Analysis of night-shift nurses' locations and durations using information communication equipment: A prospective observational study of a mixed obstetric ward with severe patients in⋯

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博 士 論 文

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（情報通信機器を用いた重症患者を有する産科混合病棟の
夜勤帯看護師の滞在場所と滞在時間の分析）

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Abstract

Approximately 80% of hospital-based childbirth in Japan takes place in mixed obstetric

wards, which comprise a mix of the obstetrics department and other departments. Although

mixed obstetric wards treat patients from multiple departments, previous studies have not

clarified the procedures used by nursing staff in the ward, or nursing by night-time nurses.

The purpose of this study was to reveal the actual status of night-shift nurses in a mixed

obstetrics ward that treats severe patients. This time motion study used smartphones and

beacons to measure the place and duration of stay for night-shift nurses working in a mixed

obstetric ward. We found that nurses' mean bedside stay time per patient in a general

patient room was 31.9 minutes on days when there were severe patients hospitalized in the

severe patient room, and 33.6 minutes on days when there were no severe patients.

Furthermore, the mean stay time in each place during a nurse's 13-hour shift was 39.2% in

the nurse station, 34.4% in the general patient room, and 1.7% in the severe patient room.

We believe that these results can be used as data for the placement of nursing staff involved

in operating a safe mixed ward.

Introduction

In 2017, 946,065 babies were delivered in Japan[1] . In the same year, 27.7% of the total population was 65 years old and older[2]. In October 2014, an estimated 937,000 hospital patients per day were aged 65 years and over, accounting for 71% of all hospitalized patients[3]. Due to the low birth rate, in Japanese hospitals, childbirth is often carried out in mixed wards, including obstetrics and other departments. This is because the designation of hospital beds in Japan reflects the declining birth rate and aging population, in response to the introduction of the 2003 Diagnostic Procedure Combination (DPC), which is a diagnostic group that classifies patients according to their disease name and treatment type; it is a new medical cost calculation method that determines the hospitalization cost per day for each classification. According to an investigation in 2016 by the Japanese Nursing Association, 77.4% of hospitals capable of handling childbirth were doing so in mixed obstetric wards[4]. It also revealed that, in mixed obstetric ward hospitals, there was an increase in non-obstetric patients being admitted in order to use obstetric beds[4].

In mixed obstetric wards, nurses and midwives work together. Although previous studies measured nursing time with a focus on delivery and postpartum women[5)6)], the actual nursing conditions of nursing staff regarding all patients hospitalized in a mixed obstetric ward have not yet been elucidated.

The composition of the nursing service (e.g., staffing ratios, workload) and nurse characteristics (e.g., experience level, educational background) influences patient outcome, quality of care, and nurse retention[7)-10)]. According to a 2007 systematic review and meta-analysis related to the link between nursing staff levels and patient outcomes, an increase in the number of registered nurses (RN) was linked to an increase in positive patient outcomes, including improvements in mortality rate, rescue rate, pulmonary failure rate, hospital-acquired pneumonia rate, and length of hospital stay[11)]. Nursing staff can also influence the emergency Caesarean section rate and infant NICU hospitalization rate[12)]. Conversely, long shift times and amount of shift labor for nurses can influence nursing errors[13)-15)], which, in turn, threaten patient safety. The number of labor hours per day is related to needlestick accidents in nurses[16)]; long labor hours threaten nurses' safety. Through the "Night Shift / Shifted Work Guidelines for Nursing Work," the Japanese Nursing Association recommends that nurses should work less than 13 hours in a single day[17)]. However, an investigation in 2014 revealed that only 19.6% of two-shift system

hospitals had total shift durations of less than 13 hours[18]. Furthermore, the 2006 healthcare fees reform in Japan established a "seven-to-one" nurse placement standard (nurses-to-patients), as well as a minimum of two nurses per hospital ward in a night shift[19]. These nurse placement standards were calculated on the number of nurses on site in a day. Therefore, even if there are only two nurses on the night shift, if this is covered during the day then the nurse placement standard is still considered a "seven-to-one" ratio, since night shifts tend to have low nurse placements and longer labor hours.

Understanding the amount of work handled by nurses is important for safe and efficient work by nurses, as well as for nurse staffing. Time motion studies (TMS) is a method of work–time measurement that has been developed through industrial engineering (IE)[20]. At a basic level, time studies are detailed observations of workers, using a stop-watch to determine the time required to accomplish specific tasks[21], specifically, continuous direct observation, work sampling, and self-reporting. Of these, continuous direct observation has been shown to be more accurate than work sampling[22] and self-reporting[23], and it is the gold-standard method for measuring and quantifying clinical workflows[24]. Continuous direct observation of nurses is defined as the direct observation and following of a subject in real time[25]. Such observations require manpower and incur costs, burdening both the nurse who is being investigated and the person taking the measurements, and limiting the number

of days for which the investigation can be conducted[26)27)]. To carry out extensive "continuous direct observation" without burdening either the nurse or the researcher, unattended time studies are now being developed[28) 29)]; for example, TMS using information and communication equipment.

In this study, we examined the care provided by nursing staff in mixed obstetric wards; the aim is for midwives and nurses to work together efficiently and effectively to provide safe nursing care. This study will elucidate the nursing care provided by nurses during night shifts in mixed obstetric wards that have intensive care patients, through the following research question: what are the actual nursing conditions of nursing staff, focusing on all patients hospitalized in a mixed obstetric ward? The study investigated night-shift nurses in a mixed obstetric ward for 30 consecutive days through TMS based on information and communication equipment. The results of the investigation will be applied for considering safe nurse placement in mixed obstetric wards.

Methods

1. Subject and Period of Investigation

The study subjects were the night-shift nurses working in the mixed obstetric ward of a public general hospital in the Kinki Region of Japan, which has 56 beds (out of 206 in total),

with 6 beds in the severe patient room, 2 in severe neonatal, 3 in LDR (Labor Delivery Recovery), and 45 in general patient. The ratio of nursing personnel to patients was 7:1; the ward had both male and female patients. The period of investigation was from 08:30 on June 29, 2016 (start of day shift), to 09:14 on July 29, 2016 (end of night shift). Midwives' delivery assistance was excluded from the investigation.

2. Work system for night-shift nurses in a mixed obstetric ward

Night shift is from 20:15 to 09:14 – four night-shift nurses work on site. When there are patients in the severe patient room, one of the nurses handles the severe patient room, while the remaining three handle the general patient room. When there are no severe patients, all four nurses handle the general patient room. If there is a woman in labor during the night shift, one midwife is called on duty from home. The midwife on the night shift, in principle, only provides nursing support during the childbirth, while the night-shift nurses provide neonatal care immediately after childbirth. Furthermore, when there are obstetric patients such as postpartum women and infants, night-shift nurses will provide their nursing care (Figure 1).

3. Investigation method

1) Measurement of place and time of stay for nurses, using beacons and smartphones

This was measured using smartphones (ZenFoneGo (ZB551KL), ASUSTeK Computer

Inc.) and wireless beacons (Stick-N-Find, StickNFind Technologies) with Bluetooth Low

Energy specification. The beacons were installed in 92 places within the ward to collect

nurses' positional information. The nurses were asked to keep the smartphones with them

while working (**Figure 2**), to record the reception time, beacon ID, and intensity of the radio

wave received from the beacons. The recorded data were used as positional information for

the nurses (**Figure 3**). The interval of transmitting beacon radio waves was set to 10 seconds.

2) Collection of information about patients' attributes from the ward administrative diary

 We collected the number of patients, and their ages and departments as attributes of
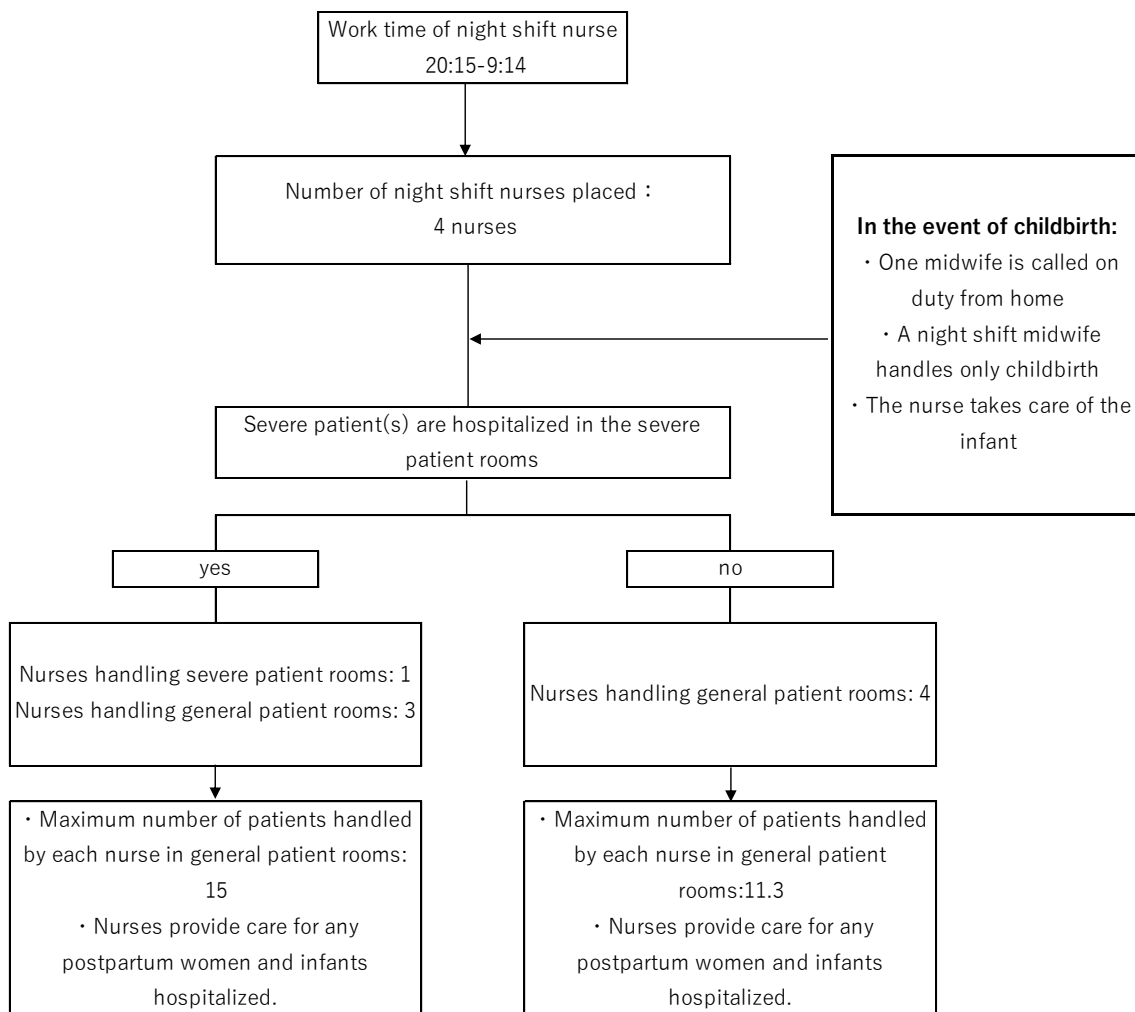
patients hospitalized in the ward.

Work time of night shift nurse
20:15-9:14

Number of night shift nurses placed：
4 nurses

In the event of childbirth:
・One midwife is called on duty from home
・A night shift midwife handles only childbirth
・The nurse takes care of the infant

Severe patient(s) are hospitalized in the severe patient rooms

yes

no

Nurses handling severe patient rooms: 1
Nurses handling general patient rooms: 3

Nurses handling general patient rooms: 4

・Maximum number of patients handled by each nurse in general patient rooms: 15
・Nurses provide care for any postpartum women and infants hospitalized.

・Maximum number of patients handled by each nurse in general patient rooms:11.3
・Nurses provide care for any postpartum women and infants hospitalized.

Figure 1　Work system for night-shift nurses in a mixed obstetric ward

Maximum number of patients overseen by a single nurse handling the general patient room on a day when severe patient(s) were present: For 45 hospital beds (45 people), 15 people in the case of three nurses overseeing the general hospital room and 11.3 people in the case of four nurses overseeing the general hospital room on a day when severe patient(s) were not present.

Figure 2　Schematic diagram of the mixed obstetric ward

The severe patient room is equipped with a drug preparation table, ECG monitor, and PC

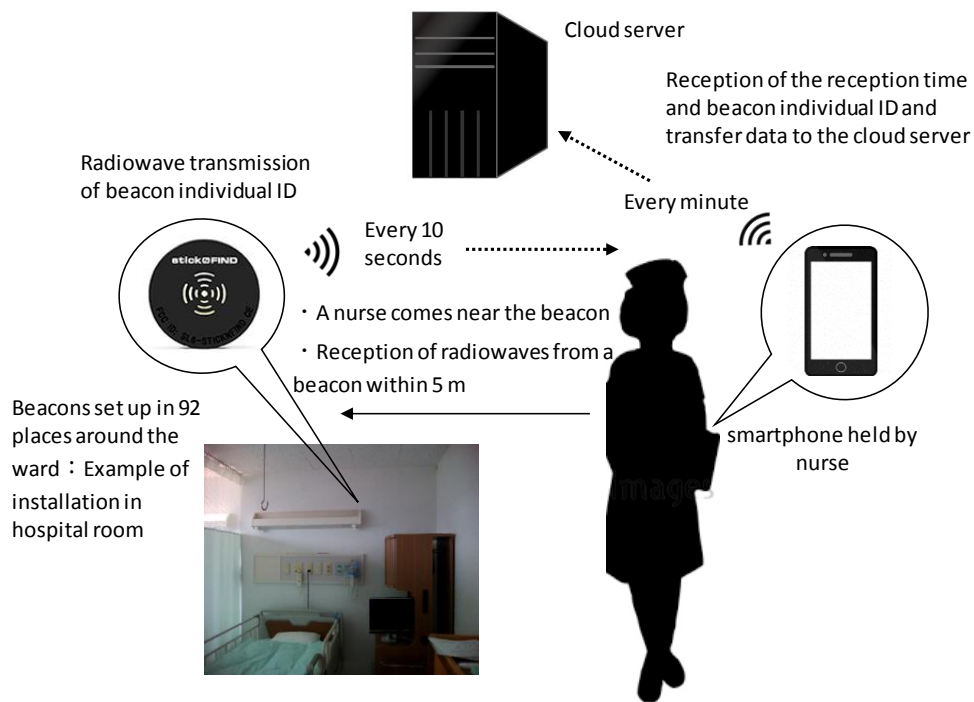for patients, which allows both direct and indirect nursing.

Figure 3   Schematic diagram of measuring place and time of stay for a nurse working

in the mixed obstetric ward

4. Statistical analysis

We excluded from the analysis days with missing data (due to communications failure)

and days when there were five instead of four night-shift nurses. We calculated the

percentage of staying time in each place within the nurse's ward. Nurses' stay time was

compared according to the presence or absence of patients in the severe patient room, using

a Mann-Whitney U test. All statistical analyses were performed with IBM SPSS statistics ver.

25 for Windows software, with significance set at $P<0.05$.

5. Definition of research terms

The terms of this research are defined as shown below.

Obstetric-related areas: severe neonatal room, LDR (Labor Delivery Recovery), obstetrics nurse station, breastfeeding room, postpartum women's room.

Severe patient hospitalized: A severe patient(s) is hospitalized in the severe patient room.

Obstetric patients: Women with labor pains, postpartum women, infants, severe infants.

Method of calculating a nurse's stay time at a patient's bedside in the general patient room: This was analyzed based on the number of patients hospitalized in the general patient rooms of the mixed obstetric ward at the starting time of night-shift work, 20:15. We excluded patients who were staying at home.

6. Ethical considerations

This study was approved by the Ethics Committee of Kobe University Graduate School of Health Science (No. 442). Research subjects (i.e., the nurses) received a written document regarding the research and completed a consent form to participate. We then obtained their consent to participate in this study. We also provided a written research document to patients hospitalized in the mixed obstetric ward during the study period, then obtained their consent to participate in this study. All study participants (including nurses as well as patients) agreed to participate in this study.

<center>Results</center>

1. Aggregation of attributes of patients hospitalized during the investigation period

The investigation period was 30 days. We analyzed a total of 100 night-shift nurses who worked over 25 days of the investigation period, which excluded three days with data loss and two days where staff changes were made (from four to five night-shift nurses). On 11 days, there were severe patient(s) in the severe patient room. On four days, there were severe patient(s) but no obstetric patients. On seven days, there were no severe patient(s) but there were obstetric patients. On three days, there were neither severe patient(s) nor obstetric patients.

Table 1 shows the daily mean data of the number of patients hospitalized and their relevant department during the 25 days of the investigation. On average, 35.4 patients were hospitalized each day, with 3.1 being newly admitted, 2.6 discharged, and 1.3 patients undergoing surgery. They were hospitalized in the internal medicine, pediatrics, surgery, orthopedics, obstetrics and gynecology, and otolaryngology departments.

Table 2 shows the daily average number of hospitalized patients in the general, severe, and obstetric patient rooms. On average, there were 30.0 in the general room and 1.2 in the severe patient room, with 0.9 being either women with labor pains or postpartum women. The average number of infants was 0.8, with 0.2 severe infants.

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Some data are not shown in the chart; for example, the average age of patients hospitalized during the 25-day investigation period was 58.1 (SD=30.0) years. The median age was 68.0, with a minimum age of 0 and a maximum of 99. There were three transvaginal deliveries during the investigation period (two natural, one aspiration), all of which took place during night shifts.

 The number of patients per nurse in the general patient room during night shift was 10.1 patients on days with severe patient(s); this reduced to 7.2 patients on days without severe patient(s). We observed a significant difference between the number of patients per nurse in the general patient room on days with and without severe patient(s) (Mann-Whitney U test, p=0.000).

Table1　Number of patients hospitalized in the mixed obstetric ward

during the 25-day investigation period (daily average)

	Average（SD）	Minimum	Maximum
Number of patients in ward	35.4 (4.4)	26	41
Number of hospitalized patients	3.1 (2.5)	0	8
Number of discharged patients	2.6 (1.5)	0	6
Number of operated patients	1.3 (1.3)	0	3
Department			
Internal medicine	6.3 (2.2)	3	11
Pediatrics	3.8 (1.3)	2	7
Surgery	5.7 (1.6)	4	9
Orthopedics	15.9 (1.6)	4	19
Obstetrics and Gynecology	3.2 (1.7)	0	6
Otolaryngology	0.5 (0.7)	0	2

SD: standard deviation

Table2　Number of patients hospitalized in the mixed obstetric ward

during the 25-day investigation period (daily average)

	Average（SD）	Minimum	Maximum
General patient	30.0 (3.1)	23	36
Severe patient in severe patient room	1.2 (1.4)	0	5
Pregnant women, Postpartum women	0.9 (0.8)	0	2
Infant	0.8 (0.7)	0	2
Severe infant	0.2 (0.4)	0	1

SD: standard deviation

2. Proportion of average time spent in a place by night-shift nurses

 Figure 4 shows the average proportion of time that nurses spent in each part of the ward

during the 13-hour night shifts over the 25 days of the investigation. These were as follows:

37.9% in the nurse station, 30.5% in the general patient room, 17.3% in the nap or rest

room, 7.7% in the severe patient room, 3.5% in the obstetric-related area, and 3.1% in other

places. Nurses overseeing severe patients spent 41.4% of their time in the severe patient

room, 28.2% in the nurse station, and 6.3% in the general patient rooms. Nurses overseeing

general patients spent 39.2% of their time in the nurse station, 34.4% in the general patient

rooms, and 1.7% in the severe patient room. The average proportions of time spent in the

obstetric-related area by each type of nurse were 4.0% by severe-patient nurses and 4.4% by
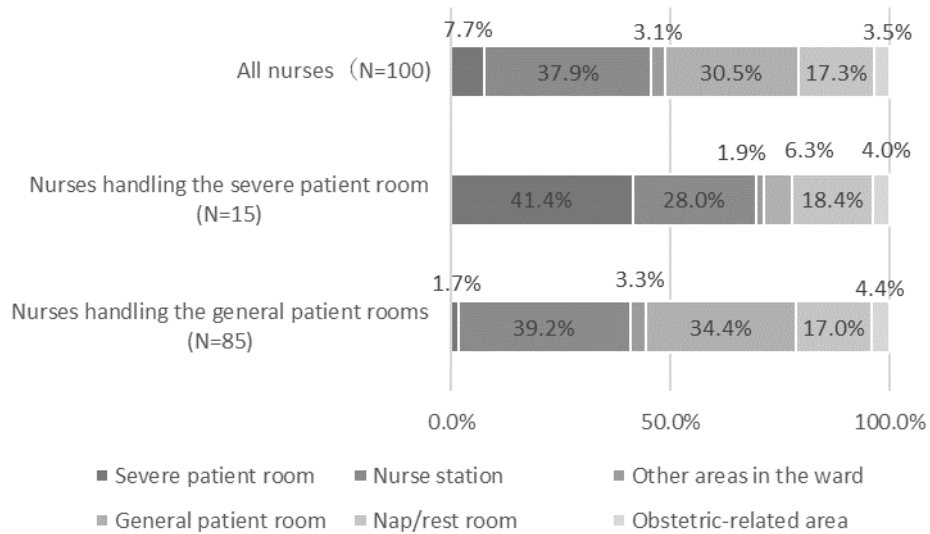
general-patient nurses.

Figure 4 Average proportion of time spent in each place by a night-shift nurse

3. Comparison of the time of stay for night-shift nurses, according to the presence or absence of severe patient(s) in the severe patient room

Table 3 shows the comparison data of stay times of night-shift nurses based on the presence or absence of severe patient(s) in the severe patient room. On average, the time of each bedside stay for night-shift nurses in the general patient rooms was 32.6 minutes per patient. The average time of bedside stay for night-shift nurses per patient in the general patient rooms was 31.9 minutes when there were severe patient(s). On days with no severe patients, the time spent was 33.6 minutes. There were no significant differences between the two (p=0.244).

We observed a significant difference between the time of stay in the severe patient room

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and nurse station. When severe patient(s) were hospitalized, the nurses stayed in the severe patient room for a long time, with a short time spent at the nurse station.

Table 3　Comparison of time of stay of night-shift nurses in each place within the ward, according to whether or not there were severe patient(s) in the severe patient room (Average bedside stay time during the night shift per nurse)

| | All nurses (N=100) | Patients hospitalized in the severe patient room | | |
		Yes (N=60)	No (N=40)	P-value
Average time of stay of nurses at bedside (min)				
Average time of stay at bedside per general patient (SD)	32.6 (7.1)	31.9 (8.1)	33.6 (5.5)	0.244
Average time of stay (min)				
Severe patient room (SD)	60.1 (128.7)	98.1 (155.3)	3.1 (5.2)	0.000
Nurse station (SD)	294.9 (92.2)	271.4 (87.8)	330.3 (88.1)	0.001
General patient room (SD)	237.4 (107.1)	237.3 (125.9)	237.4 (71.7)	0.247
Nap/rest room (SD)	134.6 (31.4)	132.6 (34.1)	137.7 (27.0)	0.373
Obstetrics-related area (SD)	27.6 (97.0)	14.9 (54.1)	46.6 (137.2)	0.069
Other areas in the ward (SD)	24.4 (12.6)	24.8 (14.3)	23.9 (9.7)	0.885

N: number Mann-Whitney's U-test SD: standard deviation

Total number of nurses: Four nurses placed × 25 days = 100 nurses

Number of nurses on days when there were severe patient(s): Four nurses placed × 15 days＝60 nurses

Number of nurses on days when there were no severe patient(s): Four nurses placed × 10 days = 40 nurses

4. Average time spent by night-shift nurses in the obstetrics-related area, according to the characteristics of obstetric patients hospitalized in the mixed obstetric ward

Some data are not shown in the chart; for example, we analyzed the average time of stay for nurses in the obstetrics-related areas, according to the characteristics of obstetrics patients. On days when there was a normal childbirth (2 days), the average time of stay was 29.0 minutes. On the day when an infant was hospitalized in the severe neonatal room (2 days) (there was also a day when there was an abnormal birth), the average time of stay was 198.4 minutes. Over the course of the 14 days when a postpartum woman and infant were hospitalized, the average time was 15.4 minutes. On the seven days without obstetrics patients, the average time of stay was 2.7 minutes.

Discussion

1. Place and average time of stay of night-shift nurses

If nurses stay longer in rooms with severely injured patients, it can be predicted that their stay times in other rooms will be shorter; however, it is not clear where this happens. In this study, using objective data, we were able to clarify the locations and durations of the nurses who simultaneously worked the night shift of the mixed obstetric ward. The average time of stay for night-shift nurses at patients' bedsides in the general patient rooms was 32.6 minutes. The results of a similar previous study found this to be 44 minutes per patient bedside per day[30]. The present study analyzed the data of night-shift nurses, who only work

13-hour shifts, as opposed to the nurses in the previous study, who worked 24-hour shifts. Thus, the amount of time spent per total shift hours at each patient's bedside was found to be longer in this study than in the previous study. During this study, the average number of inpatients per day was small, with only 30 patients in the general patient rooms, which have 45 beds. This may further explain the increase in nurses' time of stay at each patient bedside. In addition, the elderly tend to have a longer nursing time[30)31)] and the nurses' bedside stay time may be related to patients' needs for wound treatment, respiratory care, management of a syringe pump, roll-over, meal intake, and change of clothing[30)]. The patients in our investigation had a maximum age of 99 years old and included many orthopedic patients, which we believe explains why nurses' time of stay at bedside was longer per patient in this study than the previous study.

According to our study, nurses overseeing the general patient room spent 39.2% of their time at the nurse station and 34.4% in the general patient room. This was similar to a previous study that conducted a seven-day investigation in an acute phase ward of a university hospital using ultrasonic positioning; in that study, night-shift staff spent 39.5% of their time at the nurse station and 41.4% of their time in the hospital room[32)33)], which was the same as our study, with nurses spending 34.4% of their time in the general patient room plus 4.4% in the obstetric-related area. In a previous overseas study, Battisto et al.

reported that nurses spent 42.0% of their time at patients' bedside and 22.5% at the nurse station[34]. A study by Hendrich et al. reported that nurses spent 30.8% of their time in the hospital room and 38.6% at the nurse station[35]. Battisto et al. reported that nurses spent 25% of their time handling documentation and 55% on direct patient care[34]. According to a nurse workload investigation using TMS, regarding nursing activities during the night shift, nurses most frequently handled documentation, such as reports between nurses, patient observations, and taking measurements[36]. Therefore, we believe it is valid to assert that the time spent at the nurse station where such nursing activities are performed, and in the general patient rooms where direct patient care is carried out, was long.

Nurses handling the critical care patient room spent a lot of time there. We believe that this is because that room is equipped with facilities that allow nurses to carry out both direct and indirect care, such as preparation of documentations, medications, etc. It has been reported that the three activities of documentation, communication regarding the patient, and medication administration account for the majority of the actual time spent engaged in nursing work[35].

Furthermore, our results clarified the characteristics of night-shift nurses' stay time in obstetrics-related areas. On days when childbirth occurred or severely ill infants were hospitalized, nurses stayed longer in the obstetrics-related area. According to a previous

study, the time spent providing nursing care to an infant child was the longest on the day of birth[6]. Furthermore, nurses spent more time there in the event of abnormal transvaginal delivery[37)38]. An abnormal childbirth is expected to prolong time spent providing nursing care in obstetrics-related areas, not only for postpartum women but also for their infants. For this reason, we believe that nurse staffing on days with childbirth event(s) and days with hospitalization of severe infant(s) is important.

Measuring the place and time of stay of all nurses who work in the ward (those who provided consent) for 25 days reveals their work behavior (location and duration).

This information is useful for staff members, who can better understand, objectively, how they are working. In addition, when considering the placement of nurses by nurse managers, bedside stay time for nurses per patient and stay time in the critical care room could be the basis of staffing decisions once it is documented. This study's information can help to develop a meaningful reference for safe staffing.

2. Characteristics of nursing care, according to the presence of severe patient(s) in the severe patient room

Although no significant difference was observed when severely ill patients were hospitalized, nurses' time of bedside stay per patient in the general patient room during the night shift was shorter. This is because, when a severely ill patient was hospitalized in the

critical care room, the number of patients per nurse in the general patient room became significantly larger. Moreover, as staying time in the critical care room increased, the average bedside stay time per patient in the general patient room was considered to be short. Previous studies have shown that nurse staffing is related to patient outcomes[11]. Since the presence of severely ill patients increases the number of patients overseen by each nurse in the general patient rooms, and since this shortened the average time of the nurses' bedside stay per patient, this may affect patient outcomes.

3. Placement of nursing staff involved in the operation of a safe mixed ward.

According to Kitajima, who studied mixed obstetric wards within general hospitals in Japan, the number of annual deliveries and beds in obstetrics departments have been decreasing with the increase in the number of departments in the mixed obstetric ward[39]. Therefore, selecting which department to mix with obstetrics is important to ensure the safe and reliable nursing of patients admitted to mixed obstetric wards. The presence of patients in the critical care room affects the time spent with patients in the general patient rooms. In our study, the influence on nurses' place and time of stay was considered on a day with a childbirth and on a day when a severely ill infant was hospitalized. The California Nurse-to-Patient Ratios stipulate a nurse-to-patient ratio by taking into consideration obstetrics placements (Labor & Delivery, Postpartum, Well-Baby Nursery)[40]. We believe

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that obstetrics requires the fine-tuned placement of nurses, depending on patients' characteristics (delivery period, puerperium period, typical newborns, etc.). As a result of investigating 27 hospitals in Japan, on average, severely ill patients occupied 18.1% of beds in general wards but large differences were found between wards[41]. Some wards had just 1.2% of severe patients, while others had 44.1%[41]. When nurses stay in the critical care room for a long time, they spend less time in obstetrics-related areas. If the obstetrics-related area stay time of the nurse decreases and the nursing time for obstetrics subjects decreases, obstetrics patients' safety cannot be protected. The postpartum women are hospitalized for about five days, and nighttime nursing assistance and breastfeeding care are valuable opportunities for them. It is not preferable for postpartum women to reduce the nursing interactions they receive. It would be desirable to avoid mixing obstetrics and severely ill patients in hospital wards, in order to provide appropriate nursing care suited to patient characteristics. In addition, it is necessary to fine-tune nurse staffing according to patient characteristics.

Conclusion

In this study, we investigated all night-shift nurses in a mixed obstetric ward for 30 consecutive days, using TMS based on information and communication equipment. During

the 25 days that were analyzed, the time of stay for nurses at patients' bedsides in the general patient room during the night shift was 31.9 minutes, when severe patients were in the severe patient room, and 33.6 minutes on days without severe patients. When there were severe patients, nurses' time of stay in the severe patient room was significantly longer, while their time of stay in the nurse station was significantly shorter. Our findings demonstrate that the place and time of nurses' stay are affected by the presence of severe patients. Furthermore, among obstetrics patients, days with childbirth and days with severe infants led to nurses' longer stay time in obstetrics-related areas.

We believe that the results of this study can be used as data for the placement of nursing staff involved in the operation of a safe mixed ward.

Limitations

With regards to data measurement, the scope of installation of the beacons was an issue. This study installed 92 beacons within the hospital ward. However, when a patient left the hospital ward for tests, procedures, surgery, etc., we were unable to measure the place and time of stay for nurses that accompanied them out of the ward. Furthermore, this method of study did not take into consideration the content of the work handled by nurses; we believe that to analyze work content, it would be useful to combine methods such as

person-to-person time study and self-measured time study. This study also has limitations in terms of the sample representation; there is thus an issue with generalizing the results. In the future, it will be necessary to compare survey results for wards with different total numbers of beds in the hospital, clinical department, number of deliveries, etc.

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