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Are anesthesia start and end times randomly distributed? The influence of electronic records

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Abstract

Study Objective—To perform a frequency analysis of start minute digits (SMD) and end minute digits (EMD) taken from the electronic, computer-assisted, and manual anesthesia billing-record systems.

Design—Retrospective cross-sectional review.

Setting—University medical center.

Measurements—This cross-sectional review was conducted on billing records from a single healthcare institution over a 15-month period. A total of 30,738 cases was analyzed. For each record, the start time and end time were recorded. Distributions of SMD and EMD were tested against the null hypothesis of a frequency distribution equivalently spread between zero and nine.

Main Results—SMD and EMD aggregate distributions each differed from equivalency ($P < 0.0001$). When stratified by type of anesthetic record, no differences were found between the recorded and expected equivalent distribution patterns for electronic anesthesia records for start minute ($P < 0.98$) or end minute ($P < 0.55$). Manual and computer-assisted records maintained nonequivalent distribution patterns for SMD and EMD ($P < 0.0001$ for each comparison). Comparison of cumulative distributions between SMD and EMD distributions suggested a significant difference between the two patterns ($P < 0.0001$).

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Conclusion—An electronic anesthesia record system, with automated time capture of events verified by the user, produces a more unified distribution of billing times than do more traditional methods of entering billing times.

Keywords

Anesthesia billing; anesthesia procedure start times; electronic anesthesia record; end minute digit; start minute digit; procedure timekeeping

1. Introduction

Accurate billing is a critical issue in the complex world of healthcare reimbursement and spending. This is particularly true of time-based bills such as those generated by the practice of anesthesia. In contrast to other medical specialties, Medicare and other third parties use a unique calculation to determine compensation for anesthesiologists' services. For each anesthetic, preestablished base units are used to reflect the difficulty of the particular procedure. Extra modifier units are added based on the difficulty of the case. Then, for every 15 minutes that a patient is in the uninterrupted care of an anesthesia provider, an additional time unit is applied. Finally, the total of all units is multiplied by the local unit conversion factor to arrive at a final payment.

The length of surgery reflects a combination of surgical skill, procedure type, patient complexity, and a host of other perioperative factors within and outside the control of the surgeon. Time controlled exclusively by the anesthesiologist is usually a small portion of the total surgical time [1–3]. Consequently, anesthesiologists are reimbursed more for longer operations of the same difficulty. Inaccurate timekeeping may easily lead to underbilling, which may impact a practice's revenue stream, or to overbilling, which may be viewed as an intentional act (fraud), despite the fact that it is often an unintentional misrepresentation of anesthesia times. The Centers for Medicare and Medicaid Services (CMS) has explicitly declared that time units are to be rounded to one decimal place.¹ Currently, there are more penalties and fines related to Medicare medical billing than to any other sector of anesthesia billing [4]. Civil monetary penalties under 42 USC Section 1320a-7a range from \$10,000 to \$50,000 per violation, as well as an assessment of up to three times the amount claimed for each billed item (http://www.cms.gov/Outreach-and-Education/Medicare-Learning-Network-MLN/MLNProducts/Downloads/Fraud_and_Abuse.pdf). The current attention paid to healthcare policy and cost by healthcare providers, consumers, and payers corresponds to federal interest in billing fraud and its deleterious effects on taxpayers in the United States.

In this study, we conducted a frequency analysis of end minute digits (EMD) taken from the billing records of an academic anesthesia department over the past 14 months. We hypothesized that start minute digits (SMD) and EMD would be homogeneously distributed for records maintained entirely by computer, whereas billing with paper-based records would exhibit terminal digit bias with clustering of SMD and EMD around 0s and 5s. Given

¹Medicare Claims Processing Manual, Chapter 12, Part 50, Section G. Washington, D.C.: Centers for Medicare and Medicaid Services. In: <https://www.cms.gov/Regulations-and-Guidance/Guidance/Manuals/downloads/clm104c12.pdf>.

the theoretical differences in financial incentives between relative value unit (RVU)-generating academic faculty and locums tenens employees, we performed a separate subgroup analysis to examine EMD distribution patterns for those directly employed versus those locums tenens employees paid using an external reimbursement system unrelated to time-based billing.

2. Materials and methods

After approval by the University of Florida Institutional Review Board, we conducted this cross-sectional review on billing records from Shands Hospital at the University of Florida. Anesthetics included all of those conducted at Shands Hospital at the University of Florida, including those involving labor and delivery and those conducted at the Florida Surgical Center ambulatory surgery facility. Facilities at Shands Hospital at the University of Florida include the North Tower, where all types of procedures are performed; Florida Surgical Center, an ambulatory surgical facility; and the South Tower, a hospital opened in November of 2009, focusing on orthopedic, trauma, and oncologic procedures.

Anesthetic billing records between January 1, 2009 and March 31, 2010 were reviewed. This time period was selected due to the simultaneous use of three different anesthetic record keeping systems during a transition from manual anesthesia records to electronic anesthesia records. Each record was classified as an electronic anesthesia record (EAR), computer-assisted record (CAR), or manual anesthesia record (MAR) to further specify the type of anesthesia information management system (AIMS) employed for a given anesthetic case. The EAR was defined as an entirely electronic record, by which the anesthesia start and end times are entered simply by clicking the relevant icon. All EARs in this series were conducted using the GE Centricity Perioperative Anesthesia system (GE Healthcare, Waukesha, WI, USA). This system was the sole type of anesthetic record at the Florida Surgical Center and South Tower. Here, anesthesia start and end times were entered simply by clicking a button. The CAR system represented a hybrid approach whereby physiologic parameters were automatically recorded, but anesthesia start and end times were manually handwritten or typed into a tablet personal computer (PC) that collected vital sign data from anesthetic monitors and the anesthetic machine. The CAR system was custom-built and used nearly exclusively for cardiac anesthetics performed in two dedicated operating rooms (ORs) within the North Tower.

The MAR was defined as a strictly paper-based anesthetic record where anesthesia start and end times were manually entered. The MAR represented the default anesthetic record used in the North Tower. For methods requiring human entry, times are commonly entered by the certified registered nurse anesthetist/Anesthesia Assistant (CRNA/AA) or resident and are reviewed by the anesthesiologist for modification if entered in error, as the anesthesiologist retains the final responsibility for the case record.

During this study period, no ongoing analysis of anesthesia and/or surgical times was conducted for quality assurance purposes. Therefore, anesthesiologists, surgeons, and nurses had no hospital-driven incentives to modify any of the reported times. All record entry systems contained mechanisms for revision of the inserted anesthesia start and end times.

For each anesthetic chart, the anesthesia start and end times were recorded into a billing database at the conclusion of the anesthetic case, and from this database, the SMD and EMD for each time were then extracted for the purposes of this study. For instance, if the anesthesia start time was 09:24, then the SMD was 4. The specific OR also was recorded to appropriately classify the chart as an EAR, CAR, or MAR. Charts for which a locums tenens provider participated in the start and/or conclusion of an anesthetic were flagged as locums-involved. This flag designated the potential for an alternative motivation toward recording anesthesia billing times. Because standard OR start times at the University of Florida are 07:30, 08:00, and 08:15, we limited the data set to those cases beginning after 09:00 and before midnight to remove potential start time bias.

A total of 44,941 records were reviewed. When restricted to those cases beginning between 09:00 and midnight, 30,738 cases were included in the analysis. The majority of cases (75%) were performed in the North Tower, with 19% performed at the Florida Surgical Center, and 6% at the South Tower ($P < 0.0001$). All cases performed for labor and delivery, which comprise approximately 6% of total cases, took place in the North Tower. Seventy-three percent of cases were charted using the MAR, 26% with the EAR, and 2% using CAR ($P < 0.0001$). Locums tenens providers were involved in 8.1% of cases.

Tests for distribution of cases among various hospitals and record types were conducted using the chi-square test. The distributions of SMD and EMD were tested against the null hypothesis of an equivalent distribution pattern using a modified chi square test. That is, the null hypothesis maintained that the distribution of SMDs and EMDs (0 - 9) were equivalently distributed over 10 levels, with 10% in each level. The test of distribution was repeated for each type of anesthetic record, and for locums tenens versus nonlocum tenens. The actual distributions of SMD and EMD taken from nonlocums were then compared against the actual locums distribution as a tertiary comparison. Significance was predetermined with alpha set to 0.01 due to the large sample sizes involved. All analyses were conducted using SAS version 9.2 software (SAS Institute, Cary, NC).

3. Results

3.1 SMD

In aggregate, SMD ($P < 0.0001$) distributions differed from equivalency (Fig. 1). Values recorded as 0 or 5 were the most frequent overall events for SMD. Similar differences between recorded and the expected equivalent distributions were noted for MAR ($P < 0.0001$) and CAR ($P < 0.0001$) charting. No differences were observed, however, between recorded and the expected equivalent distributions for the EAR group ($P < 0.98$; Fig. 2).

3.2 EMD

In aggregate, EMD ($P < 0.0001$) distributions differed from equivalency (Fig. 3). End minute digits recorded as 0 and 5 were again the most frequent events for EMD. Similar differences between recorded and the expected equivalent distribution were noted for MAR ($P < 0.0001$) and CAR ($P < 0.0001$) charting, as observed with SMD. No differences were observed, however, between recorded and the expected equivalent EMD distributions in

EMD for the EAR group ($P < 0.55$; Fig 4). A comparison of the cumulative distributions of SMD and EMD suggested a statistically significant difference between the two distributions ($P < 0.0001$; Table 1).

3.3 First start times

To evaluate the effect that first-start cases may have on terminal digit bias, a separate series of analyses were conducted for surgeries beginning between 0700 and 0800. For EAR, there was no statistically significant difference for SMD ($P = 0.26$) or EMD ($P = 0.17$). There were significant differences among SMD and EMD for both CAR and MAR ($P < 0.0001$ for all comparisons; Table 2).

3.4 Locums tenens

The SMD and EMD distributions for providers reimbursed through the faculty group practice relative to locums tenens agencies were nonequivalently distributed ($P < 0.0001$ for each combination). EMDs of 0 and 5 represented 40% of all SMD and 50% of all EMD for the locums tenens providers versus 30% of SMD and 31% of EMD for nonlocums providers. A direct comparison of distributions among locums versus nonlocums providers suggests differing patterns of distribution for SMD ($P < 0.001$) and EMD ($P < 0.0001$; Table 2). Because of potential confounding due to EAR data entry, which exhibited homogeneous distributions for SMD and EMD, comparisons between locums and nonlocums faculty also were conducted separately exclusive of the EAR records. The differences from equivalency were maintained for each provider type in EMD and SMD distributions, even after excluding records charted using the EAR system ($P < 0.0001$ for each comparison).

4. Discussion

To the best of our knowledge, no previous studies have investigated the impact of end minute rounding relative to anesthesia billing times. Our results suggested that an EAR system, with automated time capture of events verified by the user, produced a more unified distribution of billing times than a paper-documented time entry. These findings were consistent across providers with different mechanisms of reimbursement such that neither locums nor nonlocums providers demonstrated homogeneous distributions, although higher rates of bias were observed for locums staff. No differences were noted in the distribution of terminal digits in comparisons of times entered at the beginning and end of an anesthetic.

Anesthesia information systems have become the cornerstone of information flow throughout the perioperative period [5]. These systems offer benefit over MAR systems in 7 separate domains: cost containment, operations management, reimbursement, quality improvement, patient safety, documentation, and clinical and translational research [6]. The accurate recording of anesthesia times specifically applies to the domains of cost containment, reimbursement, quality improvement, and documentation. To this end, our results corroborated previous work suggesting that manual records may be less accurate than EAR systems [7–9]. Reich et al demonstrated that MARs exhibit a “smoothing effect” across a range of hemodynamic variables [10]. A review of over 29,000 EARs documented that 19% of cases had at least one data point manually deleted or modified, with heart rate,

blood pressure (BP), and pulse oximetry values the most commonly invalidated measurements, although the authors did not include data concerning anesthesia start and end times [11].

One factor contributing to potential overbilling is the lack of individual provider consensus about the role of rounding in the listing of anesthesia billing times [12]. There have been few studies of rounding of billing and computerized medical records. While Spring et al found that computerized documentation improved anesthesia billing [13], our results suggested that it does not affect billing in regard to rounding of SMD or EMD. No prior studies have examined the impact of computerized anesthetic records on time-based recording and the potential avoidance of the appearance of fraud. Furthermore, little is known about human psychology as it relates to the role of rounding entered times that describe the anesthesia billing interval, ie, anesthesia start and end times.

The results of this study suggest that anesthesia start and end times are evenly distributed between digits 0 and 9, as observed by EAR entries. The focused densities clustered around 0 and 5 in the CAR and MAR likely represent the effects of terminal digit bias. Computerization of the anesthetic record itself did not seem to minimize the effect of rounding, as the CAR still required manual input of start and end times. Conversely, the EAR required the user only to initiate time recording, thus minimizing the opportunity for rounding times, and otherwise making alterations inconvenient.

The tendency toward rounding may reflect more about human psychology than financial impetus. Although attending anesthesiologists at our institution have a financial incentive to increase RVUs, they are not generally the ones who input those values; instead, this function is nearly always performed by the CRNA/AA or resident participating in the case. The divorce between time entry and financial motivation is furthered by separately analyzing times entered by locums tenens providers. Nearly all providers routinely use MAR and EAR in our system. Although fraudulent and/or misrepresentative time rounding to increase RVU generation is possible with the EAR, the absence of focal densities in the EAR analysis further shows that such rounding is not a deliberate, deceptive attempt to increase RVUs.

Rounding of anesthesia times may simply reflect innate human nature rather than a financially motivated action. Indeed, the preference in reporting certain end digits was first reported in the 1940s [14]. Reviews of census data suggest that socioeconomic and cultural differences may account for significant levels of rounding in reported ages. For instance, in China and Taiwan, there is an increased proportion of reported ages with an end digit of 3, but an apparent avoidance of end digits of 4. Census data collected from poorly educated populations demonstrate a predominance of reported ages ending in 0 and 5 [15]. A review of reported last menstrual periods collected in California in the 1980s suggested that the numbers 1, 5, 10, 15, 20, 25, and 28 were the most “preferred” recorded times, each occurring more frequently than would otherwise be expected due to chance. Furthermore, when compared with ultrasound estimates of gestational ages, last menstrual periods recorded as a nonpreferred value lead to more accurate gestational age estimates than those last menstrual periods estimated using “preferred” times [16]. Similar to our trend of

increasing clustering across time, the proportion of birth weights with zero recorded for the end digit increased as the birth weight itself increased [17].

Perhaps no group has explored the role of rounding in medicine as well as those involved in hypertension research. A review of 85,000 BP measurements from general medical practices in England between 2001 and 2003 demonstrated heaping of terminal digits according to the following descending order: 0, 5, even, and odd numbers. Overall, zero accounted for 64% of systolic (SBP) and 59% of diastolic readings, a substantial difference from the expected proportion of 10%, with a reported P -value < 0.000001 [18]. Addressing the concern that these results may reflect issues arising from a generalist practice, a review of end digit bias in BP measurements taken from a specialty hypertension practice found that zero was recorded for 40% of SBPs measured by nurses and 31% of SBPs measured by physicians [19]. There was less zero-preference for younger patients and those with elevated body mass indices. The authors attributed these trends to the increased attention paid to these populations within the clinic, although they were unable to offer evidence to support this theory [19]. Although these rounding behaviors may appear benign, a documented end digit of zero significantly increased patients' likelihood of being classified as eligible for pharmacologic therapy of hypertension across multiple hypertension treatment guidelines [20]. This broad tendency to round medical measurements across multiple disciplines suggests that rounding is likely an intrinsic aspect of human behavior.

For all three methods of entry for anesthesia start and end times, manual revision of the listed times was possible. It is important to note that during the studied time frame, there were no hospital-based quality improvement initiatives to optimize anesthesia and/or surgery ready times. That is, anesthesiologists did not receive feedback or critiques for overtly long or short anesthesia ready times. Anesthesiology teams certainly had the option to update the estimated anesthesia start and end times if they were not recorded in real time, although the prevalence of such a practice is unknown. Given the additional steps required for MAR and CAR entry of times in comparison to EAR, it is possible that the incidence of backlogging times was lower in the EAR than the MAR or CAR groups. The results suggested that even if there were similar patterns of backlogging among the three anesthesia record types, EAR backlogging was associated with less rounding. Given recent attention to documenting of anesthesia start and end times for quality improvement purposes, modern anesthesia information systems may wish to include automated electronic alerts of expected anesthesia start, ready, and end times to prevent backlogging of data entry minutes to hours from the actual times of event occurrence [21,22].

Our cross-sectional approach suffered from issues common to studies against large datasets. For instance, the large sample size necessitated loss of resolution and encounter-specific details and likely encompassed erroneously entered data that was not intentionally entered. Chi-square analyses likely overstated the significance of statistically significant differences among distributions, as the large sample size magnified even small differences among minute digit distributions. Therefore, we attempted to decrease the risk of a Type 1 error by setting alpha to 0.01. The choice of locums tenens providers as a subgroup with a reimbursement not based on times represents a suboptimal alternative to residents, whose possible financial motivations for rounding are likely minimal at best. Nevertheless, the

evident separations between time entries and financial incentive indicate rounding to be a pervasive, but subconscious, activity. A prospective study including psychometric evaluations would be necessary to more definitively capture the motivations behind rounding of billing times.

In conclusion, our data suggest that the entry of anesthesia start and end times are susceptible to terminal digit bias. This bias may be influenced by the AIMS, depending on the method of human-computer interaction. Further work is necessary to better characterize other effects of human-computer interaction on data entry bias for perioperative variables.

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Fig. 1.
Aggregate distribution of start minute digits.

Fig. 2. Distribution of start minute digits by type of anesthetic record. (**A**) The electronic anesthesia record followed an equivalent distribution pattern ($P < 0.98$), whereas (**B**) the manual anesthesia record and (**C**) the computer-assisted record exhibited clustering ($P < 0.0001$).

Fig. 3.
Aggregate distribution of minute digits.

Fig. 4. Distribution of end minute digits by type of anesthetic record. (A) The electronic anesthesia record followed an equivalent distribution pattern ($P < 0.55$), whereas (B) the manual anesthesia record and (C) the computer-assisted record exhibited clustering ($P < 0.0001$).

Table 1

Comparison of cumulative distributions between start minute digits (SMD) and minute digits (EMD)

Minute digit	SMD frequency	EMD frequency	SMD (%)	EMD (%)
0	5360	5228	17.44	17.01
1	2937	2604	9.55	8.47
2	2687	2778	8.74	9.04
3	2316	2236	7.53	7.27
4	2721	2732	8.85	8.89
5	4213	4872	13.71	15.85
6	2678	2643	8.71	8.6
7	2453	2456	7.98	7.99
8	2752	2521	8.95	8.2
9	2621	2668	8.53	8.68

Table 2

Comparison of frequencies and percentage distributions between locums and nonlocums providers in SMD and EMD entries

Minute digit	Nonlocums SMD frequency	Locums SMD frequency	Nonlocums EMD frequency	Locums EMD frequency	Nonlocums SMD (%)	Locums SMD (%)	Nonlocums EMD (%)	Locums EMD (%)
0	4797	563	4617	611	17	22.4	16.36	24.31
1	2713	224	2471	133	9.61	8.91	8.75	5.29
2	2473	214	2594	184	8.76	8.52	9.19	7.32
3	2171	145	2111	125	7.69	5.77	7.48	4.97
4	2511	210	2577	155	8.9	8.36	9.13	6.17
5	3771	442	4230	642	13.36	17.59	14.99	25.55
6	2467	211	2469	174	8.74	8.4	8.75	6.92
7	2284	169	2324	132	8.09	6.73	8.23	5.25
8	2560	192	2316	205	9.07	7.64	8.21	8.16
9	2478	143	2516	152	8.78	5.69	8.91	6.05

SMD=start minute digit EMD=end minute digit.