**RESEARCH ARTICLE**

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# Emergency departments key performance indicators: A unified framework and its practice

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## Summary

**Context:** An emergency department (ED) in a hospital provides 24-hour care for the injured/severely ill patients. EDs are essential in any health care system. However, they face many challenges to provide timely treatment such as shortage of specialists, inadequate infrastructure, and unavailability of hospital beds, among others. These challenges are worldwide and undermine the effectiveness of operations and quality of services throughout the hospital.

**Methods:** This study aims to improve the performance of EDs using key performance indicators (KPIs). The KPIs will help decision makers to monitor and manage the performance of EDs systematically. Based on an in-depth field study, expert opinions, and literature review, we propose 5 categories of KPIs regarding Capacity for, Temporality of, Quality of, Outcomes of, and Economics of emergency care. The KPIs are applicable to the basic stages of emergency care. The achievement of the KPIs in each stage will be a function of (1) how the KPIs are used, (2) resources for achieving the KPIs, and (3) management of the resources. The unified systemic framework to manage EDs is presented as an ontology that articulates the very large number of potential ways of ED performance management.

**Results:** Seventy-five KPIs were defined for monitoring purposes. The KPIs and the proposed framework were validated and applied in 2 EDs at a public children's hospital and a medium size clinic in Chile.

**Conclusions:** Based on the study, we propose to standardize the essential information necessary to assess the

performance of EDs in Chile using KPIs for their continuous improvement.

## 1 | INTRODUCTION

In the past few years, Chilean authorities have taken several steps to improve the country's health care services. These include the self-management of public hospitals, the introduction of accreditation systems, the definition of diagnostic-related groups, the design of a 2011 to 2020 national health strategy, and the implementation of the "AUGE" program (explicit health guaranties). All these actions became essential elements of the clinical-administrative and financial management system of the Chilean health services. However, factors such as long waiting time for medical care or surgery, high demand and collapse of emergency services, failure in the provision of health benefits, and problems accessing services have caused dissatisfaction in patients. Additionally, given the demographic and geographic characteristics of Chile, its emergency services must also deal with natural disasters that often hit the country.

Problems affecting emergency services such as overcrowding have been well documented worldwide. In countries such as Spain, the causes of emergency department (ED) collapse are diverse both internally and externally. Among the internal causes, there are factors associated with the allocation of beds and their actual availability, which impact the quality and satisfaction of the services provided to the patients and also the satisfaction of their relatives and health personnel.[1] Dissatisfaction can finally be expressed through violence against health professionals and also causing what it is known as the burnout syndrome of health workers.[2] Other causes of overcrowding that have been reported in countries as diverse as the United States, England, Australia, Spain, Canada, New Zealand, and Taiwan are grouped into 3 categories: those related with the demand (non-emergency visits, patients who frequently re-visit the unit, volume increase in certain periods [eg, winter]), those associated with the efficiency or response capacity of the ED (staff size, resolution capacity, among others), and those related with exit factors such as lack of hospitalization beds.[3]

Numerous problems arise from overcrowding, including extended waiting times, increased suffering for those in pain, unpleasant environments, patient dissatisfaction, decreased physician productivity and frustration among medical staff, and sometimes poor clinical outcomes.[4,5] The same issues are affecting Latin American countries where studies additionally show shortage of physicians to allow a constant flow of patients, a deficient primary care, low goals of competition and improvement, lack of economic resources and infrastructure that, at the end, leads to the same deficiencies in the diagnostic and therapeutic processes.[6]

In Chile, as in other countries, emergency services are key within the health care network and the same issues appear. In fact, during the last years, due to epidemiological changes, changes in the needs and perceptions of the population and deficiencies in primary care, overcrowding has grown adding risk to the population already at risk, causing dissatisfaction with the services and damaging the image and prestige of health care institutions.[7] Additionally, according to the Ministry of Health, 1 out of 5 emergency patients waited for more than 12 hours for a hospitalization bed (aprox. 78.9% of patients).[8] Thus, and following the same phenomenon worldwide, overcrowding results in longer waiting times, diversions of ambulance routes, longer stays, greater number of medical errors, higher patient mortality, and a greater loss of resources due to financial losses.[9] Signs and symptoms of work-related stress have also been observed.[10]

EDs in Chile permanently face over demand of low or medium severity patients (some between 80% and 90% of the total consultations), which should be seen at the primary care level.[11,12] Unless the problem is solved in the near

future, the general public may no longer be able to rely on EDs for quality and timely urgent care, placing the population at risk. This amplifies the importance that EDs work efficiently so they can treat patients who need immediate medical care.

Despite injections of resources to the Chilean healthcare system, the need to review how EDs are being managed is latent, for which it is necessary to have quality information that helps identify where the problems are, and to provide relevant information that assists managers and organizations on their decision-making process to continuously improve.

Many previous studies have focused on general hospital performance management issues related to organizational strategies, and their correct control and implementation. [13-21] In this study, we focus exclusively on the performance of EDs.

Chile has an extensive emergency health care network connecting different institutions. The network is distributed in sectors of high demand throughout the national territory, totaling 161 public hospitals and other medical facilities. These establishments are of high complexity, ie, they must have the necessary equipment and qualified human capital to handle any kind of emergency. However, nowadays public hospitals in Chile face several problems associated with management, the most important being overcrowding of the EDs. Some causes as mentioned before related to overcrowding are insufficient resources related to infrastructure and supplies, high waiting times for hospitalization appointments, and lack of sufficient health professional staff. However, more work needs to be done given the lack of valid and reliable information in many EDs.[22]

Each country has characteristics that may differ regionally which should be considered when assessing health care services. Data provided by performance indicators reflects the quality of health systems and acts as a guide to define future actions and research. Previous studies have reported some valuable experiences. A study by Madsen et al[23] identifies different types of performance indicators used by Danish EDs through a literature review between 1980 and 2010.

Fieldston et al[24] use a scorecard in a large urban children's hospital to assess the flow of patients and direct resources to areas of most need. Additionally, Welch et al[25] provide a set of operational indicators, their metrics, and definitions. Their study responded to the increasing demand placed by insurance companies, hospitals, Medicare, and Medicaid (in the United States) for measuring and improving the performance of EDs.

Dynamic reporting tools such as dashboards can be developed to measure the ED's performance. However, it is a challenge to choose an effective and balanced set of performance indicators. Safdari et al[26] have developed a set of key performance indicators to use in a Balanced Scorecard (BSC) for EDs. Also, Ismail et al[27] present a methodology that integrates BSC and simulation models to improve the performance of EDs of a university hospital in the north of Dublin. A simulation model was integrated with the BSC to support the decision-making process. By analyzing scenarios, 3 key performance measurements were identified: (1) maximum waiting time in the triage; (2) misuse of resources in some treatment; and (3) substantial records of patient neglect (ie, being left without treatment). Similarly, Abo-Hamad and Arisha[28] simulated 2 performance indicators for an adult ED of an Irish University Hospital: (1) patient flow analysis (mean waiting time for patients and length of stay), and (2) efficiency (productivity, resource utilization, and layout efficiency). The authors also integrated simulation with the BSC to improve the communication of objectives and to take necessary actions to monitor achievements and lead to corrections.

In Chile, 1 study carried out in 2005 aimed to identify the eventual deficits in infrastructure, technology, or key staff in EDs using indicators suggested by the Ministry of Health including number of weekly hours hired from health care professionals and staff, built surface, and its distribution, quantity, type and quality of equipment and information systems, stock of critical resources, operational budget, investment and maintenance, statistics of urgent consultations, and expenditures by health care facilities. One of the main barriers for this study was the amount of data available and its quality; the EDs that participated in the study were characterized by deficiency and non-standardization of the data.[11]

Nonetheless, few health departments have fully developed robust performance management systems, missing the opportunity to transform the practice and performance of these units.[29] In this context, KPIs provide valuable

information for institutions to identify the most relevant organizational aspects, set goals, support action plans, monitor implementation, and to report results. KPIs allow hospital stakeholders to identify critical points and problems that can be solved with low-cost actions, both in time and resources.[30]

The present study aims to propose a set of KPIs for EDs in Chile that better fit the country and its health care system. This study includes performance indicators suggested by previous publications, and others captured by our own research experience. The work focused on KPIs related to processes carried out by EDs, as these processes strongly reflect the value proposition being provided to the public and try to handle the different problems that have been identified previously in the literature.

## 2 | METHODS

We present our method for developing EDs' KPIs schematically in Figure 1. It is divided into 4 stages: (1) gathering information, (2) identifying process flows, (3) proposing performance indicators, and (4) validating indicators.
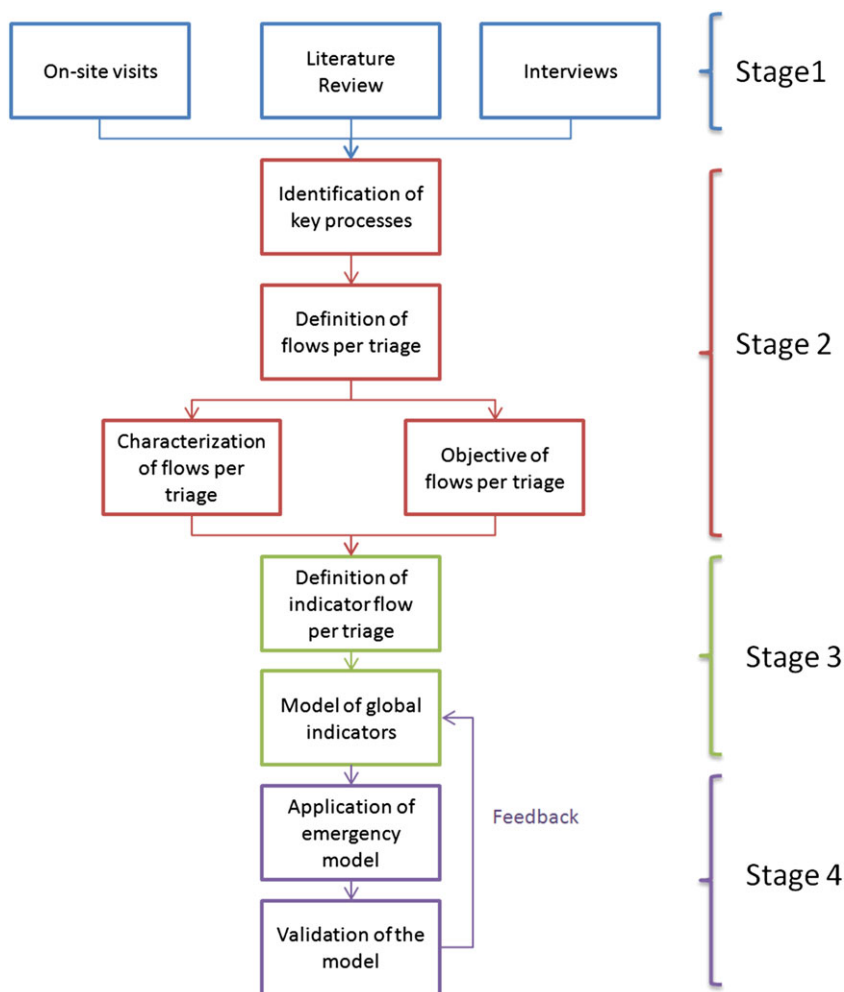


**FIGURE 1** Method [Colour figure can be viewed at wileyonlinelibrary.com]

Stage 1.   The steps of gathering information include an evaluation of the EDs management through identifying their measurement systems in place. This stage draws on 3 main sources: field visits to observe operation of EDs in hospitals and clinics, expert opinion from professional staff and technicians of EDs, and literature review of national and international publications regarding of performance measurements in hospitals.

Field visits were carried out in 5 ED's in Chile and 1 ED in Spain. Expert opinion was given by physicians, nurses, technicians, and administrative staff who belonged to 4 hospitals located in Santiago-Chile (see Table 1). The study also included a search of publications with the following keywords in English and Spanish: performance indicators, emergency departments, key performance indicators, EDs, strategic performance measurement.

Stage 2.   Based on the information gathered, the second stage consisted of plotting the process flows of a standard ED by each triage category (C1, C2, C3, C4, and C5). The flows were subsequently categorized and differentiated per the nature of their work, goals, and processes.

Stage 3.   In the third stage, based on Stage 2's analysis of process flows, we propose a unified framework for ED performance indicators using an ontology. The framework is shown in Figure 2 and described below. It is presented as a high level ontology as described by Ramaprasad and Syn[31] and Cameron et al,[32] in the context of public health informatics and mHealth, respectively.

Performance management in emergency-care can be deconstructed into 4 constituent constructs. They are as follows: (1) the object of performance management, (2) the resources managed to obtain the performance, (3) the processes of management, and (4) the criteria of performance. The criteria of performance, in turn, can be deconstructed into 2 constructs, namely: (1) stage of emergency care at which performance is measured, and (2) key performance indicators (KPIs). These 5 constructs define the dimensions of the framework. Each column in Figure 2 represents a dimension. Thus:

Performance management of ED = f (Object, Resources, Management, Stage, KPI).

The coordinates on each dimension are labeled using a taxonomy of elements derived from Stages 1 and 2. We will describe the construction of each taxonomy right to left in Figure 2.

The KPI taxonomy is a synthesis of 511 indicators derived from the analysis of the flows in Stage 2, and the review in Stage 1. To define the key indicators of the ED, the set of indicators were rigorously analyzed following a series of inclusion criteria. The first inclusion criterion is to avoid duplication of performance indicators. Next, indicators were selected based on measurability in the ED and ease of implementation (non-complex nature). Finally, the contribution of the indicators in the normal operation of the ED was discussed, leaving only those that make a substantial contribution to process improvement. Following these criteria, the original list was reduced to 79 indicators, which constitute our first proposal of performance indicators for an ED. The proposed set also includes a categorization of the indicator's importance based on 2 levels, where level 1 represents a very important indicator, and level 2, an important indicator.

**TABLE 1**   Description of participating hospitals

| Hospital | Characteristics | Number of Beds | Field Visit | Expert Opinion |
|----------|-----------------|----------------|-------------|----------------|
| CH1 | Medium-size children hospital | 200 aprox. | X | X |
| CH2 | Medium-size clinic that belongs to a state company | 130 aprox. | X | X |
| CH3 | Large university medical center | 600 aprox. | X | |
| CH4 | Large complexity hospital | 380 aprox. | X | |
| CH5 | Large complexity hospital | 940 aprox. | X | X |
| SH6 | Large university medical center | 400 aprox. | X | X |

**Performance**

| Object | Resources | | Management | | Stage | KPI | |
|---|---|---|---|---|---|---|---|
| Describe | Human | | Alignment | | Admission | Capacity | |
| Explain | Financial | | Allocation | | Triage | Demand | |
| Predict | Material | [±] | Capacity | [resources] | Care | Supply | |
| Control | Informational | | Utilization | |   Medical | Temporal | [±] |
| | Spatial | | Integration | [for] |   Nursing |   Waiting | [of/for emergency-care] |
| | Temporal | | Accountability | | Testing |   Processing | |
| | | | | |   Support | Quality | |
| | | | | |   Diagnostic | | |
| | | | | | Discharge |   Compliance | |
| | | | | | |   Errors | |
| | | | | | |   Staff satisfaction | |
| | | | | | | Outcome | |
| | | | | | |   Effectiveness | |
| | | | | | |   Patient satisfaction | |
| | | | | | | Economic | |
| | | | | | |   Financial | |
| | | | | | |   Revenue | |

**Illustrative Components:**

Describe human resources alignment for admission capacity-demand for emergency-care.
*Example: Describe how human resources are aligned to meet the capacity demand for admission to emergency care.*
Explain financial resources utilization for care-medical temporal-waiting for emergency-care.
*Example: Explain the use of financial resources to reduce waiting time for emergency medical care.*
Predict spatial resources integration for testing-diagnostic outcome-patient satisfaction of emergency-care.
*Example: Plan physical location of diagnostic testing labs to improve patient satisfaction.*
Control material utilization for care-nursing quality-staff satisfaction for emergency-care.
*Example: Control of material used by the nursing staff to their satisfaction.*

**FIGURE 2** Unified framework of performance management of emergency departments (EDs)

The list of indicators was validated in 4 hospitals with operative EDs. Managers of these EDs (physicians and nurses) analyzed the set of indicators and suggested modifications and new indicators. Based on this feedback, 75 KPIs were defined, see Table 2.

The 75 indicators were grouped by the authors into 10 types: errors, capacity, clinical, waiting time, satisfaction, costs, internal processes, finance, and process time indicators. The 10 types were further reorganized into a 2-level taxonomy as shown in Figure 2. The first level of the KPI taxonomy has 5 elements: Capacity, Temporality, Quality, Outcome, and Economy. Each of the 5 was subcategorized as 2 or 3 sub-elements. Thus, Capacity may be for Demand or Supply (of care); Temporality may be for Waiting time for or Processing time; Quality may be regarding

**TABLE 2** Set of KPIs by category and importance

| Category | No of KPIs | No of Very Important KPIs |
|---|---|---|
| Quality | 23 | 13 |
| Temporal | 20 | 18 |
| Economic | 15 | 2 |
| Capacity | 11 | 11 |
| Outcome | 6 | 6 |
| Total | 75 | 50 |

**TABLE 3** Key performance indicators for April 2016 from a medium size children hospital and a medium size clinic

**Category 1: Indicators of Quality**
**Subcategory: Errors**

| Objective | Indicator | Metrics | Frequency | Children hospital | Medium size clinic |
|---|---|---|---|---|---|
| Minimize unanswered calls to internal consulting physicians | Calling rate to internal consulting physicians with no response | No of unanswered calls / No of calls made | Monthly | NI | NI |
| Minimize errors (negligence) | Reported error rate in medical and nursing procedures | No of adverse event reports / No of treatments | Annual | 7 | 0 |
| Minimize treatment errors in diagnosis support | Error rate in activities supporting diagnosis (tests requests, results, handling of samples, others) | No of irrelevant supporting activities / No of supporting activities requested | Monthly | NI | 0 |
| Minimize readmission for the same or similar pathology | Patient readmission rate | No of patients that seek attention again for the same or similar pathology within 72 hours / No of treated patients | Monthly | 7% | 1.1% |
| Minimize nosocomial infections | Intrahospital infection rate | Number of nosocomial infections / Total No of patients | Monthly | NI | 0 |
| Minimize rate of deceased patients while waiting for hospitalization | Rate of deceased patients waiting to be hospitalized | No of patients deceased while waiting for hospitalization / No of patients with hospitalization order | Monthly | 0 | NI |
| Minimize occurrence of sentinel events | Rate of sentinel events | No of patients with sentinel events / No of total of patients | Monthly | 0 | 0.04% |
| Minimize complication rate | Rate of medical complications[a] | No of patients with complications / No of total treatments | Monthly | 2% | NI |
| Minimize patient accident rate | Patient accident rate (falls or others) | No of patient accidents / No of total treatments | Monthly | 0 | 0.02% |
| Minimize personal accident rate | Personal accident rate (medical sharps, splatters) | No of personal accidents / No of total treatments | Monthly | 0 | 0 |
| Minimize medication error rate | Medication error rate | No of memos sent by mistake in a patient's medication / No of total of patients | Monthly | 0.00% | 0.02% |
| Minimize non-relevant categorization rate | Non-applicable hospitalization rate | No of C4 and C5 patients that are hospitalized / No of C4 and C5 patients | Monthly | 2% | 1% |
| Minimize non-applicable referral rate of school accidents | Applicable referral rate due to school accidents | No of patients with school accidents (C1, C2, and C3) / No of patients with school accidents | Monthly | NI | NI |

**Category 1: Indicators of Quality**
**Subcategory: Standard compliance**

| | Metrics | | Frequency | Children hospital | Medium size clinic |
|---|---|---|---|---|---|
| Complying with time standards according to patient classification | Standard compliance rate of treatment times according to triage classification C1 | No of patients that comply with the standard / No of patients | Monthly | 100% | 100% |
| | Standard compliance rate of treatment times according to triage classification C2 | No of patients that comply with the standard / No of patients | Monthly | 100% | 63% |
| | Standard compliance rate of treatment times according to triage classification C3 | No of patients that comply with the standard / No of patients | Monthly | 92% | 96% |
| | Standard compliance rate of treatment times according to triage classification C4 | No of patients that comply with the standard / No of patients | Monthly | 99% | 100% |
| | Standard compliance rate of treatment times according to triage classification C5 | No of patients that comply with the standard / No of patients | Monthly | 100% | 100% |
| Complying with standard triage classification time (10 min) | Standard compliance time of triage classification times | No of patients that comply with the standard / No of patients | Monthly | 81% | 100% |
| Complying with guides and clinical protocols | Existence of unit protocols | No of existing protocols according to clinical manuals | Annual | 1 | 20 |
| Complying with ministry requirements | Getting quality certificates or renewing quality certificates | No of times a quality certification has been awarded | Annual | 1 | 2 |

**Subcategory: Staff satisfaction**

| | | | | | |
|---|---|---|---|---|---|
| Decrease number of litigations | Litigations | No of litigations | Annual | 0 | 0 |
| Decrease complaint rate | Complaint rate | No of complaints per triage classification / No of patients per triage categorization | Quarterly | NI | 0.02% |
| Increase staff satisfaction | Average rate of staff satisfaction | Average of satisfaction survey answers / No of total surveyed staff | Annual | NI | NI |
| Decrease quit or transfer rates | Average quit or transfer rates by request | No of people that quit or are transferred by request / No of total of staff | Annual | 2% | 2% |
| Increase trained staff | Training rate (RSP) | No of trained staff (RSP) / No of total staff | Annual | 43% | 33% |
| | Training rate (infectious IAAS) | No of trained staff (IAAS) / No of total staff | Annual | 33% | 48% |

**Category 2: Temporal Indicators**
**Subcategory: Waiting Time**

| Objective | Indicator | Metrics | Frequency | Children hospital | Medium size clinic |
|---|---|---|---|---|---|
| Minimize time | Average admission waiting time | (admission start time – patient arrival time) / No of patients | Monthly | 0:01:08 | NI |

(Continues)

**TABLE 3** (Continued)

**Category 2: Temporal Indicators**
**Subcategory: Waiting Time**

| Objective | Indicator | Metrics | Frequency | Children hospital | Medium size clinic |
|---|---|---|---|---|---|
| Minimize time | Average triage waiting time | (triage start time – admission end time) / No of patients | Monthly | 0:08:19 | 0:07:18 |
| Minimize time | Average examination room waiting time for C1 patients | (admission time of patient to examination room – triage end time) / No of patients admitted into examination room | Monthly | 0:32:31 | 0:08:36 |
| | Average examination room waiting time for C2 patients | (admission time of patient to examination room – triage end time) / No of patients admitted into examination room | Monthly | 0:00:00 | 0:00:35 |
| | Average examination room waiting time for C2 patients | (admission time of patient to examination room – triage end time) / No of patients admitted into examination room | Monthly | 0:12:00 | 0:10:48 |
| | Average examination room waiting time for C3 patients | (admission time of patient to examination room – triage end time) / No of patients admitted into examination room | Monthly | 0:24:04 | 0:09:43 |
| | Average examination room waiting time for C4 patients | (admission time of patient to examination room – triage end time) / No of patients admitted into examination room | Monthly | 0:39:38 | 0:14:18 |
| | Average examination room waiting time for C5 patients | (admission time of patient to examination room – triage end time) / No of patients admitted into examination room | Monthly | 0:41:00 | 0:07:34 |
| Minimize time | Average waiting time to arrive to the internal consulting physician | (time of arrival to internal consulting physician – calling time of internal consulting physician) / No of patients cared for by consulting physician | Monthly | NI | NI |
| Minimize time | Average waiting time for medical procedure | (procedure start time – procedure request time) / No of patients under procedure | Monthly | 0:14:45 | 0:18:40 |
| Minimize time | Average waiting time for nursing procedure | (procedure start time – procedure request time) / No of patients under procedure | Monthly | 0:16:18 | NI |
| Minimize time | Average waiting time for activities that support the diagnosis | (start time supporting activities – order time of supporting activities) / No of supporting activities requested | Monthly | 0:15:15 | NI |
| Minimize time | Average waiting time for results of supporting activities | (delivery time of results – end time of supporting activities) / No of supporting activities requested | Monthly | 0:09:12 | NI |

(Continues)

**TABLE 3** (Continued)

**Category 2: Temporal Indicators**
**Subcategory: Waiting Time**

| Objective | Indicator | Metrics | Frequency | Children hospital | Medium size clinic |
|---|---|---|---|---|---|
| Minimize time | Average waiting time for medical discharge | (real time of discharge – time of discharge decision) / No of discharged patients | Monthly | 0:06:51 | 0:35:07 |
| Minimize time | Average waiting time for internal and external transfer | (real time of transfer – time of transfer request) / No of transferred patients | Monthly | NI | NI |
| Minimize time | Average waiting time for bed hospitalization | (hospitalization time – discharge order time) / No of hospitalized patients | Monthly | 0:03:00 | NI |
| Minimize time | Average waiting time (total) | (average patient cycle time – average patient treatment time) / No of discharged patients | Monthly | 0:48:17 | 0:20:32 |
| **Subcategory: Processing time** | | | | | |
| Improve resource allocation | Average resuscitation time | Total time resuscitation / No patients requiring resuscitation | Monthly | NI | 2:24:08 |
| Minimize admission process time (collection) | Average admission time (collection) | (admission end time (collection) – start time admission (collection)) / No of patients | Monthly | 0:02:22 | NI |
| Improve resource allocation | Average triage time | (triage end time – triage start time) / No of patients | Monthly | 0:04:43 | NI |
| Improve resource allocation | Average examination room time | (examination room exit time – examination room start time) / No of patients admitted into the treatment examination room | Monthly | 0:17:40 | 1:43:37 |
| Improve resource allocation | Average treatment time by internal consulting physician | (end time internal consulting physician care – star time internal consulting physician care) / No of patients cared for by internal consulting physician | Monthly | NI | NI |
| Improve resource allocation | Average time for medical procedure | (end time procedure – start time procedure) / No of patients under procedure | Monthly | 0:13:05 | 0:19:14 |
| | Average time for nursing procedure | (end time procedure – start time procedure) / No of patients under procedure | Monthly | 0:21:43 | 0:18:45 |
| Minimize time of activities supporting diagnosis | Average time of activities supporting diagnosis | (end time supporting activity – start time supporting activity) / No of supporting activities requested | Monthly | 0:06:39 | 0:22:27 |
| Minimize average time of cycle | Average cycle time of patient per category | (real time of discharge – admission time) / No of discharged patients | Monthly | 1:38:42 | 2:30:39 |
| Improve resource allocation | Average medical treatment time | (time discharge was decided – time of medical assessment) / No of discharged patients | Monthly | 0:50:27 | 1:36:13 |

**Category 3: Economic indicators**
**Subcategory: Cost**

| Objective | Indicator | Metrics | Frequency | Children hospital | Medium size clinic |
|---|---|---|---|---|---|
| Minimize resuscitation cost | Cost for resuscitation activities | Total cost for resuscitation activities | Monthly | NI | 399 USD |
| Minimize admission cost | Cost for admission activities | Total cost for admission activities | Monthly | NI | 1.237 USD |
| Minimize triage cost | Cost for triage activities | Total cost for triage activities | Monthly | NI | 2.360 USD |
| Minimize cost of primary medical attention | Cost for primary medical treatments | Total cost for primary medical treatments | Monthly | NI | 20.196USD |
| Minimize calling cost and of the internal consulting physician's visit | Cost for calling activity and visit of internal consulting physician | Total cost for calling activity and visit of internal consulting physician | Monthly | NI | NI |
| Minimize cost of medical and nursing procedure | Cost for medical and nursing procedure activities | Total cost for medical and nursing procedure activities | Monthly | NI | 47.518USD |
| Minimize cost of diagnosis support | Cost of activities that support diagnosis | Total cost of activities that support diagnosis | Monthly | NI | 29.743USD |
| Minimize cost of diagnosis revision | Cost of diagnosis review activities | Total cost of diagnosis review activities | Monthly | NI | NI |
| Minimize cost of patient discharge | Cost for patient discharge activities | Total cost for patient discharge activities | Monthly | NI | 30.377USD |
| Minimize cost of logistic support | Cost for logistic support activities | Total cost for logistic support activities | Monthly | NI | 6.047 USD |
| Minimize cost of maintenance and cleaning activities | Cost for maintenance and cleaning activities | Total cost for maintenance and cleaning activities | Monthly | NI | NI |
| Minimize average patient cost | Average patient cost per category | Total cost of patients treated by category / No of patients discharged by category | Monthly | NI | NI |
| **Subcategory: Financial** | | | | | |
| Decrease accounts payable | Outstanding patient accounts (public system-FONASA) | No of outstanding patient collection accounts / No of accounts billed to patients | Quarterly | 40% | 1% |
| | Outstanding patient accounts (private system-ISAPRE / out-of-pocket payment) | No of outstanding patient collection accounts / No of accounts billed to patients | Quarterly | 81% | |
| Stick to the budget | Budget implementation | Budget implemented / budget | Annual / monthly | 101% | 45% |
| Increase patients with regularized financial situation | Rate of patients that regularize their financial situation | No of patients that regularize their collection situation / N° of patients that received their first medical treatment | Monthly | NI | 0.13% |

**Category 4: Capacity Indicators**
**Subcategory: Supply**

| Objective | Indicator | Metrics | Frequency | Children hospital | Medium size clinic |
|---|---|---|---|---|---|
| Control asset quantity | | | | | |
| Technical instruments: Infusion pump, defibrillator, vital sign monitor, notebook, ophthalmoscope, weighing scale, saline stand, measuring rod, refrigerated glass display, etc. furniture for operating services: Weighing scale, room divider, stretcher, stretcher to transport patients, clinical cart, cradle, footstool, lamp of procedure, Overbed table, light box, etc. | Quantity of assets | No of assets breakdown according to availability at emergency unit | Biannual | 198 | 81 |
| Control use of assets to support diagnosis | Use of diagnosis support | Asset use / asset capacity | Monthly | NI | NI |
| Control availability and use of cots, wheelchairs and beds | Use (cots, wheelchairs, beds) | Asset use / asset capacity | Monthly | NI | 100% |
| Minimize non-available equipment | Non-available equipment | No of non-available equipment / No of equipment | Monthly | 0 | 0% |
| Ensure minimum staff endowment | Staff endowment per shift (physicians, nurses, paramedic and others) | No of staff members per available emergency unit | Monthly | 23 | 25 |
| Minimize absenteeism rate | Absentee rate (physicians, nurses, paramedic, and others) | Hours of medical leave / (work schedule × No of workers emergency unit) | Monthly | 1.8% | 0% |
| Minimize staff overtime rate | Weekly overtime work rate (physicians, nurses, paramedic, and others) | No of workers that worked over 48 hours per week / (No of weeks × No of full time workers) | Monthly | 17% | 25% |
| **Subcategory: Demand** | | | | | |
| Control occupation rate | Average daily census | No of patients per day at emergency unit | Daily | 158 | 184 |
| Control morning patient rate | Patient rate per morning | No of patients admitted in shift from 08:01 to 14:00 / Total patients in 24 hours | Daily | 36% | 31% |
| Control evening patient rate | Patient rate per evening | No of patients admitted in shift from 14:01 to 20:00 / Total patients in 24 hrs | Daily | 41% | 40% |
| Control night patient rate | Patient rate per night | No of patients admitted in shift from 20:01 to 08:00 / Total patients in 24 hours | Daily | 23% | 29% |

**Category 5: Outcome Indicators**
**Subcategory: Effectiveness**

| Objective | Indicator | Metrics | Frequency | Children hospital | Medium size clinic |
|---|---|---|---|---|---|
| Control number of hospitalized patients | Rate of hospitalized patients | No of hospitalized patients / No of total patients | Monthly | 9% | 23% |
| Control number of discharge patients | Discharged patients | No of discharged patients / No of total patients | Monthly | 91% | 63% |
| Minimize total withdrawal rate | Total abandonment rate | (No of admitted patients – No of patients discharged/referred/hospitalized) / No of total admitted patients | Monthly | 22% | 23% |
| Minimize withdrawal rate after triage | Total abandonment rate after triage | (No of triage patients – No of discharged patients) / No of total triage patients | Monthly | 21% | 21% |
| Control number of referred patients | Rate of referred patients | No of referred patients / No of total patients | Monthly | 0% | 14% |
| Minimize short-term mortality | Short-term mortality, after visit to the ER | Short-term mortality (7 days) after an emergency visit | Monthly | NI | NI |
| **Subcategory: Patient Satisfaction** | | | | | |
| Increase patient satisfaction | Average patient satisfaction rate | Average of satisfaction surveys answered / No of total of patients surveyed | Monthly | Monthly | NI |

[a]Measured by changes in categories of higher complexity.

Note: NI (no information) is information that at the time of the application in the ED was collected either by other departments and it was not available or never collected.

Note: waiting time for all supporting activities, such as blood test and x-rays, are included.

Note 1: The cost subcategory should include costs separated by activities if an Activity Based Costing system is implemented in the hospital.

Note 2: NI (no information) is information that at the time of the application in the ED was collected either by other departments and it was not available or never collected.

Note 3: Equivalence 1 US Dollar = 660 Chilean Pesos.

Note: NI (no information) is information that at the time of the application in the ED was collected either by other departments and it was not available or never collected.

Compliance, Errors, and Staff Satisfaction; Outcome may be regarding the Effectiveness of care or Patients' Satisfaction with it; and Economy may be about Cost or Financial Indicators. (Note: Words referring to elements of the ontology are capitalized.) Thus:

KPI ⊂ [Capacity (Demand, Supply), Temporal (Waiting, Processing), Quality (Compliance, Errors, Staff Administration), Outcome (Effectiveness, Patient Satisfaction), Economic (Cost, Financial)].

The ontology describes performance management in a simple way to understand. In the following, we discuss the validity of the ontology and its application to performance management in 2 EDs.

Stage 4. The last step was to validate the framework for performance management of EDs through application to practice and its feasibility of measurement of the set of performance indicators. Due to the available funds and the willingness of hospitals to reveal information, the set of indicators was implemented and validated in 2 out of the 5 Chilean participating EDs: (1) the medium size children hospital and (2) 1 medium-size clinic that belongs to a state company. The set of KPIs was implemented during the month of April 2016 in the medium size children hospital, which corresponds to the agreed time of work with this hospital for this research project. The implementation in the medium size clinic took place during the whole year 2016, which corresponds to the agreed time of work with this hospital for this research project. The clinic has better information systems that allowed us to work with it for more time, without invading the work of the staff.

## 3 | RESULTS

The full set of indicators was tested during April of 2016 in a medium size children hospital, located in the city of Santiago, Chile, and during the whole year 2016 in a medium size clinic, located in the city of Rancagua, Chile. The hospital and the clinic provide medical consultation, emergency, and hospitalization services among others for highly complex pathologies. The ED of the children hospital admits 150 patients on average per day, and the ED for the medium size clinic admits 184 patients. The results of the KPIs application for the month of April for the hospital and the clinic are shown in Table 3 (see also Supporting Information). An objective was established for each indicator, along with a metric and a frequency, eg, 1 waiting time indicator is the average waiting time for admission, the objective associated with it, it is to minimize the waiting time for admission, the metric is the difference between admission time and patient arrival time divided by the number of patients, and the data for this indicator is collected monthly.

All time indicators in the hospital and the clinic were measured. However, the hospital does not measure all the parameters required, and some of them were tracked independently on patient-by-patient using a card.

Currently, the hospital and the clinic do not track short-term mortality after the patient visits the ED and do not have a survey to assess patient satisfaction. All other indicators were measured.

In general, there is practical application of this set of indicators in an ED for monitoring purposes. However, their implementation will be affected by the information available in each hospital. KPIs can potentially provide valuable information for the decision-making process and highlight opportunities for improvement strategies.

## 4 | DISCUSSION

Why does an ED need to measure such a large number of KPIs? We propose a total of 75 KPIs divided into 5 categories that are relevant for monitoring purposes. Hospitals should avoid adding burden to their staff to measure these indicators. Hence, the monitoring system can be supported by information systems. In addition, we need to distinguish the difference between monitoring and improvement. The ED should monitor all the set of 75 KPIs but select only some of them in order to design improvement strategies. Some of the KPIs can be adapted or disaggregated to fit the hospital reality.

For instance, in the ED of this children's hospital and medium size clinic most of the indicators 23 (31%) of them are quality indicators. Some interesting results among the quality indicators were found when analyzing the compliance rate of treatment with the triage standards. We found that for the children's hospital, there were none C1 patients during the month of analysis, 100% of C2 patients met the standards, 92% of C3 patients were treated according to the triage standards, and 99% of C4 patients met the triage criteria. While in the medium size clinic, 100% of the C1 patients met the standards, and just 63% of C2 patients were treated according to the standards, which is a very low percentage given the severity of the patients, the standard compliance rate increases for C3, C4, and C5 patients with 96%, 100%, and 100% of compliance, respectively. In addition, patients should be classified by the triage in the first 10 minutes from their admission time; according to the results, the children's hospital ED achieved this goal just 81% of the time, while the medium size clinic always met the goal. Also, the readmission rate for patients that were readmitted with a similar or equal medical condition was of 7% in the children's hospital and 1.1% in the medium size clinic. In relation to satisfaction indicators, there was no monthly information available about patient satisfaction or personnel satisfaction for both the hospital and the clinic, and the staff-training rate was lower than 50% during the year. The monitoring system provides information that helps managers to shed lights on opportunities for improvement; for example, improve the compliance rate for C3 patients in the children's hospital and for C2 patients in the clinic and reduce the readmission rate of 7% of patients for the children's hospital. This is a starting point for managers to prioritize the indicators and find improvement opportunities for the unit.

Quality indicators become more critical after understanding the complexity behind EDs. The problem of overcrowding in Chile is a reality, during the year 2017, 17 418 175 patients were treated in an emergency unit, which represents a 16% increase from 2010.[33] An excess in demand leaves little room for others with less urgent conditions. Therefore, indicators looking to minimize errors are relevant to increase the efficiency of the unit; thus, keeping low indicators such as error rate in activities supporting diagnosis or in medical or nursing procedures can accelerate the medical attention of the patients. Another key indicator for Chile is patient readmission rates; 1 way to reduce overcrowding is keeping patient re-visits to EDs to a minimum. It is also important to highlight that Chile will benefit from controlling the mortality rate of patients waiting to be hospitalized. According to a report from the Ministry of Health, during 2010 more than 2050 patients died in emergency services waiting for a bed to be hospitalized, and in 2013 that number reached 2913 people.[34]

The standard compliance indicators are a minimum requirement for any emergency unit to provide quality care, especially when there is an increase in the number of critically ill patients that need immediate care. Especially, when an increase in severity of patient illness means a decrease in turnaround times for beds. Additionally, as ED staff become overwhelmed with caring for this type of patients, they may suffer from stress and burnout, a topic that has acquired enormous importance in recent years. Therefore, indicators that address staff satisfaction must be considered by emergency units. However, and as can be seen in the data collected from the hospitals, none of them have a staff satisfaction survey in place.

There are 20 KPIs in the time category (27%); experts classified 18 of them as very important indicators. Some of the results for the EDs under analysis included that the average cycle time of a patient, ie, the average time that the patient stayed in the ED of the children's hospital was 1 hour 39 minutes approximately while the average cycle time for the medium size clinic almost duplicated patient stayed with 2 hours 30 minutes. Now, the average treatment time was close to 50 minutes in the children's hospital, having an average waiting time of 49 minutes in total. In the medium size clinic, the average treatment time was 1 hour and 36 minutes with a waiting time close to 20 minutes. These are not bad results considering that the wait times in EDs are between 2 and 5 hours; however, there is still room for improvement in both hospitals regarding their average cycle time.

One of the most serious and significant issues is having long waiting times stressing health professionals adding risks, which could cause poor diagnosis and treatment. Sometimes, patients in Chile are forced to wait on gurneys in hallways waiting for medical attention, especially during winter periods. Avoiding excessive waiting time in the ED can contribute in reducing overcrowding and the time patients occupy an ED bed. This can be achieved by minimizing time and improving resource allocation.

In the next category, we have the economic indicators with 15 KPIs defined and 2 very important indicators. This is questionable when many organizations are under pressure to deliver effective and compassionate care at lower cost and in an integrated manner. Moreover, 1 striking result was found among the economic indicators for the children's hospital where the outstanding patient accounts were separated among those patients who belong to the public system (FONASA), and those patients who belong to the private insurance system (ISAPREs) or paid out-of-pocket. The children's hospital ED had 40% of outstanding patient accounts from the FONASA beneficiaries and over 80% of outstanding patient accounts from the ISAPREs beneficiaries or private patients. These results are indicating the cash flow problems that the children's hospital ED is facing and represent crucial indicators that any hospital or clinic should prioritize and improve.

The number of economic indicators will depend on the costing system and the data available. When an activity-based costing system is implemented in the ED, most of the cost indicators can be measured; otherwise, the level of information to manage the unit will decrease significantly. However, in Chile, few public hospitals have an information system as the one described. Therefore, in those cases, it is recommended that at least the unit is aware of the average costs per patient by triage category. From a financial point of view, a couple of the most important indicators is the payment of accounts and staying within the budget. All of this is necessary to ensure economic sustainability in the department.

The following category includes capacity indicators, totalizing 11 KPIs and all of them classified as very important. The average daily census of the ED from the children's hospital was 158 patients, with a rate of patients by morning, evening, and night of 36%, 41%, and 23%, respectively. The numbers are similar for the medium size clinic with an average daily census of 184 patients and a rate of patients admitted in the morning of 31%, in the evening of 40%, and in the night of 29%.

The census of patients has increased, and there is an overflow of patients. These indicators help track the insufficiency of infrastructure, equipment, and the shortage of health care staff in EDs.

Finally, there are 6 main outcome indicators and all very important KPIs. The rate of patient discharges was 91% in the children's hospitals, compared with the 63% observed in the medium size clinic, the other patients, 9% were hospitalized in the hospital, while in the clinic 23% were hospitalized and 4% of them were referred. In addition, 22% of patients left the children's hospital ED without medical attention, and 21% left the ED after triage. In the medium size clinic, a similar rate, 23%, of the patients left the ED without medical treatment. This is another example of an indicator that emphasizes the need for improvement strategies.

During 2017, 25.71% of emergency patients waited more than 12 hours to find a hospitalization bed; this percentage increased in relation to 2016 where 24.9% of patients waited more than 12 hours.[35] During this time, these patients occupy physical bed space and require constant monitoring by health care staff. Until the problem of insufficient inpatient beds is addressed, the ED overcrowding problem in Chile will remain. Another overcrowding-induced problem relates to the number of patients who visit EDs, register, and then leave without being seen after waiting several hours either after being admitted or after the triage. All of this data will be collected with the proposed set of KPIs; however, it is currently not reported anywhere in the country. Patient satisfaction is also an indicator under this category, but EDs generally do not register this information even though violence from patients against emergency staff for dissatisfaction has been documented elsewhere.

In summary, the ultimate goal of this set of KPIs is to provide EDs with a way to assess the effectiveness of their system. We propose that the set of 75 key performance indicators should be set in an ED for monitoring purposes. Targets need to be established and agreed against these baseline indicators. This information will help managers to identify opportunities for organizational improvement and improvement strategies.

Hospitals can select relevant KPIs to propose improvement strategies. For example, 1 strategy can be to hire additional staff during peak hours to reduce the standard compliance rate with waiting time for triage; another strategy that can emerge is to implement a better control of the exit of patients to reduce the number of patients who left the facility without paying, or to study the flows of patients using value stream map to analyze the average cycle time of patients by triage category. However, the proposal of strategies and tracking its impact is matter of a future research project.

Therefore, feasible metrics to assess the performance of an ED were identified. The set of indicators is valid and have practical application in any ED. However, there are some limitations that should be taken into consideration such as the importance of support of first line directors and leaders to collect and use the information in the decision-making process. It is also relevant the use of information systems to avoid adding extra burden to the ED staff. In addition, even though these KPIs were applied during 1 month in a children's hospital and a whole year in a medium size clinic, the results were of relevance for the administration to assess the actual performance of the ED.

The set of indicators put emphasis in the internal processes carried out in an ED and are a monitoring framework for control purposes. Patient satisfaction with care, rate of adverse events, incidence of occupational accidents, and health care cost per capita are some examples of KPIs that help in the identification of improvement strategies of health care services. In the future, we expect to apply the indicators to other EDs to probe the capability of this monitoring system to support the selection of improvement strategies.

## 5 | IMPLICATIONS FOR POLICY AND PRACTICE

- Using a proper performance measurement system is critical to monitor and improve the decision-making process in emergency departments.

- The set of KPIs presented in this research provide a comprehensive view of the services provided without placing an excessive burden on emergency departments to collect data.

- Based on our results, increasing awareness about KPIs would enhance the performance of EDs because they have a positive impact determining if improvements have being made.

- This set of KPIs allow comparison about essential performance measures of an ED or between EDs promoting learning and supporting continuous improvement, thus achieving a better understanding of ED performance.

### CONFLICT OF INTERESTS

None declared.

### ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This article does not require ethics approval. There is not human involvement in this study. Consent from the patient is not required, this study reports an assessment of the hospital situation not at the patient level.

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## SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.