



Physician turnover and its association with mortality after non-cardiac surgery: a retrospective cohort analysis of patients in South Korea

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Abstract

Purpose To assess the association between physician turnover, mortality, and length of hospital stay after non-cardiac surgery in South Korea.

Methods This retrospective cohort study is based on analysis of the medical records of patients who underwent non-cardiac surgery between January, 2010 and December, 2016. The primary outcomes were the differences in 30-day, 90-day, and overall mortality between non-cardiac surgery performed during the turnover period and that performed during the non-turnover period.

Results The subjects of the analysis were 106,832 patients who underwent non-cardiac surgery. Among them, 17,788 patients underwent surgery during the turnover period and 89,044 underwent surgery during the non-turnover period. Multivariable Cox regression analysis revealed no significant differences in postoperative 30-day mortality ($P=0.427$), 90-day mortality ($P=0.854$), or overall mortality ($P=0.928$) between surgery conducted during the turnover period and that conducted during the non-turnover period. Surgery performed during the physician turnover period was associated with a 0.21-day increase compared with surgery performed during the non-turnover period (coefficient: 0.21, 95% confidence interval: 0.00–0.42, $P=0.038$).

Conclusions Physician turnover was not associated with postoperative 30-day, 90-day, or overall mortality after non-cardiac surgery. However, the length of hospital stay was slightly longer for patients who underwent non-cardiac surgery in the turnover period.

Keywords Global surgery · Patient safety · Outcomes

Introduction

Academic hospitals inevitably undergo the academic year-end changeover when new medical school graduates commence working shifts at hospitals for the first time or interns

start their residency with greater responsibility [1]. In North America, the effects of this physician turnover on various outcomes of in-hospital patients are comprehensively defined as the “July Effect” [2]. Some reports suggest that there is an increased incidence of fatal medical errors committed by new medical residents during this period [3] and that the physician turnover impacts negatively on the outcome of in-hospital patients [2, 4]. However, other studies contradict these findings and claim that physician turnover has no effect on the outcomes of in-hospital patients [5–7]. Hence, the association between the July Effect or physician turnover and health-related outcomes at academic hospitals remains controversial.

Previous studies have demonstrated that the effect of physician turnover on the outcome of in-hospital patients was more pronounced in very ill patients with certain risk factors and that the turnover is strongly associated with poor prognosis [8]. However, in the majority of surgical populations,

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the association between physician turnover and patient outcome is minimal [9, 10]. Therefore, based on current evidence, the effect of physician turnover on the outcomes of the entire surgical population is negligible in clinical practice. Notably, all these studies were performed in the United States [9, 10], but there has been no study assessing the relationship between physician turnover and the outcome of the surgical population to reflect Asian medical settings. The effect of physician turnover on patient outcomes in Asia may be different from those in the US because of the different medical backgrounds in various countries and cultures [11]. Thus, additional studies are required, taking these differences into consideration.

The primary purpose of this study was to assess the relationship between physician turnover and the mortality of patients who underwent non-cardiac surgery at Seoul National University Bundang Hospital (SNUBH), the teaching hospital of the traditional, time-honored Seoul National University College of Medicine. We assumed that physician turnover may exhibit a negative effect on the postoperative mortality and length of hospital stay of patients undergoing non-cardiac surgery.

Methods

This was a retrospective, observational study performed with the approval of the SNUBH Institutional Review Board (IRB; approval number: B-1804/462-105, approval date: 2018.3.26). Considering the retrospective study design, the need for informed consent was waived by the IRB. We reviewed the medical records of all adult patients (≥ 20 years) who underwent surgery at SNUBH between January, 2010 and December, 2016. If a patient had undergone multiple surgical procedures within the study period, only the last procedure was assessed. This included reoperations, which were considered to have been performed in the most severely ill patients. The exclusion criteria were as follows: cardiac surgery, including major vascular surgery with intraoperative cardiopulmonary bypass; and incomplete or missing medical records. SNUBH, where the study was performed, is a large, tertiary hospital with 1360 beds, which places strong emphasis on proper training of its medical trainees.

Turnover period for trainees in SNUBH, South Korea

The Korean medical training system comprises 1 year of internship immediately after graduation, then 4 years of residency, followed by 1–2 years of fellowship. More than two-thirds of new recruitments occur on March 1, each year. Additional new recruitments are made on May 1, for trainees returning from military service. Thus, March and May are

considered the “turnover periods for trainees” in the majority of teaching hospitals in Korea, including SNUBH [12, 13] and the remaining 10 months are defined as the non-turnover period for this study.

Measurements and outcomes

The patients’ demographic information, clinical characteristics, and surgery-related information were collected for the study. All information based on the pre-anesthetic registry and the surgical registry was collected by medical record librarians who were blinded to the purpose of the study. Accurate dates of death were collected separately with permission from the Ministry of the Interior and Safety in South Korea. Therefore, regardless of follow-up loss, accurate dates of deaths for all patients as at December 31, 2017 were obtained and utilized in the study.

The primary outcome of the study was to assess the differences in postoperative 30-day, 90-day, and overall mortality between patients who underwent non-cardiac surgery during the turnover period versus those who underwent non-cardiac surgery during the non-turnover period. The high-risk patient group, comprised of patients with American Society of Anesthesiologists (ASA) classification ≥ 3 or age ≥ 65 , were analyzed separately for differences in postoperative mortality between operations performed during the turnover period and the non-turnover period. The secondary outcome of the study was to investigate the association between physician turnover and length of hospital stay after non-cardiac surgery.

Statistical methods

For the comparison of characteristics between the turnover period and non-turnover period groups, a *t*-test was used for continuous variables and a Chi square test was used for categorical variables. Univariable Cox regression analysis was performed to identify the covariates that exhibited distinct associations with postoperative 30-day, 90-day, or overall mortality. Covariables with $P < 0.05$ on this univariable Cox regression model were selected and included in the final multivariable Cox regression analysis. The subgroup analysis was performed for the group of patients with ASA ≥ 3 or age ≥ 65 , using the same method. To investigate the association between physician turnover and length of hospital stay (day) after surgery, a multivariable linear regression analysis using backward elimination method was used. The overall survival times for both the turnover period group and the non-turnover period group are shown using a Kaplan–Meier curve, and the log-rank test was used for the comparative analysis. All statistical analyses were performed using IBM SPSS version 24.0 (IBM Corp., Armonk, NY, USA). Values of $P < 0.05$ were considered significant.

Results

There were 198,206 non-cardiac surgical procedures performed between January, 2010 and December, 2016. The surgical procedures that met the following exclusion criteria were excluded from the study: 41,559 cases of multiple surgical procedures for a single patient; 22,300 patients with incomplete or missing medical records; 25,257 patients under the age of 20; and 2258 patients who underwent cardiac surgery. Ultimately, 106,832 non-cardiac surgery patients were included in the analysis: 17,788 who underwent surgery during the turnover period and 89,044 who underwent surgery during the non-turnover period (Fig. 1). Table 1 compares the patient characteristics between the turnover period group and the non-turnover period group. There were no significant differences in postoperative 30-day mortality, 90-day mortality, or overall mortality between the groups (all $P > 0.05$).

Univariable and multivariable Cox regression analysis for 30-day, 90-day, and overall mortality after non-cardiac surgery

Supplementary Table 1 shows the outcome of the univariable Cox regression analysis performed to assess the distinct relationships between each variable and postoperative 30-day mortality, 90-day mortality, and overall mortality. Variables finally selected from the initial univariable Cox

regression model were further analyzed using the multivariable Cox regression analysis, and its outcomes are summarized in Table 2. The multivariable Cox regression analysis outcome revealed no significant differences in postoperative 30-day mortality [hazard ratio (HR): 1.15, 95% confidence interval (CI) 0.82–1.60, $P = 0.427$], 90-day mortality (HR: 1.02, 95% CI: 0.84–1.24, $P = 0.854$), or overall mortality (HR: 1.00, 95% CI: 0.94–1.07, $P = 0.928$) between the surgery in the turnover period versus in the non-turnover period. The same trend was observed in the subgroup analysis of selected patients with ASA ≥ 3 and age ≥ 65 (all $P > 0.05$, Supplementary table 2).

Figure 2 shows the differences in overall survival times of the patients who underwent non-cardiac surgery during the turnover period and the non-turnover period, on a Kaplan–Meier curve. There were no significant differences in the postoperative overall survival times between the turnover period group and the non-turnover period group (mean survival time, 7.2 years, 95% CI: 7.2–2.3 versus 7.4 years, 95% CI: 7.4–7.4, respectively; $P = 0.272$).

Length of hospital stay (day) after non-cardiac surgery

Table 3 shows the results of the multivariable linear regression analysis for length of hospital stay (day) after non-cardiac surgery. Surgery performed during the physician turnover period was associated with a 0.21-day increase in length of hospital stay compared with surgery performed during the

Fig. 1 Patient selection flow chart

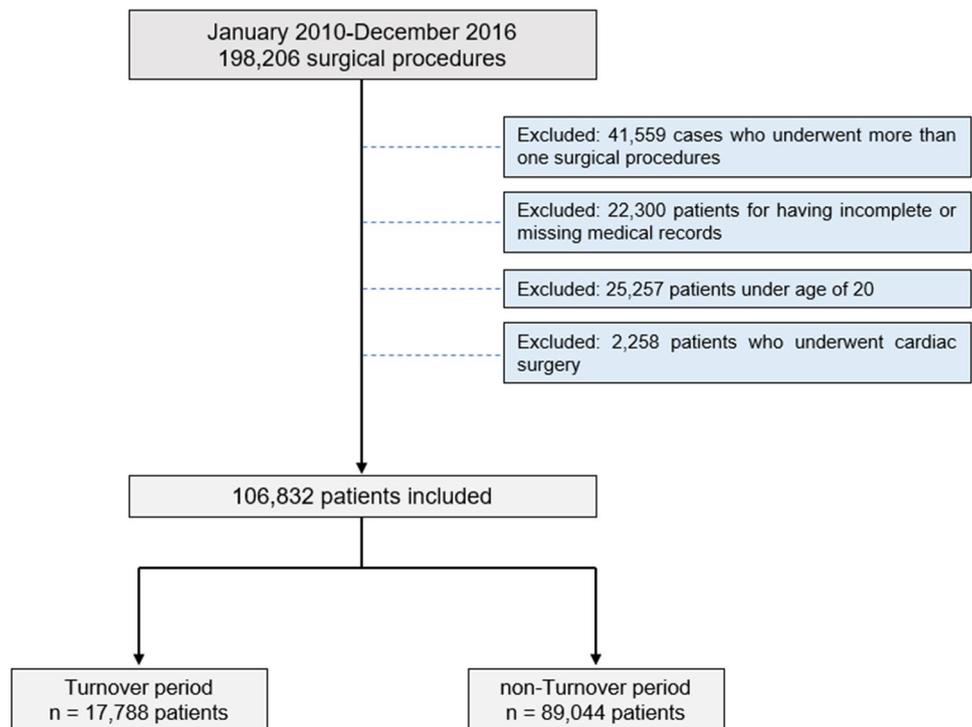


Table 1 Clinical characteristics of patients who underwent non-cardiac surgery in the turn-over period versus in the non-turn over period (2010–2016)

Variables	Turnover (<i>n</i> = 17,788)	Non-turnover (<i>n</i> = 89,044)	<i>P</i> value
Age (years)	54.1 (16.2)	54.6 (16.1)	<0.001
Body Mass Index (kg m ⁻²)	24.1 (3.5)	24.0 (3.5)	<0.001
Sex: male	7,669 (43.1%)	39,032 (43.8%)	0.077
Comorbidities at surgery			
ASA classification			0.001
1	8,459 (47.6%)	43,026 (48.3%)	
2	8,327 (46.8%)	41,585 (46.7%)	
≥3	1,002 (5.6%)	4,433 (5.0%)	
Hypertension	4,922 (27.7%)	22,264 (25.0%)	<0.001
Diabetes mellitus	2,248 (12.6%)	10,179 (11.4%)	<0.001
Ischemic heart disease	937 (5.3%)	4,475 (5.0%)	0.179
Cerebrovascular disease	822 (4.6%)	3,808 (4.3%)	0.039
Chronic kidney disease	303 (1.7%)	1,611 (1.8%)	0.331
Chronic liver disease	385 (2.2%)	1,844 (2.1%)	0.426
Malignancy	4,191 (23.6%)	21,934 (24.6%)	0.002
Characteristics of surgical procedures			
Type of surgery			0.001
General surgery	4,380 (25.1%)	22,885 (26.3%)	
Thoracic surgery	610 (3.5%)	2,868 (3.3%)	
Neuro or spine surgery	1,520 (8.7%)	7,432 (8.5%)	
Orthopedic surgery	3,654 (21.0%)	18,331 (21.0%)	
Plastic, ENT, dental, eye surgery	4,032 (23.1%)	18,976 (21.8%)	
Gynecologic or urologic surgery	3,150 (18.1%)	16,217 (18.6%)	
Procedures under sedation	85 (0.5%)	466 (0.5%)	
Type of anesthesia			0.014
General anesthesia	12,082 (68.0%)	61,097 (68.7%)	
Regional anesthesia	1,968 (11.1%)	9,710 (10.9%)	
Monitored anesthesia care	3,727 (21.0%)	18,185 (20.4%)	
Duration of surgery (min)	98.0 (91.3)	98.0 (132.9)	0.962
Duration of anesthesia (min)	134.7 (103.0)	133.5 (100.6)	0.138
Estimated blood loss (ml)	115.5 (341.9)	117.0 (444.7)	0.686
Length of hospital stay, day	6.8 (21.1)	6.6 (12.5)	0.145
Postoperative ICU admission	549 (3.1%)	2,724 (3.1%)	0.848
Surgery in weekend	186 (1.0%)	985 (1.1%)	0.479
Emergency surgery	25 (0.1%)	95 (0.1%)	0.218
Years at surgery			<0.001
2010	1,944 (10.9%)	9,947 (11.2%)	2010
2011	2,102 (11.8%)	10,495 (11.8%)	2011
2012	2,414 (13.6%)	11,444 (12.9%)	2012
2013	2,272 (12.8%)	12,330 (13.8%)	2013
2014	2,574 (14.5%)	14,201 (15.9%)	2014
2015	2,960 (16.6%)	15,745 (17.7%)	2015
2016	3,522 (19.8%)	14,882 (16.7%)	2016
Postoperative 30-day mortality	52 (0.3%)	239 (0.3%)	0.576
Postoperative 90-day mortality	136 (0.8%)	729 (0.8%)	0.462
Postoperative overall mortality	1,182 (6.6%)	5,917 (6.6%)	1.000

Presented as mean (SD) or number (percentage)

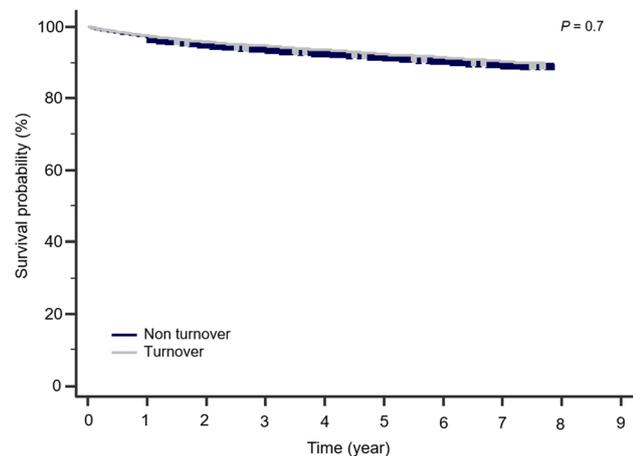
SD Standard deviation, ASA American Society of Anesthesiologists, ENT ear–nose–throat, ICU intensive care unit

Table 2 Cox regression analysis for mortality after non-cardiac surgery done during the turnover periods (2010–2016)

	30-Day mortality Hazard ratio (95% CI)	<i>P</i> value	90-Day mortality Hazard ratio (95% CI)	<i>P</i> value	Overall mortality Hazard ratio (95% CI)	<i>P</i> value
Unadjusted						
Surgery in non-turnover period	1		1		1	
Surgery in turnover period	1.09 (0.81–1.47)	0.576	0.93 (0.78–1.12)	0.463	0.97 (0.91–1.03)	0.272
Adjusted*						
Surgery in non-turnover period	1		1		1	
Surgery in turnover period	1.15 (0.82, 1.60)	0.427	1.02 (0.84, 1.24)	0.854	1.00 (0.94, 1.07)	0.928

CI Confidence interval

*Covariates of $P < 0.05$ in the univariate cox regression analysis in supplementary table 1 were adjusted in the multivariate cox regression analysis

**Fig. 2** Overall survival times in the turnover period versus the non-turnover period

non-turnover period (coefficient: 0.21, 95% CI: 0.00–0.42, $P = 0.038$). However, there was no significant association between length of hospital stay and surgery performed during the turnover period in the $ASA \geq 3$ patients ($P = 0.952$) and those ≥ 65 years old ($P = 0.376$).

Discussion

The findings of this study revealed no significant association between physician turnover and postoperative 30-day, 90-day, and overall mortality after non-cardiac surgery. An identical trend was observed in the subgroup analysis performed on patients who were at relatively high risk and with a preoperative $ASA \geq 3$ or age ≥ 65 . However, the length of hospital stay was slightly increased for patients who underwent non-cardiac surgery during the turnover period. The outcomes of our study on a patient cohort from a single tertiary academic hospital in Korea were in agreement with those of previous studies from the United States [9, 10], suggesting that the turnover period in South Korea (March and May) is safe, at least for the surgical population. Our findings demonstrated that physician turnover is not a factor for increased postoperative mortality in the surgical population, either in the United States or in South Korea, an Asian country with a different medical setting.

An important issue associated with the physician turnover effect is that the outcome varies according to the admission department. When limited to the surgical

Table 3 Multivariable linear regression analysis using the backward elimination method for length of hospital stay after surgery

	Total ($n = 106,832$) Coefficient 95% CI	<i>P</i> value	$ASA \geq 3$ ($n = 5435$) Coefficient 95% CI	<i>P</i> value	Age ≥ 65 ($n = 30,480$) Coefficient 95% CI	<i>P</i> value
Unadjusted						
Surgery in non-turnover period	1		1		1	
Surgery in turnover period	0.17 (−0.06, 0.40)	0.145	−0.14 (−3.14, 2.85)	0.925	−0.04 (−0.53, 0.46)	0.890
Adjusted*						
Surgery in non-turnover period	1		1		1	
Surgery in turnover period	0.21 (0.00, 0.42)	0.038	0.03 (−3.21, 3.32)	0.952	0.20 (−0.28, 0.57)	0.376

CI Confidence interval

*Covariates of $P < 0.05$ in the univariate cox regression analysis in supplementary table 1 were adjusted in the multivariate cox regression analysis

population, operations including orthopedic surgery [14, 15], appendicitis [16], spinal surgery [17], and neurosurgery [18] exhibited zero-to-minimal associations between physician turnover and surgical outcome. On the other hand, an association was observed between physician turnover and increased mortality for high-risk patients with septic shock [19] or other seriously ill medical patients [8] admitted with acute myocardial infarction. These differences in the association between physician turnover and patient outcome may be due to the different characteristics of the patients in each admission department. First, the key factors for the surgical outcome of a surgical population, including mortality, are efficient performance indicators for surgery and postoperative complications [20]. Therefore, the number of operations performed by trainees during the physician turnover period may not be sufficient to affect the surgical outcome since those performed by the staff surgeon were not affected by the physician turnover period. In other words, the surgical population is heavily affected by the duration of surgery of the staff surgeon and the outcomes of seriously ill medical patients are affected by all events that occur during any 24-h period. Therefore, these patients may suffer a greater impact from the physician turnover than the surgical population, since the trainees are responsible for primary management. In fact, a previous retrospective study conducted in the internal medicine inpatient unit of an academic hospital found that the mortality of these patients changes according to the workload of the teaching team [21]. Other previous studies on medical patients, which reported an association between physician turnover and patient mortality, focused on severely ill patients within the hospital; namely, those with myocardial infarction or septic shock. Thus, it appears that the trend of physician turnover associated with outcomes is observed more strongly in medical patients than in surgical patients [8, 19].

One of the strengths of this study over previous studies is that it analyzed all the postoperative 30-day mortality, 90-day mortality, and overall mortality data after non-cardiac surgery. Postoperative 30-day mortality is known traditionally as the most important indicator of postoperative outcomes [20], but postoperative 90-day mortality was recently reported as a more effective reflection of perioperative outcome [22]. Finally, overall mortality was included in the analysis to compare postoperative long-term survival. Our findings demonstrated that physician turnover has no association with either perioperative short-term mortality or long-term mortality. Second, although we performed an additional subgroup analysis on high-risk patients with ASA ≥ 3 or age ≥ 65 , no association between physician turnover and postoperative mortality was identified in this subgroup of high-risk patients, suggesting that physician turnover does not need to be considered as a risk factor for

postoperative mortality even in a relatively high-risk surgical population.

Additional important points to address are associated with the similarities and differences between this study and previous studies. Two previous studies performed in our center found that physician turnover was associated with an increased incidence of in-hospital cardiopulmonary arrest [12], but turnover was not associated with 30-day mortality according to the intensive care unit (ICU) admission period [13]. This difference is probably attributable to a simple comparison of in-hospital cardiopulmonary arrest that does not reflect the severity or morbidity of the entire in-hospital patient population during the physician turnover period. In fact, another study on ICU patients that corrected for severity and morbidity of the patients, through multivariable Cox regression analysis, showed no association between physician turnover and patient outcomes. This lack of association is similar to the outcome of this study, which focused on a population of patients who underwent non-cardiac surgery. Both studies have similar hypotheses and stated that the staffing of senior intensivists in the ICU and the main senior surgeon were the major factors that accounted for the lack of significant association between physician turnover and patient outcomes.

This study had some limitations. First, since it was a retrospective cohort study, the quality and accuracy of the data might be more limited than those of prospective studies. Second, there is a lack of generalizability as the study was performed at a single teaching hospital. Third, although we were able to obtain mortality data based on accurate information on dates of deaths regardless of follow-up loss, the exact causes of death were not identified; therefore, the outcome was limited to overall mortality instead of disease-related mortality. Finally, we included only the most recent surgical procedure for each patient in the analysis. Considering that most patients were severely ill during the studying period, some were undergoing their first procedures, while others were undergoing reoperations. Thus, the mixing of these cases into the overall cohort might have caused selection bias. Despite these limitations, our study is the first to show the lack of significant association between physician turnover and postoperative mortality in South Korea, an Asian culture, based on a large surgical adult cohort of > 100,000 patients who underwent non-cardiac surgery.

In conclusion, our findings suggest that there is no significant association between physician turnover and postoperative 30-day, 90-day, or overall mortality after non-cardiac surgery. A similar trajectory was observed in the subgroup analysis of high-risk patients with preoperative ASA ≥ 3 or age ≥ 65 years. However, we noted a slight increase in length of hospital stay for patients who underwent non-cardiac surgery during the physician turnover period.

Compliance with ethical standards

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

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