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Original article

Implementation of a centralized discharge planning office during the COVID-19 pandemic: translating the experience from the emergency to routine clinical practice

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Abstract. *Background and aim:* During the COVID-19 emergency, the Lombardy region (northern Italy) implemented a regional Centralized Discharge Planning Office (CDPO) to manage the discharge requests promptly, rapidly match the needs of discharge hospitals with the availability of admission facilities and ensure the management of the entire discharge process. To improve the discharge process in routine clinical practice, maintaining the role of the CDPO could be of great interest. This paper describes the experience of the CDPO during the COVID-19 pandemic and discusses the possibility of translating this operational model into routine clinical practice. *Methods:* The PRIAMO web portal was developed to manage discharge requests with centralized and standardized procedures. The activity on PRIAMO consisted of three stages: discharge request, sorting process, and discharge follow-up phase. To evaluate the activity of the CDPO, these indicators were considered: average time (hours) between patient discharge and transfer acceptance; average time (hours) between patient discharge and effective admission to the new facility; percentage of transfers whose destination was found directly by the CDPO; percentage of reallocations beyond 24 hours; mean distance between discharge and admission facilities. *Results:* Process indicator evaluation showed a great reduction in the time between the discharge and the admission to post-acute care facilities. Transfers whose destination was found directly by the CDPO progressively increased. Reallocations beyond 24 hours by the CDPO decreased, suggesting an improvement in the quality of the operations. *Conclusions*: Centralized discharge planning has enabled timely and efficient management of discharge requests even during a surge, saving time and costs for acute care hospitals. (www.actabiomedica.it)

Key words: Patient discharge; hospital discharge planning; centralized discharge planning office; COVID-19

Introduction

Identifying effective and standardized approaches to optimize the hospital discharge process is relevant to patient management, ensuring safe and cost-effective care transitions (1). Delayed discharge may prevent hospitals from admitting new patients, triggering effects on other aspects of the healthcare continuum, such as hospital length of stay (2). This issue is particularly relevant during times of surge when maintaining scientific and strategic criteria for hospitalization and discharge are essential to avoid the healthcare system collapse, as well as in ordinary moments to maintain the efficiency of the health system in the long term (3). During the COVID-19 pandemic, the pressure to quickly discharge patients from the hospital

intensified, especially during the pandemic peaks, when bed and staff availability were of the utmost importance (4–6). Moreover, many hospitalized patients had to be discharged to post-acute care facilities (e.g., inpatient rehabilitation facilities, skilled nursing facilities, transitional care units) to maximize their functional recovery before returning home or because of quarantine measures. Consequently, during the pandemic, implementing safe and coordinated discharge planning became even more of a priority (5).

Lombardy (northern Italy) was the first region in Europe to face the COVID-19 health emergency; the first case of SARS-CoV-2 pneumonia was diagnosed in Lombardy on 20 February 2020 (7). Subsequently, an exponential increase in hospitalizations and intensive care unit (ICU) admissions caused by infection complications were recorded (7). In this extraordinary emergency, the need for a change in the discharge planning organization was addressed by a regional government ordinance that established the implementation of a regional Centralized Discharge Planning Office (CDPO) (8). This intervention aimed to free up hospital beds in the ICU and sub-ICU rapidly and in the general wards in acute-care hospitals, transferring patients in need of post□acute care to the available non-hospital care settings (subacute, post-acute, rehabilitation centers, intermediate care, nursing homes), based on a careful assessment of the patient condition. Practically, the role of the CDPO was to manage the discharge requests promptly, rapidly match the needs of discharge facilities with the availability of admission facilities and ensure planning, execution, and monitoring of the entire discharge process. In light of the possible resurgence of the pandemic emergency and to improve the hospital discharge process in routine clinical practice, maintaining the role of the CDPO could be of great interest. From this perspective, this paper aims to describe the experience of the CDPO during the first 6 months of the COVID-19 pandemic and to discuss the possibility of translating this operational model into routine clinical practice.

Methods

The CDPO was implemented to address the need for the timely transfer of patients no longer needing acute care to non-hospital facilities during the COVID-19 health emergency. The "Martinitt e Stelline – Pio Albergo Trivulzio" institute (Milan) was chosen as the physical and operational headquarter for the realization of the CDPO. The admission facilities were all registered institutions listed by the Lombardy region; if other institutions had joined because of the emergency, they would have been responsible for requesting that their ATS be granted (Agenzia Territoriali della Salute; territorial sub-articulation of Regional Sanitary Service) and be registered by the Lombardy region (8).

The CDPO managed two main categories of patients: COVID-19 and COVID-free. The COVID-19 category comprised patients diagnosed with COVID-19, admitted to intensive/sub-intensive facilities, internal medicine, and specialty departments, considered clinically stable to be transferred but unsuitable to be turned home because still in need of oxygen therapy or because of quarantine measures. Patients admitted for other health problems and who tested positive for COVID-19 after hospital admission were considered in this category. The COVID-free category comprised patients without a diagnosis of COVID-19 admitted in HUB facilities, intended as "centers of excellence" that provide major complexity care. These patients suffered from acute (cerebral, cardiovascular, respiratory, etc.) conditions and were eligible for rehabilitation. All patients admitted without SARS-CoV-2 infection had to be tested negative again before being discharged and transferred to other care settings. Patients who became negative during hospitalization, with clinical outcomes of COVID-19 pneumonia and eligible for respiratory and/or motor rehabilitation, were managed as a separate group during discharge. The activity of the CDPO started effectively on 16 March 2020. From March 10 to March 15, the activity of the CDPO was mainly oriented toward implementing the key operational elements (start-up phase). The reported results refer to the first 6 months of the CDPO activity (16 March to 11 September 2020).

Operation processes

A web portal called PRIAMO (Biomedical Computing Systems) was developed to manage discharge

requests with centralized and standardized information and procedures. PRIAMO operates in the cloud on a dedicated server (12 GB RAM/Intel 6 vCPU processor). Data are stored in an Oracle database on a shared server (64 GB RAM/Intel 6 vCPU processor). Each operation in PRIAMO is tracked by the date and time of execution and user. The activity of the CDPO on PRIAMO consisted of three phases (Figure 1):

1. *Discharge request (discharge facility):* the hospital that needs to discharge a patient fills out a form in PRIAMO based on patient category (COVID, COVID-free, negativized patient), which contains clinical information, patient classification according to the validated evaluation scales: the National Early Warning Score (NEWS), which collects the usual physical parameters that allow rapid and shared assessment of patient clinical condition by healthcare personnel, the Care Dependency Scale (CDS), which evaluates basic and instrumental activities of daily living, and the Care Intensity Scale (CIS), which describes the degree of required care, only for COVID-19 patients. See supplementary materials for details about NEWS, CDS, CIS, and discharge criteria (9,10). The Lombardy region validated the discharge forms.
2. *Sorting process (CDPO):* the discharge facility is authorized to report in PRIAMO any direct agreement with the admission facility or to request the CDPO intervention to identify an appropriate destination. CDPO operators conduct the sorting process through two tools. The first is a digital interface to sort admission facilities (which have signaled a free bed in the last 24 hours) by distance from the patient's address. The interface also shows details on the types of vacant beds and the receptive capacity over the previous 15 days, some relevant facility characteristics, and the general type of predicted care setting through a customized machine learning model. The second tool is a compatibility score between the patient and the target facility, which tries to quantitatively answer the following question: *"For this patient to be sorted, has the hypothetical facility already accepted a similar patient?"*. This score is based on the data collected on the history of each admission facility and considers numerical and categorical features (CDS, the admission objective, sex, disease, etc.). If a transfer proposal is not defined within 48 hours from the request, the patient is placed on a special list, shared with all admission facilities that may propose themselves to the discharge facilities as destinations.

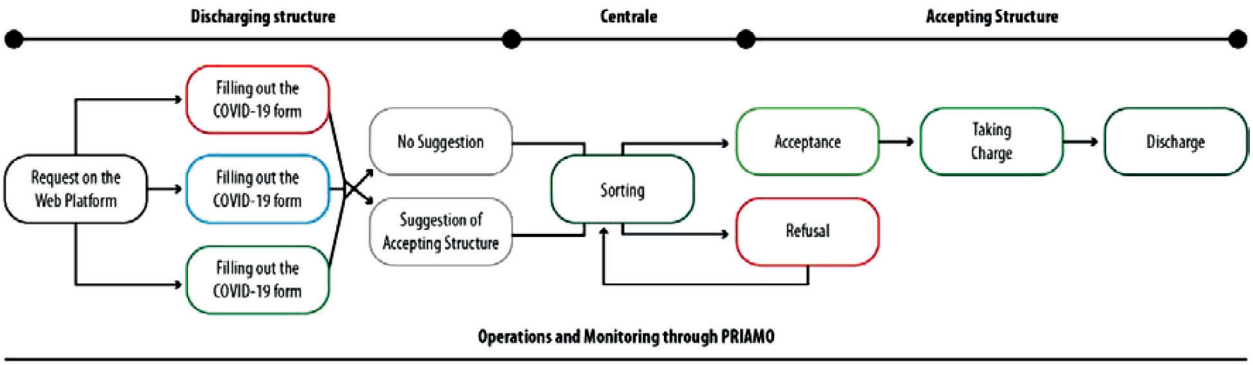

Figure 1. Schematic diagram of the CDPO operation process. 1. Discharge request: the hospital that needs to discharge a patient fills out a form in PRIAMO based on patient category (COVID, COVID-free, negativized patient), which contains clinical information and patient classification. 2. Sorting process (CDPO): the discharge facility is authorized to report in PRIAMO any direct agreement with the admission facility or to request the CDPO intervention to identify an appropriate destination. 3. Discharge follow-up phase (admission facility): Following patient assignment, the admission facility proceeds to admit or reject the patient, then reports the date of admission and final discharge on PRIAMO. The sorting process is repeated in case of refusal by the admission facility.

3. *Discharge follow-up phase (admission facility):* Following patient assignment, the admission facility proceeds to admit or reject the patient, then reports the date of admission and final discharge on PRIAMO. The sorting process is repeated in case of refusal by the admission facility. At the end of the study period, all transferred patients were classified by the admission facility into six different categories, according to their outcome: "still in hospital", "discharged recovered", "discharged", "discharged, in quarantine", "discharged to other settings" and "deceased".

CDPO structure

The CDPO is composed of four operational units:

1. *Call center*: composed of healthcare professionals and administrative staff, receiving requests from facilities for authentication and introduction to the PRIAMO portal, logistical or informatic support, as well as other information requests.
2. *COVID-19 and COVID-free units*: four healthcare professionals, including one physician and an administrative employee (for each unit), dedicated to the PRIAMO portal back office for data retrieval/alignment from discharge and acceptance facilities and the sorting process.
3. *PRIAMO support unit*: a team of three to four healthcare professionals and administrative staff dedicated to helping desk activities (via phone) and delivery (via email) of PRIAMO handbooks produced by B.C.S. Biomedical Computing Systems.
4. *Secretary unit*: composed of administrative staff (two employees).

Process quality indicators

To describe and evaluate the activity of CDPO, these indicators (per day) were considered: the average time (hours) between patient discharge and transfer acceptance; the average time (hours) between patient discharge and effective admission to the new facility; percentage of transfers whose destination was found directly by the CDPO operators; percentage of reallocations beyond 24 hours among patients whose beds were found directly by the CDPO operators; mean distance (km) between discharge and admission facilities. Quality indicators were assessed from 13 April 2020 to 11 September 2020 to avoid biases due to the initial emergency period and the CDPO start-up phase.

In addition, an estimation of the appropriateness of the admission facility selection by the CDPO was provided through an automatic learning algorithm CatBoost, considering the period from 16 March 2020 to 9 May 2020 (11–13). A customer satisfaction survey was also administered to the facilities (score from 1, not satisfied, to 5, very satisfied).

Evaluation scales

National Early Warning Score (NEWS)

The NEWS consists of the collection of usual physical parameters that allow a rapid and shared assessment of patient clinical condition by healthcare personnel, with the aim to reduce mortality and improper access in intensive units. The NEWS identifies three alert levels (high, medium, and low) depending on the degree of criticality in relation to the final score obtained (9).

Care dependency scale

The care dependency scale (CDS) consists of 15 items regarding basic and instrumental activities of daily living, such as elimination, hygiene and comfort, mobilization, diagnostic procedures, therapeutic procedures, and perception (10). Scores between 7 and 11 indicate high care dependency, scores between 12 and 19 indicate medium care dependency and scores between 20 and 28 indicate low care dependency.

Care intensity scale

The care intensity scale (CIS) considers the following items: respiratory rate, saturation, supplementary O_2, body temperature, systolic pressure, heart rate, and consciousness.

Estimation of the appropriateness of selection of the admission facility

An estimation of the appropriateness of the admission facility selection by the CDPO was provided through an automatic learning algorithm (CatBoost) (11–13). The estimation of the adequacy of the admission facilities was assessed according to the following steps:

1. It was assumed that the patients had an appropriate destination place after discharge.
2. An automatic model of prediction of two main settings, namely "specialized rehabilitation" and "intermediate care", was applied.
3. The differences between the predicted and actual destinations were assessed.

The information used by the algorithm included age, sex, presence of a support administrator, nocturnal and diurnal non-invasive ventilation, tracheostomy, the goal of hospitalization, assessment of instability, index event period, nutritional status, social support, behavioral disorders, presence of psychiatric disease, and primary disease. NEWS, CDS, and CIS scores were also considered. Other information was obtained from the free text fields "Reason for Hospitalization" and "Department," or the similarity cosines between the Word2Vec representations of the mentioned fields and appropriate sentences representative of both, such as "Fracture," "amputation," "ischemia," "hemorrhage," "ulcer," "sepsis," "disorders," "pneumonia," "diabetes," "decompensation," "tumors," "psychiatry" for the first and "geriatrics," "rehabilitation," "subacute" for the second. The model achieved 85% accuracy on a 10-fold cross-validation (compared with 67% for the presence of specialized rehabilitation beds). Default parameters were applied.

Statistical analysis

Descriptive and univariate statistical analyses were used for the present study.

Results

In the whole study period, the number of discharge requests was 14,328; 7,263 (51%) were females, and the mean (SD) age was 74 (13) years. There were 4,405 (31%) COVID-19 patients; 1,938 (44%) were females, and the mean (SD) age was 70 (16) years. Among the COVID-free patients, 5,358 (54%) were females, and the mean (SD) age was 76 (13) years.

The distribution of patients by the main disease is shown in Figure 2. Lung diseases were the most prevalent among COVID-19 patients (3,583 patients, 81%), followed by neuromuscular diseases (n=344, 8%) and internal diseases (n=246, 5%; Figure 2). Among COVID-free patients, neuromuscular diseases were the most reported (n=5,862 patients, 59%), followed by cardiovascular (n=2,202, 22%) and lung diseases (n=1,223, 12%; Figure 2).

In the study period, the mean (SD) number of days of hospitalizations was higher for COVID-free

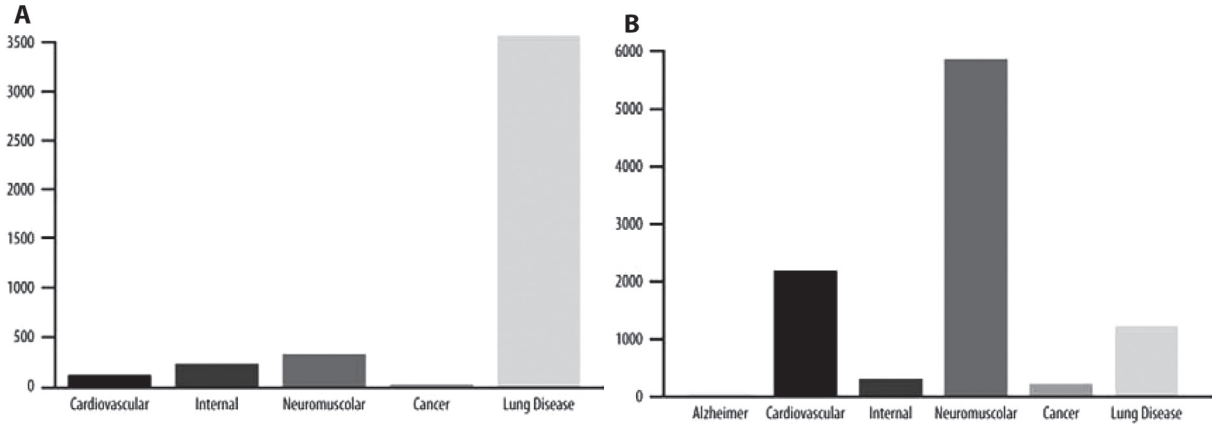

Figure 2. Distribution of transferred COVID-19 **(A)** and COVID-19-free **(B)** patients (y-axis) by main disease (x-axis).

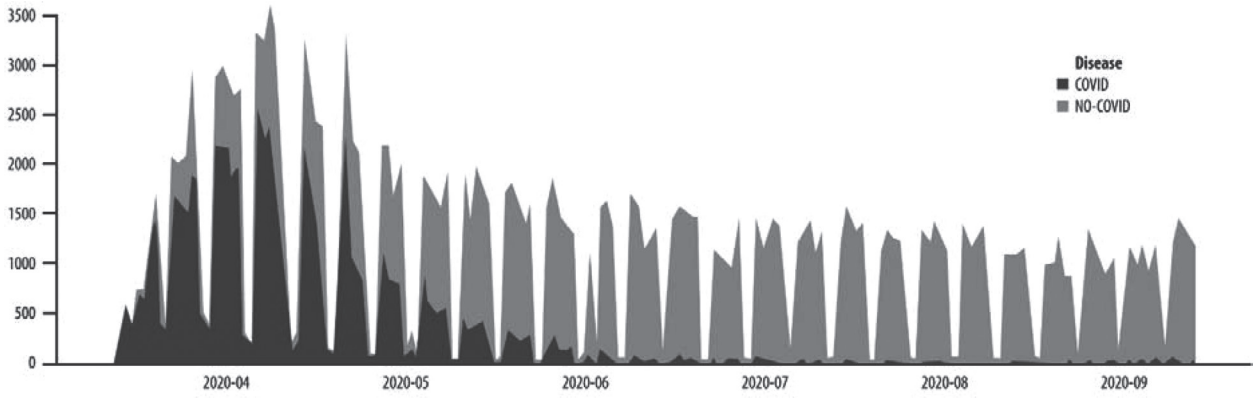

Figure 3. The number of patients transferred (y-axis) sorted by disease (COVID-19 and COVID-19-free) per day (x-axis).

patients (32 [22] days) than for COVID-19 patients (24 [16] days).

The mean (SD) daily number of discharge requests in the study period was 40 (63) among COVID-19 patients and 90 (58) among COVID-free patients. A decrease in the number of discharge requests from COVID-19 patients was reported in mid-April, simultaneously with an increase in the number of discharge requests from COVID-free patients (Figure 3).

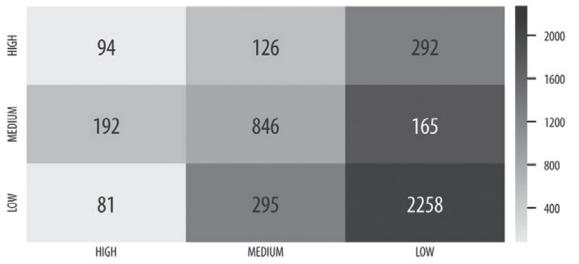

Figure 4. The number of COVID-19 patients transferred by the combination of CIS (x-axis) and CDS (y-axis) scores.

Care intensity and care dependency scores

Figure 4 shows the distribution of transferred COVID-19 patients by low, medium, or high scores for each index; over 80% of patients were in the medium (n=846) -low (n=2,258) quadrant, related to a medium-low level of care intensity and dependency. The mean (SD) CDS score among COVID-free patients was 21.4 (3.5) (low care dependency).

Overview of results obtained during the COVID-19 pandemic

- Reduction in time between the date of patient discharge, entered by the clinicians of the discharge facility, and the date of admission in the destination facility. This indicator expresses how quickly a facility accepts the transfer and is then scheduled.
- The overall decrease in the average time (hours) between the patient's date of discharge and the date of effective admission in the new facility; the average time increased until the middle of May and then decreased. This turnaround may have been secondary to the delay effect due to the increase in transfer requests and the simultaneous decrease of available beds, and on the other hand, to the effect of the progressive improvement of efficiency of the CDPO.
- With the possibility of discharging structures to use the system autonomously, the percentage of transfers whose destination was found by the operators of the CDPO has progressively increased.
- Decrease in the percentage of reallocations beyond 24 hours among patients whose beds were found directly by the CDPO, indicating an improvement in the quality of the operation of the CDPO.
- After an initial start-up stage of the CDPO characterized by long distances between discharge and admission facilities, an overall reduction was reported during the first month of activity before settling on a mean of 20 km.
- The estimation of the appropriateness of selection of the admission facility showed an improvement over time.

Process indicators

Given the decrease in COVID-19 patient transfers, process indicators were reported only for COVID-free patients. A reduction in the time between the discharge request and the transfer acceptance was reported during the study period (Figure 5A). Figure 5B shows the mean time (hours) between patient discharge and

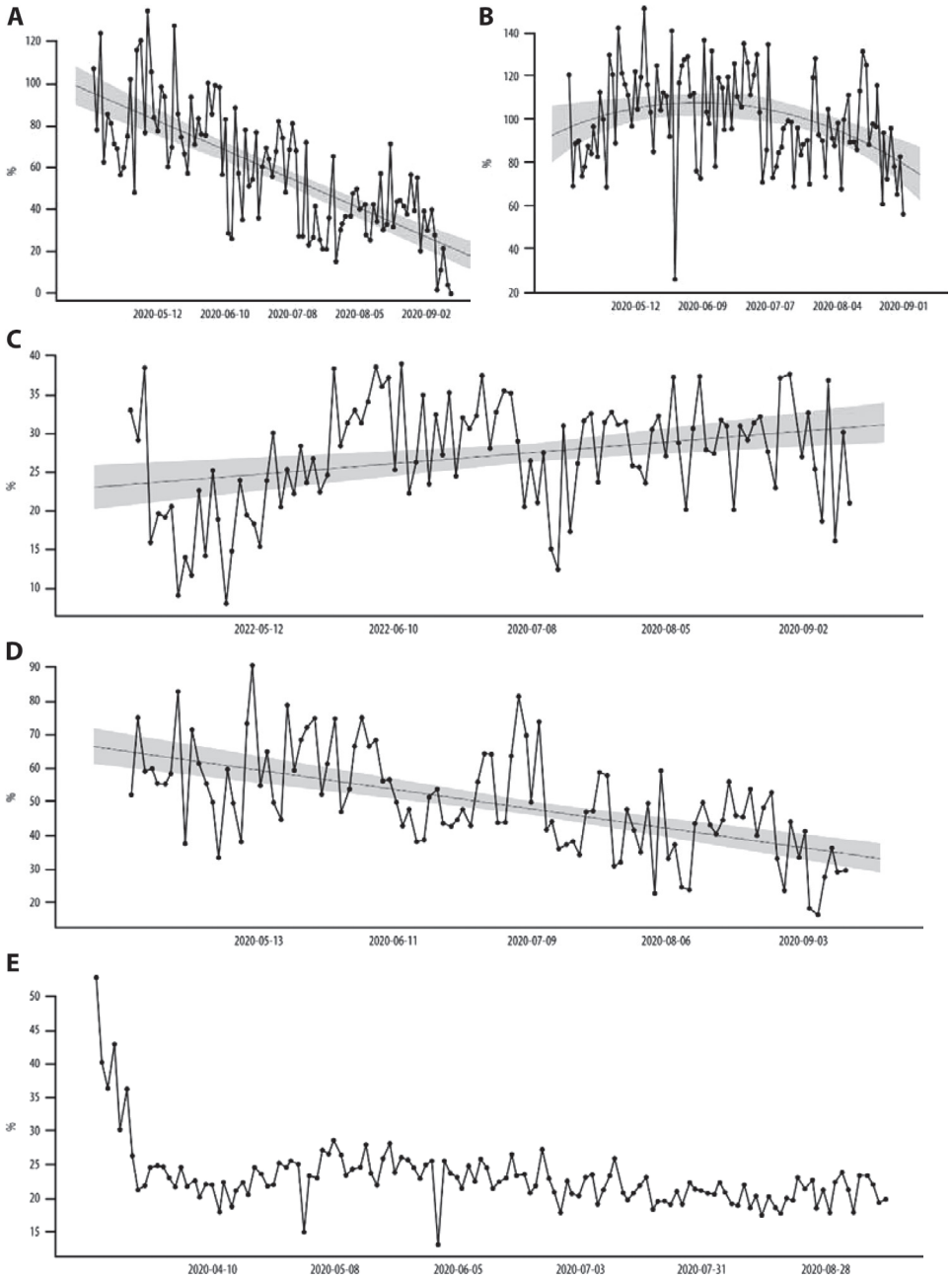

Figure 5. (A) Mean time (hours, y-axis) between the discharge and the transfer acceptance per day (x-axis). **(B)** Mean time (hours, y-axis) between the discharge and the effective admission of the patient per day (x-axis). **(C)** Percentage of transfers (y-axis) whose destination was directly found by the CDPO per day (x-axis). **(D)** Percentage of reallocations beyond 24 hours (y-axis) among patients whose beds were found directly by the CDPO per day (x-axis). **(E)** Mean distance (km, y-axis) between discharge and admission facilities per day (x-axis).

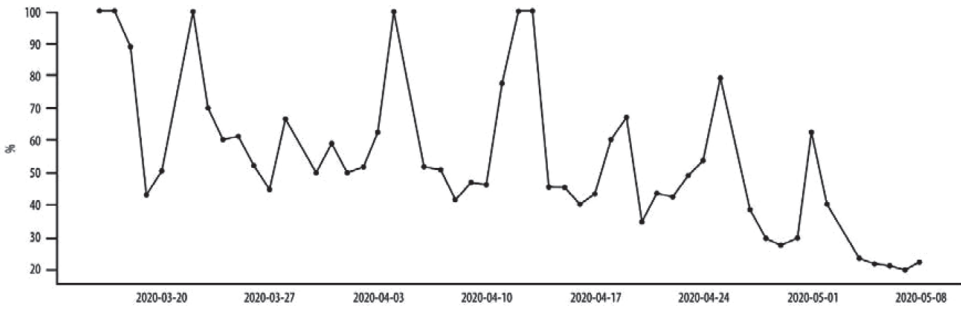

Figure 6. Trend of the estimation of setting appropriateness error.

Table 1. Distribution of transferred patients by disease and outcome (number of patients)

	COVID-19	COVID-19 free
Still in hospital	151	3209
Discharged recovered	2914	4839
Discharged	26	9
Discharged, in quarantine	375	8
Discharged to other settings	873	1464
Deceased	124	336

admission to the new facility; the mean time increased until the middle of May and then decreased (Figure 5B). The percentage of transfers whose destination was found directly by the CDPO operators progressively increased (Figure 5C), along with the decrease in the percentage of patient reallocations by the CDPO beyond 24 hours (Figure 5D). Over the study period, a progressive reduction was reported in the mean distance between discharge and admission facilities. The overall mean (SD) distance was 20 (5) km (Figure 5E). The estimation of the appropriateness of the selection of the admission facility showed an improvement over time (Figure 6).

Patients' outcome

The distribution of transferred patients at the end of the study period by disease and outcome is summarized in Table 1. The most represented category for COVID-19 patients was "discharged recovered" (20%); otherwise, the two most common outcomes for COVID-free patients are "discharged recovered" and "still in hospital", with 33% and 22%, respectively. Deceased for both groups was approximately 1%.

Satisfaction survey

A total of 48 discharge and 58 admission facilities completed the satisfaction survey. 75% of discharge facilities rated their experience with the CDPO positively (scores 3, 4 or 5), as did 74% of admission facilities (Figure 7).

Discussion

The coordination and optimization of the hospital discharge process emerged as top priorities during the COVID-19 pandemic, as healthcare providers faced complex discharge decisions requiring timely action (4–6).

In the Lombardy region, a CDPO was implemented to facilitate the pathway of patients toward appropriate discharge to rehabilitation or care facilities to complete care and get vacant hospital beds rapidly. Through the use of a web portal, PRIAMO, excellent results were reported in terms of speed and appropriateness in identifying admission facilities, which became increasingly consolidated after the first moments

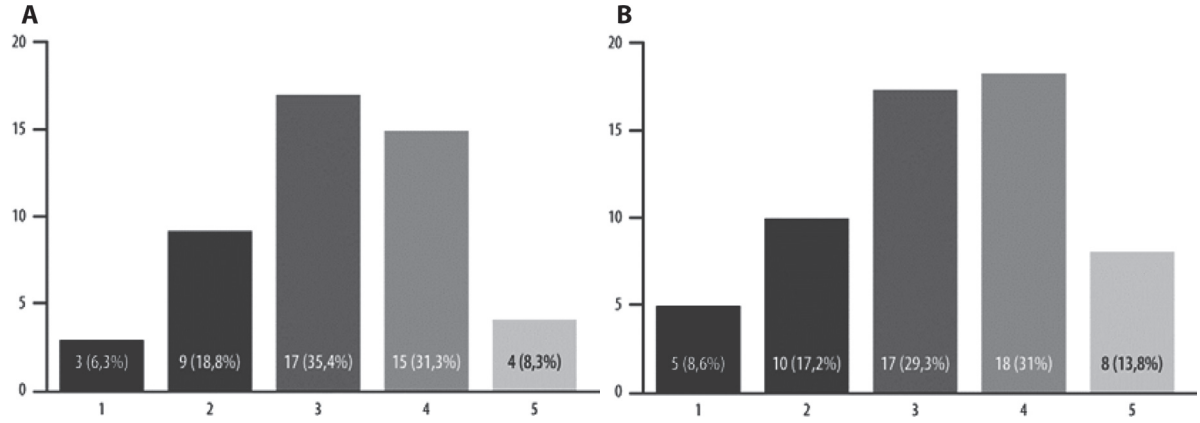

Figure 7. Customer satisfaction survey scores were reported by discharge facilities (n=48) **(A)** and admission facilities (n=58) **(B)**.

of the pandemic. In particular, the process indicators evaluation suggests a great reduction in the time between the discharge and the admission to post-acute care facilities. Thanks to the possibility for discharge facilities to use the PRIAMO portal autonomously, the percentage of transfers whose destination was found directly by the CDPO progressively increased; at the same time, the percentage of reallocations beyond 24 hours by the CDPO decreased, indicating an improvement in the quality of the operations.

The PRIAMO portal, developed and refined in a very short time, is adaptable to the ordinary management of the supply/demand needs of the territory. Indeed, the centralization of hospital discharge operations is essential in the daily management of patients to harmonize supply and demand, which individual facilities generally manage in an uncoordinated manner. The discharge centralization is also useful for planning purposes, optimizing the review of the available beds based on the clinical characteristics of the patients, as well as promptly identifying the most appropriate facility in terms of responsiveness to the precise needs of the patient, promoting a rational allocation of resources without compromising access to care. Moreover, implementing a CDPO in routine practice may facilitate discussions among providers, patients, and their families. Indeed, a coordinated discharge system could help healthcare workers provide consistent and reliable information about the options for post-acute care to patients and families. In addition, if validated in different centers, the model could help monitor the quality of care in post-acute rehabilitation units. Specifically, it could compare output data across facilities or provide longitudinal views of a single facility across time. Assessing the discharge destination could facilitate risk stratification, long-term planning, and appropriate resource allocation. Lastly, this model can help trace pathways and responsibilities between discharging and accepting structures. At the same time, some cons can be listed, such as the possible de-responsibility of the discharging teams regarding the discussion with the patient and the caregiver of the most appropriate discharge methods or the lack of implementation of a shared program between the various profs of the discharging structure.

This study presents some limitations, such as the lack of qualitative or quantitative statistical analyses to precisely assess the CDPO performance and the lack of analyses about implementation costs and the implications for a national application. However, the results of this experience were collected mainly during the emergency phase of the COVID-19 pandemic and represent the starting point for further evaluations of the complexity of this intervention and the different involved variables.

Conclusions

This experience highlights the positive effect of centralized discharge planning, which allows discharge requests to be promptly and efficiently managed even

during surge periods, saving time and costs for acute care hospitals. Therefore, the operating methods and practices implemented are believed to be maintainable over time as part of constructing a comprehensive, integrated care path.

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Conflict of Interest: Each author declares that he or she has no commercial associations (e.g., consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article.

Authors Contribution: Designed the study: FP, BC, GC; methodology: FP, FC; statistical analysis and visualization CF; conducted the study: MP, MV, EC, FB; analyzed/interpreted data: All Authors. Wrote the article: FP, FR. Proofed/revised article: All Authors. Submission approval: All Authors.

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