*Available online at* **www.ijmrhs.com**

**ISSN No: 2319-5886**

**International Journal of Medical Research & Health Sciences, 2019, 8(2): 115-119**

# Efficacy and Safety of Cloud based Continuous Monitoring Systems in Management of Patients in Non-ICU Settings in a Tertiary Care Hospital

**T. Anil Kumar[1], Ashwin Kulkarni[1]*, Sneha Dutta[2], Sneha Varghese[2] and Vishwanath K[1]**

*[1] Department of Medicine, Ramaiah Medical College, Bangalore, Karnataka*

*[2] Ramaiah College of Pharmacy, Bangalore, Karnataka*

**Corresponding e-mail: drashwinkulkarni@yahoo.in*

## ABSTRACT

***Introduction:*** *Continuous monitoring is the most vital aspect in the management of patients in non-ICU settings. Continuous monitoring systems have revolutionized the management of vulnerable patients which alerts the doctors to identify the critical events and intervene timely. In this study, we present our experience of using cloud connected continuous monitoring systems at our hospital.* ***Objectives:*** *To study the efficacy and safety of continuous monitoring systems in the management of patients in a non-ICU setting.* ***Material and methods:*** *A retrospective hospital-based study was conducted in the Acute Medicine ward (AMW) of Ramaiah teaching Hospital, Bangalore. Patients were connected to a cloud based continuous monitoring system for automatic collection and documentation of vital signs. All patients admitted in AMW between September 2017 and January 2018 was included in the study. For comparison, data were collected from September 2016 to January 2017 when the continuous monitoring systems were not implemented. We compared the number of admissions, code blue events.* ***Results:*** *Total of 470 patients in the pre-ICU settings were connected to a continuous monitoring system. There was 88% reduction in the ICU admissions as compared to the previous year. About 11.2% of patients were transferred to ICU and in these patients, continuous monitoring helped the doctors to identify the critical event. There was a significant reduction in code blue events using a continuous monitoring system. There was a significant reduction in medical expenses also.* ***Conclusion:*** *Continuous monitoring reduced the clinical burden on ICU due to the availability of remote monitoring capabilities, and continuous monitoring of reduced medical expenses for patients with improved clinical outcomes.*

**Keywords:** Continuous monitoring, Pre-ICU, Code blue, Viral fever

## INTRODUCTION

Continuous monitoring in the non-ICU setting has been shown to reduce ICU readmissions and hospital length of stay. In fact, up to 75% of non-do-not-resuscitate (DNR), hospital deaths occur in unmonitored settings outside the ICU. Currently, monitoring outside the ICU is a manual process with nurses spending nearly 15% of their time collecting and documenting vitals. Further, there is a high demand for ICU beds in MSR Teaching hospital with patients being turned away due to lack of bed availability leading to loss of revenue. We implemented a cloud based continuous monitoring system in the Acute Medicine ward (AMW) to manage vulnerable patients who did not have a clear indication for ICU-level care but required close surveillance. We hypothesized that the availability of the continuously monitored ward would improve ICU efficiency making it available only for the highest risk patients requiring interventional care. Further, this would also improve patient safety in the wards. A cloud-connected patient monitoring system, allows clinicians to manage patients remotely on their smart-phones. It measures key vital signs like heart rate, blood pressure, oxygen saturation, temperature, respiratory rate, and ECG.

- Cloud connected continuous monitoring system automates manual monitoring and documentation of vitals increasing nursing productivity
- It provides patient vital sign information every 5 minutes to generate high-resolution long-term trends that ensure the patient safety

- By remotely connecting patients to doctors through the smart-phone, continuous monitoring system ensures proactive clinical decision-making to improve patient outcomes

**Objectives of the Study**

To study the impact of continuous monitoring on patients in a non-ICU setting with special reference to a number of such patients shifted to ICU, code blue rates in the ward and safety of monitoring vulnerable patients in non-ICU settings.

## PATIENTS AND METHOD

A retrospective hospital-based study was conducted in M.S. Ramaiah Teaching Hospital, Bangalore in the Acute Medicine ward (AMW). The AMW is a 10-bedded ward where patients are continuously monitored with the cloud connected continuous monitoring system. Patients getting admitted were a vulnerable group of patients who did not require ICU care at the time of admission but required continuous monitoring for possible deterioration. Such patients usually get admitted in ICU just for monitoring, however, they might not require intensive management. Patients in AMW were connected to these monitors for automatic collection and documentation of vital signs. The long-term trends of vital signs and live vitals were monitored by nurses managing the ward on a tablet that centralizes all patient data. Treating physicians had remote access to long-term trends on their smart-phones through the app of the continuous monitoring system. All data was held securely and anonymously on the cloud. In the occurrence of any deterioration, patients were shifted to ICU and managed accordingly. For comparison and analysis, data was collected for the same period last year i.e. September 2016 to January 2017 when continuous monitoring systems were not installed. All patients admitted in AMW between September 2017 and January 2018 were included in the study. We have compared the number of admissions, number of code blue events. We have also tried to assess the outcome of patients who are on continuous monitoring in terms of safety, efficacy and its financial aspects.

## RESULTS

A total number of admissions in medicine wards and acute medicine ward to the hospital is shown in Table 1.

**Table 1 Number of admissions during the study period**

| Time-period | Sept. 2016 to Jan. 2017 | Sept. 2017 to Jan. 2018 |
|---|---|---|
| Total number of admissions in medicine wards | 1336 | 1920 |
| Admissions in Acute Medicine Ward | 0 | 470 |

The admission criteria and the reason for admission in AMW are explained in Table 2.

**Table 2 Admission criteria for AMW**

| Admission criteria for patients to the Acute Medicine Ward |
|---|
| Airway: Threatened airway |
| Breathing: RR<8 or>36 cpm, hypoxemia |
| Circulation: Systolic BP<90 mmHg with symptoms, PR<40 or>140 bpm |
| Neurology: Sudden collapse, suspected stroke, repeated or prolonged seizures |
| Miscellaneous: Age>60 years, COPD, sleep apnoea, an underlying severe co-morbid illness like chronic renal failure, hepatic encephalopathy, congestive cardiac failure |

**Table 3 Reason for admission**

| Diagnosis at Admission | Percentage |
|---|---|
| Viral Thrombocytopenic Fever | 35% |
| Other Acute Febrile Illness | 25% |
| Diarrhea | 15% |
| COPD/Bronchial Asthma | 10% |
| Anemia | 10% |
| Minor Strokes | 5% |

Only 11.2% of patients required transfer to the ICU for escalation of care, suggesting a reduction in ICU admission of 88%, where these patients would have been admitted in the absence of AMW (Table 4). About 76% of patients were safely moved to the wards, while 12.8% of patients continued to be monitored on continuous monitoring systems.

**Table 4 Outcomes after admission**

| Patient outcome within the first 48 hours of admission | Percentage |
|---|---|
| Shifted to ICU requiring ventilatory care | 4.0% |
| Shifted to ICU for intensive monitoring/inotropes/dialysis | 7.0% |
| Shifted to isolation ICU (neutropenia) | 0.6% |
| Shifted to general wards | 76.0% |
| Continued to stay in acute medicine ward for monitoring | 12.4% |

About 55 patients (11.6%) were transferred to the ICU for higher-level of care as indicated by worsening of clinical parameters, which was identified by the continuous monitoring system (Table 5).

**Table 5 Indication for ICU transfer**

| Indication for ICU transfer | Number of cases |
|---|---|
| Tachycardia, Hypotension | 30 |
| Arrhythmias* | 3 |
| Oxygen Desaturation | 15 |
| Alteration in Sensorium** | 10 |
| *patients moved to CCU **Clinical diagnosis made with altered vital parameters as detected on Stasis™ | |

Comparison of ICU load of viral thrombocytopenic fever patients during the study period vis-a-vis historic data revealed a 59.5% reduction of ICU load (Table 6).

**Table 6 Number of ICU shifts**

| Variables | 2016 | 2017 |
|---|---|---|
| ICU admissions (Includes main ICU and step-down ICU) | 111 | 45 (È59.5%) |
| Acute medicine ward, under StasisTM monitoring | - | 114* |
| *20 patients were moved to the ICU following identification of altered vitals on the continuous monitoring system | | |

These patients are typically kept under observation in the ICU as they are vulnerable to deterioration. With the continuous monitoring system, there was a significant reduction in this subset of patients being admitted to the ICU as they were managed in the Acute medicine ward (Table 7).

**Table 7 Events identified by continous monitoring systems**

| Study period | Total admissions in specialty | % Code blue |
|---|---|---|
| Sep 16-Jan 17 (pre-Stasis™ implementation) | 1751 | 0.17 |
| Sep 17-Jan 18 (post-Stasis™ implementation) | 2294 (Ç31%) | 0 (È100%) |

We saw a 100% reduction in code blues during the study period (0 code blues from 2294 admissions) vis-a-vis historic data (3 code blues from1751 admissions), despite a 31% increase in admissions.

### Patient Safety and Affordability

Notably, the cost of care in the AMW was 80% less than that in the ICU indicating a reduction in patient expenditure for better clinical outcomes. Finally, the nursing ratio in AMW was 1:4/5 vis-a-vis 1:2/3 in comparable wards without continuous monitoring systems, suggesting better resource utilization in AMW and significant cost savings to the hospital.

## DISCUSSION

The study demonstrated the use of a cloud-connected patient monitoring system that provides patients' vital information and ensures proactive clinical decision making to improve patient outcomes. In this study, we have compared the number of admissions and the number of code blue events before and after the implementation of stasis. In order to assess the impact of patients in ICU, the admission rates of patients diagnosed with viral thrombocytopenic fever admitted in ICU was analyzed.

The admission criteria for patients to the acute medicine ward is defined in Table 2. Among all the patients who were admitted and monitored by stasis 35% were treated for viral thrombocytopenic fever, 25% were treated for other acute febrile illness, 15% were treated for diarrhoea. About 10% from the same cohort were treated for exacerbation

of COPD or bronchial asthma while another 10% were treated for anemia. The rest of the 5% were treated for minor strokes. Compared to the study conducted by Drew, et al., 18% were treated for a cardiac medical or surgical diagnosis, 43% were treated for a neurologic or neurosurgical diagnosis, and 39% were treated for another medical-surgical (pulmonary, sepsis, multi-system organ failure, etc) diagnosis [1].

It was noted that 11.2% of the patients were transferred to ICU for advanced patient care characterized by worsening of clinical parameters identified by the monitoring system. The critical events identified includes severe bradycardia, tachycardia, desaturation, hypotension, and bleeding manifestations. The remaining 76% moved to the wards and 12.8% of the participants continued to be monitored on stasis. Patients with viral thrombocytopenic fever are usually monitored under ICU settings as there are chances for health deterioration. Of all the critical events identified on continuous monitoring systems, the majority of the cases accounted for hypotension and bleeding manifestations and altered sensorium in contrast with the study conducted by Hu, et al., where cardiac and respiratory arrests accounted for 74% and 22% of cases, respectively [2].

Comparing the ICU load on patients, it was observed that there was 59.5% reduction of ICU load even though there was a 31% increase in the admissions. This was in accordance with a study conducted by Taenzer, et al., which showed a statistically significant reduction of 2.1% in ICU admissions post the implementation of continuous monitoring systems [3]. A study conducted by Zimlichman, et al., also showed a 39.5% decrease in ICU transfers [4]. On the contrary, a study conducted by Brown, et al., the overall ICU admission rates did not change even after the implementation of the monitoring systems [5,6].

With the implementation of continuous monitoring systems, there was a significant reduction in the number of patients admitted to the ICU as they were managed in the Acute Medicine Ward. Prior studies in this area have focused on vital signs at the time of admission. In this study, we were able to validate the Modified Early Warning Score (MEWS) as good predictors of mortality at any time point during the period of hospitalization [7]. In this study, it was noted that there was a 100% reduction in code blue out of 2294 admissions during the study period in comparison to the previous data which revealed that there were 3 code blues from 1751 admissions, in spite of 31% increase in patient admissions. This was as opposed to a study conducted by Hu, et al., where among the patients monitored by alarm systems, the majority of code blue events occurred in ICUs (68%) with 23% code blue events occurring in non-ICU units, and 9% in other facilities including OR and interventional suits [2].

The cost of care in Acute Medicine Ward was 80% less than that of ICU indicating a reduction in patient expenditure with better clinical outcomes. Clinical confidence and user satisfaction with continuous monitoring systems were very high. More than 90% of the clinicians found remote monitoring with stasis was more convenient during non-duty hours, suggesting clinical adoption of stasis. This was in accordance with the study conducted by Watkins, et al., where the majority (79%) of surveyed staffs strongly agreed that the monitor provided valuable patient data that increased patient safety and 92% of the nurses agreed that the number of alarms and alerts were appropriate [8].

The study shows that continuous monitoring of vulnerable patients is safe and efficacious. It reduced the burden on ICU wherein ICU beds can be utilized for more sick patients who need more intensive management. It reduces the incidence of code blue events in the wards. Critical worsening parameters can be identified at the right time and interventions can be done.

From the above results, it shows that continuous monitoring of vulnerable patients is safe and efficacious. It reduced the burden on ICU and ICU beds can be utilized for more sick patients who need more intensive management. It reduces the incidence of code blue in the wards. Critical worsening parameters can be identified at the right time and interventions can be done.

## CONCLUSION

Continuous monitoring in the non-ICU setting reduced the patient burden on ICU and ensured the use of ICU beds for the most deserving cases. It increased patient safety and reduced code blue rates in the wards. It also reduced the clinical burden due to the availability of remote monitoring capabilities. It substantially reduced medical expenses for patients with improved clinical outcomes. We recommend continuous monitoring for the following subset of patients to improve outcomes and operational efficiencies:

- High-risk pregnancies and complicated deliveries for at least 24 hours post-delivery

- Post-operative cases and major surgical cases for at least 24 hours post-surgery
- Geriatric patients with co-morbidities for the first 48 hours after admission
- COPD patients with the requirement of domiciliary oxygen therapy
- Patients moved from the ICU for the first 24 hours

## DECLARATIONS

**Acknowledgement**

We thank Dr. Narendranath, Chief Administrator, Dr. Kamath Assistant Administrator for providing the support for data collection. Dr. Roheet Rao and his team for providing the technical support and guidance

**Conflict of Interest**

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

## REFERENCES

[1] Drew, Barbara J., et al. "Insights into the problem of alarm fatigue with physiologic monitor devices: a comprehensive observational study of consecutive intensive care unit patients." *PloS One,* Vol. 9, No. 10, 2014.

[2] Hu, Xiao, et al. "Predictive combinations of monitor alarms preceding in-hospital code blue events." *Journal of Biomedical Informatics,* Vol. 45, No. 5, 2012, pp. 913-21.

[3] Taenzer, Andreas H., et al. "Impact of pulse oximetry surveillance on rescue events and intensive care unit transfersa before-and-after concurrence study." *Anesthesiology: The Journal of the American Society of Anesthesiologists,* Vol. 112, No. 2, 2010, pp. 282-87.

[4] Terrence, J., et al. "Effect of contactless continuous patient monitoring in a medical-surgical unit on intensive care unit transfers a controlled clinical trial." *American Journal of Respiratory and Critical Care Medicine,* Vol. 185, 2012.

[5] Brown, Harvey, et al. "Continuous monitoring in an inpatient medical-surgical unit: a controlled clinical trial." *The American Journal of Medicine,* Vol. 127, No. 3, 2014, pp. 226-32.

[6] van Loon, Kim, et al. "Non-invasive continuous respiratory monitoring on general hospital wards: a systematic review." *PLoS One,* Vol. 10, No. 12, 2015.

[7] Gao, Haiyan, et al. "Systematic review and evaluation of physiological track and trigger warning systems for identifying at-risk patients on the ward." *Intensive Care Medicine,* Vol. 33, No. 4, 2007, pp. 667-79.

[8] Watkins, Terri, Lynn Whisman, and Pamela Booker. "Nursing assessment of continuous vital sign surveillance to improve patient safety on the medical/surgical unit." *Journal of Clinical Nursing,* Vol. 25, No. 1-2, 2016, pp. 278-81.