



# Comparison of nursing aids and registered nurses mixed nursing staffing model with different ratios on the nursing outcomes and cost in Neurology and Neurosurgery Center

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## Abstract

**Background** This study aimed to investigate the effect of nursing aids (NAs) and registered nurses (RNs) mixed nursing staffing model with different ratios on the nursing outcomes and cost in China.

**Methods** Five thousand and ninety-one patients treated at Neurology and Neurosurgery Center were consecutively recruited in this study and divided into three groups according to the proportion of NAs and RNs: 100% RN group ( $N = 1756$ ), 90% RN group ( $N = 1654$ ), and 75% RN group ( $N = 1681$ ). Nursing outcomes including medication error, unplanned endotracheal tube extubation, bloodstream infection, respiratory tract infection, urinary tract infection, pressure ulcer, ventilator weaning, morality, hospital stay, and nursing cost were recorded.

**Results** No difference of patients' characteristics or RNs' characteristics among three groups was observed. Three-group comparison disclosed that medication error, urinary tract infection, ventilator weaning, and nursing cost were different among three groups, while no difference of unplanned endotracheal tube extubation, bloodstream infection, respiratory tract infection, pressure ulcer, mortality, or hospital stay was found. Two-group comparison revealed that medication error and nursing cost were reduced in 75% RN group compared with 90% RN group and 100% RN group, but urinary tract infection was increased while ventilator weaning was decreased in 75% RN group and 90% RN group compared with 100% RN group. Multivariate logistic regression also validated 75% RNs independently correlated with decreased medication error, ventilator weaning, and increased urinary tract infection.

**Conclusions** NAs and RNs mixed nursing staffing model with 75% RNs reduces medication error and nursing cost, while increasing urinary tract infection and decreasing ventilator weaning.

**Keywords** Cost · Mixed nursing staffing model · Nursing aids · Nursing outcomes · Registered nurses

## Introduction

Along with the growing population and aging society formation in China, health care demand is increasing dramatically in the recent decades which leads to greatly elevated acquirement of nursing aids, especially in 3A hospitals (highest level of hospital in China) [1, 2]. However, the nurses are too occupied to provide adequate nursing care to the increasing

number of patients, and the turnover rate among new nurses in 3A Hospitals in China has been reported to be as high as 5 to 20%, and most of the hospitals have reported difficulties in recruiting new nurses [2–4]. These conditions indicated that the nursing staffing shortage has become a critical issue for medical institutions, and this shortage would also increase the excessive workload of existing nurses, resulting in unexpected negative patient outcomes, such as medication errors [5, 6], unplanned endotracheal self-extubation [7, 8], and increased rates of nosocomial infections [9, 10].

In order to resolve the lack of nursing staffs and decrease subsequent unexpected worse nursing outcomes, nursing aids (NAs) are introduced to care for patients and assist with various unit duties under the supervision and guidance of nurses [11]. The novel nursing staffing model with mixed registered nurses (RNs) and NAs has been proposed to decrease nurse

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workload and improve the nursing outcomes such as occurrences of pressure ulcers, falls, or infections [12–19]. In addition, the mixed nursing staffing model also reduces the medical cost resulting in decreased financial burden of both the patients and the country [20]. Although as high as 97% hospitals have changed their nursing staffing models by using NAs to perform care tasks with low skill requirements under the supervision of RNs in the United States of America (USA) [21], the application of mixed nursing staffing model is just at initial stage within recent decades in China, and which ratio of RNs vs NAs is preferable in clinical practice is still obscure.

Thus, this present study aimed to investigate the effect of NAs and RNs mixed nursing staffing model with different ratios on the nursing outcomes and cost in China.

## Methods and materials

### Patients

A total of 5091 patients treated at Neurology and Neurosurgery Center in the 2nd Affiliated Hospital of Harbin Medical University, between October 1, 2015 to September 30, 2016, were consecutively recruited in this study. The inclusion criteria were as follows: (1) diagnosed as neurological diseases admitted on Neurology and Neurosurgery Center, (2) age above 18 years, and (3) life expectancy above 12 months. Patients were excluded if they (1) were discharged within 3 days, (2) referral to other units within 3 days, and (3) died within 24 h after admission. Ethics approval of this study was obtained from the Ethics Committee of Harbin Medical University with No.20130062, and all patients provided their written informed consents.

### Baseline data collection

After admission, the following data of patients were recorded: age, gender, hospitalized ward, and underlying diseases, and Acute Physiology and Chronic Health Evaluation II (APACHE II score) was evaluated within 24 h. In addition, the following information of RNs was documented as well: age, gender, education status (junior college, undergraduate or graduate above), nursing work experience length, and ICU experience ratio. These data were collected using the Nursing Staffing Models of Neurology and Neurosurgery Center (2nd Affiliated Hospital of Harbin Medical University).

### Groups

Patients were divided into three groups according to the proportion of RNs in 6 wards of Neurology and Neurosurgery

Center: (1) 100% RN group ( $N = 1756$ ), patients received care by an average of 40 RNs and 0 NAs in the 1st and 4th wards; (2) 90% RN group ( $N = 1654$ ), patients received care by an average of 36 RNs and 4 NAs in the 2nd and 5th wards; and (3) 75% RN group ( $N = 1681$ ), patients received care by an average of 30 RNs and 10 NAs in the 3rd and 6th wards. In the daily care, RNs are in charge of professional nursing duties, while the NAs mainly performed nonprofessional nursing duties, such as bed bathing, diaper changing, time permitting, turning and nasogastric tube feeding, and so on.

### Assessment of nursing outcomes

Nursing outcomes during the hospitalization including medication error, unplanned endotracheal tube extubation, bloodstream infection, respiratory tract infection, urinary tract infection, pressure ulcer, ventilator weaning, morality, and hospital stay were collected from Nursing Staffing Models of Neurology and Neurosurgery Center and Patient Safety Department (2nd Affiliated Hospital of Harbin Medical University). Besides, nursing cost was obtained from Hospital Accounting Office (2nd Affiliated Hospital of Harbin Medical University), which included salary, compensation, personal income tax, insurance, and housing fund.

### Definitions

(1) 3A hospital in China is defined as a hospital at the highest level in China except for the national special hospital. (2) The NAs and RNs mixed nursing staffing model was defined as a model that both NAs and RNs are arranged for nursing activities. (3) APACHE II score was calculated based on several measurements including heart rate, body temperature, respiratory rate, mean arterial pressure, serum sodium level, PaO<sub>2</sub> level, platelet count, white blood cell count, and Glasgow coma score and adjusted for patient age and chronic health problems [22].

### Training for NAs

NA was firstly required to be qualified for assisting in nursing tasks and to obtain a Nursing Care Training Certification issued by the Harbin Department of Health. Then, NA was assigned to undergo a three-month training program as lecture: practice ratio 3:2 in Harbin Department of Health and subsequently to carry out an orientation program in the 2nd Affiliated Hospital of Harbin Medical University.

### Statistics

Statistical analysis was performed using SPSS 21.0 software (IBM, USA). Data were presented as mean  $\pm$  standard deviation or count (percentage) according to the types of data.

Comparison among three groups was determined by one-way ANOVA test or chi-square test, followed by two-subgroup comparison that was determined by Turkey’s multiple comparison test or chi-square test, and the effect of different proportion of RNs on nursing outcomes was determined by multivariate logistic regression analysis.  $p < 0.05$  was considered as significant.

## Results

### Characteristics of patients

In the study duration, numerically decreased number of patients was admitted in 75% RN group ( $N = 1681$ ) and 90% RN group ( $N = 1654$ ) than 100% RN group ( $N = 1756$ ). The average ages of patients in 75% RN group, 90% RN group, and 100% RN group were  $61.5 \pm 14.8$ ,  $62.3 \pm 15.1$ , and  $62.1 \pm 15.7$  respectively ( $p = 0.285$ ), and the male/female numbers in 75% RN group, 90% RN group, and 100% RN group were 934/747, 918/736, and 1032/724 respectively ( $p = 0.086$ ). Besides, no difference of admitted wards ( $p = 0.341$ ), underlying diseases ( $p = 0.269$ ), or APACHE II score ( $p = 0.161$ ) among three groups was discovered either with the detailed information of patients listed in Table 1.

### Characteristics of RNs

As to RN characteristics which are shown in Table 2, no difference of age ( $p = 0.774$ ), gender ( $p = 1.000$ ), education

status ( $p = 0.864$ ), nursing work experience ( $p = 0.214$ ), and ICU experience ratio ( $p = 0.464$ ) was observed among 75% RN group, 90% RN group, and 100% RN group.

### Comparison of nursing outcomes

Three-group comparison disclosed that the occurrences of medication error ( $p = 0.030$ ), urinary tract infection ( $p < 0.001$ ), and ventilator weaning ( $p < 0.001$ ) were of difference among 75% RN group, 90% RN group, and 100% RN group as shown in Table 3, while no difference of unplanned endotracheal tube extubation ( $p = 0.786$ ), bloodstream infection ( $p = 0.093$ ), respiratory tract infection ( $p = 0.868$ ), pressure ulcer ( $p = 0.254$ ), mortality ( $p = 0.272$ ), or hospital stay ( $p = 0.399$ ) among three groups was found. Further followed two-group comparison revealed that (1) medication error occurrence was decreased in 75% RN group compared with 90% RN group ( $p = 0.032$ ) and 100% RN group ( $p = 0.012$ ); (2) urinary tract infection occurrence was increased in 75% RN group ( $p < 0.001$ ) and 90% RN group ( $p < 0.001$ ) compared with 100% RN group; and (3) ventilator weaning occurrence was reduced in 75% RN group ( $p < 0.001$ ) and 90% RN group ( $p < 0.001$ ) compared to 100% RN group.

### Comparison of nursing cost

Three-group comparison revealed that nursing cost was different among 75% RN group, 90% RN group, and 100% RN group ( $p < 0.001$ ) (Table 4). Followed two-group comparison

**Table 1** Patients’ characteristics among 75% RN, 90% RN, and 100% RN groups

Parameters of patients	75% RNs ( $N = 1681$ )	90% RNs ( $N = 1654$ )	100% RNs ( $N = 1756$ )	<i>p</i> value
Age (years)	$61.5 \pm 14.8$	$62.3 \pm 15.1$	$62.1 \pm 15.7$	0.285
Gender (n/%)				0.086
Male	934 (55.6)	918 (55.5)	1032 (58.8)	
Female	747 (44.4)	736 (44.5)	724 (41.2)	
Wards (n/%)				0.341
Neurological ward	985 (58.6)	928 (56.1)	1002 (57.1)	
Neurosurgery ward	696 (41.4)	726 (43.9)	754 (42.9)	
Underlying diseases (n/%)				0.269
Intracranial tumors	158 (9.4)	126 (7.6)	136 (7.7)	
Brain injury	287 (17.1)	300 (18.1)	322 (18.3)	
Cerebrovascular disease	746 (44.4)	758 (45.8)	820 (46.7)	
Nervous system infection	164 (9.8)	168 (10.2)	190 (10.8)	
Spinal cord diseases	166 (9.9)	164 (9.9)	156 (8.9)	
Others	160 (9.5)	138 (8.3)	132 (7.5)	
APACHE II score	$16.1 \pm 6.2$	$15.9 \pm 5.8$	$16.3 \pm 6.3$	0.161

Data were presented as mean  $\pm$  standard deviation or count (percentage). Comparison among three groups was determined by one-way ANOVA test or chi-square test.  $p < 0.05$  was considered as significant

RNs registered nurses, APACHE II Acute Physiology and Chronic Health Evaluation II

**Table 2** RNs experience among 75% RN, 90% RN, and 100% RN groups

Parameters of RNs	75% RNs (N = 30)	90% RNs (N = 36)	100% RNs (N = 40)	<i>p</i> value
Age (years)	26.5 ± 4.9	25.6 ± 5.1	26.1 ± 5.3	0.774
Gender ( <i>n</i> /%)				1.000
Male	0 (0.0)	0 (0.0)	0 (0.0)	
Female	30 (100.0)	36 (100.0)	40 (100.0)	
Education status ( <i>n</i> /%)				0.864
Junior college	14 (46.7)	19 (52.8)	19 (47.5)	
Undergraduate	15 (50.0)	17 (47.2)	20 (50.0)	
Graduate or above	1 (3.3)	0 (0.0)	1 (2.5)	
Nursing work experience (years)	4.9 ± 1.6	4.2 ± 1.5	4.7 ± 1.8	0.214
ICU experience ( <i>n</i> /%)				0.464
Yes	9 (30.0)	8 (22.2)	7 (17.5)	
No	21 (70.0)	28 (77.8)	33 (82.5)	

Data were presented as mean ± standard deviation or count (percentage). Comparison among three groups was determined by one-way ANOVA test or chi-square test.  $p < 0.05$  was considered as significant

RNs registered nurses, ICU intensive care unit

illuminated that nursing cost was lower in 75% RN group compared with 90% RN group ( $p < 0.001$ ) and 100% RN group ( $p < 0.001$ ).

### Effect of different proportions of RNs on nursing outcomes after adjustment

In order to further explore the independent effect of different proportion of RNs on nursing outcomes (which were different among three groups in Table 5), multivariate logistic regression was performed which included patients' characteristic in the analysis. And we observed that compared with 100% RNs: (1) 75% RNs independently decreased medication error ( $p = 0.018$ ) and ventilator weaning ( $p < 0.001$ ) while increased urinary tract infection ( $p = 0.001$ ), and (2) 90% RNs did not affect medication error, but independently raised urinary tract infection ( $p = 0.005$ ) while reduced ventilator weaning ( $p = 0.003$ ).

## Discussion

In this present study, we observed that (1) 75% RNs attenuated medication error but increased urinary tract infection and decreased ventilator weaning. (2) Seventy-five percent of RNs did not affect unplanned endotracheal tube extubation, bloodstream infection, respiratory tract infection, pressure ulcer or hospital stay length, and most importantly, it did not increase the mortality. (3) Seventy-five percent of RNs greatly reduced average nursing cost.

The aging of China's population has led to an increase of neural diseases such as cerebrovascular diseases, brain injuries, spinal cord diseases, and so on, which increases the

dramatic needs of nursing care sources [1]. However, greatly increasing work load and deteriorate physician–patient relationship lead to insufficient nursing sources and high turnover rate in China, which make it difficult to meet the standard criteria of high quality of nursing care [5–10]. Besides, sustainably elevated medical cost including nursing cost concerns government and hospital a lot, thus how to reduce the nursing cost, and meanwhile maintain the quality of nursing care is also a great issue (Reports published on Website of China Food and Drug Administration with site <http://samr.saic.gov.cn/>). A number of Chinese medical institutions have introduced NAs and RNs mixed nursing staffing model to resolve the problem in accordance with the experiences in USA; however, rigorous study about the outcomes of this novel model in China is not ever reported officially, and what the best ratio of NAs and RNs is still obscure in clinical practice; thus, it is essential to investigate the application of NAs and RNs mixed nursing staffing model with different ratios on the nursing outcomes and cost in China.

Medication error has been disclosed to be a common issue that approximately 50% of nurses report the occurrence of medication error per year, which is associated with gender, marital status, and medication error experience [23–25]. And great efforts have been made to reduce medication error such as improvement of nurse education, nurse inspiration, nursing staff model, and so on [26, 27]. As to nursing staff model, a recent study illuminates that NAs and RNs mixed nursing staffing model presented with fewer medication errors than full RNs staff [16], while another study reversely illustrates that NAs and RNs mixed nursing staffing model did not influence the occurrence of medication errors [13]. In this present study, we observed that NAs and RNs mixed nursing

**Table 3** Nursing outcomes among 75% RN, 90% RN, and 100% RN groups

Parameters	75% RNs (N = 1681)	90% RNs (N = 1654)	100% RNs (N = 1756)	<i>p</i> value <sup>a</sup>	Subgroup comparison	<i>p</i> value <sup>b</sup>
Medication error ( <i>n</i> /%)	60 (3.6)	84 (5.1)	94 (5.4)	<i>0.030</i>	75% RNs vs 90% RNs	<i>0.032</i>
					75% RNs vs 100% RNs	<i>0.012</i>
					90% RNs vs 100% RNs	0.719
Unplanned endotracheal tube extubation ( <i>n</i> /%)	34 (2.0)	30 (1.8)	30 (1.7)	0.786	75% RNs vs 90% RNs	0.660
					75% RNs vs 100% RNs	0.496
					90% RNs vs 100% RNs	0.815
Bloodstream infection ( <i>n</i> /%)	178 (10.6)	146 (8.8)	151 (8.6)	0.093	75% RNs vs 90% RNs	0.086
					75% RNs vs 100% RNs	0.051
					90% RNs vs 100% RNs	0.813
Respiratory tract infection ( <i>n</i> /%)	71 (4.2)	64 (3.9)	70 (4.0)	0.868	75% RNs vs 90% RNs	0.604
					75% RNs vs 100% RNs	0.726
					90% RNs vs 100% RNs	0.861
Urinary tract infection ( <i>n</i> /%)	201 (12.0)	180 (10.9)	132 (7.5)	< 0.001	75% RNs vs 90% RNs	0.148
					75% RNs vs 100% RNs	< 0.001
					90% RNs vs 100% RNs	< 0.001
Pressure ulcer ( <i>n</i> /%)	37 (2.2)	48 (2.9)	54 (3.1)	0.254	75% RNs vs 90% RNs	0.199
					75% RNs vs 100% RNs	0.111
					90% RNs vs 100% RNs	0.767
Ventilator weaning ( <i>n</i> /%)	646 (38.4)	763 (46.1)	954 (54.3)	< 0.001	75% RNs vs 90% RNs	< 0.001
					75% RNs vs 100% RNs	< 0.001
					90% RNs vs 100% RNs	< 0.001
Mortality ( <i>n</i> /%)	247 (14.7)	213 (12.9)	233 (13.3)	0.272	75% RNs vs 90% RNs	0.128
					75% RNs vs 100% RNs	0.228
					90% RNs vs 100% RNs	0.735
Hospital stay (days)	23.5 ± 13.6	22.9 ± 12.8	23.1 ± 12.7	0.399	75% RNs vs 90% RNs	0.379
					75% RNs vs 100% RNs	0.641
					90% RNs vs 100% RNs	0.895

Data were presented as mean ± standard deviation or count (percentage). Comparison among three groups was determined by one-way ANOVA test or chi-square test; comparison between two subgroups was determined by Turkey’s multiple comparison test or chi-square test. *p* < 0.05 was considered as significant, and the value was presented in italics

RNs registered nurses

<sup>a</sup> Comparison among three groups

<sup>b</sup> Comparison between two subgroups

**Table 4** Nursing cost among 75% RN, 90% RN, and 100% RN groups

Parameters	75% RNs (N = 40)	90% RNs (N = 40)	100% RNs (N = 40)	<i>p</i> value <sup>a</sup>	Subgroup comparison	<i>p</i> value <sup>b</sup>
Nursing cost per person (Yuan/month)	2040 ± 286	2502 ± 290	2613 ± 283	< 0.001	75% RNs vs 90% RNs	< 0.001
					75% RNs vs 100% RNs	< 0.001
					90% RNs vs 100% RNs	0.197

Data were presented as mean ± standard deviation. Comparison among three groups was determined by one-way ANOVA test followed by Turkey’s multiple comparison test. *p* < 0.05 was considered as significant, and the value was presented in italics

RNs registered nurses

<sup>a</sup> Comparison among three groups

<sup>b</sup> Comparison between two subgroups

**Table 5** Effect of different proportions of RNs on nursing outcomes by multivariate logistic regression analysis

Parameters	Proportion of RNs	Odds ratio	95% confidence interval	<i>p</i> value
Medication error	100% RNs	1		
	90% RNs	0.915	0.678–1.235	0.562
	75% RNs	0.684	0.499–0.936	0.018
Urinary tract infection	100% RNs	1		
	90% RNs	1.388	1.102–1.749	0.005
	75% RNs	1.503	1.189–1.900	0.001
Ventilator weaning	100% RNs	1		
	90% RNs	0.814	0.712–0.932	0.003
	75% RNs	0.677	0.592–0.775	< 0.001

Data were presented as odds ratio and 95% confidence interval. Multivariate logistic regression analysis was performed to evaluate the effect of different proportion of RNs on nursing outcomes adjusted by patients' characteristic.  $p < 0.05$  was considered as significant, and the value was presented in italics

RNs registered nurses

staffing model with 75% RNs attenuated medication error incidence. The discrepancy among studies might be due to differed medical department, nurse sources, and experiences. And the reduction of medication errors might result from that more attention of medication guidance was given by NAs.

Previous studies disclosed that the correlation of NAs and RNs mixed nursing staffing model with the occurrence of infections, pressure ulcer, ventilator weaning, hospital stay, and so on. A previous study disclosed that NAs and RNs mixed nursing staffing model decreases bloodstream infection, while increasing urinary tract infection and presenting with a lower rate of ventilator weaning [16]. Another study revealed that no significant differences in occurrence of pressure ulcer, respiratory tract infection, or hospital stay length were observed between NAs and RNs mixed nursing staffing model and RNs only staffing model, while urinary tract infection was increased and successful weaning was decreased in NAs and RNs mixed nursing staffing model group [20]. Partially, in line with previous studies, we observed that NAs and RNs mixed nursing staffing model with 75% RNs increased urinary tract infection and decreased ventilator weaning, while it did not influence unplanned endotracheal tube extubation, bloodstream infection, respiratory tract infection, pressure ulcer, or hospital stay length. As to mortality, a previous study illustrates that NAs and RNs mixed nursing staffing model has no effect on mortality in respiratory care center, and in this study, we also discovered no association of NAs and RNs mixed nursing staffing model with 75% RNs with mortality in Neurology and Neurosurgery Center of our hospital. The possible explanations of increased urinary tract infection and decreased ventilator weaning in 75% RN group were that NAs mainly performed nonprofessional nursing duties, such as bed bathing, diaper changing, time permitting, turning and nasogastric tube feeding, and so on, and

lack of RNs would reduce the professional process that increased urinary tract infection and decreased ventilator weaning. And similar unplanned endotracheal tube extubation, bloodstream infection, respiratory tract infection, pressure ulcer, hospital stay length, and mortality in 75% RN group might be on account of that these outcomes were mainly affected by the disease conditions, surgical process and medicine treatment, and less affected by nursing care especially for mortality; meanwhile, NAs might present with more effect on these outcomes than urinary tract infection and ventilator weaning.

As to attenuate the burden of nursing cost, a study shows that NAs and RNs mixed nursing staffing model raises nursing cost [16] while another study presents that NAs and RNs mixed nursing staffing model has no impact on nursing cost [20]. In our study, we observed NAs and RNs mixed nursing staffing model with 75% RNs decreased nursing cost. This discrepancy with previous studies might be that: Previous studies recruit NAs as extra labor but not replace the needs of RNs, while in our study, the total number of NAs plus RNs was similar among three groups, and NAs were well trained and certificated. As to the explanation of reduced cost in 75% RN group, the cost including salary, compensation, personal income tax, insurance, and housing fund were all lower for NAs than RNs; thus, 75% RNs decreased the nursing cost.

There were some limitations existed in this study. (1) The investigation was only conducted in a single department instead of the entire hospital; thus, further exploration based on hospital level was needed. (2) Only nursing cost were evaluated, but total direct medical/nonmedical cost, indirect medical cost, and implicit cost were not assessed, which needed to be further explored as well.

In conclusion, NAs and RNs mixed nursing staffing model with 75% RNs reduces medication error and nursing cost, while increasing urinary tract infection and decreasing ventilator weaning.

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### Compliance with ethical standards

Ethics approval of this study was obtained from the Ethics Committee of Harbin Medical University with No.20130062, and all patients provided their written informed consents.

**Conflict of interest** The authors declare that they have no conflict of interest.

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