse workload. In his study, Hurst[16] demonstrated that during periods of nurse workload increase, or nurse understaffing, NI frequency also increased. There are many scoring systems for assessment of health staff workload; in our study, we used the PRN system. The staff nurses were listed, and the duties for each patient were noted. In the PRN system, the maximum care time for each patient in optimal circumstances is suggested to be up to 745 minutes. In his study, Saulnier[15] reported that the mean care time for each patient was 245 minutes. In the same study, there was a statistically significant correlation between daily and total PRN with MRB (+) NI development. It was seen that MRB (+) NI development increases while the total and daily PRN incline. Likewise, in our study there was a direct correlation between total and daily PRN and MRB (+) NI development. During the inclination period in PRN, MRB (+) NI development also increased ($p=0.001$). It is seen that as the nurse workload increased, the care period for each patient decreased. The daily attendance period for MRB (+) patients was 66 minutes, whereas the period for MRB (-) patients were 95 minutes. The period of care was found lower than the study. This result shows us that increased workload of nurses is a risk factor for MRB (+) NI development.

Robert et al,[17] examined nosocomial bloodstream infections in a surgical ICU related to increased nurse workload for a period of 8 months. In this study, 28 patients with NI were compared with the data of the control group, composed of 90 patients who were hospitalized for more than 3 days in the same ICU. Elongated intravenous catheter usage, total parenteral support, and declined nurse/patient ratio were found to be correlated with NI development.[17] Likewise, in our study, times of nurse understaffing in our ICU were correlated with an increase in the risk of NI.

As reported from the studies, in order to offer a high quality service in the ICU, and to reach an adequate nurse staffing level, a standard ratio of nurse/patient is mandatory. The role of nurse understaffing in nosocomial viral gastrointestinal infections on a general pediatrics ward was evaluated in one study, and determined that nurse absentees in a neonatal ICU may yield NI epidemics.[18] Similarly, in another study in England,[14] it has been demonstrated that the quality of service increased with an incline in staffing levels, and a decline in nurse workload. Inclined staffing levels, and a decline in nurse workload would contribute in controlling NI.[14]

Generally, the TISS and Omega scores, assess the nurse workload associated with technical procedures and are sensitive to a possible increase in the severity of illness due to MRB NI. The PRN system, but not the TISS or the Omega, takes into account routine infection control procedures and basic care. These 3 tools underestimate the daily workload related to nursing procedures now recommended for MRB infected ICU patients. This workload can be assessed by a functional analysis of care, as illustrated in this study. The results may vary across units; in particular, they may be sensitive to study design and equipment. One of the limitations of this study is the limited time period of the research, which was conducted in a relatively small ICU in a university neurology clinic. This would possibly prevent the application of our findings to hospitals with larger ICU units with different NI profiles. This limitation should be borne in mind in evaluation of our findings.

In conclusion, the risk of NI development in an ICU is directly correlated with increased nurse workload, applied intervention, and LOS. Understaffing in the ICU is an important health problem that especially affects care-needing patients. Nosocomial infection development has laid a heavy burden on the economy of many countries. To control NI development in the ICU, nurse workload, staffing level, and working conditions must be arranged. Unlike general bias, the major factors that increase health costs are NI and LOS rather then staff salaries. Further studies including large groups of patients in multiple ICU locations, with control of the number of nurses should be conducted to clearly define the implications and effect of nurse workload and other factors on NI and LOS.

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