Improving the Outcome of Sick Children Referred from District Hospitals in and around Puducherry by Establishing a Communication Network: A Community-based Quality Improvement Initiative

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Abstract

Introduction: Transferring patients between hospitals is an important aspect and is often the weak link in the health system. Robust real-time communication before transfer may be a valuable tool to improve the emergency care of children. Our study was aimed at developing evidence for the effectiveness of efficient communication networks between a tertiary care hospital and the referring hospitals in improving patient outcomes.

Materials and methods: We carried out a prospective observational study conducted in two phases. After the collection of baseline data in phase I, a communication network was established between our hospital and referring hospitals as the part of intervention. The effectiveness of the intervention was ascertained in the second phase.

Results: A total of 3,460 pediatric patients sought care from the emergency department of our hospital during the study period, 1,658 during phase I and 1,802 in phase II. Of the total patients admitted in pediatric emergency, 1,436 (86.61%) survived in the pre-establishment phase (phase I), and 1,762 (97.62%) survived in the post-intervention phase (phase II). The duration of stay during phase II was lower than in phase I, the difference being statistically significant. Propensity score matching analysis and interrupted time series analysis using a control chart also suggested improved survival of children during phase II after the intervention.

Conclusions: Our study showed that the establishment of a communication network improved the outcome of children attending our pediatric emergency. Further research is needed to assess if the usefulness of the intervention was not due to secular trends or the difference in patient profiles between the two phases.

Keywords: Emergency medicine, Inter hospital transport, Telecommunication, Telemedicine.

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Highlights

Inter hospital communication and transport of sick children remain weak in the health system, and improving this vital link can potentially save many lives. This study offers data to prove that establishing a communication network between referring hospitals and the receiving hospital can improve the outcomes of sick children in a tertiary care center.

Introduction

Survival, health and development of the child in the first 5 years of life are major public health concerns and achievable milestones for public health services worldwide. Remarkable declines have been seen in child mortality, yet disparities remain.[1] According to the United Nations report for 2019, it is predicted that 5.2 million under-5 children expired before turning five and 2.4 million neonates expired within the first 28 days of life.[2]

Ensuring an easy approach to institutional care is essential for the health and well-being of children. The Integrated Management of Childhood Illness (IMCI) plan looks to improve prevention and care for children through proper community and household care,

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primary healthcare services, and strong referral systems at first-level hospitals. It is expected that 10–20% of unwell children seeking primary care, particularly those who are the most seriously ill, will need treatment in a first-referral or district hospital if the current recommendations are followed.[3] Transferring patients between hospitals is an important part of patient care and is frequently performed to improve a patient's current care. Prehospital transfer methods for children coming to the Emergency Department are inadequately documented.[4] An exclusive pediatric transport team may ensure protected transport and reduce the occurrence of major untoward events.[5] The current international guidelines, of various professional bodies from developed countries. However, in developing countries like India, where resources are limited, these guidelines need to be tweaked to suit the local conditions.[6] Robust real-time communication may be a valuable tool for reaching out to district hospitals to improve the emergency care of children. Though its usefulness seems obvious, it needs validation in our setting, especially regarding operational feasibility. Hence, our study was aimed at developing evidence for the effectiveness of efficient communication networks between hospitals. We studied the effect of a robust communication network with a tertiary care center on the survival of children and the duration of hospital stay of children referred from district hospitals in and around our geographical area.

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Conflict of interest: Dr Narayanan Parameswaran is associated as Associate Editor of this journal and this manuscript was subjected to this journal's standard review procedures, with this peer review handled independently of the Associate Editor and his research group.

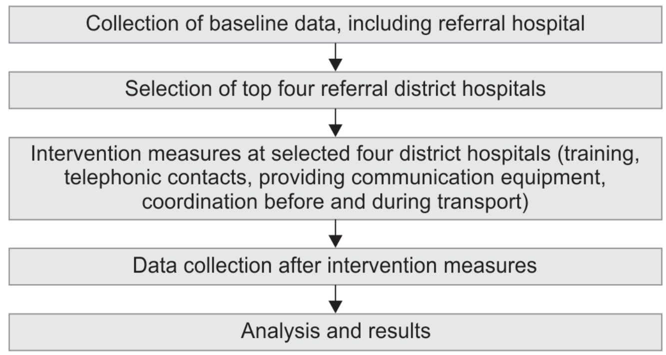

Fig. 1: Study flowchart

Materials and Methods

Our study was an observational study performed prospectively, similar to a quality improvement initiative. (comparison before and after implementation of a set of interventions). The study was conducted among children who were over 30 days old up to 12-year-olds attending pediatric emergency services at a tertiary care teaching hospital in Puducherry, South India. On average, a total of 80 patients per day avail of care in the pediatric emergency services at JIPMER.

The study had two phases. During phase I of the project, data on children admitted to our pediatric emergency was collected, and the top four referring hospitals were identified. Then the intervention (establishment of a communication network between our hospital and these hospitals) was initiated. Following this, during phase II, data from children admitted to our pediatric emergency was again collected.

As a routine procedure, all children attending emergency pediatric care in our center were initially evaluated at the triage station by a pediatric resident physician. Depending on their clinical status, children were categorized as levels 1, 2, 3, 4, and 5, level 1 being the sickest and level 5 being the most stable. Children categorized as levels 1 and 2 were shifted to the resuscitation area. Children belonging to levels 3 and 4 were initially brought to the Emergency Department, and based on their medical condition and reaction to management, they were later moved to either the general pediatric ward or the pediatric intensive care unit (PICU). After a sufficient observation period, level 5 children were discharged from the emergency ward. To collect data for the study, baseline parameters like age, gender, arrival time, place of referral, primary symptoms, vital signs at arrival, and triage classification were collected from the triage register kept at the pediatric casualty triage desk. From the register kept in the emergency room, the outcome from the emergency department such as transfer to a pediatric ward, PICU, discharge, death, or leaving against medical advice was recorded. For children requiring admission to the pediatric ward or PICU, the duration of hospitalization and final outcome (survival or death) were obtained from the respective ward's admission register and the hospital information system (HIS). From the above information, the top four district-level referring hospitals were identified. These four referring hospitals were provided with communication equipment (tablet with an internet connection). The communication equipment (tablet with an internet connection) had Epi Collect software to enter the data, and the equipment was protected with Sophos Central Mobile Advanced Software. A training program was conducted for the data entry operators (DEOs) learned about the entry of data in Epi collect 5, and a trial run was done for a few days. Data entry operators were stationed in these four centers to collect information about the patients attending the emergency of these hospitals, including vital parameters and intubation status, before being referred to our pediatric emergency department. The DEOs entered this data into the Epi-collect software and uploaded it daily. The study team (investigator and guide) visited these four hospitals multiple times and interacted with the doctors. Referral patterns and data collection were reviewed weekly by the team members and the involved doctors until no complaints were received from referring doctors. The doctors and staff nurses working in those four hospitals were requested to communicate with our pediatric emergency before planning to refer any child. The receiving hospital (our tertiary care center) offered telephonic assistance in stabilizing the child and taking precautions before transport. This assistance/advice was offered by the consultant/senior resident on duty in the emergency. This communication also resulted in prior preparedness at our center to receive the child. After establishing robust communication with referring district hospitals, data regarding patient outcomes were collected to assess the impact of the communication network (Fig. 1).

The results obtained were used to estimate the effect of robust communication with a tertiary care center on improving the outcomes of the sick children brought to the district hospitals in and around Puducherry. We also did a qualitative study to assess the physicians' perceptions in the referring hospitals regarding the effectiveness of the communication network using in-depth interviews (interview guide available as online Supplementary file 1).

The sample size was calculated based on the observed survival (unpublished data) of pediatric patients admitted to our tertiary care hospital in the recent past, which was 71%. Assuming a 7% improvement in survival post-intervention with an alpha error of 5% (95% CI), power of 90%, and absolute precision of 2%, 2,934 pediatric patients were required in our study. The pre-intervention phase lasted for eight months, from August 2019 to March 2020. During this pre-intervention phase, a total of 1,658 children were studied. During the post-intervention phase, which spanned eight months from September 2021 to June 2022, a total of 1,802 children were included in the study. The study protocol had the approval of the Institute Ethics Committee under the reference number JIP/IEC/2018/0200.

Data collected through paper-based forms were entered into Epi Collect5 (a mobile application) and analyzed using Stata software version 14.0 (Stata Corp., Texas, USA) and SPSS version 25. The survival of the children was expressed as the proportion of children who survived until discharge out of all children admitted. A comparison of the outcomes of children between phases I and 2 was performed and expressed as proportions. The association of baseline characteristics with outcomes was analyzed using the Chi-square test. A logistic regression model was employed, incorporating variables that exhibited a p-value below 0.2 in the unadjusted analysis. Based on this, adjusted prevalence ratios (APRs) were computed with corresponding 95% confidence intervals (CIs). The propensity score for outcome (survival/death) was calculated for the entire study population. The outcomes of children between phases I and II were compared after propensity score matching to account for possible confounders. Interrupted time series analysis was also done using a control chart. Subgroup analysis of data from the four referral hospitals alone was done to compare the survival before (phase I) and after (phase II) the intervention. The duration of hospital stay of children was expressed as median (interquartile range). The association of baseline characteristics with the duration of hospital stay was analyzed using the Chi-square test. A generalized linear model regression was performed, incorporating variables with a *p*-value below 0.2 from the unadjusted analysis. The beta coefficient, along with 95% CI and *p*-values, was computed.

Results

A total of 3,460 pediatric patients sought care from the emergency department of our hospital during the study period, 1,658 during phase I and 1,802 in phase II. Baseline characteristics of the patients are summarized in Table 1. Of 3,460 patients, most of the children [phase I 747 (45.05%) vs phase II 677 (37.56%)] were in the age-group of 1–12 months, and the proportion of boys was similar in both phases. The most common form of transportation during both phases was public transportation [phase I 654 (39.45%) vs phase II 789 (43.71%)], followed by self-owned vehicle [phase I 600 (36.19%) vs phase II 568 (31.47%)]. About half of the referrals [phase I 1,086 (65.50%) vs phase II 878 (48.81%)] were from government hospitals (Table 1).

Of the total patients admitted in pediatric emergency, 1,436 (86.61%) survived in the pre-establishment phase (phase I), and 1762 (97.62%) survived in the post-intervention phase (phase II) (Table 2). Any possible association of baseline characteristics with survival was initially analyzed using the Chi-square test. A generalized multivariate analysis model was then performed, incorporating variables with a *p*-value of less than 0.2 from the unadjusted analysis, and APRs with 95% CI were calculated.

Table 1: Baseline characteristics of study children in phase I and phase II

Characteristic	*Phase I (N = 1,658) n (%)*	*Phase II (N = 1,802) n (%)*	*p-value*
Age-group			
1–12 months	747 (45.05)	677 (37.56)	0.01
1–2 years	163 (9.83)	216 (12.02)	
3–5 years	270 (16.28)	327 (18.12)	
6–9 years	275 (16.59)	331 (18.39)	
10–12 years	203 (12.24)	251 (13.91)	
Gender			
Male	1,016 (61.28)	1,074 (59.67)	0.313
Female	642 (38.72)	728 (40.33)	
Mode of transport			
Ambulance	404 (24.37)	421 (23.49)	0.01
Private vehicle	1,254 (75.6%)	1,381 (76.6%)	
Place of referral			
Medical college	402 (24.25)	507 (28.18)	0.01
Government hospital	1,086 (65.50)	878 (48.81)	
Pvt. clinic	170 (10.25)	415 (23.02)	
Arrival status			
Directly came without a referral	1,326 (79.9)	1,333 (73.9)	0.01
Came with a referral letter	332 (20)	470 (26)	
Contact before referral			
Not contacted	1,510 (91.07)	1,607 (89.03)	0.062
Contacted	148 (8.93)	195 (10.97)	
Intubated before referral			
Not intubated	1,535 (92.58)	1,501 (83.16)	0.01
Intubated	123 (7.42)	304 (16.84)	
CPR requirement at admission			
CPR not given in emergency	1,547 (93.31)	1,769 (98.01)	0.01
CPR given in emergency	111 (6.69)	36 (1.99)	
IV line before referral			
No IV line	1,382 (83.35)	1,447 (80.17)	0.02
IV line	276 (16.65)	358 (19.83)	
Triage classification			
Level 1	144 (8.69)	230 (12.74)	0.01
Level 2	300 (18.09)	341 (18.89)	
Level 3	936 (56.45)	1,052 (58.28)	
Level 4	272 (16.41)	181 (10.03)	
Level 5	6 (0.36)	1 (0.06)	
Outcome			
Expired	222 (13.39)	40 (2.22)	0.01
Survived	1,436 (86.61)	1,762 (97.62)	

In the multivariate model, mode of transport by bus and Triage (level 2–5) were significantly associated with the survival of children.

Of the total, 3,460 patients, the median length of hospital stay was 5 (3–9) days. The duration of stay during phase II was lower than in phase I, with a statistically significant difference (Table 2). Association of baseline characteristics with the length of hospital

Table 2: Comparison of survival and duration of hospital stay of children referred from district hospitals

Study period	*Expired n (%)*	*Survived n (%)*	*Total*	*p-value*	*Median duration of hospital (IQR) days*	*p-value*
Phase I	222 (13.39)	1,436 (86.61)	1,658 (100)	0.01	6 (4–10)	0.01
Phase II	40 (2.22)	1,762 (97.62)	1,802 (100)		5 (3–9)	
Total	262 (7.57)	3,198 (92.35)	3,460 (100)		5 (3–9)	

Table 3: Comparison of primary outcome between the two groups after propensity matching

Groups	*Expired*	*Survived*	*Total*	*p-value*
Propensity scores matched control group	24 (40%)	36 (60%)	60 (100%)	0.01
Propensity score intervention group	12 (8%)	131 (91.6%)	143 (100%)	
Total	36 (17.7%)	167 (82.3%)	203 (100%)	

Table 4: Comparison of survival during phase I and phase II in the four hospitals with intervention (communication network)

	Phase I		*Phase II*		
Hospitals	*N*	*Survived, n (%)*	*N*	*Survived, n (%)*	*p-value*
Hospital 1	171	135 (79%)	168	155 (92%)	0.01
Hospital 2	128	101 (79%)	71	67 (93%)	
Hospital 3	189	161 (85%)	107	107 (100%)	
Hospital 4	65	57 (88%)	85	83 (93%)	
Total	553	454 (82%)	431	412 (95.5%)	

stay was analyzed using the Chi-squared test, and generalized linear model regression was performed. In the multivariate model, age-group 1–12 months and male sex were found to be an independent predictors of the duration of hospital stay for children.

Propensity score matching-based analysis was carried out in an attempt to decrease the effect of confounding when estimating the effect of survival. The propensity score was calculated for both the control and intervention groups. Propensity scores were estimated using logistic regression and assigned to the participants. Children with similar propensity scores were compared between the control and intervention groups. On comparing the intervention group with the propensity score-matched control group with one- and-one pair matching, it was observed that 131 (91.6%) survived in the intervention group and 36 (60%) survived in the propensity score-matched control group. For assessing the statistical significance of a difference in proportions McNemar's test was used (Table 3).

A comparison of the survival of children in phases I and phase II from the four referring hospitals alone with intervention is shown in Table 4. Of the total 553 children from the four referral hospitals, 454 (82%) survived phase I, before the establishment of the communication network. In phase II, after the establishment of a communication network, a total of 431 children were referred, of which 412 (95.5%) survived. Thus, a comparison of both phases showed improvement in the survival of children during phase II ($p < 0.05$) (Table 4).

Interrupted time series analysis tested whether the implementation of telecommunication as an intervention improved the survival rate of children referred from the other hospitals. The control chart is a graph used to study quality improvement projects.

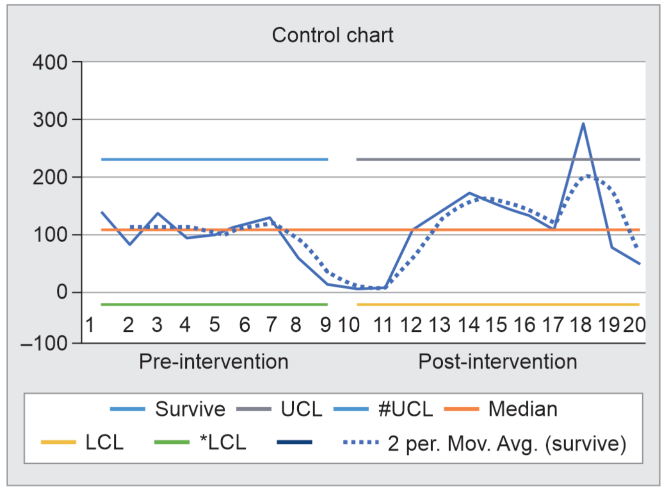

Fig. 2: Comparison of pre- and post-intervention phases in the survival of children

*LCL, lower control chart; #UCL, upper control chart

The centerline in the control charts (Fig. 2) is the mean of the data points (survival plotted month-wise). The upper and lower control limits are defined based on the data distribution, approximately three standard deviations above and below the centerline. The control chart displays the survival of children in both phases. In phase II (post-intervention phase), six out of 10 points (month-wise survival) were above the median line, below the upper control limit when compared to phase I (Pre-intervention phase), and most observations were around the median line. The graph suggests that the implementation of a telecommunication network was associated with an improvement in the survival of the child.

We did a qualitative study to assess the effectiveness of the communication network, using in-depth interviews with referring hospital physicians. All the respondents felt that the tablet-based telecommunication application was user-friendly and convenient. The telecommunications intervention improved their experience while referring patients to a higher health center. Improved support, better information about bed occupancy, prior notification, an opportunity to receive patient follow-up information, and the strengthening of peripheral hospitals were the perceived advantages of the intervention for the referring hospitals. However, the perceived disadvantage of referral was discussing the case with the referral hospital for a longer time, approximately 30 minutes on occasions. All the respondents wanted to continue the intervention, i.e., to continue the deployment of the tablet-based intervention. The respondents also found that the phone number used for communicating with the referral hospital was one of the essential factors for the success of the intervention. Hence, the respondents suggested continuing the phone number for future communication with the referral health facility. Some of the responders suggested that follow-up of referred cases could be improved, and bed occupancy could be updated through a website for referring sick cases.

Discussion

The referral system plays a vital role in the management of diseases in any healthcare system. An operational guideline by the WHO shows that more than 50% morbidity could have been seen at the PHC level.[7] Referrals from small hospitals in the peripheral to higher centers for intensive care are frequent. However, the absence of an organized referral and feedback system hinders the delivery of optimal care. The establishment of specialized pediatric critical care units has further accelerated referrals from community, district, and other peripheral healthcare facilities.

Our hospital is a multispecialty teaching and referral center that primarily serves patients from four neighboring districts. The hospital's independent pediatric emergency service logs roughly 25,000 patient visits annually, of which about 6,000 results in admission. Most of these patients are referred by hospitals in the surrounding public and private health facilities. Due to the lack of a standardized referral system in India, many these referred cases are in critical condition when they arrive.

This study was designed to assess the effect of establishing a communication network on the survival and duration of stay of children attending our pediatric emergency. The baseline characteristics of the study population showed that the majority of the children were aged 1–12 months, followed by those in the 6–9 years age-group, and the proportion of boys was similar in both phases. In a similar study done by Ezhumalai et al. from North India, the median age of children in the pre-intervention phase was 3.6 (IQR 1.9–7), and the post-intervention phase was 3.8 (IQR 2.3–7) years. The proportion of boys was 61.3% during the pre-intervention phase and 60% in the post-intervention phase.[8] Most of the referral cases in our study were from government hospitals, followed by other teaching institutions and private clinics. Similar findings were observed by Khan et al. from North India, who found that the majority of the cases were from district hospitals (45%) and district medical colleges (25%).[9] Only a small fraction of the patients were referred from private hospitals (9%). The referral pattern of this study is similar to our study.

Even though the comparison of the survival of children in phases I (87.61%) and phase II (97.62%) reveals that the survival after our intervention was better. A retrospective observational study done in adult patients by Armagnac et al. in Florida found that in telemedicine progressive care unit patients with telemedicine intervention, survival benefit was 20% compared to the non-telemedicine intervention group.[10]

Lilly et al. conducted a study that revealed significant improvements in hospital and ICU mortality rates, as well as reduced length of stay, among patients receiving ICU telemedicine intervention compared to control subjects. Statistical adjustments revealed a better outcome for patients in the intervention group. The hospital length of stay was reduced by an average of 0.5, 1, and 3.6 days, while the ICU length of stay decreased by 1.1, 2.5, and 4.5 days for patients staying in the ICU for 7, 14, and 30 days or more. These findings suggest the potential benefits of using telemedicine interventions in healthcare settings to improve patient outcomes.[11]

A systematic review was conducted by Wilcox et al., to estimate the effect of telemedicine on patient's outcomes. The study included 11 controlled trials and observational studies of critically ill adults and children. Hospital mortality and ICU mortality were assessed in this study. Pooled data from nine studies showed that telemedicine reduces ICU mortality (RR, 0.79; $p = 0.02$).[12]

In a study like our prospective observational study, there can be multiple confounders. There was nearly an 18 month interval between phase I and phase II. In fact, the post-intervention data collection was carried out after the two waves of the COVID-19 pandemic, while the baseline (phase I) was before the pandemic. Hence, the observed improvement in survival could be just a chance variation as the patient profiles were not identical. To address this issue of multiple confounders and possible secular trends in our comparison of outcomes in the two phases, we attempted further statistical analysis to minimize the effect of these confounders.

A propensity score-matched analysis was carried out to adjust for confounders. After matching the propensity scores of children in the intervention groups and the control group and then comparing them, the survival in the intervention group was still better (Table 3).

In addition, interrupted time series analysis using a control chart (Fig. 2) was attempted. The control chart revealed that the improvement in survival after the intervention was sustained. Finally, we also looked at the subgroup of children from the four hospitals alone in which we implemented the intervention. We compared their survival before (phase I) and after the intervention (phase II). It was found that there was a significant difference in the survival of children between phase I (82%) and phase II (95%) in this subset of children too. Hence, the improvement in survival observed during phase II (post-intervention cohort) was consistently seen with all the different types of analysis we had done. In spite of this, we still cannot rule out the possibility of a secular trend or random chance in our observations, as the two cohorts were separated by a time period of 18 months.

Secondly, we also compared the duration of hospital stay for the children between phases I and phase II. We found that the duration of hospital stays in phase II with a median (IQR) of 5 (3–9) days was shorter than in phase I with a median (IQR) of 6 (4–10) days. A study done by Lilly et al. found that the mean length of hospital stay was 13.3 days in the preintervention group and 9.8 days in the post-intervention group.[13] Similarly, Ahring et al., Champion et al., Furaso et al., also reported improvements in survival and length of stay before and after telemedicine mediated intervention in ICU patients.[14–16] In their study, Nassar et al. found that the implementation of a telemedicine program into a network of 7 hospitals did not reduce mortality rates or LOS.[17] Though we found a shorter duration of stay in phase II as compared to phase I, as discussed with respect to the primary objective (survival of children), there might be multiple confounders for this outcome too. Hence, it is difficult to attribute the observed improvement in duration of stay to our intervention alone.

Limitations

A key limitation of our study was the inability to include all healthcare facilities that referred patients to us. Due to logistical constraints, our interventions were focused on just four hospitals, which had the highest referral rates during the pre-intervention period. Moreover, the pre-intervention and post-intervention phases were separated by a period of 18 months due to the COVID-19 pandemic, bringing in additional challenges in interpreting our observations. One of the ways we tried to address this was by using propensity score matching because all children in our population were not good candidates who might have benefitted from the intervention. During both phases, only less than one third (30%) of admitted children were triaged as level 1 and level 2 (unstable) at admission. For other children triaged as levels 3–5 (nearly 70%), since they were relatively stable, prior communication would not have made much difference in their final outcome (survival). But this analysis using propensity scores did bring down the sample size significantly, reducing the power of the study. For our secondary objective of assessing the perception of the referring units by qualitative methods, we had used an interview guide instead of a structured questionnaire. We used the interview guide, because we thought it would bring out issues unknown to us. Finally, in a design like ours, with the possibility of multiple confounders, it is challenging to attribute the changes in outcomes observed to the intervention alone.

Conclusion

Our study showed that the establishment of an effective communication network improved the survival of children attending our emergency. Considering our study design, the effect of the intervention is difficult to establish with any amount of certainty. Further studies are required to understand if the usefulness of the intervention was not due to secular trends or the difference in patient profiles between the two phases. Similarly, though our study reveals a decrease in the duration of the hospital stay of the children attending our emergency following the intervention, this may also be due to the secular trend or different patient profiles between the phases.

Authors' Contributions

NP: Conceptualized the study, the data analysis plan and edited the manuscript; JA: Data collection, analysis and drafted the initial version; NP and JA: Approved the final version; NP: Guarantor for this manuscript. Co-authors have contributed significantly to the research (planning, approving the protocol, monitoring implementation) and preparation of this manuscript, and their inclusion as co-authors is appropriate.

Supplementary Materials

All the supplementary materials are available on the website www.ijccm.org.

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