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Implementation of an organizational infrastructure paediatric plan adapted to bronchiolitis epidemics

David Lavilledieu^a, Hamouda Abassi^{a,g}, Gregoire Mercier^b, Myriam Guiraud^c, Guillaume Du Chaffaut^c, Christophe Milesi^d, Gilles Cambonie^d, Arthur Gavotto^{a,*}, Eric Jeziorski^{e,1}, Pascal Amedro^{a,f,1}

^a Pediatric Cardiology and Pulmonology Department, M3C Regional Reference Centre, Montpellier University Hospital, Montpellier, France

^b Medico-economic Research Laboratory, UMR 5112, CNRS, University of Montpellier, Department of Epidemiology and Biostatistics, Montpellier University Hospital, Montpellier, France

^c Hospital Management Department, Montpellier University Hospital, Montpellier, France

^d Department of Paediatric and Neonatal Intensive Care, Montpellier University Hospital, Montpellier, France

^e Department of Paediatrics, Montpellier University Hospital, Montpellier, France

^f PHYMEDEXP, University of Montpellier, INSERM, CNRS, Montpellier, France

^g Self-Perceived Health Assessment Research Unit, EA3279, Public Health Department, Aix-Marseille University, Marseille, France

ABSTRACT

Introduction: Acute bronchiolitis epidemics are known to destabilize healthcare structures and stand as a major public health issue. Our tertiary care regional university hospital designed an organizational infrastructure paediatric plan (OIPP) to adapt to bronchiolitis epidemics. This study aimed to assess the impact of the OIPP on the length of stay and quality of care of children hospitalized for bronchiolitis.

Methods: This epidemiological study analyzed data from 2 epidemic seasons before and after the OIPP implementation. The OIPP used a standardized algorithm of patient orientation and a 4-level stratification of care.

Results: A total of 1636 children were included in the study, with 718 children before and 918 children after the OIPP implementation. The length of stay significantly decreased after the OIPP implementation, from 5.1 ± 6.8 days to 3.9 ± 3 days ($P < 0.001$). The 30-day readmission for bronchiolitis remained stable (4.6% vs. 3.4%, $P = 0.2$). The net annual patient service revenue increased from 1,292,532 € to 1,545,720 €.

Conclusion: The implementation of the OIPP resulted in a significant decrease in the average hospital length of stay. This plan improved patients' quality of care while maintained a balanced budget.

Trial registration number: ClinicalTrials.gov NCT03663660.

Keywords:

Infections
International health
Epidemiology
Bronchiolitis
Epidemics
Paediatrics
Respiratory syncytial virus

Introduction

In infants, acute bronchiolitis occurs in seasonal epidemics and is spread by interhuman transmission [1]. This is a viral respiratory infection affecting the smaller bronchial tubes, usually involving the respiratory syncytial virus (RSV) [2]. It is a major cause of lower respiratory tract infections and hospital visits during infancy and childhood. About one among five children is admitted in a paediatric unit within his first year of life as a result of RSV bronchiolitis [3]. In the past years, the bronchiolitis epidemic season has progressively increased in terms of emergency rooms' admissions and hospitalisations, leading to recurrent hospital disruption [4]. The current trend towards a reduction of hospital beds is exacerbating the pressure of bronchiolitis epidemics on healthcare systems.

Abbreviations: ER, emergency room; HI-ICU, high-intensity medical intensive care unit; LI-ICU, low-intensity medical intensive care unit; PMSI, Programme de Medicalisation des Systemes d'Information; N-ICU, neonatal medical intensive care unit; NIV, non-invasive ventilation; OIPP, organizational infrastructure paediatric plan.

* Corresponding author at: Paediatric Cardiology and Pulmonology Department, Montpellier University Hospital, 371 Avenue du Doyen Giraud, 34295 Montpellier, France.

E-mail address: a-gavotto@chu-montpellier.fr (A. Gavotto).

¹ Both authors contributed equally to this study.

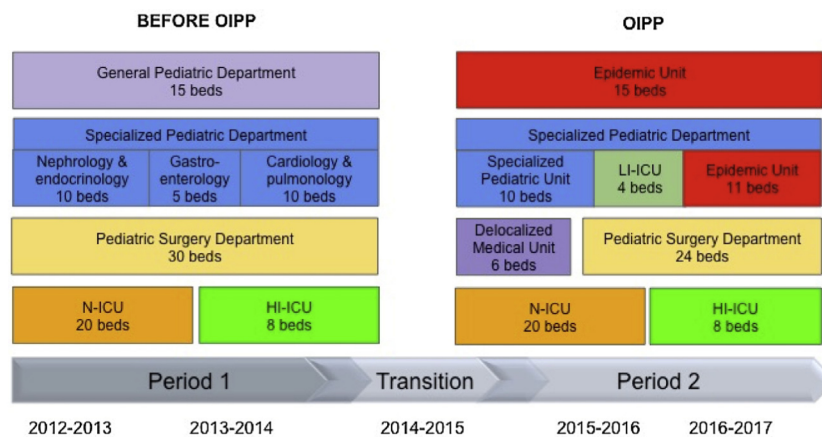


Fig. 1. Organization diagram before and after the OIPP. This graph represents hospital areas and beds dedicated to children with bronchiolitis in the institution before (period 1) and after (period 2) the OIPP implementation. Legends: HI-ICU, high-intensity medical intensive care unit; LI-ICU, low-intensity medical intensive care unit; N-ICU, neonatal medical intensive care unit; OIPP, organizational infrastructure paediatric plan.

Despite the significant impact of this disease, few therapeutic strategies have been effective. Indeed, the current guidelines about bronchiolitis management did not reduce the massive influx of patients during epidemic periods. The management of children hospitalized for bronchiolitis has usually been limited to support care [5].

In this context, before each winter season, many paediatric departments struggle to define an ideal organization to cope with bronchiolitis epidemics. In the past decade, the number of children hospitalized for bronchiolitis in our institution doubled, from 246 in 2004 to 476 in 2014. Therefore, all the paediatric structures of this tertiary care regional university hospital designed an original organizational infrastructure paediatric plan to best adapt to these growing bronchiolitis epidemics. This plan included a referral flowchart for hospitalized children, an increase in medical and paramedical staff and a restructuring of the paediatric units, with a specific stratification into 4 levels of care.

This study aimed to assess the impact of this organizational infrastructure paediatric plan on the length of stay and quality of care of children hospitalized for bronchiolitis. Moreover, the financial aspects and the staff member's evaluation of the implementation of this plan in the institution were analyzed.

Methods

Study design and population

This epidemiological retrospective controlled study was carried out in Montpellier University Regional Hospital, France. This institution is the tertiary care paediatric hospital of a region of 1.2 million inhabitants and 12,000 births a year. All children aged less than 2 years hospitalized with a diagnosis of an acute bronchiolitis were eligible for the study. Two groups of patients were defined, depending on the hospitalization period: the group 1 included children admitted prior to the organization plan implementation and the group 2 represented children admitted afterwards. The inclusion period for the group 1 ran from November 2012 to April 2013 and from November 2013 to April 2014 (period 1). The inclusion period for the group 2 ran from November 2015 to April 2016 and from November 2016 to April 2017 (period 2). Patients hospitalized during the transition period (e.g. winter 2014–2015) were not eligible for the study, as the organizational plan was tested for the first time during this period and therefore not fully functional (Fig. 1).

Indications to hospitalization were similar during the 2 study periods:

- O₂ saturation (SpO₂) persistently lower than 90–92%, entity of respiratory distress, presence of apnoea.
- Dehydration.
- Moderate to severe bronchiolitis (Table 1).

The hospital discharge database (Programme de Medicalisation des Systemes d'Information, PMSI) was used for patients screening. This database uses a standardized diagnosis coding from the 10th revision of the International Classification of Diseases (ICD-10) [6]. Therefore, the following terms and their international codes were selected to identify the patients: acute bronchiolitis (J21), acute bronchitis due to respiratory syncytial virus (J20.5) and respiratory syncytial virus pneumonia (J12.1). The institution's department of medical information imported and analyzed all data required for the study.

The organizational infrastructure paediatric plan (OIPP)

The institution is a tertiary care regional university hospital with three departments of medical paediatrics (e.g. general, specialized and intensive care paediatrics) and one department of surgical paediatrics (98 beds, overall). Before the implementation of this plan, children with bronchiolitis referred by the paediatric emergency room (ER) were preferably hospitalized in the general paediatric department, unless requiring intensive care. The lack of beds regularly led to hospitalize these children in the 2 other departments (e.g. specialized and surgical paediatrics) (Fig. 1).

In 2014, the medical directors of the 3 paediatric departments, along with the institution administration, drafted a new organizational infrastructure paediatric plan (OIPP), detailed as follows:

- The plan was set up during the winter epidemic, e.g. from November to April. It was first implemented in November 2014.
- A unique flowchart was drafted to frame patients' referral into the different hospitalization units, from the paediatric ER, and designed upon a 4-level of care (Fig. 2): patients could be referred to the "epidemic unit" in the general paediatric department (level 1), the neonatal care unit (N-ICU, level 2), the low-intensity medical intensive care (LI-ICU, level 3), or the high intensity medical intensive care unit (HI-ICU, level 4). Bronchiolitis severity was assessed by the usual consensus documents (Table 1) [7].
- The stratification into 4 levels of care required identifying specific hospital areas and beds dedicated to children with bronchiolitis. The level 1 (e.g. the epidemic unit) consisted of non-severe forms of bronchiolitis among children >1 month old requiring hospital-

Table 1
Bronchiolitis severity assessment.

	Mild	Moderate	Severe
Respiratory rate	Normal to slightly increased	Increased	Markedly increased compared to normal values
Respiratory effort	Mild chest wall retraction	Tracheal tug Nasal flare Moderate chest wall retraction	Marked chest wall retraction Nasal flare Grunting
Oxygen saturations	No supplemental oxygen requirement, O ₂ saturations >95%	Saturations 90–95%	Saturations <90%, may not be corrected by O ₂
Feeding	Normal to slightly decreased	50–75% of normal feeds	<50% of feeds, unable to feed
Apnoea	Nil	May have brief episodes	May have increasing episodes

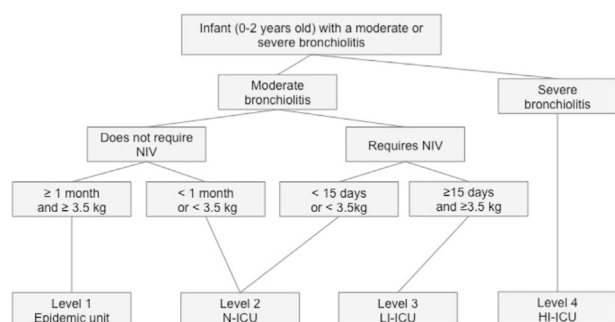


Fig. 2. The OIPP stratification into 4 levels of care. This graph represents the orientation protocol used from the paediatric ER to refer patients to the different hospitalization units, following a 4-level of care. Legend: HI-ICU, high-intensity medical intensive care unit; LI-ICU, low-intensity medical intensive care unit; N-ICU, neonatal medical intensive care unit; NIV, non-invasive ventilation; OIPP, organizational infrastructure paediatric plan.

ization in a general paediatric department. The level 2 consisted of 4 beds inside the existing N-ICU, in an isolated area dedicated to neonates with bronchiolitis. The LI-ICU (level 3) consisted of the identification of 4 beds (out of 25) inside the specialized paediatrics department (e.g. in the cardiology and pulmonology unit) for children requiring non-invasive ventilation (NIV). The level 4 represented children with severe conditions related to bronchiolitis and requiring hospitalization in the paediatric intensive care unit (high-intensity intensive care unit, HI-ICU). The levels 1 and 4 were existing units, the level 2 and 3 were specifically created for the OIPP inside existing units, usually dedicated to other types of care.

- The decrease in beds within the specialized paediatrics department was compensated by the identification of 6 beds inside the paediatric surgical department for uninfected children and/or scheduled hospitalizations (Fig. 1).

The OIPP required recruiting medical and paramedical staff and reorganizing the permanence of care. A paediatric specialist nurse was positioned at the ER admission to help orientate children, and implement the 4-level of care flowchart. Creating the LI-ICU within the specialized paediatric department required to increase the number of specialist nurses from 1.5 to 3 full-time equivalents for 10 beds, as required by health authorities. Overall, the OIPP required recruiting 10 full-time equivalent specialist nurses, and 6.5 full-time equivalent paediatric nurse assistants. Moreover, the medical permanence of care was upgraded with an additional intern night shift and a senior on call 24/24 h.

During the OIPP, children with and without bronchiolitis requiring hospitalization were orientated to the different units under the coordination of a nurse administrator, and following specific orientation protocols (Fig. 2):

- Children with bronchiolitis: children >1 month old and >3.5 kg who did not require NIV were hospitalized in the level 1 unit (e.g. the “epidemic unit”).
- Neonates <15 days and <3.5 kg were hospitalized in the level 2 unit (e.g. the N-ICU).
- Children requiring NIV or children aged >15 days were hospitalized in the level 3 unit (e.g. the LI-ICU).
- Children with severe bronchiolitis were hospitalized in the level-4 unit (e.g. the HI-ICU) based on the following conditions: respiratory failure requiring mechanical ventilation support, apnoea with desaturation, and/or severe impairment of general conditions [7].

In terms of biomedical material resources, high flow nasal cannula therapy was used as NIV in the level-3 unit and the ER, requiring to acquire 4 AIRVO™ 2 machines (Fisher & Paykel Healthcare, Auckland, New Zealand).

The medical directors of the different paediatric departments drafted harmonized care protocols. All paramedics, residents and fellows working in the units involved in the OIPP followed a 3-day intensive training programme before each epidemic season. At the end of each winter epidemic season, healthcare professionals filled out a questionnaire evaluating the OIPP.

Study outcomes

The primary outcome of this study was the hospital average length of stay. This data is commonly used in healthcare systems to evaluate new hospital organizations because it affects the morbidity, the rate of hospitals occupation (saturation) and the cost of hospitalization [8–11].

In order to evaluate the 4-level of care design, the number of transfers from a unit to another per patient and per hospitalization was analyzed, as well as the distribution of patients hospitalized in each unit. The hospitalization rate in each level of care was defined as the percentage of time spent in each sector. The rate of children readmitted for bronchiolitis within 30 days after hospital discharge was informed, as a quality of care indicator of the OIPP.

The financial aspects of the OIPP implementation were analyzed, given the profound structural modifications for the institution. The financial analysis was performed from the hospital perspective. In term of costs, staff (caregivers' recruitments and payment of guards), and the biomedical equipment were taken into account. In terms of income, we used the DRG tariffs for the hospital stays of each patient included in the study.

In terms of quality of care from healthcare professionals' point of view, the institution senior health executive analyzed the staff questionnaires, anonymously.

Formal aspects

The study was conducted in compliance with the Good Clinical Practices protocol and Declaration of Helsinki principles. After

approval by the Local Ethics Committee (2018-IRB-MTP-05-04), and the National Committee on Data Protection (CNIL), the study was registered on ClinicalTrials.gov (NCT03663660). The institution received approval from health authorities to import all hospitalized patients information from the social security database.

Statistical analysis

Patients' characteristics were presented using median and range, or mean and standard deviation (SD) for continuous variables, and frequencies and proportions for categorical variables. Groups (defined by the time period) were compared using Student or Wilcoxon rank test for continuous variables and chi-square or Fisher test for categorical ones. Statistical bilateral significance threshold was set at 5%. Statistical analyses were performed using SAS version 9.1 (SAS Institute, Cary, North Carolina).

Results

From November 2012 to April 2017, a total of 2042 children under 2 years were hospitalized in the institution with a diagnosis of bronchiolitis. Among them, 406 children were hospitalized during the transition period (winter 2014–2015) and therefore were not analyzed, 718 children were hospitalized during the 2 winter seasons before the OIPP (period 1) and 918 were hospitalized during the two winter seasons after the OIPP implementation (period 2). Therefore, a total of 1636 children were included in the study. Their mean age was 6.1 ± 8.6 months, with a male predominance (55.6%), and 146 (8.9%) children born prematurely. There was no significant difference in terms of main population characteristics between children hospitalized in the period 1 and those hospitalized in the period 2 (Table 2).

The hospitalization rate in HI-ICU was not statistically different between the 2 periods, before and after the OIPP (8% vs. 7%, respectively, $P=0.06$, respectively) (Table 2).

The mean hospital average length of stay significantly decreased after the OIPP implementation, from 5.1 ± 6.8 days in the period 1 to 3.9 ± 3 days in the period 2 ($P<0.001$). The hospitalization rate significantly decreased between period 1 and 2 in the N-ICU and the general paediatric department, by 20% in those 2 units, overall. The hospitalization rate in the LI-ICU (level 3) represented 21% in the period 2.

The number of unit transfers per patient moderately increased after the OIPP implementation, from 1.2 ± 0.7 transfers per hospitalization in the period 1 to 1.3 ± 0.7 in the period 2 ($P<0.01$). The bed occupancy rate in the LI-ICU (level 3) was 92% (median of 6 beds) (Table 2). The distribution over time of children hospitalized for bronchiolitis within each unit was represented in Fig. 3.

We found no significant difference between the two study periods, concerning the readmission rate within 30 days after hospital discharge: 33 children (4.6%) required hospital readmission during the period 1 versus 31 (3.4%) during period 2 ($P=0.2$).

The net annual patient service revenue increased from 1,292,532 € to 1,545,720 € between period 1 and 2. This increase mainly came from the LI-ICU tariff supplement reimbursed by the social security (+ 241,050 €). The net annual cumulative profit was 469,207 € after the OIPP implementation.

The overall evaluation of the OIPP by the health care professionals was good (76%) or very good (12%). For 85% of them, the orientation of patients had significantly improved. A large majority judged that the level of care was adapted to the actual patients' severity (88%). For 85% of them, the OIPP reduced the risk of nosocomial infection. The staff members felt that the OIPP saved them time (85%). We observed a much mixed evaluation from the paramedics working in the medical unit relocated in surgery: some of them felt

that their training was "correct" (33%) or "middling" (41%) and that patient orientation was "correct" (54%) or "middling" (46%).

Discussion

This epidemiological study from a cohort of 1636 children highlighted the interest of an organizational infrastructure paediatric plan adapted to bronchiolitis epidemics in a tertiary care regional hospital.

Interestingly, despite a constant increase in ER admission for bronchiolitis in the institution, the OIPP implementation resulted in a significant reduction in the hospital average length of stay. Indeed, this original stratification into 4 levels of severity probably participated in the optimization of care. The OIPP provided a single intensive training plan dedicated to all healthcare professionals working in the different paediatric departments involved in bronchiolitis epidemics. Experts agree that implementing a standardized system for patient sorting and resource allocation ensures consistent care for all those affected during major epidemics and disasters resulting in a large influx of patients [12,13]. Thus, the OIPP appears to be in line with such concepts, and therefore seemed to succeed in improving health performance, while maintaining safety.

Epidemics are known to destabilize healthcare structures and stand as a major public health issue. Prior preparation is necessary for hospitals to take care of patients while maintaining an optimal quality of care. In the USA, following the H1N1 pandemic, several studies have tried to determine the tools to put in place to manage future similar crisis situations [12,14]. Other similar regional institutions similar have set up organizational plans during winter epidemics [15].

When designing the OIPP stratification into 4 levels of care, we feared that it might increase the number of transfers from a unit to another, resulting in more workload for the nursing staff. Fortunately, this increase remained low and acceptable, with an average 1.3 transfers per patient and per hospitalization (vs. 1.2 before the OIPP) and the nurses' questionnaires related an overall improved organization. Moreover, the absence of increase in readmission rates after hospital discharge confirmed that, despite shorter hospitalizations, the quality of care remained optimal and patients were not discharged too early after the OIPP implementation. Indeed, the readmission rate for bronchiolitis in this study was 4.6% before the OIPP and 3.4% afterwards, which is quite similar to that found in the literature [16].

The use of high-flow nasal cannula in a conventional hospitalization paediatric unit (level 3) might have participated in the decrease of the length of stay. Similarly, Riese et al. reported that the use of high-flow nasal cannula outside intensive care services reduced the length of hospital stay [10]. It is important to note that, in our study, the rate of patients hospitalized in the paediatric high-intensity intensive care unit (level 4) was similar before and after the OIPP, therefore the most severe forms of bronchiolitis remained stable.

In a difficult economic context, the OIPP implementation should not place the institution in financial deficit, in order to be perpetuated. Therefore, the hospital administration obtained approval from the health authorities to tariff the low intensity intensive care unit as a regular paediatric intensive care unit. As a result, after payment of staff and material charges, the OIPP was financially beneficial. After 3 winter epidemic seasons, and a maintained balanced budget, the OIPP recently went out of the test period and was implemented in the long term by the hospital administration.

The evaluation by all healthcare professionals concerned by the OIPP was quite encouraging. They much appreciated the recruitment of temporary staff, the harmonized training programme, and the homogenization of patients in each dedicated area by level of

Table 2

Comparison of outcomes between period 1 (before OIPP) and period 2 (OIPP).

Outcomes	N	Period 1Before OIPP	N	Period 2OIPP	P-value
Gender (male)	718	418 (58.2)	918	491 (54.8)	0.06
Age (months)	718	5.7 ± 7.8	918	6.5 ± 9.3	0.08
Preterm (N)	718	65 (9.1)	918	81 (8.8)	0.9
Average length of stay (days)	718	5.1 ± 6.8	918	3.9 ± 3	<0.001
General paediatric department hospitalization rate (%)	718	82 ± 34	918	68 ± 43	<0.001
N-ICU hospitalization rate (%)	718	8 ± 25	918	2 ± 15	<0.001
LI-ICU hospitalization rate (%)	718	0 ± 0	918	21 ± 37	<0.001
HI-ICU hospitalization rate (%)	718	8 ± 23	918	7 ± 22	0.2
Number of unit transfers per hospitalization (N)	718	1.2 ± 0.7	918	1.3 ± 0.7	<0.001
Readmission <30 days after discharge (N)	718	33 (4.6)	918	31 (3.4)	0.2

Legend: OIPP, organizational infrastructure paediatric plan; N-ICU, neonatal intensive care unit; LI-ICU, low intensity intensive care unit; HI-ICU, high intensity intensive care unit. Values are mean ± SD or N (%). Significant P-values are marked in bold.

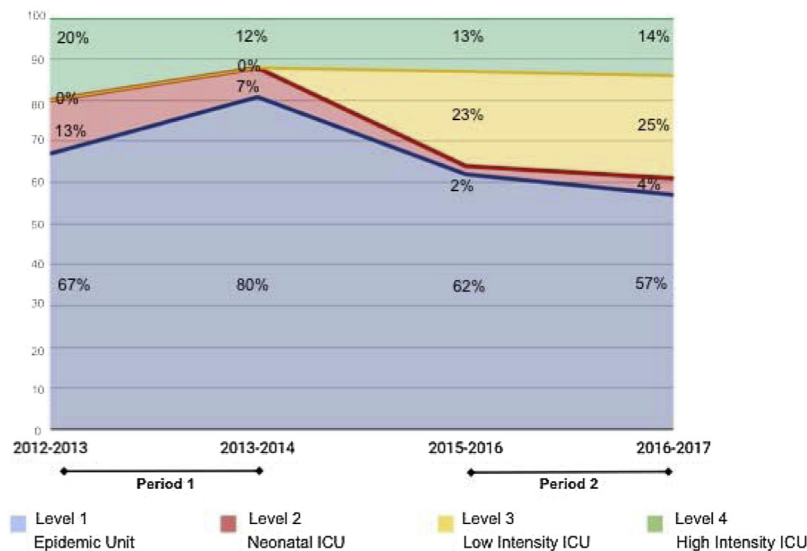


Fig. 3. Evolution of the distribution of hospitalization length for bronchiolitis within each unit over time. This graph represents the distribution (in %) of length of stay for bronchiolitis within each unit before (period 1) and after (period 2) the OIPP implementation. Legend: ICU, intensive care unit.

severity. However, we observed a much-mixed evaluation from paramedics in the medical unit delocalized in surgery. Indeed, these staff members, trained in paediatric surgery, had to adapt to medical pathologies.

Study limitations

In this single centre retrospective study, the comparison of the OIPP to an “historic” cohort presented some limitations. Despite access to exhaustive sources from the discharge database, we were unable to study detailed medical data such as virology and population characteristics (exposure to passive smoking, underlying pathology, clinical severity score of bronchiolitis, etc.). For instance, we did not study the impact of the OIPP on nosocomial infections. In addition, this study spanned a period of 5 years, during which practices might have evolved. However, the last French guidelines (2000) and the more recent recommendations of the American Academy of Paediatrics did not bring many differences in care [5].

Conclusion

The implementation of an organizational infrastructure paediatric plan adapted to bronchiolitis epidemics in a regional tertiary care paediatric hospital resulted in a significant decrease in the average hospital length of stay. Using a standardized algorithm of patient orientation and a 4-level stratification of care, this plan improved the quality of care, while maintained a balanced budget

for the institution. The evaluation of the plan by caregivers suggested an improvement of their working conditions. This plan was the result of intense collaborative work between healthcare staff members and hospital managers, and after a 3-year period of test, it was implemented in the long term by the hospital administration.

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Competing interests

None declared.

Ethical approval

The study was approved by Montpellier University Hospital Institutional Ethics Committee (2018-IRB-MTP-05-04).

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