A Quality Improvement Initiative for Early Initiation of Emergency Management for Sick Neonates

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Objective: To determine efficacy of Point-of-care Quality improvement (POCQI) in early initiation (within 30 minutes) of emergency treatment among sick neonates.

Design: Quality improvement project over a period of twenty weeks.

Setting: Special Newborn Care Unit (SNCU) of a tertiary care center of Eastern India.

Participants: All consecutive sick neonates (≥ 28 wk gestation) who presented at triage during morning shift (8 am to 2 pm).

Intervention: We used a stepwise Plan-do-study-act (PDSA) approach to initiate treatment within 30 min of receiving sick newborns. After baseline phase of one month, a quality improvement (QI) team was formed and conducted three PDSA cycles (PDSA I, PDSA II and PDSA III) of 10 d each, followed by a post-intervention phase over 3 months.

Main outcome measure(s): Percentage of sick babies getting early emergency management at SNCU triage.

Results: 309 neonates were enrolled in the study (56 in baseline phase, 88 in implementation phase and 212 in post-intervention phase). Demographic characteristics including birthweight and gestational age were comparable among baseline and post intervention cohorts. During implementation phase, successful early initiation of management was noted among 47%, 69% and 80% neonates following PDSA I, PDSA II and PDSA III, respectively. In comparison to baseline phase, the percentage of neonates receiving treatment within 30 minutes of arrival at triage increased from 20% to 76% (P<0.001) and the mean (SD) time of initiation of treatment decreased from 80.8 (21.0) to 19.8 (5.6) min (P<0.001) during post-implementation phase. Hospital mortality (33% *vs* 15%, P=0.004) and need for ventilator support (44% *vs* 18%, P<0.001) were also significantly lower among post intervention cohort in comparison to baseline cohort.

Conclusion: Stepwise implementation of PDSA cycles significantly increased the percentage of sick newborns receiving early emergency management at the SNCU triage, thereby resulting in better survival.

Keywords: *Outcome, PDSA cycle, Point-of-care Quality improvement, Triage.*

Perinatal and neonatal care have improved remarkably over last few decades, resulting in substantial decrease in national neonatal mortality rate; although, as per India Newborn Action Plan, our goal is to achieve single digit neonatal mortality rate by 2030 [1,2]. This entails addressing the major causes of neonatal mortality including cost effective strategy to solve the problems [3]. We detected various lacunae within our system (reducing delay in emergency management of sick babies, ensuring early initiation of breast feeding, reducing sepsis, ensuring KMC in eligible babies) which can be addressed to reduce neonatal death.

Existing literature revealed that delay in emergency treatment of sick neonates may increase the risk of mortality and long term morbidities [4,5]. We also noticed that outborn babies referred from distant places are more vulnerable to death in comparison to inborn babies. These neonates were already compromised during the time of referral. Even after reaching at referral centre, these already compromised out born babies suffer further delay in initiating emergency treatment due to various administrative and procedural reasons. A relevant prospective cohort study observed similar findings and documented that hourly delay in initiation of appropriate resuscitation or persistence of hemodynamic abnormalities was associated with a statistically significant increased risk of death among sick neonates [4]. Based on this literature review, we planned to undertake a quality improvement (QI) initiative to reduce the time of initiation of management of neonates presenting to triage with emergency signs. We prioritized reducing delay in emergency management of sick babies, because it is important to patient outcomes, affordable in terms of time and resources, easy to measure and under control of team members.

METHODS

All consecutive sick neonates presenting at the triage area during morning shift (8 AM to 2 PM) of a tertiary-care medical center between February and June 2017, were approached for enrolment. Neonates attending triage seeking emergency management during the month of February 2017 formed baseline cohort; those during March 2017 formed implementation cohort; and those between April and June 2017 formed post-intervention cohort. Neonates with major congenital malformations, neonates of <28 weeks of gestation and who expired shortly (within thirty minutes) after receiving in the triage area were excluded (***Web Fig. 1***). We defined a neonate as sick if presenting with any of the emergency signs: Significant hypothermia (axillary temperature < 35.5°C), apnea or gasping respiration, severe respiratory distress [rate >70, severe retraction (subcostal, intercostals and supraclavicular and suprasternal retraction), grunt], central cyanosis, shock (cold periphery, Capillary filling time >3s, heart rate >160/min) coma, convulsions or encephalopathy [6]. The study was approved by the Institutional Review Board of our institute and informed written consent was obtained from parents of each enrolled neonate.

According to POCQI module [7] quality improvement team comprised of total nine members (a team leader, one supervisor, an analyser, two time keeper and communicator and four nursing staffs) including two faculty members was formed. The team reviewed the literature on evidence based practices for emergency management, and presented the recommendations informally which were then agreed upon or modified for local implementation.

Baseline phase and Root cause analysis: A time keeper and communicator, who were not involved in managing the sick neonate, were commissioned as observer to note the practices and the time of initiation of emergency management by using stop watch in triage. The doctors and the nursing staffs involved in management received no feedback about the time of initiation of management of sick neonates. During baseline phase, 20% (56) sick neonates attended SNCU triage received treatment within 30 minutes and median time to initiate emergency treatment was 80 minutes (60 to 104 minutes) (***Web Fig. 2***).

We performed a cause and effect analysis of delay in emergency care using process flow chart (***Web Fig. 3***), fishbone diagram (***Web Fig. 4***) and a key driver diagram (***Web Fig. 4***). While analyzing the existing process flow chart, used at our SNCU triage, we found that maximum delay occurs during receiving the baby, examining by the on duty doctors and execution of advice by the nursing staff (***Web Fig. 3***). We found following lacunae; there was no assigned doctor and nurse in triage area, no measurement of time by using stopwatch, no separate emergency tray in triage, lack of urgency, no written policy, and lack of positive attitude.

The aim of the study thus was to initiate early (within 30 min) emergency management of sick neonates at triage of SNCU from baseline 20% to at least 80% over a period of eight weeks of baseline and implementation phase (February-March, 2017).

Implementation phase: We tested change ideas, studied and acted upon these change ideas to achieve our aim. Three Plan-Do-Study-Act (PDSA) cycles, each for ten days, were conducted in morning shift (8 AM to 2 PM). During PDSA 1, doctors and nurses of morning shift were assigned by preparing a separate triage roster and designated them by using triage sticker. Throughout PDSA 2, we arranged a separate emergency tray in triage by using check list. During PDSA 3, we arranged training of doctors and nurses about POCQI module and emergency triage assessment and treatment (ETAT); and displayed the treatment protocol in triage [6-9]. During the implementation phase, a corrected process flow chart was used (***Web Fig. 5***). Balancing measure was overcrowding at triage area. Frequent feedback with run charts of percentage of babies receiving emergency treatment within 30 minutes and appraisal in weekly meetings were done to motivate stakeholders and encourage compliance.

Post-intervention phase: Between April and June 2017, the QI team encouraged the implementation of the change ideas of early initiation of emergency management, continued to monitor the percentage of sick neonates receiving treatment within 30 minutes with run chart and provided feedback to the treating residents and nursing staffs. To identify opportunities for process improvement, the QI team continued to meet with clinical teams weekly, audited cases of delayed management and addressed logistic issues related to supplies and equipment.

Pertinent maternal and neonatal data were documented in case record forms. The time gap between the arrival of a sick neonate in the triage and initiation of treatment was noted using a stop watch. The primary outcome was percentage of sick babies getting emergency early management at SNCU triage. Secondary outcomes were hospital mortality, requirement of mechanical and non-invasive respiratory support and requirement of ionotropic support.

Statistical analysis: Statistical analysis was done by using SPSS for Windows version 16 software (SPSS Inc., Chicago, Illinois). Between groups, data for continuous variables were evaluated using a *t* test for independent variables. Comparisons of proportions were made using Chi-square testing.

RESULTS

Among total 390 sick neonates, 356 were enrolled (56 in baseline phase, 88 in implementation phase and 212 in post intervention phase) in this study (***Web Fig. 1***). Demographic characteristics were comparable among baseline and post intervention cohorts (***Table* I**).

TABLE I DEMOGRAPHIC CHARACTERISTICS OF NEONATES ENROLLED IN THE STUDY

Characteristics	*Baseline (n=56)*	*Implementation Phase (n=88)*	*Post intervention Phase (n=212)*
Maternal characteristics			
*Maternal age, y	28 (3)	27 (5)	28 (4)
Preterm delivery	18 (33.3)	35 (39.7)	98 (46.2)
#Risk factors	0	5 (5.7)	13 (6.1)
Maternal hypertension	12 (22.2)	14 (16)	26 (12.3)
Maternal diabetes	6 (11)	7 (8)	19 (9)
Vaginal delivery	37 (66.6)	52 (59)	125 (59)
Neonatal characteristics			
#Gestational age (wk)	36 (1.3)	37 (1.2)	36 (1.6)
#Birthweight (g)	2312 (180)	2380 (208)	2346 (160)
Male gender	31 (55.5)	56 (63.6)	137 (64.6)
AGA	43 (77.7)	53 (60.2)	155 (73.7)
SGA	12 (22.2)	33 (37.5)	52 (24.5)
LGA	1 (0.1)	2 (2.3%)	5 (2.4)
Significant hypothermia	24 (44.4)	17 (19.3)	84 (40.7)
Apnea/gasping	18 (33.3)	56 (63.6)	82 (39)
Severe respiratory distress	20 (36)	33 (37.5)	87 (41)
Central cyanosis	5 (0.08)	4 (4)	59 (2.8)
Shock	12 (22.2)	47 (53.4)	88 (41.5)
Convulsions/coma/ encephalopathy	18 (33.3)	58 (66)	80 (38.5)

*Data expressed in n(%); *mean (SD) and #median (IQR); AGA (appropriate for gestational age); SGA (small for gestational age); LGA (large for gestational age); #Risk factors for early onset sepsis include: very low birth weight (<1500 g), prematurity, prolonged rupture of membranes(>24 h), foul smelling liquor, multiple (>3) per vaginum examinations in 24 h, intrapartum maternal fever (>37.8°C).*

During implementation phase, we registered successful early initiation of management among 47%, 69% and 80% of sick neonates following PDSA 1, PDSA 2 and PDSA 3, respectively (***Web Fig. 6***). Throughout the time of post implementation phase, 80%,76% and 74% of sick neonates received early emergency treatment during each month of April, May and June of 2017, respectively. (***Fig*. 1**). In comparison to baseline phase, the percentage of neonates receiving treatment within 30 minutes of arrival at triage increased from 20% to 76% (*P*<0.001) and the mean time of initiation of treatment decreased from 80.8 (20.9) to 19.8 (5.6) minutes (*P*<0.001) during post-implementation phase (***Fig*. 1** and ***Table* II**). Hospital mortality (33 *vs* 15%, *P*=0.004) and need for ventilator support (44 *vs* 18%, *P*<0.001) were also significantly lower among post- intervention cohort in comparison to baseline cohort (***Fig*. 1** and ***Table* II**). There was substantial improvement in early emergency management during evening and night shift (42% and 33%, respectively) without implementing PDSA cycles (***Web Fig*. 7**).

DISCUSSION

This QI effort was a stepwise introduction of measures to initiate emergency management of sick neonates within 30 minutes driven by PDSA cycles. We showed improvement in mean time of initiation of treatment, without crowding in the triage area which was our key balancing measure. The mean time decreased by 60 minutes and the percentage of neonates received treatment within 30 minutes increased from 20% to 80%. This improvement was sustained throughout the post-intervention phase.

Han, *et al*. [4] conducted a nine-year retrospective cohort study of 91 infants and children who presented to local community hospitals with septic shock and required transport to central referral centre. They showed that when community physicians had implemented therapies

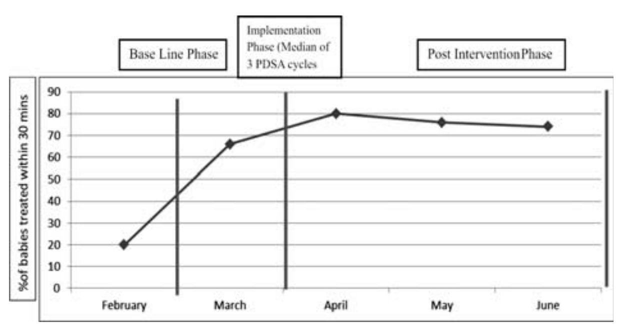

***Fig*. 1** *Percentage of neonates treated within 30 minutes in baseline phase, implementation phase and in the post intervention phase.*

WHAT IS ALREADY KNOWN?

- Early initiation of emergency management at triage reduces complications and mortality among sick neonates.

WHAT THIS STUDY ADDS?

- A quality improvement initiative focusing on stepwise successful implementation of PDSA cycles significantly increased the number of sick newborns receiving early emergency management at SNCU triage, thereby resulting in better survival.

TABLE II OUTCOME OF SICK NEONATES ENROLLED IN BASELINE AND POST-INTERVENTION PHASE

Characteristics	*Baseline phase (n=56)*	*Post-intervention phase (n=212)*	*Odds ratio/ Mean difference (95% CI)*	*P value*
Neonates treated within 30 min	11 (20)	161 (76)	12.91(6.21-26.81)	<0.001
Time of initiation of treatment*	80.8 (20.96)	19.8 (5.6)	-61.0 (-64.18 - -57.8)	<0.001
Hospital mortality	18 (33.3)	32 (15)	0.37 (0.19-0.73)	0.004
Total hospital stay (d)#	16 (10-24)	12 (8-22)	–	–
Need for ventilator support	24 (44.4)	38 (18)	0.29 (0.15-0.54)	<0.001
Duration of ventilator support (d)#	4 (2-6)	3 (2-5)	–	–
Need for ionotropic support	18 (33.3)	35 (16.5)	0.41 (0.21-0.81)	0.01
Need for >1 ionotropes	12 (22.2)	29 (13.6)	0.58 (0.27-1.22)	0.15

*Values in No. (%), #Median (interquartile range) or *mean (SD).*

that resulted in successful shock reversal (within a median time of 75 minutes), almost all of the infants and children presenting with septic shock survived. That each hour of delay in resuscitation was associated with a 50% increased odds of mortality. Rivers, *et al*. [5] showed that implementation of early goal-directed therapies in the emergency department, improved survival outcomes in adult septic shock significantly. Study by investigators in London also found that avoidable delays and inappropriate management contributed to poor outcome among children with severe meningococcal disease [10].

Booy, *et al*. [11] described a remarkable improvement in outcome of meningococcal disease by dissemination of recommended guidelines for managing meningococcal disease to area community hospitals through educational outreach programs, facilitation of early communication and management recommendations between the local and referral hospital, and utilization of a mobile pediatric critical care transport team. By implementing these change ideas there was an impressive reduction of mortality from meningococcal disease in Southern England from 23% to 2% in a span of just 6 years [11].

In our study, we implemented some simple measures in a stepwise manner through PDSA cycles as per POCQI module [7]. Each PDSA cycle helped us to test small interventions leading to valuable learning and refinement of neonatal emergency management. Moreover, clinical team was motivated with prominent display of run charts which served as an instant display of outcome. This enabled team ownership, enthusiasm, participation and an opportunity to improve. The percentage of babies receiving early emergency management were increased remarkably in evening and night shifts, though we did not assign any dedicated doctor and nursing staff for triage in these shifts. Secondary outcomes like in-hospital mortality, need for mechanical ventilation, and need for ionotropic support also decreased significantly.

Our study has several limitations. Firstly, being a single-center study, all the interventions implemented by us may not be generalizable to other settings. Moreover due to lack of human resources we were not able to assign nursing staff and doctors separately for triage in evening and night shift. Secondary outcomes like mortality is affected by a numerous factors other than delay in initiation of treatment, we did not study those factors. Hence, to further establish our study findings, further research is necessary with large sample size incorporating all factors.

We decided to share our study findings with appropriate authorities to motivate them and to ensure further logistic support and human resources to implement these change ideas in other shifts and health delivery facilities. Stepwise successful implementation of PDSA cycles significantly increased the percentages of sick newborns received early emergency management at SNCU triage and thereby resulting in better survival among them. However, larger trial over longer duration with continued surveillance is required to confirm this fact.

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Contributors: AM and MB contributed equally to this study. AM: study design and execution, preparation of manuscript and critical review; MB, BM, SM, BA: study design and execution, data collection and analysis, preparation of manuscript; BB: data analysis, preparation of manuscript and critical review. All authors agreed and approved the final version and vouch for the accuracy of the submitted manuscript.

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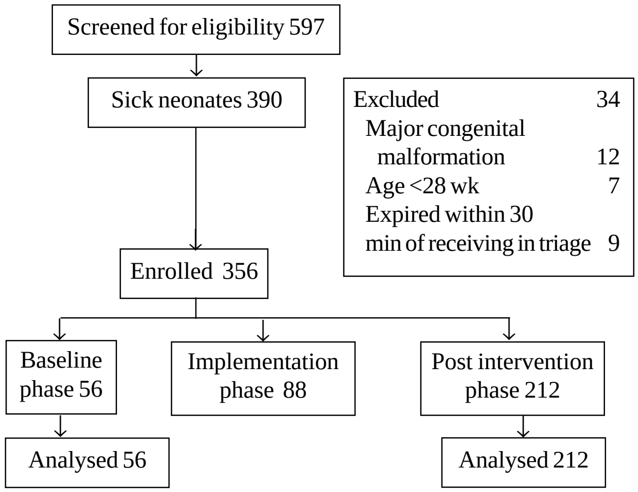
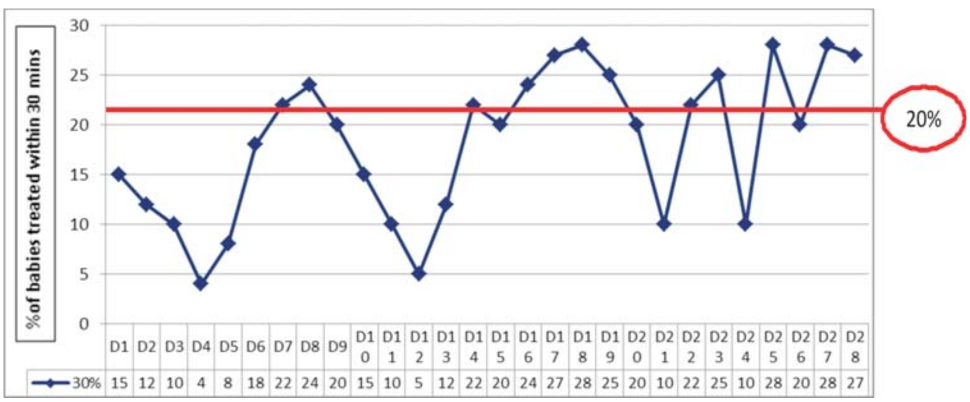
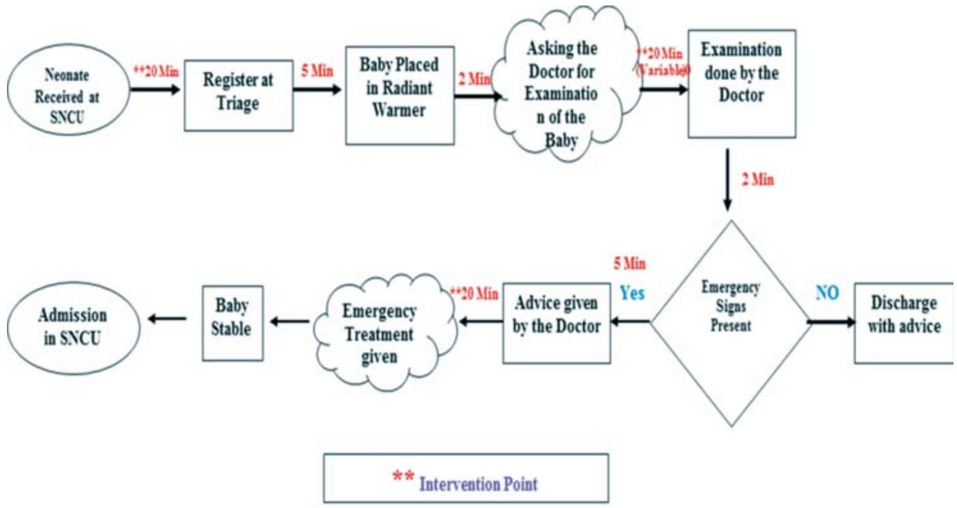


***Web Fig.* 1** *Study flow chart*

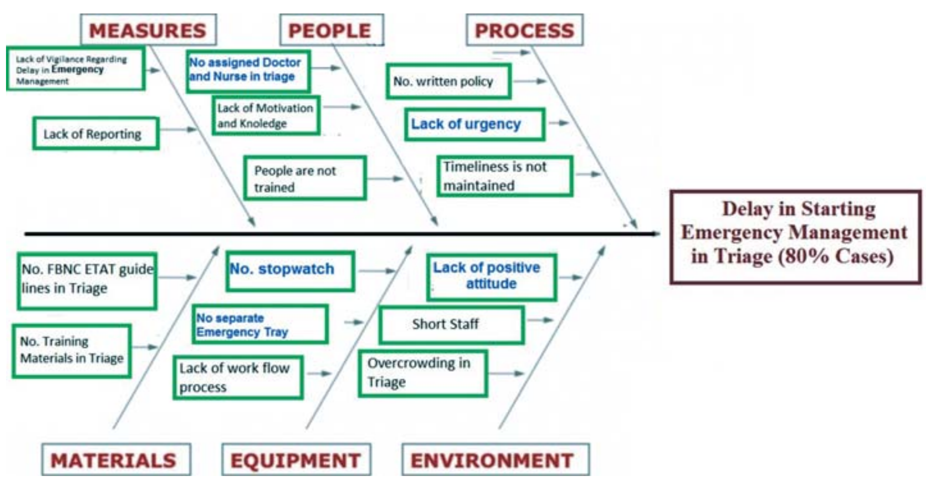


***Web Fig.* 2** *Run chart in baseline phase (encircled values are median during that phase).*

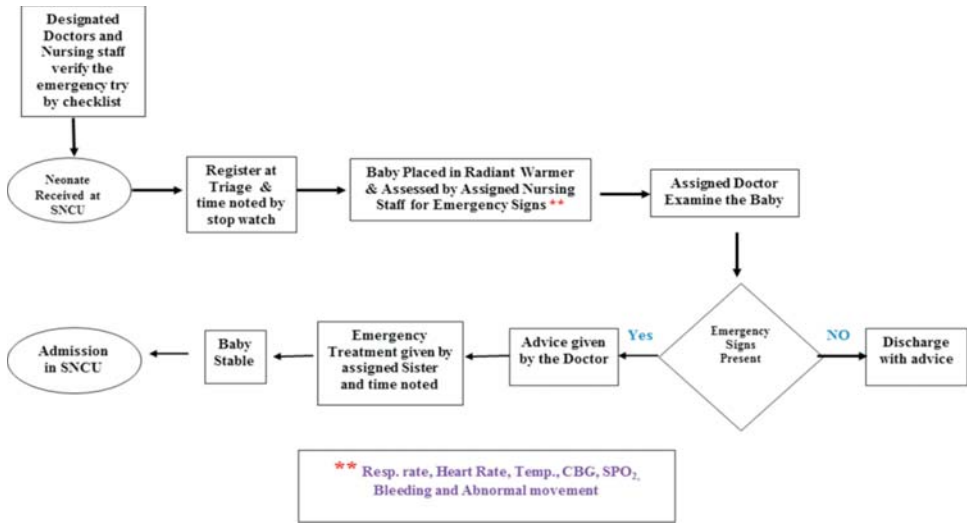


*(Different shapes are used to visualize the steps of a process (process mapping) in a flow chart: start and finish (oval), routine actions that always happen (rectangles), option points (diamonds) – these are steps that lead to different options, unclear steps (clouds) are used when we are not sure what happens); **These intervention point are the bottle neck in receiving early emergency management at triage.*

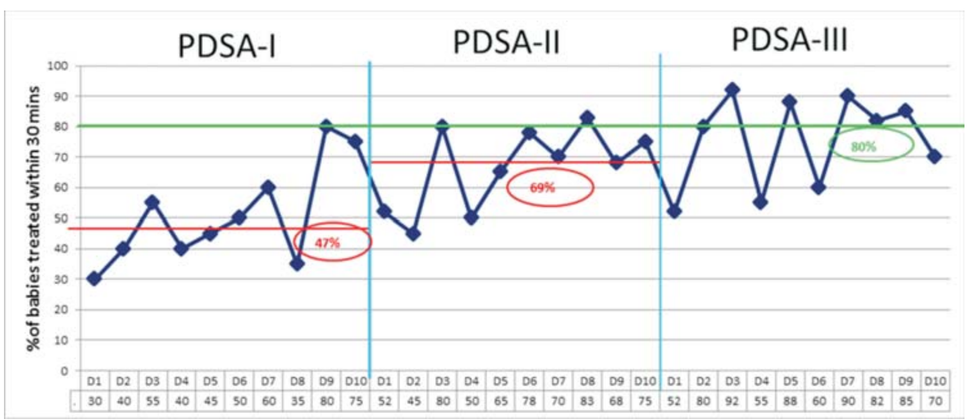
WEB FIG. 3 *Flow chart used at triage during baseline phase*.



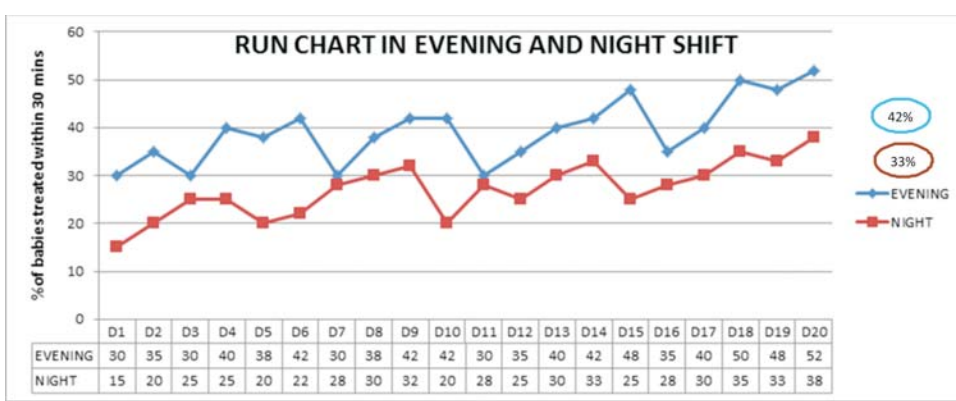
WEB FIG. 4 *Fish bone diagram showing cause-effect analysis of delay in emergency management.*



WEB FIG. 5 *Corrected process flow chart used during implementation phase.*



WEB FIG. 6 *Run charts in the implementation phase showing persistent improvement in the percentage of babies treated within 30 minutes. (encircled values are median during that phase).*



WEB FIG.7 *Run chart of evening and night shift during implementation phase (encircled values are median during that phase).*