

Analyzing medical errors in the emergency department— A case study of a Taiwan medical center

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Abstract. In Taiwan, emergency physicians work rotating shifts to provide 24 hour service; however, inappropriate shift work schedules may negatively affect physician health and jeopardize patient safety. To investigate if shift work schedules or other factors affected medical errors, two-year data (2009–2010) were collected in the emergency department of a 1000-bed regional teaching hospital in northern Taiwan. The collected data, including all the emergency physicians' work schedules and reported medical errors, were statistically analyzed to determine the severity of medical errors and to assess the factors that cause these medical errors. Due to a limited number of reported errors, no significant relationship between work shifts and medical errors was found; however, statistical results indicated that the medical errors could be classified into a few categories and these errors tended to occur during certain work shifts and periods of time. This study will serve to direct further investigation of the causes of the high frequency errors and allow development of corresponding strategies to prevent such errors.

Keywords: emergency department, shift work, medical errors, patient safety

1. INTRODUCTION

Due to the lack of human resources in healthcare institutions, healthcare workers often work extra hours to provide comprehensive medical and surgical services. In 2011, the Council of Labor Affairs conducted a survey (CLA, 2012) to investigate the working conditions and compensation of healthcare staff in 50 Taiwan hospitals. The results showed that 12% of hospitals breached the work day/vacation day ratio and 8% of hospitals concealed the fact that staff worked extended and excessive working hours.

Emergency physicians take turns working different shifts to provide year-round, 24-hour-a-day medical services. Physicians often have to swap shifts and operate under "on call" status so that patient needs can be met

(Carter & Lapierre, 2001) Shift work often prevents healthcare employees from living a normal life. Knauth (1996) stated that shift work affects an employee's physical and psychological health as well as social relationships, and when medical staff are emotionally affected, the quality of medical care and patient safety can suffer.

To avoid long working hours for residents and ensure patient safety, the Accreditation Council for Graduate Medical Education (ACGME) proposed work hour regulations. In 2003, the ACGME enacted resident duty-hour standards programs to control the work hours of residents. In 2010, ACGME further stated that work weeks for residents should be limited to 80 to 88 hours (Jamal et al., 2011). Based on ACGME standards programs, in 2011, the Department of Health Executive Yuan in Taiwan (DOH, 2011) conducted a survey and

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found that resident physicians worked about 74.6 hours per week, which conformed to the 80 to 88 hours of work per week standard. However, the results did not disclose the fact that some hospitals concealed the true attendance records to meet ACGME standards.

In Taiwan, many studies have explored the shift work systems of nurses and the effects on quality of patient care (Chan, 2003; Chang, Lee, & Lee, 1998; Chuang, 2008), but very few have focused on the shift work systems of physicians and associated quality of medical care. The main objectives of this study were to collect and analyze empirical data to investigate if shift work schedules, or other factors, contributed to medical errors. The ultimate aim of this research is to reduce medical errors and promote patient safety.

2. LITERATURE

2.1 Shift work

Shift work systems allow provision of services in workplaces where 24-hour operation is required. According to Benjamin(1984), shift work has a start-time that does not fall between 7 am and 9 am. Hedges and Sekscenski (1979) defined shift work as any period of work where more than half of the work time is outside the hours of 8 am and 4 pm. Deros et al. (2009) proposed that a shift system consists of two or more shifts or teams who work in unstructured and irregular time blocks, which can extend conventional working hours to year-round or all-night working hours. Beers (2000) stated that shift work can be flexible, and therefore, many different industries, including medical, industrial, and service industries, rely on shift systems.

Many industries hire staff for shift work. In 1995, a study investigated the work habits of 3000 to 5000 million U.S. employees and found that about 30% worked in atypical jobs that did not have a 9 am to 5 pm schedule. In 2005, Taiwan's Institute of Occupational Safety & Health (IOSH) survey (IOSH, 2007) indicated that fixed day shift workers made up around 79.3%, fixed night shift workers made up around 2.7%, shift workers made up around 8.7%, and unfixd shift workers made up around 7.8% of the work force. Shift work was more prevalent in the manufacturing, service, and healthcare industries.

Many studies have reported that shift work affects employee physical and mental health. Hedges and Sekscenski (1979) concluded that shift work (shift or fixed night shift) affects the psychological, behavioral, social, and physiological well-being of employees.

Johnson (1999) found that shift work can lead to difficulty adjusting to work and rest periods. Compared to fixed work hour workers, shift workers are more prone to depression and work/family conflicts. In addition, sleep problems among shift workers have also been reported; therefore, ergonomics scholars have attempted to identify ways of minimizing the impact of shift work on sleep. Knauth (1996) recommended that a shift work system should operate so as to minimize accumulative fatigue and toxic exposure times (to chemicals for example), and should aim to achieve more flexible working arrangements. Shift changes should also be kept to a minimum.(Sinden & Haynes, 2010). Although shift work affects employee physiology and psychology, many industries adopt shift systems to reduce the number of employees on their payroll. In some workplaces, in particular hospitals, 24-hour operation is required to take care of patients around the clock, so shift work has become the norm.

2.2 Medical errors and events

National medical error research indicates that the current healthcare environment involves risk and injury (Brennan et al., 1991; Vincent, Moorthy, Sarker, Chang, & Darzi, 2004) The World Alliance for Patient Safety Report (2007) determined that about 10% of hospitalized patients were harmed by preventable medical errors, and some severe errors resulted in death. Between 1996 and 1998, Australia's statistics showed that inpatient medication errors made up 2.4% to 3.6% of all medical errors, 30% to 60% of which were preventable (WHO, 2005). In addition, according to the Taiwan Department of Health Medical Assessment Team statistical data (Shin, 2005), medical assessment errors increased every year from 147 in 1987 to 406 in 2001. Among the 406 errors in 2001, 25% were medical irregularities and 20% were accidents.

Regarding the definition of medical error, the Institute of Medicine (IOM) report adopted the definition of Reason (2000). Briefly, a medical error occurs when the treatment plan cannot achieve the goal or the wrong treatment plan is used to achieve the goal, and includes both process errors and inappropriate treatment planning. Wears (2000) stated that the term "medical error" creates a negative perception, and that "adverse events" should be used instead. Brennan et al. (1991) also stated that medical practices were often the cause of adverse event injuries and not the patient's condition. Therefore, the Taiwan Joint Commission on Hospital Accreditation (TJCHA) (Shih & Hou, 2004) introduced Medical Error Definitions (Table 1), which outlined definitions of a variety of medical errors and events. This study utilized these definitions of medical errors and events.

Table 1: Medical error definitions

Medical error event	Definition
Medication errors	A medication error is any preventable event that may cause one patient harm or lead to inappropriate use while the medication is in control of the healthcare professional, patient, or consumer.
Patient falls	A fall is an event that results in a person coming to rest inadvertently on the ground or floor or other lower level (WHO, 2007).
Surgical adverse events	Harm events related to preoperative care, surgery, or postoperative care (Henriksen, Battles, Keyes, & Grady, 2008).
Adverse transfusion events	Adverse events associated with transfusions, including decision to transfuse, prescription and request, patient sampling, pre-transfusion testing, collection from the blood refrigerator, and administration to the patient (Stainsby, Russell, Cohen, & Lilleyman, 2005).
Health care events	An inaccurate or incomplete diagnosis or treatment leads to injury, infection, or patient harm. Includes errors, adverse events, and hazards.
Public accidents	Accidents that occur in hospitals, including accidents involving faulty equipment; hazardous material leaks; fire, flood or earthquake; radiation exposure; and leakage of electricity, which may cause injury and loss of life.
Security incidents	Incidents that occur in hospitals, including theft, harassment, abduction, violation, missing patients, and homicide events.
Self-injurious behavior	Any behavior initiated by the individual that directly results in physical harm to that individual. Physical harm includes bruising, lacerations, bleeding, bone fractures and breakages, and other tissue damage (Murphy & Wilson, 1985).
Adverse events of infusion	Adverse events related to infusion, including over-infusion, under-infusion, or failure to infuse; self-extubation; usage errors during infusion, and errors in the infusion process.
Cardiac arrest	Cessation of normal circulation of the blood due to failure of the ventricles of the heart to contract effectively. Not a complication of disease.
Anesthetic adverse events	Any anesthesia event including those related to anaphylactic reactions, device malfunctions, medication side effects, unusual vascular or neurologic injuries, and complications of healthcare records (Dutton,

	2011)..
Examination and Diagnostic errors	Any defect from ordering tests to reporting results and appropriately interpreting and responding to these actions (Bonini, Plebani, Ceriotti, & Rubboli, 2005).
Other	Any deviation from usual medical care that causes injury to the patient or poses a risk of harm. Includes errors, adverse events, and hazards (WHO, 2005).

2.3 The impact of shift systems on medical errors

Although shift systems allow hospitals to supply patients with all-day service, such systems affect the physical and mental health of physicians. Many studies have found that the average sleep time of night shift workers is decreased 15% to 20% compared to day shift workers. In addition, daytime sleep quality is poorer than night (Åkerstedt & Fröberg, 1976); therefore, shift work often leads to sleep disorders, and in severe cases, can cause insomnia, drowsiness, fatigue, decreased attention, and increased depression.(Åkerstedt, 2003). Because emergency and critical care staffs have specialized procedures and work in high-stress environments, the emergency room, operating rooms, and intensive care units are the most common places for medical adverse events (Hoff, Jameson, Hannan, & Flink, 2004).

The quality and safety of the healthcare system not only depends on healthcare worker knowledge and available technology, but also depends on human factors (Vincent, et al., 2004). Hickam et al.(2003) found that excessive work pressure placed on employees is a powerful predictor of subsequent resignation, absenteeism, and inefficiency. Work pressures, job dissatisfaction, and overwork are likely to result in medical negligence. A number of studies have also reported that physician work dissatisfaction affects prescribing behavior (Burns & Carter, 1985; Melville, 1980). All these phenomena are great threats to patient safety.

2.4 Research objective

This study aimed to explore the relationship between shift systems and medical errors. The Department of Health Executive Yuan Taiwan Patient Safety Culture Work Objective of emphasizes human "behavior," but very few studies have focused on the "essential cause" of working conditions and working environments, although the essential cause may impact human behavior. Hence, most studies of shift systems have focused on physical and psychological impacts on the staff (Åkerstedt, 2003; Åkerstedt & Fröberg, 1976; Hedges & Sekscenski, 1979;

Johnson, 1999; Knauth, 1996), while only a few have explored the relationship between shift systems and medical errors. Thus, this study aimed to explore this relationship in more detail.

3. RESEARCH METHODS

Data analyzed in this study were obtained from a 1000-bed medical center emergency department located in northern Taiwan. Schedules of the emergency physicians and reported medical errors in 2009 and 2010 were collected. The unit had about 25–30 emergency physicians, and all physicians worked shift work schedules consisting of four shifts: day shift (8 am to 4 pm), evening shift (4 pm to 11 pm), night shift (11 pm to 8 am), and weekend shift (11 am to 11 pm). According to the TJCHA definition (see Table 1), errors and events were classified into 13 medical error types including medication errors, patient falls, surgical adverse events, adverse transfusion events, healthcare events, public accidents, security incidents, self-injurious behavior, adverse events of infusion, cardiac arrest, adverse anesthesia events, examination and diagnostic errors, and other.

After the medical errors and events were categorized, physician schedules were checked and the time that the medical errors occurred was noted. Finally, the statistical software was applied for tests, including percentage ratio, Chi-Square test, and Kruskal-Wallis one-way analysis of variance rank test. Statistical results were used to explore the relationship between scheduling and medical errors.

4. RESULTS

The results serve to characterize the severity of medical errors and assess the potential factors that caused these medical errors. As shown in Figure 1, the three most frequently occurring types of medical errors were medication errors (56.19%), patient falls (10.26%), examination and diagnostic errors (9.37%). Other medical errors included adverse transfusion events (5.00%), adverse events of infusion (5.00%), other events (3.87%), surgical adverse events (3.31%), self-injurious behavior (2.69%), cardiac arrest (2.69%), and security incidents (1.63%).

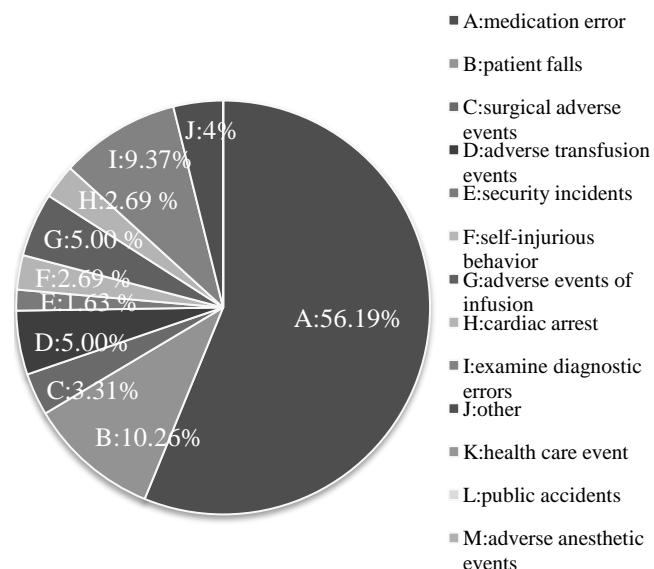


Figure 1: Emergency department medical errors, 2009–2010.

By focusing on the medical errors and events that were directly related to physicians, we found that, as shown in Figure 2, medication errors were committed by physicians most frequently. The medical errors and events that occurred were other events (22.25%), medication errors (20.51%), surgical adverse events (4.38%), examination and diagnostic errors (3.25%), and adverse transfusion events (1.12%).

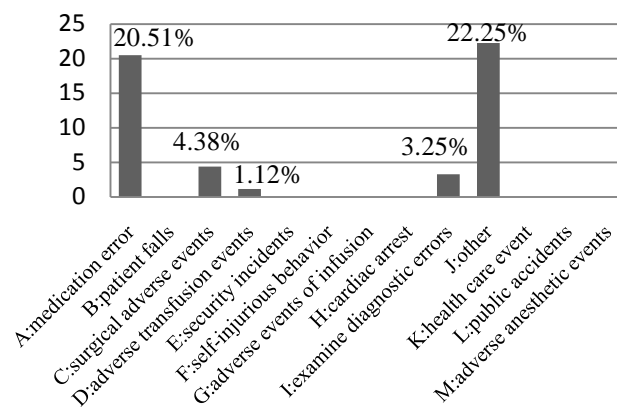


Figure 2: Emergency physician medical errors and events, 2009–2010.

Among all the recorded medical errors and events, 52.38% occurred during the day shift (8 am to 4 pm), 33.33% occurred during the evening shift (4 pm to 11 pm), and 4.76% occurred during the night shift (11 pm to 8 am) (Figure 3). Figure 4 illustrates that most medical errors resulting directly from physician failure occurred in three specific time periods: 6 pm to 8 pm (23.81%), 12 noon to 2 pm (19.05%), and 2 pm to 4 pm (14.29%).

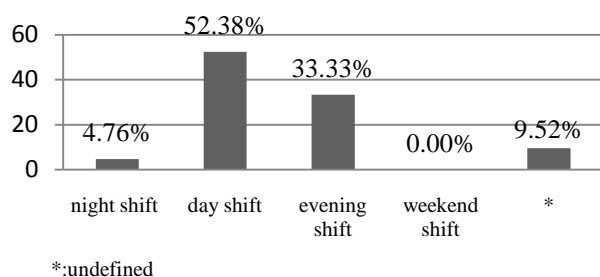


Figure 3: Medical error events by shift, 2009–2010.

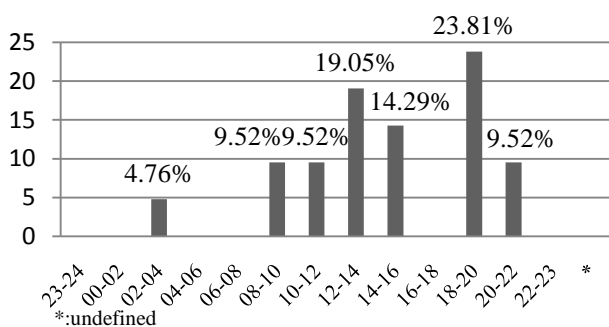


Figure 4: Medical errors by time, 2009–2010.

An analysis of the relationship between the working hours of emergency physicians and occurrence of medical errors illustrated that 33.33% of medical errors and events occurred in the second hour after the start of work, 28.57% in the fourth hour after the start of work, and 14.29% in the sixth hour after the start of work (Figure 5).

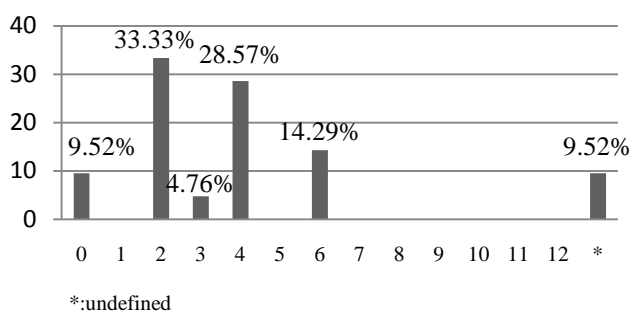


Figure 5: Relationship between working hours of emergency physicians and occurrence of medical errors and events.

By testing the relationship between the occurrence of medical errors and work shift with a Chi-square analysis, as shown in Table 2, a Pearson chi-square value of 26.8 with 28 degrees of freedom was obtained ($p = 0.529$), which represented a less than 0.05 level of significance. Medical

errors were not related to shift, as different shifts did not exhibit an increase or decrease in medical errors.

Table 2: Chi-square test

Chi-square test			
	Value	Df.	Asymptotic significance (2-tailed)
Pearson	26.8 ^a	28	0.529
Likelihood ratio	25.09	28	0.622
Connected	1.09	1	0.3
Observed	21		

^a Expected number of 40 cells (100.0%) less than 5. The minimum expected number is 0.05.

This study also used a Kruskal-Wallis one-way analysis of variance ranks test to analyze shifts and medical errors. The results showed that H of the statistic P-value was 0.306, and correction H of the statistic P-value was 0.042 (Table 3). Therefore, physician duty shifts were not likely related to medical errors.

Table 3: Kruskal-Wallis one-way analysis of variance ranks test

Kruskal-Wallis Test on data				
shift	N	Median	Ave Rank	Z
*	5	0	47.5	0.7
daytime	25	0	46.7	1.61
evening	20	0	41.1	0.14
nighttime	20	0	-34.4	-1.36
weekend	10	0	-32.5	1.16
Overall	80		40.5	
H = 4.82 DF = 4 P = 0.306				
H = 9.94 DF = 4 P = 0.042 (adjusted for ties)				
*: undefined				

5. DISCUSSION

Based on the two-year data collected in a 1000-bed regional teaching hospital in northern Taiwan, this study found no significant relationship between shift work and medical errors. A potential reason could be due to the fact that physicians had plenty of time for rest, resulting in the low incidence of medical errors and events in the hospital. More specifically, the physicians in the hospital worked no more than two consecutive shifts; no physicians worked continuously for more than 20 hours. This finding suggested other hospitals to reduce the continuous duty

time of physicians, which should ultimately result in a reduction in medical errors.

Beside the non-effect of work shift on medical error, this study revealed several findings. First of all, medication errors were the most common (55.15%) of the thirteen types of medical errors and events. It was also the most commonly occurring medical errors caused by physicians. Thus, the hospital needs to pay more attention to prevention of medication errors. Second, we also found "other errors" were the high frequent errors committed by physicians. "Other errors" mostly involved administrative processes or information system problems. In particular, when physicians used computers, the system automatically reminded physicians of the necessary procedures, but when the computers crashed, physicians had to rely on personal judgment at every step. In addition, when the system crashed, physicians had to handwrite their prescriptions, and because there are a lot of drugs with similar names that other staff may have difficulty identifying, errors were more likely. Therefore, computer issues might have been the main reason that contributed to this type of medical error and need be further solved by adequate solution. Finally, this study also found that medical errors occurred frequently between 6 pm to 8 pm (23.81%), 12 noon to 2 pm (19.05%), and 2 pm to 4 pm (14.29%). The reason might be due to the heavy traffic in these periods of time, especially the time between 6 pm to 8 pm. To prevent medical errors, the number of the paramedics should be increased during those three time periods. An analysis of the relationship between the working hours of emergency physicians and occurrence of medical errors, the medical errors occurred high frequency in the second hour (33.33%) and in the four hours (28.57%) after the start of work. This result enlightens follow-up study focusing on research corresponding strategy development to preventing the errors.

6. CONCLUSIONS

By analyzing two-year data collected in a 1000-bed regional teaching hospital in northern Taiwan, this study attempted to find the relationship between work shift and medical error made by physicians. The results showed no significant shift effect on different types of medical errors. However, medication errors were the most frequently errors committed by the physicians, directing future study to analyze the causes of the medication errors. Furthermore medical errors occurred most frequently in the evening time shift and in the period between 18:00 to 20:00 and in the 2nd hour after work. A deliberate investigation should confirm whether these high error numbers were due to high patient number or other reasons, such as work shift,

employee shortage, shift change, etc. Due to limited data available, the results may not represent the overall situation of Taiwan hospitals. To provide established knowledge of medical errors, sufficient data collected from more hospitals will be necessary in future research.

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