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# CAN REAL-TIME LOCATION SYSTEM REPLACE CURRENT STANDARD FOR CAPTURE OF LENGTH OF STAY?

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## ABSTRACT

***Background:*** *Emergency Department Length of Stay (ED-LOS) is a crucial measurement for clinical and operational decisions and is used for regulatory reporting and research purposes. Accurate and standardized measurement of this duration improves the effectiveness of decisions and findings. Further, automated capture can eliminate dependence on human task-based data-entry.*

***Objective:*** *Compare a real-time location system (RTLS)-based measure of LOS against the current standard of practice (EMR); examine factors associated with discrepancy in LOS.*

***Method:*** *Estimation of LOS using the first and last RFID record in the RTL system, and statistical assessment of their similarity to the corresponding measurement from the EMR.*

***Result:*** *Length of stay durations from the two methods have very similar distributions, with a slight shift.*

***Conclusion:*** *RTLS provides an efficient and standardized means to measure LOS.*

Keywords: RTLS, Length of Stay, Wearable device.

## BACKGROUND

ED crowding, as a barrier for effective and timely care has been discussed academically for decades since 1990 ([1] and [2]). One of the primary throughput measurements in ED crowding models is the patient's Length of Stay (LOS). LOS is defined as the duration from the first documented time at the patient's arrival to the ED to the time the patient departs from the ED [3]. Studies specifically are focusing on finding the factors that are affecting LOS directly and indirectly. For instance, Driesen, et al. [3] have done PRISMA analysis to investigate the root causes of increasing in ED-LOS or Chaou, et al. [4] have done a retrospective electronic data analysis over different factors affecting ED-LOS.

Considering the advancement in capturing the real-time location of patients and their movement, RTLS as an automated approach for gathering and reporting the data may reduce the potential human error. Laskowski-Jones [5] study has focused on the application of RTLS and its impact on workflow efficiencies. Arunachalam, et al. [6] have discussed the adoption of RTLS to optimize ED workflow. Boulos and Berry [7] also highlight how synchronization of RTLS with management systems of healthcare services, conceptually can decrease patients' waiting and transfer times. The real-world applications of RTLS for timestamp measurement in ED were discussed in Geers, Pasupathy [8] by emphasizing on patients abandonment factors. More specifically, Arunachalam, et al. [9] and Arunachalam, et al. [10] have studied the measurement of contact time of the patient care team during treatment using RTLS. But comparison of RTLS-based calculation of ED-LOS versus the electronic medical record (EMR)-based method has never been explored in literature due to the lack of availability of required technologies in practice [10].

Technically, the current approach of ED-LOS calculation is based on the timestamp pertaining to a manual task in the Electronic Medical Records (EMR) system. With RTLS being operational at Mayo Clinic's St. Marys Hospital ED in Rochester, MN, the comparison of EMR-based and RTLS-based methods can provide valuable insights for refinement and/or translation for practice use.

In this paper, the real-time calculation of ED-LOS using RTLS is compared with its current method. The pros and cons and the corresponding obstacles of such a shift are discussed and future challenges are discussed.

## MATERIAL AND METHODS

### A. Study Design and Data

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Mayo Clinic's St. Marys Hospital ED in Rochester, Minnesota, operates as one of the most modern emergency centers in the US. The emergency department has 73 rooms which were equipped with high-density RFID readers since 2015. More than 190 patients are treated per day and all receive RFID wristbands at registration time.

In this preliminary work, the one-month worth of RFID data acquired from 5,538 ED patients. Corresponding EMR records are extracted from the database for the same period. Approximately, ten percent of the records on either side with no matching pair on the other side were discarded during data cleaning and before analysis.

### B. ED-LOS Measurements

Current EMR protocols defined the ED-LOS as the time interval between arrival to ED and the physical departure of the patient from ED. These values are subject to human and system errors. To estimate the LOS using RFID, we proposed subtracting the first and last available records of RFID for each patient from the RTLS database, as shown in Figure 1.

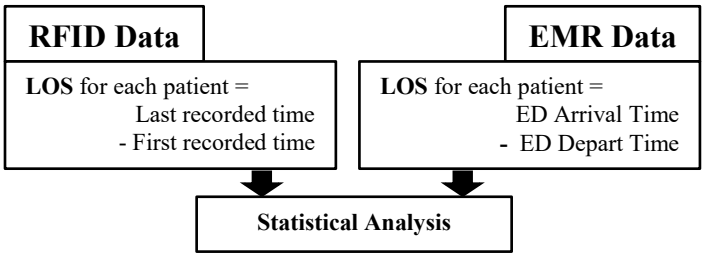


**FIGURE 1:** METHOD OF COMPARING RFID AND EMR DATA

### C. Statistical Analysis

To compare the similarity of LOS measurements using RFID and EMR records, the distribution of both data was computed. The mean and standard deviation of measurements from each source were also calculated. To assess the similarity of the two measurements, the percentage difference between the two measurements is computed as follows:

$$Avg\ Diff\ \% = \frac{EMR\_LOS - RFID\_LOS}{EMR\_LOS}$$

## RESULTS

Table 1 shows general comparison of the two approaches to measure the LOS in mean and standard deviation. It also provide -s the mean and standard deviation over all measurement ratios.

**TABLE 1:** MEAN AND STANDARD DEVIATION OF LOS OVER 5538 ED PATIENT VISITS, MEASURED USING RFID AND EMR DATABASE.

| LOS RFID (h) | | Difference % | | LOS EMR (h) | |
|---|---|---|---|---|---|
| **Mean** | **STD** | **Mean** | **STD** | **Mean** | **STD** |
| 3.62 | 3.85 | 0.06% | 1.3% | 4.18 | 5.61 |

As was known, the average LOS of data from EMR is about 4.18 ± 5.6 hours, while LOS measurements from the RFID system shows more stable values with a lower average of 3.62 ± 3.8 hours. Meanwhile, the average difference as a percentage between the two measurements over all patients is 0.06% ± 1.3% which confirms the similarity in the central tendency of these two measurements.

Figure 2 visualizes the distribution of the LOS values measured based on the RFID data (red), and the distribution computed from the EMR database (blue). This figure shows how well the two methods match in general, with a slight shift of the EMR-based LOS towards longer durations.

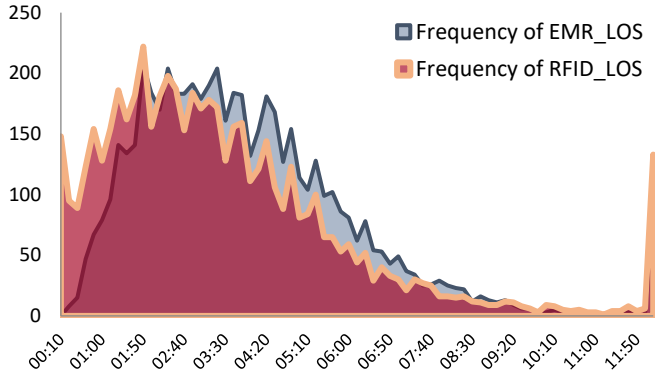


**FIGURE 2:** LOS DISTRIBUTIONS MEASURED USING THE TWO APPROACHES SHOW A SIMILAR PATTERN WITH A SLIGHT SHIFT TOWARDS LONGER DURATIONS.

To investigate the potential factors affecting this shift, we categorized patients based on different parameters including but not limited to the disposition type. There were six patients who left the ED without being treated and caused a huge difference between the two estimations, that were excluded from the rest of the analysis.

**TABLE 2:** RFID GENERALLY UNDERESTIMATED THE LOS COMPARED TO THE EMR DATA.

| Disposition Type | Average Difference% |
|---|---|
| Discharge | -5% |
| Elopement after treatment started | 3% |
| Expired | 12% |
| Hospital Observation | 13% |
| Hospital Observation (No ED OBS Bed) | 31% |
| Inpatient Admission | 10% |
| Left Against Medical Advice | **-34%** |
| To OR--Pending Final Disposition | 13% |
| Transfer to External Hospital | 34% |

Table 2 shows the average percentage difference values separately for each disposition type, excluding the left before treatment being completed. In this table, positive values represent cases, when the LOS extracted from the EMR, was

larger than the LOS measured by the RTLS system. As shown in this table, there is only one row with a considerably large negative value, namely the left against medical advice.

## DISCUSSION

Internet of things (IoT) technologies including RTL systems such as RFID has been used successfully used in the supply chain, logistics and manufacturing industries. It is well known that the installation and application of RTLS systems are expensive and some even medium-sized hospitals are in doubt of using this technology. However, articulation of the literature shows healthcare has started to acknowledge the importance of these systems. Successful integration of RTLS technologies into existing hospital workflow allows for better adoption and use.

In this paper, we proposed and evaluated the use of RFID sensors to provide an automated way of measuring the ED-LOS. A similarity assessment between the two methods was performed by computing the mean and standard deviation of the ratio of the two measurements. As shown in Table 1 the average difference percentage over all subjects is one, which indicates the overall similarity between the two methods.

Meanwhile, a relative shift between the two distributions was noticed. The discrepancy possibly lies in erroneous capture in both methods. For instance, the lag in a manual task can lead to prolonged durations. Future studies can focus on separately comparing arrival times and depart times to validate the use of RTLS for automated capture of LOS.

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