



## Original Contribution

# At all hospitals in the State of Iowa over a decade, the number of cases performed during weekends or holidays increased approximately proportionally to the total caseload<sup>☆</sup>



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## A B S T R A C T

**Study objective:** We tested the hypothesis that over many years – a decade – hospitals' proportions of surgical cases that were performed on weekends and holidays remained stable.

**Design:** Retrospective cohort study.

**Setting:** Iowa Hospital Association data were from January 1, 2007, through June 30, 2017. The N = 42 hospitals included were those with at least 10 cases performed during holidays or weekends for each of the periods.

**Measurements:** The number of surgical cases performed at each hospital during each of the 21 half-year periods was considered the count of unique combinations of hospital, patient, and date with at least one major therapeutic procedure.

**Main results:** Absolute predictive errors in cases per weekend or holiday day were calculated using a proportional model and using a quadratic model for each hospital and half-year period. Pooling among hospitals, the sample mean absolute predictive errors were greater for the proportional model than for the quadratic model ( $P < 0.0001$ ). However, the mean difference was just 0.0027 cases per weekend or holiday day (SE 0.0001), significantly less than even 1 case per day ( $P < 0.0001$ ). The sample means of the pairwise differences in predictive errors were smaller than 1 case per day for all 42 hospitals, significantly so for 41 of the 42 hospitals ( $P \leq 0.005$ ). These conditions applied to all other hospitals in the state, because each performed few cases on weekends and holidays.

**Conclusions:** For the anesthesia group caring for patients at a hospital over several years, weekend and holiday anesthesia caseload should be expected to increase approximately proportionately to changes during regular workdays. Average weekend workload can be benchmarked using hospitals' percentages of operating room cases performed on weekends and holidays.

## 1. Introduction

Recently, some anesthesiologists at a large hospital in the State of Iowa reported their impression that more anesthetic cases were being

performed on weekends. Anesthesiologists in-house were more often responsible for multiple cases and the anesthesiologists on-call from home were more often being called to work [1]. Indeed, analyzing the department's data, the count of cases performed on weekends and

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**Table 1**  
Demographic characteristics of the cases performed during the N = 21 half-year periods<sup>a</sup>.

Characteristic of the data and hospitals in Iowa	Mean (SD) <sup>b</sup>
Cases performed at any of the 121 hospitals with at least one case that was of at least one major therapeutic procedure	125,775 (1882)
Cases performed on weekends or holidays at any of the 121 hospitals	8364 (883)
Cases performed among the 42 hospitals with at least 10 cases performed on weekends or holidays	110,161 (1969)
Cases performed on weekends or holidays at the 42 hospitals	7778 (817)
Percentage of cases performed on weekends or holidays at any of the 121 hospitals	6.65% (0.65%)
Percentage of cases performed at the 42 hospitals	87.58% (0.61%)
Percentage of cases performed on weekends or holidays that were performed at one of the 42 hospitals	92.99% (0.42%)
Percentage of cases performed on weekends or holidays among the 42 hospitals	7.06% (0.68%)
Weekend or holiday days per half-year period	56.5 (2.5)

<sup>a</sup> The dates were from January 1, 2007, through June 30, 2017. Investigators repeating our calculations using data from different regions can use this information to make comparisons between their studied population of cases and ours.

<sup>b</sup> SD represents standard deviation.

holidays had increased. Over 12 years, while the total count of anesthetics increased > 50% and the count of anesthetizing locations with at least 50 cases increased > 50%, the percentage of surgical cases performed during weekends or holidays remained relatively unchanged at 4.1% (SD 0.3%).<sup>5</sup> Thus, the growth of cases on weekends and holidays matched the increase during regular workdays.

In the current study, the generalizability of this observation of proportional growth was analyzed for all hospitals, statewide, over a decade. Our Hypothesis #1 was that, over these many years, percentages would change by a statistically significant amount. We would not expect otherwise because conditions change at hospitals (e.g., trials of performing elective cases on weekend) [2]. Our Hypothesis #2 was that the significant differences of Hypothesis #1 would be too small to be of managerial importance. Specifically, the errors resulting from using the proportional model would be too few cases per day (< 1 case) relative to a more general quadratic model to influence appropriate weekend and holiday anesthesia staffing [2–10]. If supported, anesthesiologists could plan that, from one year to the next, weekend and holiday call responsibilities would grow approximately proportionally to the hospitals' anesthesia caseload, and thus to the numbers of anesthesiologists [11].

What makes our study of these hypotheses unique is its evaluation not for 1 or 2 hospitals, but all hospitals in Iowa. What makes the data unique for studies of many hospitals (i.e., suitable for operating room management study) are the inclusion of all patients regardless of payer (i.e., not a study of Medicare billing data) and of all cases and dates of surgery (i.e., not a national sample or limited use file with redaction of actual dates).

## 2. Methods

The University of Iowa Institutional Review Board determined that this research with previously collected public use data did not meet the regulatory definition of human subjects research.

The data were released by the Iowa Hospital Association [12]. The dates used were those available from the Iowa Hospital Association when the study was initiated: January 1, 2007, through June 30, 2017 (i.e., 21 half-year periods). We showed recently that, for the largest hospital in Iowa, semiannual data was the briefest period potentially to have significant changes in numbers of cases [13].

The number of surgical cases performed at each hospital during each half-year period was considered to be the count of unique combinations of hospital, patient, and date with at least one major therapeutic procedure (Table 1). Major therapeutic procedures were studied because these nearly always require an anesthesia provider for care, unlike minor therapeutic and diagnostic procedures, for which inferring anesthesia presence is unreliable. The inpatient procedures

were counted as major therapeutic if their International Classification of Diseases, Version 9, Clinical Modification (ICD-9-CM) or Version 10 Procedure Coding System (ICD-10-PCS) codes had corresponding categories of “procedures that are considered valid operating room procedures by the Medicare Severity Diagnosis Related Group grouper and that are performed for therapeutic reasons.” [14, 15]. Outpatient surgery procedures were counted as major therapeutic if the Healthcare Common Procedure Coding System (HCPCS) code had corresponding surgery flag code = 2, representing “invasive therapeutic surgical procedure.” [16]. No distinction was made between whether a case was listed in the inpatient or outpatient database because there would be little functional difference in cost between median hospital length of stay of 0 or 1 days [17, 18] (i.e., a difference of 1 day [19]).

The 10.5 years studied corresponded to 3834 days, of which 2740 were Mondays-Fridays. The count of cases with at least one major therapeutic procedure and performed on one of the 2740 days was calculated for each such day. The counts were sorted in ascending sequence. Days that had counts of cases up to the 3rd percentile (1st to 82nd of 2740 weekdays, where  $82 = \text{FLOOR}(0.030 \times 2740)$ ) were federal holidays. The days up to the 3.04th percentile (83rd to 93rd of 2740 weekdays, where  $93 = \text{FLOOR}(0.034 \times 2740)$ ) were all one day before and/or one day after federal holidays. Thus, we treated the days with fewer cases than the 3.04th percentile as holidays. The choice was unimportant to our study because there were 93 such holiday days as compared with 1094 weekend days (i.e., the percentages of cases performed on weekends or holidays was principally a function of weekends). Having chosen holidays, the N = 42 hospitals included were those with at least 10 cases performed during holidays or weekends for each of the 21 half-year periods (Tables 1 and 2; see Results Section 3.2).

### 2.1. Statistical analyses to test Hypothesis #1

If the percentage of cases performed on weekends or holidays were a constant, there would be no significant monotonic change over the N = 21 half-year periods. Kendall's  $\tau_b$  was calculated for each of the 42 hospitals between the percentage of cases performed on weekends or holidays and the half-year period. Calculations were performed using the STATA 15.1 *ktau* command (StataCorp, College Station, TX).

If the percentage of cases performed on weekends or holidays were a constant, there would be no serial correlation among successive periods. The run test for random order was performed for each of the 42 hospitals' percentage of cases performed on weekends or holidays. The orders studied were the successive 21 half-year periods. This test for serial independence counts the numbers of successive observations either greater than or less than the median percentage of the 21 periods. The STATA *runtest* command was used.

For each of the 42 hospitals, two models were fit to the data. First, the median percentage of cases performed on weekends and holidays

<sup>5</sup> Standard deviation calculated among 24 half-year periods.

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