International Journal of Basic and Applied Biology
Print ISSN: 2394-5820, Online ISSN: 2349-2539, Volume 2, Number 6; July-September, 2015, pp. 408-414

http://www.krishisanskriti.org/ijbab.html

Performance Analysis of Tele-ICU in Present Day Healthcare Industry & Implementation of Standard Care Protocols

Sumit Saini[1] and Anju Gupta[2*]

[1,2]Guru Jambheshwar University of Science & Technology, Hisar - 125001, Haryana, India
E-mail: [1]sumit.healthcareit@gmail.com, [2]anjugupta.bme@gmail.com

Abstract—*Tele-ICU is a command centre in which a critical care team (intensive clinicians and critical care nurses) is connected with patients in distant ICUs to exchange health related data through real-time audio, visual, and electronic means. The aim of the study is to analyse Performance of Tele-ICU in present day healthcare industry & how Implementation of standard care protocols affects the performance. This study also includes various methodologies followed to check the performance changes, and cost-effectiveness of tele-ICU and to study the possible challenges to broader adoption. While our studies conclude on cost based on mortality and length of stay has reduced, actual costs were not reported. Another problem with this is lack of consistent measurement, lack of knowledge, reporting, and adjustment for patient severity. From the data available, tele-ICU seems to be a promising path, especially Tier II & Tier III cities where there is a limited number of certified specialists.*

The standard care protocols should be followed in the ICU to diagnose and treat the patients. These include drugs, fluids, investigations, insertions, procedures, observations and checks which have been grouped into programs. The care giver (physician or nurse) can quickly select the appropriate start up program for the patient and modify it later according to the diagnosis, thus potentially allowing more time for him/her to concentrate on the patient. Use of standard care protocols help to tackle problems such as the facilitation of shared care, the reduction in junior doctors' hours, reduction of LOS of patients, and reduction of mortality rate as well. Such protocols provide a locally agreed standard to which the organization and clinicians can work and against which they can be audited.

1. INTRODUCTION

Tele-ICUs are networks of audio-visual communication and computer systems that link critical care doctors and nurses (intensives) to intensive care units (ICUs) of other remote hospitals. One common problem is a shortage of intensive clinicians in the Tier-II & Tier III cities, and the demand for them is also going to increase with the increase in the population. Our research have shown that hospitals with a dedicated intensive clinicians on staff had a significant reduction in ICU mortality and average LOS. The complexity of today's ICU services entails the need for sharing health information through off-site ICU centers. Tele-ICU is the use of health information exchanged from a hospital critical care unit to another site via electronic communications. The physician in the "command center" can communicate by voice with the remote ICU personnel and can receive clinical data about the patients. Tele-ICU intensive clinicians provide real-time services to multiple care centers regardless of their locations.

Tele-ICU uses an off-site command center in which a critical care team (intensive clinicians and critical care nurses) is connected with patients in distant ICUs through real-time audio, visual, and electronic means. Similar to a bedside team, offsite tele-ICU intensive clinicians require full access to patient data. Tele-ICU is capable of providing real-time monitoring of patient instability or any abnormality in laboratory results, ordering diagnostic tests, making diagnoses and ordering treatment, and implementing interventions through the control of life-support devices. As a result, tele-ICU holds great promise in improving the quality of critical care given to patients and increasing the productivity of intensive clinicians. This article explores the available studies related to efficacy and cost-effectiveness of tele-ICU applications and outlines possible barriers to broader adoption.

2. AIMS AND OBJECTIVES OF STUDY

2.1 Designing Of Standard Care Protocols–Objective achieved

We designed some basic protocols to be followed in the ICU to treat protocol specific cases. Based on our analysis, we came up with designs of 3 standard care protocols:

- OP Protocol
- Snake Byte Protocol
- VAP Prevention Protocol

2.2 Creating and Development of these designed Care Protocols–objective achieved

Based on our design, we started development of these 3 designed care protocols. We followed predefined workflow specific to each protocol which we finalized in our designing phase. In each care protocol program we included drugs, fluids, investigations, insertions, procedures, observations and checks which have been grouped into programs. E.g.: OP Protocol that need to be followed in the ICU to treat OP poisoning cases.

To **conFig. a new care protocol** we followed these steps:

1. Select the Patient Group for which you want to define the protocol.
2. Select the desired care element from the Observations and Interventions list.
3. The selected care element will appears in the **Protocol** details list.
4. In the Name field, enter a name for the protocol i.e. OP Protocol. This name will appear in the patient application.

Similarly we created OP Protocol, Snake Bite Protocol & VAP Prevention Protocols.

2.3 Implementation of Protocols–Objective Achieved.

Once configuration of care protocols are done, then we concentrated on implementation of these care protocols on selected sites.

One of our selected sites had Total ICU Bed Occupancy with **Organophosphorus Poisoning (OP) & Snake Byte Poisoning** cases as follows:

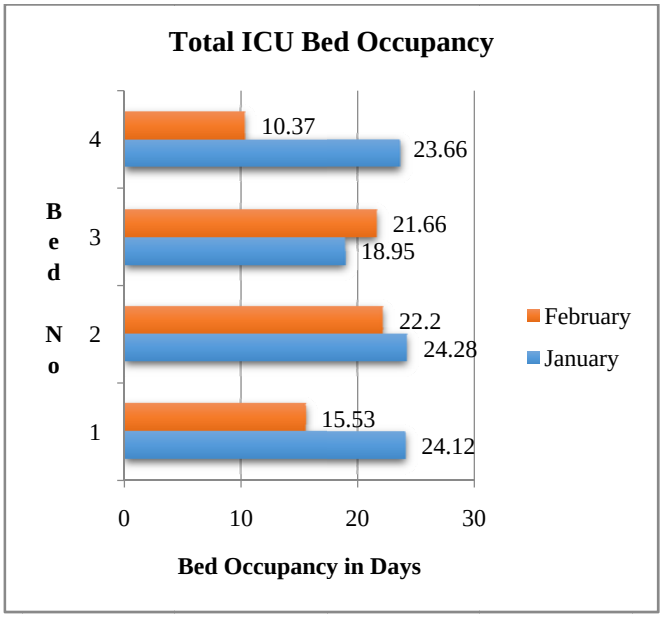

Fig. 1: Total ICU Bed Occupancy in Days.

In these ICU Beds, Distribution of Organophosphorus Poisoning (OP) & Snake Byte Poisoning Cases over Patient Groups & Sex was as follows:

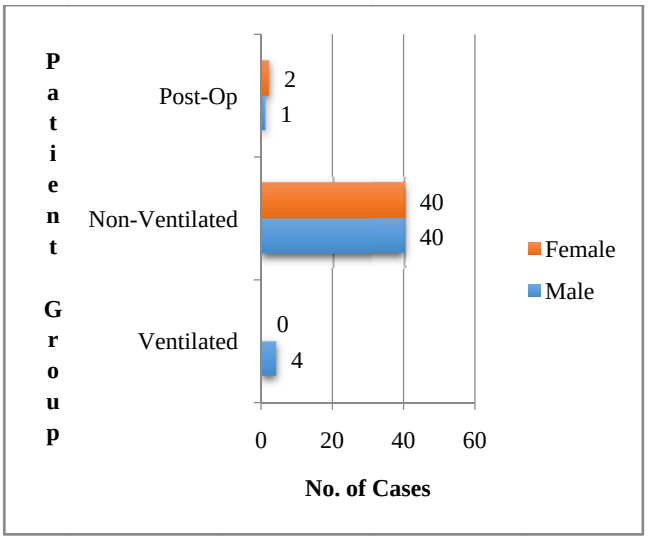

Fig. 2: Distribution of Total Number of Cases over Patient Groups & Sex.

In these ICU Beds, Distribution of **Organophosphorus Poisoning (OP) & Snake Byte Poisoning** Cases over Diagnosis was as follows:

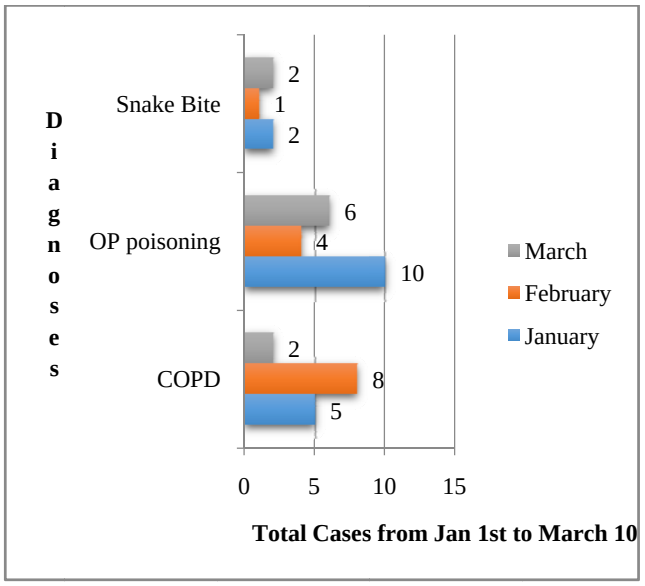

Fig. 3: Distribution of OP & Snake Byte Poisoning Cases over Diagnosis.

2.4 Analysis And Final Verification Of These Protocols–Objective achieved

After Implantation of these care protocols in ICUs, we observed drastic improvement in the recovery of the patients.

	Diagnosis vs ICU Outcome over time											
	January				February				March			Grand Total
Name	Improved	No change	Dead	Transferred	Improved	No change	Dead	Transferred	Improved	No change	Dead	
Acquired valvular defect	1			1								2
Acute renal failure								1	1			2
ARDS					1							1
Asthma			1		1							2
Bleeding disorder								1				1
Cardiogenic shock		1	2					1				4
Chronic Kidney Disease on Hemodialysis					1							1
COPD	3	1		1	6		1	1	1			14
Ischemic Heart Disease		1										1
Meningitis		1										1
OP poisoning	6		2	2	4				2	1		17
Others (unregistered diagnosis)	7		1	2	6	1	3		4		2	26
Pneumonia					1							1
Postoperative care	2											2
RTA		1	1									2
Snake Bite	1			1	1				1			4
Surgery and high risk patient	4											4
Trauma	2											2
Grand Total	26	5	7	7	21	1	4	4	9	1	2	87

Fig. 4: Analysis Report of Implementation of Care Protocols.

As shown in the above picture, no of deaths decreased gradually from January to March.

2.5 Point-In-Time Critical Care For The Patients–Objective achieved

Tele-ICUs use telecommunication networks to provide expert support and counsel 24hrs to ICUs in remote hospitals. Major benefits include improved access to physicians and experienced critical care nurses. This also providing an extra layer of support to ICU staff all seven days a week and evening shifts, as well as during emergencies. Our study also found out that Approximately 50 tele-ICU command centres reach more than 200 hospitals and 10 percent of all critically ill patients. This following example illustrates how this objective is achieved: A person goes into cardiac arrest and he manages to reach Medical Centre as early as possible. He was immediately taken to the ICU, where an abnormal heart rhythm begins to develop. Another arrest could have occurred soon. Every moment was crucial. Little is known about the patient at this point, and key lab results are pending. Many things need to be taken care simultaneously like entering orders for care, reviewing lab results as they become available, and researching the EHR for essential history and details about the patient.

2.6 Enable Standardization of Care–Objective achieved

Some of the following procedures are examples of how Tele-ICU plays a major role in Standardization of care: Implementation of Standard CARE PROTOCOLS in ICU systems. Virtual Rounding which can be achieved only by sitting and analysing the patient from Tele-ICU command centre. Patient care hand-offs just by connecting to the camera connected to the patient's bed.

Electronic Documentation which again helps us in reducing paper work.

2.7 Design Protocols for 24*7 Monitoring of Patient Vital Parameter Using Clinical Rules–Objective achieved

To monitor patients vital parameters 24*7, we integrated notification system with the bed side ICU application and created rules & notification messages, and direct the sending of messages. Clinical rules consist of a trigger, a condition and a notification. Trigger is an ICU data item that starts the rule evaluation when it is saved in the ICU specific database. Condition contains the clinical reasoning and knowledge. If the condition is evaluated as 'True' with patient data, a notification is generated. Notification is a message that is shown in the ICU Application Patient Inbox and can be further sent by e-mail.

The following is an overview of how we defined a rule. The example rule is triggered by the B-Hgb value and the rule checks whether the value is below 90 g/L. The notification message shown is -Hgb is low (85 g/L)

First, assign a new rule to a group. Then define the trigger and the need for validation.

Define the rule details.

a) Give a name to the rule and assign it to a group.

b) Set the rule to active.

c) Select the trigger.

2.8 Virtual Rounding For Acutely Ill Patients Proactively & Periodically–Objective achieved

Virtual Rounding is centralized or remotely based critical care team is interconnected with the bedside ICU team and patient via audio-visual communication and computer systems. Virtually an intensive clinicians and experienced critical care nurse will be added to the team at the patient's bedside. The tele-ICU team can provide support for a large number of ICU patients irrespective of geographical locations for multiple hospitals.

2.9 To Reduce Length Of Stay Of The Patient In Hospitals This In Turn Helps Them In Saving Money–Objective achieved

Decreased length of stay (LOS) is the key outcome measure for ICUs. There is substantial evidence that the intensive clinicians model can lead to reduced LOS in both the ICU and the hospital. In all, 6 of 13 studies found a statistically significant decrease in hospital LOS and 11 of 17 found a significant decrease in ICU LOS.

Patient Outcomes after ICU Installation[14]		
Outcome	Low-Intensity Staffed ICU	High-Intensity Staffed ICU
ICU LOS	2–13 days	2–10 days
Hospital LOS	8–33 days	7–24 days
Mortality	12 percent	8 percent

Fig. 5: Patient Outcomes after Tele-ICU Installation.

After implementation of standard Care Protocols which we configured, there was significant decrease in ICU LOS. Our research showed that the adoption of tele-ICU in a heterogeneous ICU population decreased ICU LOS. This indicated that tele-ICU cases of similar type and acuity still had better outcomes than their non-tele-ICU counterparts, and both unadjusted and adjusted data indicated decreased ICU LOS. Additionally, we observed that secondary outcomes such as hospital LOS, ICU mortality, and hospital mortality decreased as a result of tele-ICU as well. Study also showed that tele-ICU improved ICU survival and hospital survival.

Below picture is the graphical representation of LOS in Days:

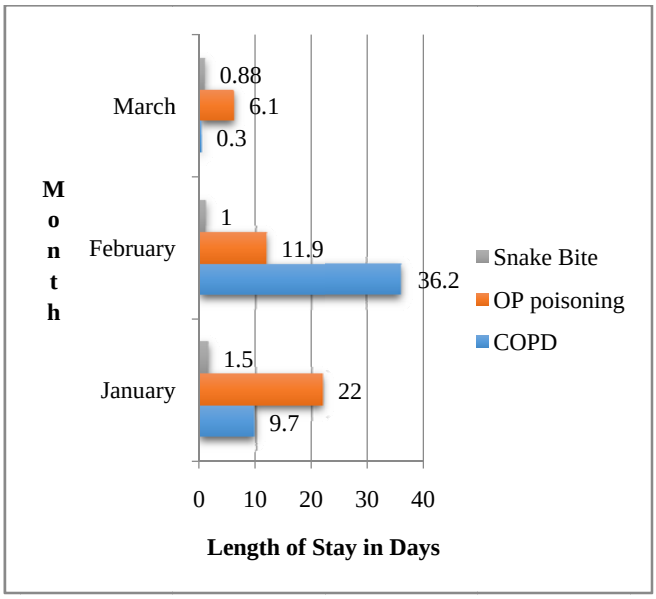

Fig. 6: Graph of Reduction of LOS in days after implementation of Care Protocols.

2.10 To Give Medical Care To The Rural Poor And Improve Their Health Status–Objective achieved

In rural areas, health care systems struggle to maintain adequate numbers of clinical staff to serve their patient populations. Medical specialists are in particularly short supply. Although more percent of the Indian population resides in rural areas, very less percent of physicians and lack of specialists practice in these areas. Lack of access to medical specialists is not just a rural problem. Many urban areas also do not have enough specialists to provide care in fields such as heart attacks and others. Studies have shown that Tele-ICU can improve access to specialty care in such areas.

2.11 To Reduce Paper Work–Objective achieved

Tele-ICU not only allows physicians to see more patients online in a day but also with less paperwork to complete. Tele-ICU is the use of health information exchanged from a hospital critical care unit to another site via electronic communications. Electronic databases were searched to identify relevant patient information. Electronic data handling will result in reduction of paperwork.

2.12 To Reduce Probability Of Infections During The Process–Objective achieved

We found out from our research that Tele-ICU adoption resulted in lower rates of preventable complications such as VAP or bloodstream infections. In Tele-ICU, there is very less shifting of patients form one hospital to another hospital which will result in reduced septic & infections. Early administration of enteral nutrition restores intestinal capability and functioning, improves wound healing and decreases chances of infections. These benefits leads into the reduction of complications reduced length of stay and decreased risk of death.

2.13 To Reduce Human Errors–Objective achieved

Major percentage of patients dies because of human errors in India. Intensive care unit (ICU) is the major area where errors occur frequently. Despite the impact of these errors, little research has identified the human factors that contribute to errors in the ICU. In addition, we also identified the contribution of certain devices to the prevalence of error. More importantly, the most critical devices for patient care were also identified as the devices that were rated highest in prevalence. Developing medical devices designed to reduce the device-related potential for patient harm should be a primary goal in patient safety. Recent study suggested that nearly 17 percent of all hospital admissions resulted in an Adverse Event (AE), with half of these being preventable. Historically, a human error in clinical settings has been treated as an issue of clinical risk management, the aim of which was to deal with the consequences of AEs by controlling the potential for litigation based on claims of medical negligence. Several alternative approaches have been proposed and applied to improve our understanding of human error in health care.

Human Error Reduction Technique provides below mentioned factors:

a) Lists possibilities of errors associated with a set of generic task types.

b) The probabilities for error are identified based on a review of the human performance and human factors.

c) Human Error Reduction Technique provides a list of error-producing conditions (EPCs) that can affect both task performance and the potential to increase the probability of error when a specific task is performed in the presence of these conditions.

d) This approach helps in identification of conditions and task features that can lead to estimates of the human error.

Basis of our approach includes:

a) Unfamiliarity with a situation.

b) Time pressure in error detection.

c) Low signal-to-noise ratio.

d) Mismatch between an operator's mental model and that imagined by the device designer.

e) Impoverished information quality.

f) Ambiguity in performance standards.

g) Disruption in normal work-sleep cycles.

h) Unreliable instrumentation.

The analysis results of our study illustrate us the possibility of increasing our understanding of human errors related to devices in the ICU. This is very important to achieve the goal of improving patient safety.

3. STANDARD PROTOCOL

3.1 OP Protocol for the ICU: Protocol Description

Organophosphate poisoning (OP) is an important clinical problem in rural areas. Organophosphate compounds are a diverse group of chemicals used in both domestic and industrial settings, such as pesticides, ophthalmic agents and anthelmintic. Organophosphate compounds inhibit esterase enzymes, especially acetylcholinesterase in synapses and on red-cell membranes. Acetylcholinesterase inhibition results in accumulation of acetylcholine and overstimulation of acetylcholine receptors in synapses of the autonomic nervous system, CNS, and neuromuscular junctions, resulting in muscle overstimulation. Symptoms include muscle weakness, fatigue, muscle cramps, fasciculation, headache, convulsions, ataxia, depression of respiration and circulation, tremor, increased salivation, lacrimation, sweating, urination, paralysis & possibly coma.

In bedside ICU applications, we can define some basic protocols to be followed in the ICU to treat OP poisoning cases. These include drugs, fluids, investigations, insertions, procedures, observations and checks which have been grouped into programs. The care giver (physician or nurse) can quickly select the appropriate startup program for the patient and modify it later according to the diagnosis, thus potentially allowing more time for him/her to concentrate on the patient.

4. METHODOLOGY

4.1 Method 1:

In small hospitals where standard protocols are not implemented, we noted down some of the key factors like:

- How patient's raw data is collected & which data is being used.
- What is the LOS of the patient?
- What is the cost of the treatment?
- What is the time taken for the treatment?

4.2 Method 2:

In large scale hospitals where all standard protocols are being implemented, again the following key factors are noted down:

- How patient's data collection strategy changed.
- How length of stay of the patient reduced.
- How there was a significant reduction in the cost of the treatment.
- How the time taken for the treatment reduced.

5. EXPECTED OUTCOME

The acute nature of ICU patients' healthcare needs and the high cost associated with critically ill patients makes survival rates and cost savings among the most desirable outcomes measured. Consequently, integration of distance monitoring and intensive clinicians' services into bedside care were significantly associated with a decrease in the mortality rate and LOS in hospitals that were early adopters of tele-ICU. By optimizing telemedicine applications in the ICU, both the mortality rate and LOS could be influenced positively.

6. KEY BENEFITS OF TELE-ICU

Tele-ICU solution provides lots of advantages not only for patients, but also for hospitals also. Some of them are as follows:

6.1 For Hospitals:

Our tele-ICU program works in conjunction with the hospitalists and other members of the onsite clinical team. The Advanced ICU Care team is involved in monitoring the ICU patient care through secure access to patient information from check-in until discharge, and is able to provide round-the-clock patient care and staff assistance. Once a patient is admitted in the ICU, Advanced ICU Care provides real-time patient monitoring, with contact between the Advanced ICU Care team and the bedside nurse, hospital staff and the patient's family. If a patient's condition changes, the Advanced ICU Care intensive clinicians is able to promptly address the situation–saving time and lives. The combined

skills and collaboration between the Advanced ICU Care staff and the hospital team help ensure that patients receive immediate and effective care.

6.1.1 Solving challenges for Hospitalists:

Through the continuous support of live video monitoring and conferencing, hospitalists benefit from the advanced technology of Advanced ICU Care in several ways. We focus on the ICU, so you can focus on the rest of the hospital. Hospitalists in our partner hospitals have told us that they:

- Are more productive and able to focus on patient care
- Experience fewer interruptions from the ICU due to the 24/7 availability of intensive clinicians expertise to monitor and direct clinical interventions such as ventilator changes or intubation
- Have increased leadership support for clinical initiatives with timely data analysis, protocols, recommendations and resources for making change
- And, most importantly, are better rested and have improved work-life balance

6.1.2 A track record of success

Through the application of evidence-based, standardized best practices, tele-ICUs are expert recommendations and 24/7 availability to hospital doctors and nurses. A tele-ICU program provides long-term solutions to help improve ICU performance. And, Advanced ICU Care has a proven track record of successful partnerships with hospitals across the country. On average, hospitals that incorporate Advanced ICU Care's solution into their ICUs achieve:

- 40% improvement in mortality rates
- 25% improvement in length of stay
- 17% improvement in ICU admissions

6.2 For Patients:

- Better and affordable care with benefits of improved LOS.
- Able to stay & get treated in peripheral set-ups more often with similar quality of care as metros.
- Avoid expensive/dangerous transfers in critical conditions.

7. CHALLENGES

- Even though Tele-ICU solution has lots of advantages and better outcomes, we also cannot ignore the challenges we have if we go for this solution. Some of them are:
- Lack of knowledge about these techniques in nurses.
- Short supply of intensive care specialists and experienced critical care nurses.
- Limited resources and devices in small hospitals of Tier II & Tier III cities.
- Another biggest challenge is financial problem in such small cities, villages.
- Setting up the solution, travelling, approaching physicians, all these will consume more time and money than expected.
- Another challenge is Internet. Internet is the key factor of complete Tele-ICU solution.

Tele-ICU is a new solution; there is a lack of knowledge in many bedside doctors and nurses because of which they do not understand how the system works. The purpose of the system is to provide improved safety through redundancy and enhance outcomes through standardization of care by implementing STANDARD CARE PROTOCOLS. The tele-ICU team plays a supportive role; they have an update of all the patients in the unit and can alert the bedside staff if any problems occur. Our study noted that "the hospital admitting physician continued to be the attending of record and was responsible for establishing the care plan," while the tele-ICU staff were the primary contact for the on-site nurses.

Another challenge in ICU is the technology acceptance by the clinicians. This could be one major reason why some studies did not show improvement in LOS and mortality in tele-ICU patients. The lack of integration and the lack of interoperability were other problems at some hospitals, especially those that did not have electronic records. Sometimes the monitored unit will not share clinical notes or computerized provider order entry which will be a major challenge for Tele-ICU; instead, these notes were faxed daily.

REFERENCES

[1] Advisory Board (2006) "The eICU: Beyond the Hype."

[2] Anthony (2001) Anthony, L.C. ET. al., "The eICU: It's not just telemedicine," Crit. Care Med. 29, No 8 (Suppl.) N183-9

[3] Bekes (2004) Bekes, C. "PRO: Multiplier," Criti. Care Med. 32, No. 1 287-8

[4] Berge (2005) Berge K. H., "Resource Utilization and Outcome in Gravely Ill Intensive Care Unit Patients With Predicted In-hospital Mortality Rates of 95 percent or Higher by APACHE III Scores: The Relationship With Physician and Family Expectations," Mayo Clinic Proceedings

[5] Breslow (2004) Breslow, M. J., ET. Al."Effect of a Multiple-Site Intensive Care Unit Telemedicine Program on Clinical and Economic Outcomes: An alternative paradigm for intensive clinicians staffing," Crit. Care Med. 32 , No. 1 31 -38.

[6] District Govt. Hospital, Tumkur.

[7] Max Healthcare, Delhi. (http://www.Maxhealthcare.com/)

[8] Karnataka State Healthcare Project.

[9] HRSA (2006) Health Resources and Services Administration's Report to Congress "The Critical Care Workforce: A study of the Supply and Demand for Critical Care Physicians"

[10] Lemshow (1988) Lemeshow S., ET. Al.., "Predicting the Outcome of Intensive Care Unit Patients," Journal of American Statistical Association, 83 No 402, 348-356

[11] Lemeshow (1993) Lemeshow, S., ET. al., "Mortality Probability Models (MPM II) Based on an International Cohort of Intensive Care Unit Patients," JAMA, 270(20) 2478-86

[12] Leong (2005) Leong, J. R., ET. al., "Journal Club Critique: eICU program favourably affects clinical and economic outcomes," Critical Care 9 E33 (http://ccforum.com/content/9/5/E22 /) [Commentary on Breslow (2004)]