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Factors That Influence Nurse Staffing Levels in Acute Care Hospital Settings

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Abstract

Purpose: To identify which patient and hospital characteristics are related to nurse staffing levels in acute care hospital settings.
Design: A cross-sectional design was used for this study.
Methods: The sample comprised 1,004 patients across 10 hospitals in the Andalucian Health Care System (southern Spain) in 2015. The sampling was carried out in a stratified, consecutive manner on the basis of (a) hospital size by geographical location, (b) type of hospital unit, and (c) patients' sex and age group. Random criteria were used to select patients based on their user identification in the electronic health record system. The variables were grouped into two categories, patient and hospital characteristics. Multilevel linear regression models (MLMs) with random intercepts were used. Two models were fitted: the first was the null model, which contained no explanatory variables except the intercepts (fixed and random), and the second (explanatory) model included selected independent variables. Independent variables were allowed to enter the explanatory model if their univariate association with the nurse staffing level in the MLM was significant at $p < .05$.
Results: Two hierarchical levels were established to control variance (patients and hospital). The model variables explained 63.4% of the variance at level 1 (patients) and 71.8% at level 2 (hospital). Statistically significant factors were the type of hospital unit ($p = .002$), shift ($p < .001$), and season ($p < .001$). None of the variables associated with patient characteristics obtained statistical significance in the model.
Conclusions: Nurse staffing levels were associated with hospital characteristics rather than patient characteristics.
Clinical Relevance: This study provides evidence about factors that impact on nurse staffing levels in the settings studied. Further studies should determine the influence of patient characteristics in determining optimal nurse staffing levels.

Patient allocation and nurse staff management are of growing interest in health and human resource management (Anderson, Charlesworth, & Mossialos, 2020; Cho et al., 2015; Watt, Charlesworth, & Gershlick, 2019). Findings from the literature indicate that there is a close relationship between having the appropriate number of nurses, clinical safety, and the quality of care in patients admitted to hospitals

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(Aiken et al., 2014; Bruyneel et al., 2015; Butler et al., 2019). An appropriate level of patients per nurse during the shift is associated with reducing both the incidence of adverse events during the hospital stay and deaths within 30 days of admission (de Cordova, Johansen, Martinez, & Cimiotti, 2017). A large European study showed that each patient added to the workload of a nurse in a surgical unit reduces the probability of patient survival by 5% (Aiken et al., 2014).

Nurse staffing levels (NSLs) are typically expressed in two ways: the number of nurses working per shift or over a 24-hr period divided by the number of beds occupied by a patient over the same time period, or the number of nursing hours per patient bed day (HPPD) (Min & Scott, 2015; Twigg, Duffield, Bremner, Rapley, & Finn, 2011) and the nurse-to-patient ratio system (Driscoll et al., 2018).

In addition to the variable number of patients cared for by a nurse, there are other variables associated with staff and patient characteristics that influence the quality and safety of care. These include burnout, emotional exhaustion, intention to leave (Griffiths, Ball, Murrells, Jones, & Rafferty, 2016) and nurse-sensitive patients (Stalpers, de Brouwer, Kaljouw, & Schuurmans, 2015). A recent study analyzed different approaches to determining NSLs, concluding that approaches based on the acuity care level of the patient are better than those based on financial targets such as HPPD (Paulsen, 2018). However, no study has identified the optimal NSL yet for patients of a given acuity level (McHugh & Stimpfel, 2012).

In the past 40 years, instruments aimed at measuring the allocation of patients based on workload were based on tasks developed by nurses (Barrientos-Trigo, Gil-Garciía, Romero-Sanchez, Badanta-Romero, & Porcel-Galvez, 2019). Intensive care units (ICUs) are where such instruments have been developed most extensively. For instance, patients in ICUs can be assessed using a range of scales such as the Nine Equivalents of Nursing Manpower Score or Nursing Activities Score (De Souza-Urbanetto et al., 2013; Stafseth, Tønnessen, & Fagerström, 2018).

There are a range of staffing methodologies that are currently applied in ICUs, and in this line of research it has been shown that even small variations during implementation can influence changes in patient mortality (Griffiths et al., 2019; West et al., 2014).

Recently, new tools have been developed to set staffing levels and manage workloads that try to overcome the weaknesses of previous systems (Griffiths, Saville, Ball, Jones, et al., 2020). Rafaela is a system formed by three subscales that measure patients' needs, care intensity, and nurse staffing level (Fagerström, Kinnunen, & Saarela, 2018). Despite being considered as a reliable and valid tool, the Rafaela method has limitations since it requires continuous data input and support to guarantee the quality of the information, as well as training for nurses and managers in the use of the tool (Lillehol, Lønning, & Andersen, 2017).

The Safer Nursing Care Tool is designed to link staffing levels to care levels that are driven by patient acuity and dependency measures (Fenton & Casey, 2015). This tool imitates previous models since levels of care are not accurately described and are based on the skill mix of registered nurses and nursing assistants. In addition, each level of care involves a time multiplier to adjust the staff according to HPPD (Griffiths, Saville, Ball, Chable, et al., 2020). Furthermore, other studies have confirmed the relationship between individual patient acuity and nursing care value. In this way, acuity is defined as the individual patient need for nursing care (Garcia, 2017; Welton & Harper, 2015). Then, the variability in acuity influences the level of patient care, contributes to the nurse–patient assignment decision, and is used to measure the value of nursing care (Garcia & Jenkins, 2018; Moon, Clancy, Welton, & Harper, 2019).

Within this context, the INICIARE (Inventario del NIvel de Cuidados mediante IndicAdoresde clasificacion de Resultados de Enfermeria) scale is a relatively new instrument that measures patients' dependency levels and has demonstrated excellent values of reliability ($\alpha = 0.98$) and validity (76.8% variance explained) for different acute care settings (Barrientos-Trigo et al., 2019). It is based on indicators of the Nursing Outcomes Classification, which is an international classification of sensitive nursing outcomes in the patient's condition and the efficacy of nurses (Moorhead, Johnson, Swanson, & Maas, 2018), grounded in Henderson's theory based on 14 activities of daily living believed to return patients to independence (Watkins, 1996).

Therefore, this study aims to identify which patient and hospital characteristics are associated with NSLs in acute care hospital settings.

Methods

Study Design

The present study was part of a larger project designed to investigate the measurement of nurse human resource requirements by care levels of patients (stratified by acuity) and dependency as assessed by the INICIARE

scale within a range of different units and hospitals. A cross-sectional design was used for this study.

Sample and Participants

The study was conducted in 2015 in the Andalucian Health Care System (southern Spain). The Andalucian Health Care System is run by the regional government. It is divided into two levels of care. On the one hand is the primary health care system for Andalusia. This is the first level of access for the people of Andalusia, and integrated health services include preventive, curative, and rehabilitative care. On the other hand, specialty care provides the technical and human capabilities appropriate to the diagnosis of, treatment of, and rehabilitation for conditions that cannot be handled at the primary level. Hospitals provide an extensive range of acute inpatient and outpatient specialist services together with the indispensable provision systems, which allow emergency admissions (Bernal-Delgado et al., 2018).

Specialty care comprises 26 public hospitals providing health coverage to 8 million citizens. Hospitals were classified into three hospital categories according to their level of specialization and reference population: primary (>500 beds and large metropolitan areas), specialist (between 200 and 500 beds and small metropolitan areas), and tertiary hospitals (<200 beds and rural areas).

The size of the sample and sampling method were based on achieving representativeness. The sampling was carried out in a stratified, consecutive manner on the basis of (a) category of the hospital, (b) type of hospital unit, and (c) sex and age group. Ten hospitals were finally included (three primary, three specialty, and four tertiary hospitals); the unit types were classified into medical and surgical units. Patients were selected on a random basis through their user identification in the electronic health record system. The inclusion criteria were patients older than 16 years, male or female, and admitted to Medical and Surgical inpatient units.

The required sample size was 998 patients. Based on official activity data, the total number of admissions was estimated to be 204,879 (with a confidence level of 95% and an error margin of 3%), with an error rate of 15% against possible losses during the data collection. The sample size was limited to 1,148 patients, which resulted in a total of 1,004 patients.

Recruitment

The recruitment of the research team was carried out in two phases. In the first phase, the principal investigator along with the nursing directors of each hospital selected 31 nurses trained to collaborate with the project (coordinating team; Figure 1).

The number of participating nurses varied according to the size of the hospital and the number of participating units, from 3 to 4 nurses in small hospitals to 30 to 35 nurses in large hospitals. In the second phase, the coordinating team was responsible for recruiting nurses responsible for collecting patient data. A total of 157 clinical nurses participated in the training and the conduct of the study, collecting the accounts of the patients who participated in the study. Nurses' participation was voluntary, and they did not receive any compensation.

Training

The coordinating team members were responsible for conducting at least one training workshop in their

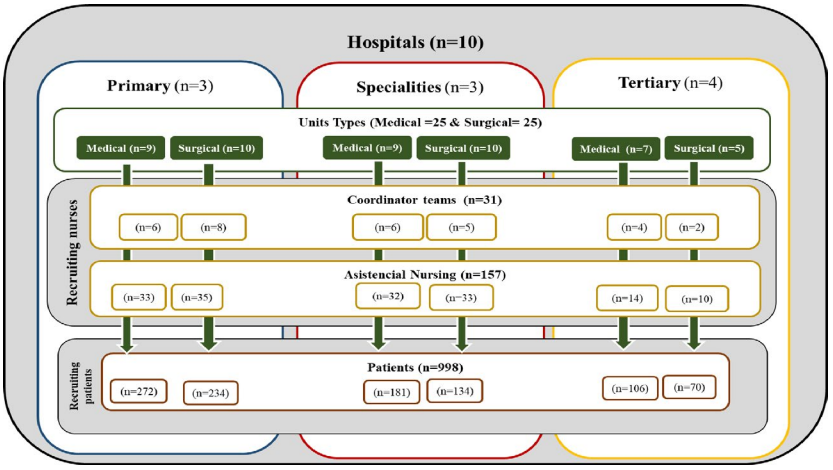

Figure 1. Sampling and recruitment flow chart.

centers. In the workshops, the nurses were presented with the background of the study (aim of the study, purpose, and use of the Nursing Outcomes Classification), the data collection procedure (clinical interview techniques, inclusion criteria, schedule, use of the informed consent), and training in the administration of the different scales. The training was conducted 2 weeks before data collection.

Measures

The variables have been grouped into two categories (patient and hospital characteristics); instruments that measure patient acuity and dependency were used. Patient characteristics included age, gender, and length of stay. Hospital characteristics included type of hospital (primary, specialty, or tertiary), type of inpatient unit (medical or surgical), nurses' work shift (morning, afternoon, or night), season (winter, spring, summer, or autumn) and NSLs. NSLs were assessed using a single self-report questionnaire regarding the number of patients each participating nurse had cared for on his or her last shift (Cho, Chin, Kim, & Hong, 2016). The nurse participants reported the total number of nurses working during the last shift, and the number of patients admitted in the unit, based on official registration electronic records in real time. The data were checked by the team coordinator. The final number of patients comprised all the patients who at some time were admitted to the participating unit.

Instruments included the INICIARE scale, Pfeiffer's test, and Barthel Index. The INICIARE scale was used to assess nursing care dependency in inpatients (Morales-Asencio et al., 2015). The INICIARE scale is a recently created instrument designed to assess nursing care dependency and acuity in patients, and it has shown excellent psychometric properties (intraclass correlation coefficient [ICC] = 0.830–0.964; internal consistency total Cronbach's α = 0.98 and value by subscales between Cronbach's α = 0.92–0.98). It consists of 55 items measured on a 5-point Likert scale (5 reflects the most desirable patient condition, and 1 reflects the least desirable). The scoring range is 55 to 275, with three cut-off points (four intervals) that indicate levels of dependency (Barrientos-Trigo, 2015).

Pfeiffer's test is widely used to assess cognitive status. It consists of 10 items and has two cut-off points. Cognitive impairment is suspected when the error score is equal to 3 or more in people who can read and write, or to 4 or more in people who cannot read and write. The inter-rater reliability and test–retest reliability are 0.738 ($p < .001$) and 0.925 ($p < .001$), respectively, with an internal consistency of 0.82. The test has a convergent validity of 0.74 ($p < .001$) and discriminant validity of 0.230 ($p < .001$). The area under the receiver operating characteristic curve was 0.89. Sensitivity and specificity were 85.7 and 79.3, respectively (Pfeiffer, 1975; Martínez de la Iglesia et al., 2001).

The Barthel Index is used to measure the capacity to perform activities of daily living. It consists of 10 items with five scoring intervals between 0 and 100: the lower the score is, the greater the dependency will be, and the higher the score is, the greater the independence will be (Liu, Unick, Galik, & Resnick, 2015; Wade & Collin, 1968). Internal consistency using Cronbach's alpha ranges from 0.62 to 0.80, with inter-rater reliability using ICC being 0.89. Validity obtained an acceptable correlation with actigraphic data measuring physical activity (r = 0.50; p = .02; Resnick & Galik, 2007).

Data Collection

Nurses rated the patients who met the inclusion criteria during their shift. Data collection was undertaken until data saturation was reached and the full complement of data was collected for each unit. The coordinating team supervised weekly the data collected, evaluating the number of patients who had been recruited. In addition, they guarded the surveys that were sent by postal mail to the research center in closed and filed envelopes, guaranteeing their access only to authorized persons.

Recording

The data were compiled through a digital database, specifically encrypted for the study. The survey was hosted through an online survey platform.

Ethical Considerations

The study protocol was approved by the ethics committee at the Andalusian Healthcare System (Code: 1967). Patients were informed verbally and in written form about the objectives and purpose of the study. The participating nurses and patients signed a declaration of informed consent and were aware of their rights to withdraw from the study at any time. The anonymity of the patients was preserved at all times by using numbers assigned to the participants.

Data Analysis

Firstly, a bivariant analysis was undertaken of the NSLs and independent study variables. The

dependent variable was the NSL and the independent variables were sociodemographic and clinical patient characteristics and hospital characteristics. Frequencies, percentages, means, and standard deviations were calculated as appropriate, for each variable. The chi-square statistic was used to test for association between pairs of categorical and ordinal variables; Student's *t*-test was used to test for the mean difference between two groups; analysis of variance was used to test the variability in means when there were three or more groups; and Pearson's r was used to test for the linear association between two quantitative variables.

Secondly, multilevel linear regression (with random intercepts) models (MLM) were fitted to the data where patients (level 1) were tested within the hospitals to which they were admitted (level 2). Two models were fitted: the first was the null model, which contained no explanatory variables except the intercepts (fixed and random), and the second was the explanatory model, which included selected independent variables. Independent variables were allowed to be entered in the explanatory model if their univariate association with the NSL in the MLM was significant at $p < .05$.

ICCs were calculated for both the null and the explanatory models. The difference between the log likelihood ratios (-2LL) for the null and explanatory models was used to determine whether the independent variables had significantly improved the fit of the model. Descriptive analysis was undertaken using SPSS software (IBM Corp., Armonk, NY, USA and the MLwiN program (University of Bristol, Bristol, UK) to fit the multilevel model.

Results

Patients and Hospitals Characteristics

The number of patients was 1,004, 52.2% male and 47.8% female. The mean length of stay was 10.7 days (SD = 10.9), with a statistically significant difference between medical and surgical units (M = 11.6 days vs. M = 9.65 days, respectively; $p < .001$). The age of participants ranged from 16 to 93 years, with a mean of 64.5 years (SD = 17.1) and a statistically significant difference between medical and surgical units (M = 65.3 years vs. M = 63.6 years; $p < .037$). Participants had a Barthel Index that was severe or moderate (56.2%), and 86% of the participants had no cognitive impairment according to Pfeiffer's test. More than half of the participants (52%) were classified as high care dependency according to the INICIARE scale.

In relation to the hospitals, most of the assessments were carried out in primary hospitals (66%) and medical inpatient units (56.3%), mainly during winter (38%) and spring (46%), with the most prevalent shift being during the morning (56.7%; Table 1).

Descriptive Analysis of Nurse Staffing Levels

The highest NSLs (patients per nurse) were found in specialty hospitals (M = 11.5; SD = 3.12) and surgical units (M = 11.1; SD = 3.73). Summer (M = 11.6; SD = 3.72) had the highest NSL with respect to seasonality. Regarding shift patterns, the NSL was highest during the evening and night shifts (M = 12.4; SD = 3.4) vs. morning shift (M = 8.9; SD = 2.48).

Factors That Influence Nurse Staffing Levels

For the multilevel analysis, two hierarchical levels were established to control patient (level 1) and hospital (level 2) variance. The difference in -2LL between the null and explanatory models was 10,971.341 ($p < .001$). The amount of variance explained (R^2) was was 63.4% at the patient level and 71.8% at the hospital level. Statistically significant factors were the type of unit ($p = .002$), shift ($p < .001$), and season ($p < .001$). Tests performed on the model variables related to patient acuity and dependency, and no statistically significant differences were obtained on the INICIARE scale ($p = .609$), Barthel Index ($p = 0.659$), or Pfeiffer's test ($p = .218$). Table 2 shows the results of the multilevel regression analyses.

Discussion

This study aimed to identify which patient and hospital characteristics are associated with NSLs in acute care hospital settings. The allocation of patients per nurse in this study coincide with studies carried out in the United States and Europe. In those countries, the organizational and hospital characteristics, such as type of unit and shift, were associated with NSLs at the expense of variables related to the patient's condition such as acuity or dependency level (Casalicchio, Lesaffre, Küchenhoff, & Bruyneel, 2017; Morioka, Tomio, Seto, & Kobayashi, 2017). However, recent studies have recommended the inclusion of patient-related variables such as complexity of care and patient needs to improve the adjustment of NSLs in acute care hospital settings (Ausili et al., 2020; Halm, 2019).

In relation to the unit type, surgical units had higher NSLs (patients per nurse) (M = 10.6; SD = 3.53) than medical units (M = 9.77; SD = 3.11). Despite this

Table 1. Sample Descriptive by Patient and Hospital Characteristics and Nurse Staffing Levels (*N* = 1,004 patients)

	M	*SD*	*n*	%
Patients characteristics				
Age (years)		64.5	17.1	
Gender				
Male			524	52.2
Female			480	47.8
Length of stay (days)	10.7	10.9		
Barthel Index				
Total dependency			149	14.8
Severe dependency			291	28.9
Moderate dependency			274	27.3
Mild dependency			71	7.2
Independence			219	21.8
Pfeiffer's test				
Unconscious			8	1
Oriented			865	86
Disoriented			131	13
INICIARE scale				
High-care dependency			521	52
Moderate-care dependency			238	23.6
Risk of care dependency			151	15
Independence in care			94	9.4
Hospital characteristics				
Type of hospital				
Primary			664	66
Specialties			165	16.5
Tertiary			175	17.5
Type of inpatient unit (IU)				
Medical IU			565	56.3
Surgical IU			439	43.7
Shift				
Morning shift			569	56.7
Evening shift			368	36.7
Night shift			67	6.7
Season				
Winter			382	38
Spring			457	45.7
Summer			102	10
Fall			62	6.3
Nurse staffing levels (patients per nurse)				
Type of hospital				
Primary			10.3	3.6
Specialties			11.5	3.1
Tertiary			10.2	2.7
Type of IU				
Medical IU			9.9	3.1
Surgical IU			11.1	3.7
Shift				
Morning shift			8.9	2.5
Evening or night shift			12.4	3.4
Season				
Winter			10.3	3.5
Spring			10.4	3.3
Summer			11.6	3.7
Fall			9.9	2.9

difference in the study, we found insufficient evidence in the literature about the allocation of nursing staff in medical and surgical units. Recently, Cho, Lee, You, Song, and Hong (2020) identified that the lack of nursing staff in these units was associated with poorer patient safety, worse nursing care quality and job satisfaction, together with a higher intent to leave the profession.

Results showed that shift patterns could range from 8.94 patients per nurse on morning shifts to 12.4 patients per nurse on evening or night shifts. This traditional shift pattern (50% in the morning, 30% in the evening, and 20% at night) is based on projected activity levels of nurses over a three-shift pattern, but takes scant account of the fluctuating demand and dependency of care and patient status (Ohnstad & Solberg, 2017).

Other studies have shown that NSLs are reduced during night shifts, putting patients at greater risk (Ball, Murrells, Rafferty, Morrow, & Griffiths, 2014; Kutney-Lee et al., 2015; Thompson, Stock, & Banuelas, 2017). However, patient care needs do not match the deployment of shift personnel. The study results shows that a more accurate distribution of staffing is needed, one that accommodates peak workloads and fluctuations in requests throughout the day.

With regard to seasonality, NSLs (patients per nurse) are higher during the summer season (M = 11.34; SD = 3.6). This might reflect the decrease in recruitment during the vacation period in hospitals, despite scientific evidence that there is no drop in demand for nursing during summer vacation vs. the rest of the year (Ohnstad & Solberg, 2017).

In some studies, it has been found that lower patients loads for nurses and better outcomes, such as a reduction in mortality or complications, occur when the ratio

Table 2. Factors Influencing Nurse Staffing Levels

Multilevel analysis overview

Parameters	Null model	Explanatory model	Difference	*p* value
Distance	19,075.708	8,104.367	10,971.341	<.001
Unexplained variance				
Level 1: Patients	7.228 (0.179)	3.046 (0.115)		
Level 2: Hospitals	4.299 (0.359)	1.195 (0.142)		
Intraclass correlation	37.15%			
Explained variance: R^2				
Level 1: Patients		63.4%		
Level 2: Hospitals		71.8%		

Explanatory multilevel linear regression model

Variable		Coefficient	Standard error	Z^2	*p* value
Constant		9.675	0.106	8330.87	<.001
Unit	Medical	Reference			
	Surgical	0.3	0.098	9.37	.002
Shift	Morning shift	Reference			
	Evening and night shifts	1.233	0.107	132.79	<.001
Season	Winter	Reference			
	Spring	-0.114	0.106	1.16	
	Summer	0.418	0.181	5.33	.021
	Autumn	0.21	0.218	0.93	

of patients per nurse does not exceed 5:1 (Bruyneel et al., 2015; Ma, McHugh, & Aiken, 2015). In the context of the Andalusian Healthcare System this is a worrying situation, because this study suggests that the number of patients per nurse is three times higher at particular points in the day (16 patients per nurse during the night shift), and little attention is given to the dynamic fluctuations in patient intensity and complexity over the course of a 24-hr period (Fujita et al., 2019). In addition, it is during the night shift when most of the adverse events occur (Hayashi et al., 2020).

Defining the optimal number of patients per nurse is critical to ensure care quality and patient safety. Numerous studies have shown that adjusting the NSL to care needs or care complexity not only reduces mortality rates but also decreases the occurrence of adverse events in inpatient units (Duarte, Stipp, da Silva, & de Oliveira, 2015). In a multicenter study in California, a better work environment lowered the odds of administration of the wrong medication by 45%, followed by 39% for pressure ulcer occurrence and 32% for falls with injury (Cho et al., 2016). Therefore, adjusting the NSL would enable efficient nursing human resources management, thus reducing morbidity rate, mortality rate, and hospital stays, while generating much higher cost effectiveness (Ma et al., 2015; Qureshi, Purdy, Mohani, & Neumann, 2019)

Within the current study, only variables linked to the organization and hospital management were associated with NSLs. However, further scientific evidence is available that highlights the importance of the patient's dependency and acuity levels to assign the appropriate nursing workload (Vortherms, Spoden, & Wilcken, 2015; Wynendaele, Willems, & Trybou, 2019). Therefore, it is essential to adjust the proportion of nurses to the required needs, such as acuity and dependency levels, in order to provide quality and safety of patient care within the context of hospital management resource planning models. This would require further prospective observational studies comparing health outcomes among health institutions that use NSL allocation models that consider the patient's dependency and acuity levels with other institutions that use models that do not. In the same way, it would be possible to carry out experimental research that tests models generated considering these variables in order to adjust them to the desired health outcomes.

Limitations

Although, the study results may be useful in revealing the modifiable variables that influence NSLs, the cross-sectional nature of the data obtained allow for the identification of an association rather than a clear cause-and-effect relationship between the variables tested.

Conclusions

This research contributes to the body of knowledge on NSLs. The study identifies that the NSLs were associated with hospital characteristics such as the type of hospital unit, shift, and season. Although patients should be at the forefront of resource management, this study reveals that neither patient status nor the level of care dependency are currently included in the day-to-day planning of NSLs. Patients´ characteristics need to be mapped into a new staffing methodology to facilitate the distribution of patients in acute care medical and surgical units.

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The ethics committee of the Andalusian Healthcare System approved the project with the ethical approval number 1967.

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Clinical Resources

- International Council of Nurses. Nursing Now. https://www.nursingnow.org
- RN4CAST. Nursing forecasting in Europe. http://www.rn4cast.eu
- World Health Organization. Nursing Now Campaign. https://www.who.int/hrh/news/2018/nursing_now_campaign/en/

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