Two mattresses for neonates compared for cost and quality of nursing care

Paul De Raeve, RN, MSc, MQA, NMDS co-ordinator, Nursing Department, Academisch Ziekenhuis van de Vrije Universiteit Brussel, Belgium (✉)

Rita Vercruysse, RN, Head Nurse, NICU, Nursing Department, Academisch Ziekenhuis van de Vrije Universiteit Brussel, Belgium

Tony Waterschoot, RN, Quality Assurance Nurse, NICU, Nursing Department, Academisch Ziekenhuis van de Vrije Universiteit Brussel, Belgium

Geert Van Droogenbroeck, RN, Nurse, NICU, Nursing Department, Academisch Ziekenhuis van de Vrije Universiteit Brussel, Belgium

Adel Bougatef, MD, Head of NICU, Nursing Department, Academisch Ziekenhuis van de Vrije Universiteit Brussel, Belgium

Yvan Vandenplas, MD, PhD, Chair of Paediatrics, Academisch Ziekenhuis van de Vrije Universiteit Brussel, Belgium

P De Raeve, Academisch Ziekenhuis van de Vrije Universiteit Brussel, Laarbeeklaan 101, 1090 Brussel, Belgium.
e-mail: dirndrep@az.vub.ac.be

INTRODUCTION

This study investigates the influence of a visco-elastic foam (VEF) mattress (Tempur®) in relation to temperature, head development and flexibility when positioning the neonate baby. The mattress is sensitive to environmental and ventilatory airflow temperatures. Control of these factors could enhance the quality of nursing and thus improve outcome. When the baby is relaxed and comfortable, the principle of minimal handling in an environment of high technology is respected. This study also highlights the fact that nursing practices are sometimes difficult to change. However, as a result of this study, the quality of nursing care was improved at the same time as producing a decrease in nursery costs.

BACKGROUND

Critically ill neonates are commonly nursed in a supine position. This causes extension of the limbs, which can be detrimental to the psychomotor development of young babies. A flexible mattress will prevent overextension. The level of comfort of a sick neonate is directly related to its position and to minimising handling. The development of head circumference and biparietal diameter are parameters that are indirectly related to the quality of nursery care. Finally, prevention of pressure sores and necrosis is also related to the quality of nursery care.

AIMS OF THE STUDY

Staff at the neonatal intensive care unit (NICU) in the Academic Hospital of the Free University of Brussels have developed, in collaboration with colleagues in industry, a standard mattress suitable for either an open table, incubator or heated bed. The new mattress consists of a visco-elastic polyurethane foam with an open cell structure. The foam adjusts itself to the body contours; is appropriate for any bodyweight between 600 g and 3,600 g; and adapts to the temperature of the environment and the patient, without decreasing the patient's body temperature. It was hypothesised that a classic gel mattress might not have this property of maintaining body temperature. We therefore evaluated specifically the influence of the VEF mattress on the temperature of the neonate, in comparison to the traditional gel mattress (Premat®), used for many years in our NICU.

Finally, every change needs also to consider the economic costs involved. The financial cost of the Tempur® mattress was therefore compared to that of the traditional gel mattress.

DATA COLLECTION

Nursing and medical interventions cause changes in temperature in the neonate. Body temperature, and thus cold and warmth stress, is the result of many external contributory factors. In order to exclude contributory factors, and to concentrate on the impact of the mattress itself, we recorded many of these external factors. The gender and gestational age of the neonate, as well as the changes in environmental temperature (radiant warmer or incubator) and the setting of the humidifier were noted. The physical condition of the baby was expressed in variables, in-

cluding: weight; C-reactive protein (CRP) for infection; heart rhythm (normal, tachycardia, bradycardia); saturation; respiration (tachypnoea, apnoea); and temperature (cold stress, hyperthermia). The severity of pathology was assessed using the ICD-10-CM, and the nursing workload was measured by the Belgium Nursing Minimum Dataset (Sermeus, 1993) and the Northern Neonatal Network (NNN) scale (NNN, 1993).

Quality of life indicators were also recorded, including parent participation ('kangaroo-care'), skin condition, head circumference, biparietal diameter and minimal handling (clustering care). All these variables were registered in the nursing file. A Microsoft Access file was created to include all these variables so that an analysis could be carried out using Statistica®.

STUDY POPULATION

This randomised prospective study was carried out from August 1998 to April 1999. It involved 72 patients (48% male, 52% female) and generated a total of 10,758 observational recordings. The gestational age of the babies at birth was between 24 and 41 weeks (mean±SD, 32±3.7 weeks) and the weight on admission varied between 535 g and 3,600 g (mean±SD, 1,692±741 g). After randomisation with an envelope system, 57% were nursed on a VEF mattress and 43% on a gel mattress. Although the vast majority of all babies were admitted on a radiant warmer, they were transferred into an incubator when stabilised. As a consequence, 71% of all observations were performed with the baby in an incubator and 29% with the baby on a radiant warmer. The new environment, after stabilisation of the neonate, had an important influence on the temperature (Altimier *et al.*, 1999). Neonates nursed in a crib or on a heated bed were excluded from the study.

In order to test our hypothesis, a statistical analysis was carried out on the data from those observations which indicated cold stress and hyperthermia on admission and during the baby's stay in NICU. This subgroup of the study provided 2,643 records involving 34 variables. Within this subgroup, 44% of recordings were made using the VEF mattress and 56% using the gel mattress, while 68% were made with the baby in an incubator and 32% with the baby on a radiant warmer.

ETHICS COMMITTEE

The study protocol was approved by the ethics committee of the Academic Hospital of the Free University of Brussels. At least one parent of each patient enrolled in the study signed the consent form. Information was given regarding the study's aims, procedures and the possible advantages or risks of participation. It was explained that participation was voluntary and that the baby could be withdrawn by the parents at any time.

RESULTS

Severity of disease

The severity of the pathology, as evaluated by the ICD-10-CM (Figure 1), indicates that 78% of the participating babies were of low gestational age and low birthweight (code 765); 16% of babies had respiratory distress syndrome (code 769); 1% had other respiratory distresses of the neonate (code 770); 4% had a perinatal infection (code 771); and 1% had conditions involving the integument and temperature regulation of the fetus and neonate (code 778).

The model of performance (De Raeve, 1994), which measures

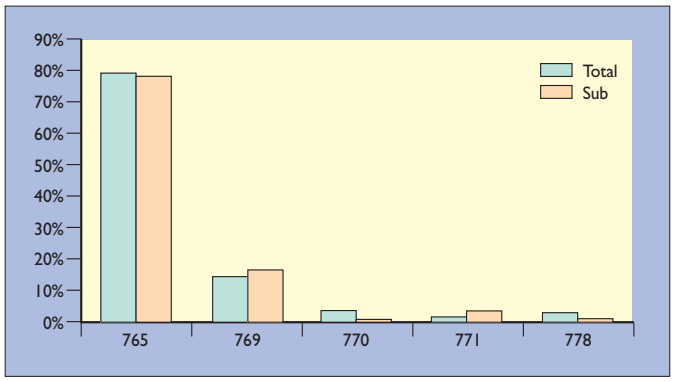

Figure 1. The distribution of pathology among the total study population, as evaluated by the ICD-10-CM. Key to ICD-10-CM codes: 765 = low gestational age and low birthweight; 769 = respiratory distress syndrome; 770 = other respiratory distress of the newborn; 771 = perinatal infections; 778 = conditions involving the integument and temperature regulation of fetus and newborn. Total = total study population. Sub = study subgroup, for whom cold stress and hyperthermia records were analysed.

the nursing workload according to 23 interventions of the Belgium Nursing Minimum Dataset, classified 26% of the total study observations (10,758) into the high workload category; 37% into the medium workload category; and 37% into the low workload category. For the subgroup of neonates, for whom only cold stress and hyperthermia records were analysed, there was a total of 2,643 observations, of which 40% were classified into a high workload category, 39% into the medium workload category, and 21% into the low workload category. According to the NNN scale, 26% of all observations were in the high dependency A category, 21% in the medium dependency B category; 52% in the low dependency C category, and 1% in the low dependency D category. For the subgroup, the NNN scale found that 43% of observations were in the A category, 16% in the B category, 40% in the C category and 1% in the D category. We therefore concluded that the subgroup of babies (2,643 observations), on whom our hypothesis was being tested, were suffering from more severe illness than our total sample (10,758 observations), including all observations made after the baby had been stabilised.

Thermoregulation

The nominal variables, 'hypotemperature' (<36.3°C) and 'hypertemperature' (>37.6°C), measured at admission and at each nursing intervention, were used to test the study hypothesis. The temperature of the neonates on admission varied between 34.5°C and 39°C (mean±SD, 36.8±0.64°C). At admission, six babies were hypothermic and seven were hyperthermic. They represented respectively 8% and 12% of the total observations. A second measurement, performed 15 minutes after admission, showed more 'hyperthermia' within our study because of the higher temperature settings of the environment. During the total eight months of the study, 1.2% of the measurements were found to be hypothermic and 5.2% hyperthermic.

It is important to analyse the different systems of ventilation and their specific settings for humidifying the airflow (Table 1 and Figure 2) in order to explain the reasons behind the observations of cold stress (1.2%) and hyperthermia (5.2%). Compared to the use of ventilation methods, we concluded that spontaneous breathing (64% of observations) was associated more often with cold stress (42% of observations) and hyperthermia (57%). Thus, the oxygen clock, present in 11% of observations (humidifier temperature setting from '2 to 5'), was associated with 13% of observations of cold stress and 16% of observa-

Table 1. Relation between ventilation mode, thermoregulation and environment

Ventilation mode	S distr	Hypothermic (1.2%)			Hyperthermic (5.2%)		
		RW	INC	Total	RW	INC	Total
Spontaneous	64%	8%	34%	42%	9%	48%	57%
0_2Clock (2–5 setting)	11%	2%	11%	13%	5%	11%	16%
Nasal CPAP (fixed 37)	11%	2%	21%	23%	4%	9%	13%
VDR (3–8 setting)	13%	10%	11%	22%	8%	5%	13%
900C	1%	0%	0%	0%	0%	1%	1%
Total	100%	22%	77%	100%	26%	74%	100%

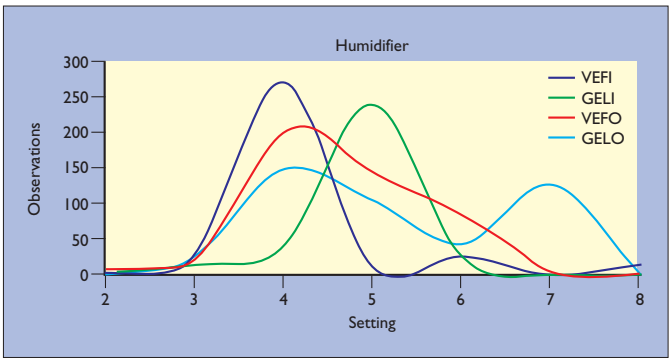

Figure 2. Settings of humidifiers of air flow systems.

tions of hyperthermia, while continuous positive airway pressure (CPAP), present in 11% of observations (humidifier settings predetermined at 37°C), was associated with 23% of observations of cold stress and 13% of observations of hyperthermia. The Volumetric Diffusive Respiration (VDR) system, present in 13% of observations (humidifier temperature setting from '3 to 8'), was associated with 22% of observations of cold stress and 13% of observations of hyperthermia. Our study found no association between hypothermia or hyperthermia and the use of the Siemens-Elema 900 C ventilator. Since VDR, CPAP and the oxygen clock involve the use of humidification, the mode of ventilation appears to have an indirect influence on hypothermia. Hyperthermia, with its higher incidence than hypothermia, was shown to be an important nursing problem.

The results demonstrate that both the temperature of the environment and the ventilation mode contribute to changes in body temperature. More specifically, we can say that babies with spontaneous respiration nursed in an incubator are at higher risk. The environmental setting of the radiant warmer and the incubator is more important then the ventilation mode itself. Other research being carried out in NICUs is confirming these findings (Altimier *et al.*, 1999). In order to control the thermoregulation, the nurse needs to control the different factors which influence the temperature of the neonate. It becomes clear that nursing care related to the basic interventions is complex and crucial for the outcome of the neonate.

Our results indicates that the temperature setting of the humidifier (Figure 2) is lower when babies are nursed on a VEF mattress than on a gel mattress, suggesting that babies on a VEF mattress maintain their body temperature more easily. This implies that standardisation of the humidifiers and their control during nursing is recommended to optimise the quality of care.

If we review the differences in thermoregulation between the two mattresses (VEF and gel), 5% of observations of cold stress were associated with the VEF mattress and 14% with the gel mattress. With regard to the cases of hyperthermia, identified as a more common problem than hypothermia, 21% of observations were associated with the VEF mattress and 60% with the gel mattress. If hypothermia on admission is compared with later hypothermia, we see that only two newborns remained hypothermic on the VEF mattress, while 19 remained so on the gel mattress. With neonates identified as hypothermic on admission, who were later observed as hyperthermic during the study, 19 were nursed on a VEF mattress and 57 on a GEL mattress.

Hyperthermia was also identified in babies who are given 'kangaroo-care' by their parents. This involves lying the baby on the thorax of the parent so that he or she can adapt to the temperature of the adult, following which the baby is put into an incubator without being woken.

Other variables recorded to determine the cause of hyperthermia were corticosteroid administration (5% of observations), blood transfusion (1%), morphine (20%) and euphiline treatment (1%). However, these factors were not found to be associated with hyperthermia.

In order to test our study hypothesis, we conducted a discriminatory analysis (grouping variables at nominal measurement level), with the following variables: gender (V2), gestational age (V3), birthweight (V5), temperature on admission (V6), type of mattress (V8), daily weight (V15), environmental temperature (V16), type of ventilation mode (V24). We wanted to know how much variance was explained by these factors, with a dependant variable being defined by the occurrence of hypothermia and hyperthermia during the baby's stay in NICU. Our analysis showed that the variables, gestational age (V3), birthweight (V5) and daily weight (V15) explained most of the variance (between 87% and 92%). The temperature on admission explained only 11% of the variance. Gender explained only 17% of variance.

Results referring to comfort and quality aspects

Positioning of the critically ill neonate is very important in this early stage of life. The trunk should be supported bilaterally. This can be achieved by a 'nest' that positions the baby and offers a good degree of comfort. It minimises extension patterns and reduces stress. If the medical condition of the baby was satisfactory, we were able to alter the retraction position of the shoulders. When possible, we positioned the baby on its side and/or in the prone position. When positioned on its side, stability of flexion of the hips and extremities, as well as of the trunk, is important, while the underlying side must be alternated to promote symmetry and discourage head flattening. The prone position facilitates flexor tone and tends to calm infants and improve their ability to self-regulate their behaviour. Positioning with slightly raised trunk and leg flexion prevents a 'W' (frog-like) posture. We aim to achieve this with a minimum of outside aids. In this way, subjectively evaluated, the baby appears to be relaxed, lying in a 'nest'. This appearance is important for the baby, the nurses and, last but not least, the parents.

Pressure sores are caused by vertical pressure or lateral movement forces. The occiput, ears, shoulders and sacrum are the parts of the body most at risk. It is advisable to change the baby's position regularly, as soon as his or her condition permits. Negative stimuli should be avoided, as these may compromise the normal development of premature or seriously ill neonates In our sample there was no observation of any level of skin damage. The variables, sedatives and muscle relaxants, are associated with the development of cranial malformations. These malformations, which have an enormous impact on the future of the life of the individual, are also associated with premature babies, and babies with oedema.

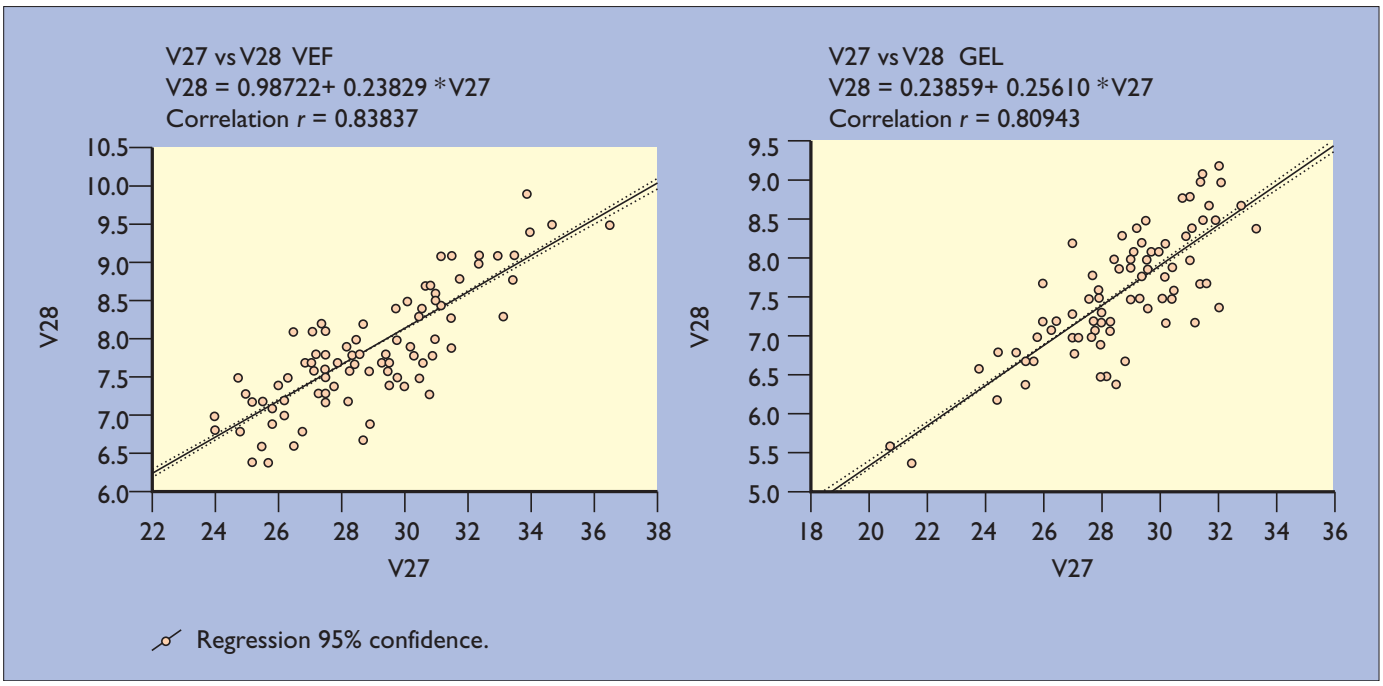

Figure 3. Correlations between the cranial and biparietal measurements for both VEF and gel mattresses. V27 = cranial measurement; V28 = biparietal measurement.

Biparietal and head circumference measurements were analysed in relation to the type of mattress used. The biparietal measurement was performed on admission and thereafter once weekly. We performed a regression analysis with the neonates nursed on a VEF mattress and those nursed on a gel mattress. Figure 3 shows that the correlation between the cranial and biparietal measurements was 0.84 for babies nursed on a VEF mattress and 0.80 for babies nursed on a gel mattress. This is an important difference for the future quality of life for the baby: when the baby is 10 years old, he or she will have a flat-shaped head about which they may be teased badly. Thus, use of the VEF mattress was associated with a more normal development of the cranial bones. This may be related to the much higher density of the VEF mattress compared to the gel mattress.

Results related to the nursing process

It became clear during the study that nursing attitudes and routines were important to acceptance of the new VEF mattress, partly because no blankets were required. In practice, if a baby showed an infection, the nursing staff tended to link this with the absence of blankets. However, a dialogue between the hospital infection co-ordinator and nurses resulted in better understanding and acceptance of the new mattress. In total, 28% of the total observations made during the study, independently of the type of mattress used, indicated an infection (CRP >15 mg/dl), while the use of antibiotic treatment (Ampiciline®, Claforan®) was noted in 27% of our observations. When the occurrence of infection was related to the occurrence of hypothermia or hyperthermia, as well as to the type of mattress, we found that 6% of observations of infection with a normal temperature were made in babies nursed on the VEF mattress, 0.07% of observations of infection were associated with hypothermia and 1% with hyperthermia. Five per cent of observations of infection and normal temperature were made in babies nursed on the gel mattress, while 0.06% were associated with hypothermia and 0.5% with hyperthermia.

Financial analysis, comparing the old and new situation

The costs of using the new VEF mattress were compared to the costs of using the traditional gel mattress, which also required rolled-up towels, positioning cushions and gel cushions, as well as the gel mattress itself. We were able to show that a quality improvement in care need not be more expensive, but in fact can cost less than the original method being used. The cost of the traditional nursing method was calculated for the year before the research project was undertaken. In 1998, 287 neonates were

admitted with an average length of stay of 20.53 days. Each gel mattress had a cost of 0.17 Euros per patient per year, with an additional cost of 23.3 Euros per patient per year for the linen used, i.e. a total cost of 23.47 Euros per patient per year. In comparison, the total cost for the VEF mattress was 0.022 Euros per patient per day, based on the initial acquisition cost and the sterilisation cost. Thus, it is clear using only one basic material (i.e. the VEF mattress) in an incubator or radiant warmer, without the need for different types of gadgets to position the neonate, has important implications for the financial budget of a NICU.

DISCUSSION

The nurses' awareness of the study made them more conscious about the dangers of hypothermia, which may have possibly resulted in an incidence of hyperthermia due to higher temperature settings of the environment.

Nursing attitudes have a great impact on nursing handling and outcome. Since the study was performed, nurses have given more attention to measuring temperature of the neonate. It was difficult for them, however, to accept a new way of caring for their patients. The absence of sheets with use of the VEF mattress was (wrongly) thought to lead to an increased risk of infection. However, by being involved in the study, nurses became more convinced that nursing handling is as important as the high technical environment.

Parents were informed about the aims and methods of the study, as well as the advantages and disadvantages involved. All the parents reacted positively, especially since no additional technological procedures were required. Only the usual routine clinical observations were carried out for the study. None commented on the absence of sheets: seeing their child comfortable and relaxed was more important. Nurses also need to be aware of the importance of informed consent.

CONCLUSION

Previously, little or no attention has been paid by the hospital equipment industry to the type of mattress used in incubators and open tables for the intensive care of neonates. A high quality mattress should be a standard part of the equipment of a bed, incubator or radiant warmer. We have shown that a quality improvement can even be related to lower cost.

Thermoregulation, babies' comfort, prevention of pressure sores, the possibility of creating different positions with one basic mattress and infection control are factors of crucial importance for the neuromotor development of the baby, especially those born prematurely. During the eight months' study, we achieved our purpose of creating, in co-operation with industry, a basic mattress for incubators and open tables which took these quality aspects into account.

This study shows the importance of measuring and controlling the temperatures of the neonate, the environment and the equipment delivering airflow. These basic nursing interventions have a significant influence on the outcome of nursing care and on the quality of life of the neonate both during his or her hospital stay and in the future. Furthermore, the nursing approach within the basic nursing interventions plays a significant role in the outcome for the neonate. The setting of the temperature of the incubator and the radiant warmer (probe) are of considerable importance. The study has also shown the importance of thermoregulation on the occurrence of hypothermia and hyperthermia. Standardisation of the equipment for air humidification is essential in ensuring that measurement of observations and nursing control are more efficient.

Installation of the new mattress gave us the opportunity to look at the positioning and the comfort of the neonate. Babies lying on the new VEF mattress appear to be relaxed. This is a subjective but rewarding feeling for nurses of great importance.

From a statistical point of view, the study was not able to prove whether the material of the mattress had an influence on hypothermia. During the study we had a low occurrence of hypothermia, but this may have been because the nurses were giving a lot of attention to the observation and prevention of hypothermia.

The parents of all the babies involved in the study were given information about the content of the study and consented to take part. The parents were keen to support a development intended to create better nursing care and improved comfort for the neonate in a difficult, life-threatening situation.

It is important that the manufacturers of incubators and radiant warmers should have more dialogue with the manufacturers of the mattresses used. Our study has shown the benefits of designing a mattress specifically to meet the needs of the neonate being nursed in intensive care. Furthermore, the new mattress has shown that it could make a significant long-term contribution to the financial costs of running an NICU.

REFERENCES

Altimier L, Warner B, Amlung S, Kenner C. (1999). Neonatal thermoregulation: bed surface transfers. *Neonatal Network*; **18:** 35–37.

De Raeve P. (1994). Personel allocation based on NMDS and the model of performance. *The Belgium Hospital*; **2:** 8–17.

Groen HW, Groenier KH, Schuling J. (1999). Comparative study of a foam mattress and a water mattress. *Journal of Wound Care*; **8:** 333–335.

Keeling EB. (1992). Thermoregulation and axillary temperature measurements in neonates: A review of the literature. *Maternal Child Journal*; **20:** 124–140.

Northern Neonatal Network. (1993). Measuring neonatal nursing workload. *Archives of Disease in Childhood*; **68:** 539–543.

Sermeus W. (1994). Nursing minimum dataset and intensity of nursing care. *Acta Hospitalia*; 57–69.