Original Investigation

Accurate measurement of ventilator length of stay and ventilator days for use in assessing patient safety and ventilator associated events

Kimiyo Yamasaki RRT [1], Joshua Mullen RRT [1], Denise Wheatley RRT [1], Ron Sanderson RRT [2]

DOI: https://doi.org/10.53097/JMV.10009

Cite: Yamasaki K, Mullen J, Wheatley D, Sanderson R. Unusual Accurate measurement of ventilator length of stay and ventilator days for use in assessing patient safety and ventilator associated events. J Mech Vent 2020; 1(2):26-31.

Abstract

Objective:

Accurate measurements of ventilator length of stay are important for quality measures and mandated by Centers of Disease Control for reporting ventilator associated events. However, it is unknown which method of such a calculation gives the more accurate results.

Design:

We collected data using three different methods of calculating ventilator length of stay in a community hospital ICU. The first method is the walk-through method for collection of data at 6 am, the second is a data base collection system we created where data was collected by respiratory therapists in a daily ventilator patient log then entered into the database, and finally from query of medical charges for ventilator days from financial department

Results:

There was statistically significant disagreement between the three methods. The walk though method and data base were not statistically different, but the data from financial charges overestimated the ventilator length of stay. Additionally, there was not statistically significant differences between the time of the walk-through data collection.

Conclusion:

Ventilator days and hours should be measured by a precise database rather than indirect methods of estimation like walk-through or financial charges. Patient exposure to risk, and reporting of ventilator time, whether days or hours should be measured directly, not estimated. A larger study needs to be performed to examine this variation in a broader medical setting.

Keywords: ventilator length of stay, ventilator associated events, ventilator associated pneumonia

Authors
1. Kimiyo Yamasaki RRT. Adventist Health Castle, Kailua, Hawaii, USA
2. Joshua Mullen RRT. Adventist Health Castle, Kailua, Hawaii, USA
3. Denise Wheatley RRT. Adventist Health Castle, Kailua, Hawaii, USA
4. Ron Sanderson, RRT, DrPH, MEd, AE-C. Respiratory center of Hawaii

Corresponding author: Kimiyo Yamasaki: kimiyo55@hotmail.com

Conflict of interest/Disclosure: None
Funding: None

Introduction

Question:
What is the most accurate way to measure "ventilator days" for quality assessment and infection control?

Ventilator days and ventilator length of stay (VLOS) were measured to calculate ventilator associated pneumonia (VAP) rate more than 15 years ago, which was recommended by the Centers for Disease Control and Prevention (CDC). VAP cases are the numerator and ventilator days are the denominator; VAP rate = VAP cases/1000 ventilator days. After years of trying to precisely define VAP, a complex algorithm was developed and VAP was replaced by ventilator associated event (VAE). VAE rate is still using 1000 ventilator days as the denominator. Unfortunately, neither VAE/VAP definitions nor precise measurement of ventilator days has been refined adequately to make VAE/VAP rate useful as a part of the CDC, [1] Hospital-Acquired Condition (HAC) reduction program that reduces payment to hospitals with high rates of certain preventable conditions such as Central-Associated Bloodstream Infection (CLABSI) and Catheter-Associated Urinary Tract Infection (CAUTI).

VLOS is critical data that helps us understand factors contributing the morbidity and mortality of the ventilator patients in intensive care unit (ICU). It is well established in the literature that increased VLOS is related to increased ICU length of stay (LOS) and hospital LOS, as well as increase morbidity and mortality of ventilator patients. [2,3]

VLOS is an outcome and dependent variable that can be used retrospectively to identify variation of independent variables such as mode of ventilation, physician practice and other interventions. Therefore, factors influencing VLOS are multivariate and can be subtle. Regrettably, appropriate attention has not been paid to this important measure. VLOS is linked to patient safety and quantifies a major drain of health care financial resources. In addition, VLOS data have not been systematically collected and analyzed. A National benchmark for VLOS and drill down of intra- and inter-hospital data is non-existent currently.

Collecting VLOS data involves keeping in mind two well-established, simple concepts. Mechanical ventilators provide necessary life support while exposing the patient to injury and possibly contributing to their death. Mechanical ventilators are used in the ICU and are extremely costly to the medical center, third party payers and patients.

Increased VLOS increases the rate of VAE. [4] Each case of VAE, formerly called VAP increases the cost to the hospital by $11,000 to $40,000 per case. [5,6] Each day on a ventilator in ICU exposes the patient to increased chance of healthcare related infections and injury. A ventilator day costs the medical center more than $4000/day. This cost is passed on to third party payers primarily Medicare and Medicaid. Despite difficult identification of VAE, it has been reduced across the nation due to implementation of the ventilator bundle and required reporting. In fact, there are other ventilator associated injuries whose costs far exceed the cost of VAP/VAE and are not analyzed or evaluated.

The need to measure VLOS outside clinical or academic research is now imperative. Interest in this measure has been generated by the impact of VAP on patient outcomes and institutions' bottom lines. The CDC and the Institute for Healthcare Improvement (IHI) [7] initially focused attention on reduction of VAP and are now requiring the measure of VLOS as a causative factor to VAE/VAP.

A few ICUs across the country have been attempting to determine their own VLOS for years. Unfortunately, not all ICUs collect their data in the same way. For example, many ICUs derive their data from "ventilator day" charges; a method which may report a 2-hour VLOS the same as a 47-hour VLOS (each counting as two days) if the 2-hour VLOS spanned midnight and the 47-hour VLOS spanned only one midnight. Other ICUs derive their data by simply walking through the ICU as recommended by the CDC at the same time each day and counting the number of ventilators currently in use; a method which systematically misses certain types of patients. This lack of a consistency in methods of data collection and interpretation has prevented any attempts to measure VLOS in a meaningful and comparable way.

The scientific method to measure VLOS is to document the date and time the patient was placed on the ventilator and the date and time the patient is discontinued from mechanical ventilation. VLOS by this method is precise and reliable. Any responsible medical center can collect this data from their medical record, but that has currently not been done consistently.
One study of 62 hospitals showed 19 million dollars savings if efficient ventilator management were being practiced. [8] This number extrapolates to 1.5 billion dollars per year. No hospital is purposely keeping

patients on ventilators, however, without a dependable way of measuring VLOS, hospitals have no way of knowing if their VLOS is unnecessarily high. For example, does ventilator discontinuation vary with time of day or day of the week? Needlessly allowing ventilator patients to stay on the machine over the weekend or overnight, or for even a few extra hours increases morbidity and expense.

Another valuable use for VLOS is the ability to track the performance of individual physicians. There may be significant VLOS variation among physicians managing ventilator patients. If VLOS is not compared among physicians, there is no way to identify and reward excellence or address inefficient practitioners. VLOS brings this practice variation into focus, so it can be addressed knowledgably and professionally. Patients are sometimes supported by ventilators unnecessarily in the post-anesthesia recovery room. This can be discovered in accurate VLOS data. Are post-surgical patients being taken to ICU to stay overnight because the anesthesia provider does not stay after a late case?

Therefore, implementation of ventilator bundles, ventilator weaning protocols, new modes should all be accompanied by following VLOS data. Logically, reducing VLOS by hours or a fraction of a day clearly increases patient safety and reduces cost. As a result, VLOS needs to be measured consistently and accurately. Looking at VLOS in these simple ways can make great improvements in increased patient safety, and reduced cost to healthcare.

In this study, we measured VLOS with three commonly used methods and compared the results and the gap between those methods.

Methods

This study was conducted in a 160-bed community medical center with an 8-bed open medical/surgical ICU with intensivist. IRB approval was not obtained as there is no possible connection between this study data and any specific patient, physician, or diagnosis.

Three methods of measuring total ventilator days were maintained over a 13-month period for total 468 patients.

1. A walk through as recommended by CDC for measuring ventilator days for the VAE reporting denominator. Standard walkthrough time chosen was 0600 counting all ventilator patients at that time.
2. A Ventilator Length of Stay (LOS) database with precise date and time of intubation and date and time of ventilator discontinuation was developed and maintained. This was an inter-relational ACCESS database where data was collected by respiratory therapists in a daily ventilator patient log. The log data was transferred to the ACCESS database by a respiratory therapist and cross-checked monthly to eliminate errors in data collection or entry.
3. Query of medical ventilator charges from the hospital finance department. These charges were entered by the finance department operators at midnight each day for every patient that was charged for mechanical ventilation that day.

We wrote a query from the database that reports the number of ventilator patients in the hospital from the time of placement on the ventilator until the time of ventilator discontinuation. As a result, we can report the number of ventilator patients at any time of day.

Results

The results of the three methods are summarized in Table 1 and Figure 1. Results of data base query by time of the day are summarized in Table 2 and Figure 2.

Statistical analysis done with one-way analysis of variants (ANOVA), additional T-test of equal variance done between each method to determine the differences between the three methods.
Analysis of variance shows that the three methods result are significantly different with P-value of 0.008. T-test between the walk through and database methods were not significantly different with P-value of 0.28. However, the T-test between the walk through and daily charges was significantly different with P-value 0.029, similarly the T-test between the data base and daily charges were significantly different with P-value 0.002.

Single factor ANOVA done to determine if the time difference for ventilator collection data and was not statistically significant with P-value 0.59.

Discussion

There is considerable variation and disagreement between the three methods of measuring ventilator days, even in this relatively small institution with small sample. The financial daily charges appear to

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Total
1.Walk through 6am	36	50	52	37	90	88	84	154	83	103	174	144	118	1213
2.Database	36.8	56.6	79.9	33.5	70.1	83.4	62.3	135.9	74.6	96.5	106.8	84.7	84.1	1005.2
3.Daily Charge	85	79	81	63	130	115	117	185	119	150	220	169	158	1671

Table 1
Comparison of Three Methods of Measuring Ventilator Days for 13 months with 468 patients

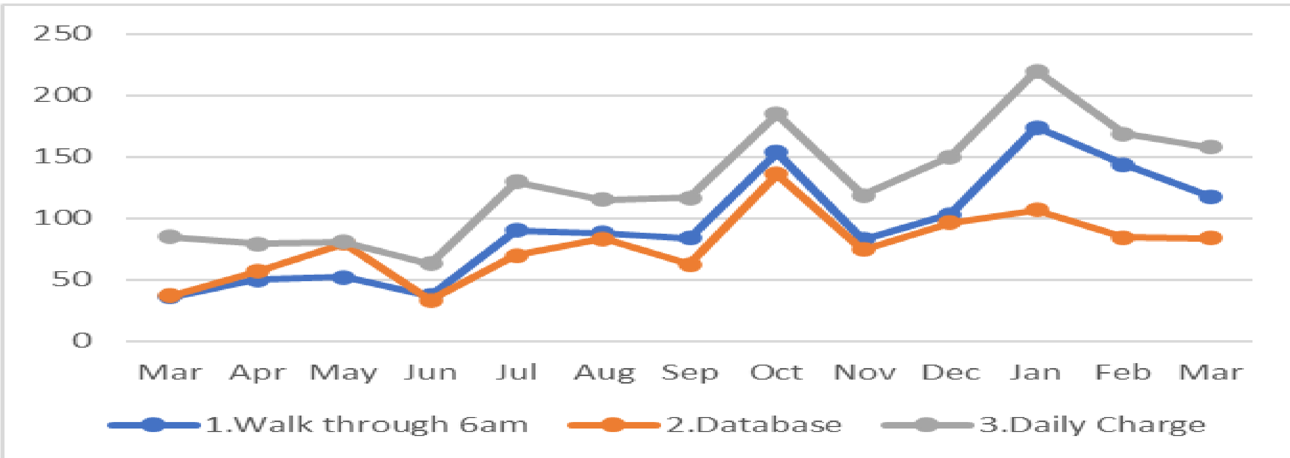

Figure 1:
Summary of results of the three methods.

Number of patients on ventilators at specific time of day during the 13-month period												
Time	0200	0400	0600	0800	1000	12pm	1400	1600	1800	2000	2200	12 am
# vent days	1082	1094	1097	1099	1073	1006	1013	976	989	1028	1057	1072

Table 2: Database Query Results of Ventilator Days at 2-hour intervals in a 24hr period

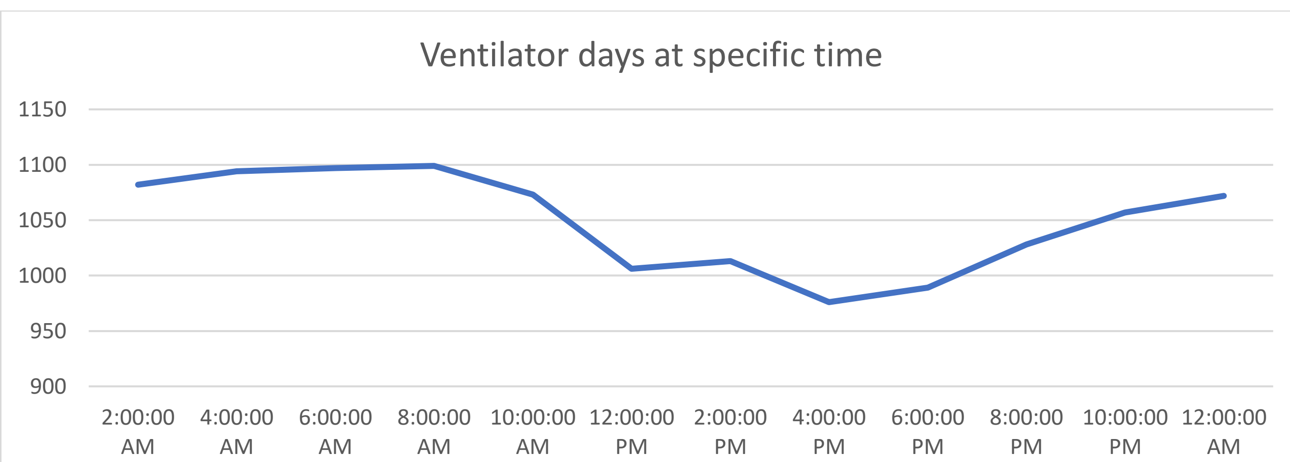

Figure 2:
Summary of difference of ventilator days as related to the time of the day in two-hour increments. The hour which shows the highest VLOS is 0800 hrs. with 1099 ventilator days while the hour which shows the lowest VLOS is 1600 hrs. with 976 ventilator days.

be non-reliable. Our results do not show a significant difference between the walk though and the data base methods, and there are no significant differences between the times within a 24-hour period as the data base obtained. The absolute time that patients are on ventilators taken from the precise database might be the best measure of patient exposure to risk and to report ventilator utilization for coding, billing, productivity, and other quality measures.

1000 ventilator days is the denominator for VAE reporting. The CDC recommends medical center walkthrough at a specific time to determine ventilator days. These data show that the choice of walkthrough time can change the magnitude of that denominator. If this medical center wants to have the best VAE reporting walk though, it appears to be at 8 in the morning. Walk through at 4 in the afternoon would be slightly different especially in a bigger center with more ventilator utilization. These numbers may vary with timing of spontaneous breathing trial (SBT), extubation times, timing of major surgeries, and activity schedule of intensivists and other staff.

Like our findings, Talbot and colleagues [9] found that the walk-through method of counting ventilator days has no significant difference between doing the walk-through at 8 pm or 4 am. We also found no difference between measuring at any time of the day. Caution has to be taken as this could be different in other institutions or different ICUs.

The inter-relational database could also be used to correlate ventilator hours to diagnosis, patients' age, physician, day of the week and hour of the day, as well as, any other interventions, mode of ventilation, or use of a new device that can be included in the data base. As an example of the benefits of such data, Burns and colleagues [10] implemented a clinical approach for their mechanically ventilated patients based on their data and were able to improve the VLOS, ICU LOS, hospital LOS and mortality and financial savings.

The ventilator day measured by daily charges is higher than other methods because the number of patients who are on a ventilator for only a few hours on any given day including the first day will be charged for one day.
It may be possible to precisely measure ventilator hours to calculate ventilator days for VAE/VAP reports and other quality measures by query of the electronic medical record or intelligent ventilators using PEEP as an indicator of time on and off the ventilator. This has not been reported.

The drawbacks of this study are the single ICU of a community hospital with small sample size. This data cannot be generalized to all types of medical centers; however, the factors contributing to this variation are in force in all medical centers.

Conclusion

Ventilator days and hours should be measured by a precise database rather than indirect methods of estimation like walk-through or financial charges. Patient exposure to risk, and reporting of ventilator time, whether days or hours should be measured directly, not estimated. A larger study needs to be performed to examine this variation in a broader medical setting.

References

1. Ventilator Associated Events. Document of the CDC January 2020. Accessed at https://www.cdc.gov/nhsn/pdfs/pscmanual/10-vae_final.pdf.

2. Moitra VK, Guerra C, Linde-Zwirble WT, et al. Relationship Between ICU Length of Stay and Long-Term Mortality for Elderly ICU Survivors. Crit Care Med. 2016; 44(4):655-662.

3. Ibrahim EH, Tracy L, Hill C, et al. The occurrence of ventilator-associated pneumonia in a community hospital: risk factors and clinical outcomes. Chest 2001; 120(2):555-561.

4. Tablan OC, Anderson LJ, Besser R, et al. CDC; Healthcare Infection Control Practices Advisory Committee. Guidelines for preventing health-care-associated pneumonia 2003: recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee. MMWR Recomm Rep 2004; 53(RR-3):1-36.

5. Rello J, Ollendorf DA, Oster G, et al. VAP Outcomes Scientific Advisory Group. Epidemiology and outcomes of ventilator-associated pneumonia in a large US database. Chest 2002; 122(6):2115-2121.

6. Chastre J, Fagon JY. Ventilator-associated pneumonia. Am J Respir Crit Care Med. 2002; 165(7):867-903.

7. Institute for Healthcare Improvement. Ventilator-Associated Pneumonia (VAP) Rate per 1,000 Ventilator Days. Retrieved from http://www.ihi.org/resources/Pages/Measures/VentilatorAssociatedPneumoniaRateper1000VentilatorDays.aspx

8. O'Neal PV, Ozcan YA, Ma Y. Benchmarking Mechanical Ventilation Services in Teaching Hospitals. Journal of Medical Systems 2002; 26:227–240.

9. Talbot TR, Starmer JM. Does the specific time of day used to capture data on ventilator-days have an impact on the documented rates of ventilator-associated pneumonia? Infect Control Hosp Epidemiol 2010; 31(5):548-550.

10. Burns SM, Earven S, Fisher C, et al. Implementation of an institutional program to improve clinical and financial outcomes of mechanically ventilated patients: one-year outcomes and lessons learned. Crit Care Med 2003; 31(12):2752-2763.