

# Trade-Offs with rehabilitation Effectiveness (REs) and Efficiency (REy) in a sample of Italian disabled persons in a in post-acute rehabilitation unit

C. Damiani<sup>1</sup>, M. Mangone<sup>2</sup>, M. Paoloni<sup>2</sup>, M. Goffredo<sup>1</sup>, M. Franceschini<sup>1</sup>, M. Servidio<sup>2</sup>, S. Pournajaf<sup>1</sup>, V. Santilli<sup>2</sup>, F. Agostini<sup>2</sup>, A. Bernetti<sup>2</sup>

*Key words:* Efficiency, effectiveness, rehabilitation, Barthel index, rehabilitation impact index, post-acute

*Parole chiave:* Efficienza, efficacia, riabilitazione, Indice di Barthel, indice di impatto della riabilitazione, post-acute

## Abstract

**Background.** Intensive Rehabilitation Centres, known in Italy as “code 56”, admit patients who need to recover from an acute episode. Different Rehabilitation Impact Indices have been proposed as composite rehabilitation outcomes measuring the rate of improvement due to a rehabilitation program. The most widely employed measure the performance of Activities of daily living in rehabilitation is the modified Barthel Index. The Barthel Index-based Rehabilitation Impact Indices are the Rehabilitation Effectiveness and the Rehabilitation Efficiency.

**Aim.** The aim of our study was to evaluate the trade-off between Rehabilitation Effectiveness and Rehabilitation Efficiency with respect to the Barthel Index admission score and the Length Of Stay, and their ideal ranges that optimized both indices.

**Methods.** We retrospectively evaluated data of all patients admitted to intensive rehabilitation unit of the Scientific Institute for Research and Healthcare San Raffaele Pisana of Rome, from January 2006 to March 2018. The primary outcome measures of our study were patient’s Rehabilitation Effectiveness and Rehabilitation Efficiency during the hospital stay.

**Results.** A database of 3,466 patients was analysed and the Rehabilitation Effectiveness and Rehabilitation Efficiency indexes were calculated. We calculated the median rank ratio of the Rehabilitation Effectiveness to the Rehabilitation Efficiency against Barthel Index scores. We calculated the median rank ratio of the Rehabilitation Effectiveness to Rehabilitation Efficiency against Barthel Index scores and days of stay. The median rank ratio of the Rehabilitation Effectiveness to the Rehabilitation Efficiency value were 1 in the range of Barthel Index scores from 32 to 42. The median rank ratio of the Rehabilitation Effectiveness to Rehabilitation Efficiency value were 1 for a Length of Stay corresponding to 33 days.

**Conclusions.** In our study we calculated the Trade-offs between Rehabilitation Effectiveness and Rehabilitation Efficiency with respect to admission Barthel Index Score and Length Of Stay in a population of 3,466 patients affected by orthopedic (1,707) and neurological (1,759) diseases. Every member of the healthcare team should be aware of such trade-offs when they make decisions about rehabilitation services.

**Legenda:** 6MWT = Six minute walk test; ADL = Activities of Daily Living; ASDL = Activities of Daily Living; BI = Barthel Index; DRS = Disability Rating Scale; EC = Ethical Committee; GOS = Glasgow Outcome Scale; IRC = Intensive Rehabilitation Centre; IRCCS = Scientific Institute for Research and Healthcare; LCF = Levels of Cognitive Functioning; LOS = Length of Stay; QOL = Quality of Life; Res = Rehabilitation Effectiveness; REY = Rehabilitation Efficiency; RIIs = Rehabilitation Impact Indices; SCIM = Spinal Cord Independence Measure; SDO = Hospital Discharge Form

<sup>1</sup> Department of Neurorehabilitation, IRCCS San Raffaele Pisana, Rome, Italy

<sup>2</sup> Department of Anatomical and Histological Sciences, Forensic Medicine and Orthopedics, Sapienza University of Rome, Rome, Italy

## Introduction

The main goals of the rehabilitation process are (a) reducing disability, (b) increasing the level of independence and (c) raising the quality of life (QOL) (1). Intensive Rehabilitation Centres (IRCs), known in Italy as “code 56”, admit patients who need to recover from an acute episode (2). The IRCs nurse recovers and rehabilitates subacute subjects transferred from an acute medical unit (e.g. orthopaedics, neurology, etc) (3). The rehabilitation programs conducted at the IRCs are generally tailored to the patient’s needs, and include physical therapy, speech therapy, and occupational therapy. In this context, an integrated care pathway should be optimised, and each stage of the rehabilitation process should be personalised with the aim of bringing the patient to the discharge from IRC with a good level of QOL. Therefore, there is an increasing necessity for rehabilitation performance measurements in order to find a trade-off between rehabilitation success, quality of care, and health care expenditure (4).

In the last two decades, different Rehabilitation Impact Indices (RIIs) have been proposed as composite rehabilitation outcomes measuring the rate of improvement due to a rehabilitation program in IRC (5). The rehabilitation success is usually determined by the total score obtained with scales that measure the performance of Activities of Daily Living (ADL). The RIIs include the difference between the scores administered at IRC admission and discharge, and the Length Of Stay (LOS). A review on RIIs (4) identified 5 different indexes employed in literature as composite rehabilitation outcome measures controlling premorbid and pre-rehabilitation functional status, and the rate of functional improvement. They found good evidence that older age, lower pre-rehabilitation functional status and cognitive impairment are predictive of poorer RIIs. A recent study investigated

the effectiveness and efficiency of inpatient rehabilitation services (6), by comparing different neurological diseases and typology of rehabilitation service. In particular, the LOS is a key factor that needs to be balanced between the benefits to patients and hospital expenditure (7). The optimization of an efficient rehabilitation pathway, that can maximize the functional level of patients during a short LOS, is desirable.

The most widely employed measure of the performance of ADL in rehabilitation is the modified Barthel Index (BI). It shows the degree of independence of a patient from any assistance, and it includes 10 items related to basic ADLs, such as eating, drinking, walking, etc. (8). This index has been validated by numerous studies in patients with different diseases (9, 10); it has also been used to draw conclusions on efficiency and effectiveness measures in rehabilitation (5). In particular, a modified Barthel Index at admission of 10 and a LOS of 30 days seemed to be the best values for maximising the improvement due to a rehabilitation program (7). The BI-based RIIs are the Rehabilitation Effectiveness (REs) (11) and the Rehabilitation Efficiency (REy) (7). The REs is defined as the percentage of potential functional improvement actually achieved, and the REy as the rate of functional recovery during rehabilitation. While a number of studies analysed the predictors of REs and REy in different typologies of patients (5), few recent studies (12-13) found a trade-off relation between REs and REy with respect to LOS and patient baseline BI. Specifically, these studies reported the ideal ranges of admission patient’s status and LOS that optimized both REs and REy. Although such outcomes are very important for clinical practice, they are strongly conditioned by contextual factors. These contextual factors, such as physical environment, culture, and national policy, may vary country by country and are thought to have an impact on the rehabilitation performance. In this context,

studies on national performance indicators for improving the quality of rehabilitation services in our country are needed. To our knowledge, no study has reported the ideal ranges of factors that maximise the rehabilitation effectiveness and efficiency in an Italian IRC.

We conducted a retrospective cohort study of all patients admitted to an Italian IRC from 2006 to 2018. The aim of our study was to evaluate the trade-off between REs and REy with respect to the BI admission score and the LOS, and their ideal ranges that optimized both indices.

## Materials and Methods

The Hospital Discharge Record (in Italian: SDO, *Scheda di Dimissione Ospedaliera*) is the database including a large amount of data related to patient's status (at admission and discharge), and to the recovery process carried out during the hospitalization at the IRC. Specifically, the SDO includes the BI at admission and discharge, and the LOS.

We retrospectively evaluated data of all patients admitted to the IRC of the IRCCS San Raffaele Pisana of Rome, from January 2006 to March 2018. Data were collected using the SDO database of patients hospitalized in this structure, under the supervision of the unit directors. The following patient inclusion criteria were applied: age  $\geq 18$  years; time between onset of disease and the rehabilitative hospitalization  $\leq 60$  days; LOS  $> 14$  days and  $\leq 90$  days; first admission to hospital. Patients with missing dates (for example about admission or discharge functional scores, or other dates regarding the onset of disabling conditions) and patients with REs  $> 100\%$  or Res  $< -100\%$  were excluded.

### *Ethical considerations*

Since March 2012 the Italian Data Protection Authority (in Italian: *Garante per*

*la protezione dei dati personali*) declared that all hospitals classified as IRCCSs (in Italian: Istituto di Ricovero e Cura a Carattere Scientifico – in English: Scientific Institute for Research and Healthcare) can perform retrospective studies without the approval of the local Ethical Committee (EC) (14), since only a formal communication is needed. Such communication has been registered by the EC of the IRCCS San Raffaele Pisana of Rome on 18/07/2018, code number: 7/18), that waived the need of participants informed consent.

### *Outcome measures*

The SDOs included in our study contain items which are specific for the Latium Region, i.e.: demographic data (name, surname, sex, date and place of birth, fiscal code, residence address, citizenship, marital status, education level, profession); hospitalization data (admission date, shelter regime, burden of hospitalization, source of hospitalization and its specialization, way of access to IRC, time between onset of disease and rehabilitative hospitalization); reason of the hospitalization and anamnestic data of patient (pathology of rehabilitation, basic and associated pathologies, cognitive, behaviour, communicative/language, sensitive, manipulation, balance and deambulation compromised; cardiovascular and respiratory system, urinary tract, sphincter control deficit; presence of ulcers and tracheostomy; coma and spinal cord injuries); functional indices at admission (Modified Barthel Index or BI; Six minute walk test or 6MWT; Glasgow Outcome Scale or GOS; Levels of Cognitive Functioning or LCF; Disability Rating Scale or DRS; Spinal Cord Independence Measure or SCIM); data about discharge (date, type of discharge, institution of patient transfer and its specialization, prostheses / aids / orthoses prescribed, rehabilitative program proposed, house-conditions at discharge, diagnosis at discharge, Day hospital access, interventions

performed, and BI, 6MWT, GOS, LCF, DRS, SCIM results).

The primary outcome measures of our study were patient's REs and REy during the hospital stay as calculated using the method described by Heinemann et al. (11) and Shah et al. (7).

The Rehabilitation Effectiveness (REs) (mean value 52.84; SD 43.28) is the percentage of potential functional improvement eventually achieved with rehabilitation. It was calculated as

$$\text{REs} = \frac{(\text{Discharge BI score}) - (\text{Admission BI score})}{(\text{Maximum BI score}) - (\text{Admission BI score})}$$

where the maximum BI score was considered '100'.

The Rehabilitation Efficiency (REy) (mean value 3.14; SD 11.84) is the rate of functional improvement during rehabilitation and was calculated as

$$\text{REy} = \frac{(\text{Discharge BI score}) - (\text{Admission BI score})}{\text{LOS}}$$

### Statistical analysis

Figure 1 is obtained, considering for each BI value at the entrance, the set of all patients that have the same value. For this set of patients, the values of REs and REy were calculated and, subsequently, the median rank of both the set of REs values and the REy values was obtained. Finally, the ratio between the median rank of the REs and the median rank of the REy was calculated, corresponding to that value of BI at the entrance.

Figure 2 is obtained by considering for each LOS value the set of all patients that have the same value. For this set of patients, the values of REs and REy were calculated and, subsequently, the median rank of both the set of REs values and the REy values was obtained. Finally, the ratio between the median rank of the REs and the median rank of the REy corresponding to that LOS value was calculated.

## Results

According to the Italian law, patients entering a rehabilitation structure must have a BI value at the admission of at least 10 and not more than 49. According that, patients without a hospitalization and/or discharge BI value, were discarded.

Days of hospitalization were analysed and calculated as the difference between discharge and admission date, and patients with days of stay  $< 5$  and  $\geq 80$  were eliminated because periods too short or too long are indicative of exceptional cases, such as clinical or bureaucratic complications.

On the data so far cleaned, a first statistical analysis of the difference ( $\Delta B$ ) between the discharge and hospitalization BI values was performed. The trend of  $\Delta B$  is shown in Figure 3.

It is noted that  $\Delta B$  also assumes values less than zero, indicating a worsening of the patient's state of autonomy. It is assumed that this may be due to contingent situations, the occurrence of competing pathologies or other. All patients with  $\Delta B < 0$  were deleted from the database. It also appears that a significant group of patients has  $\Delta B = 0$ , showing an anomalous trend with respect to the distribution. A detailed comparison between the values of the individual components led us to believe that the data of these patients (with  $\Delta B = 0$ ) have not been entered correctly. All patients with  $\Delta B = 0$  and with all BI subcodes identical in discharge and admission have been deleted from the database. The total number of patients in the database thus cleaned went down to 3,466.

4,056 SDO were analysed: of these, only 3,466 were eligible, according to the inclusion and exclusion criteria mentioned above; the remaining 590 SDO were incomplete for some other item, so it was necessary to discard them.

The database of 3,466 patients was analysed and the REs and REy indexes

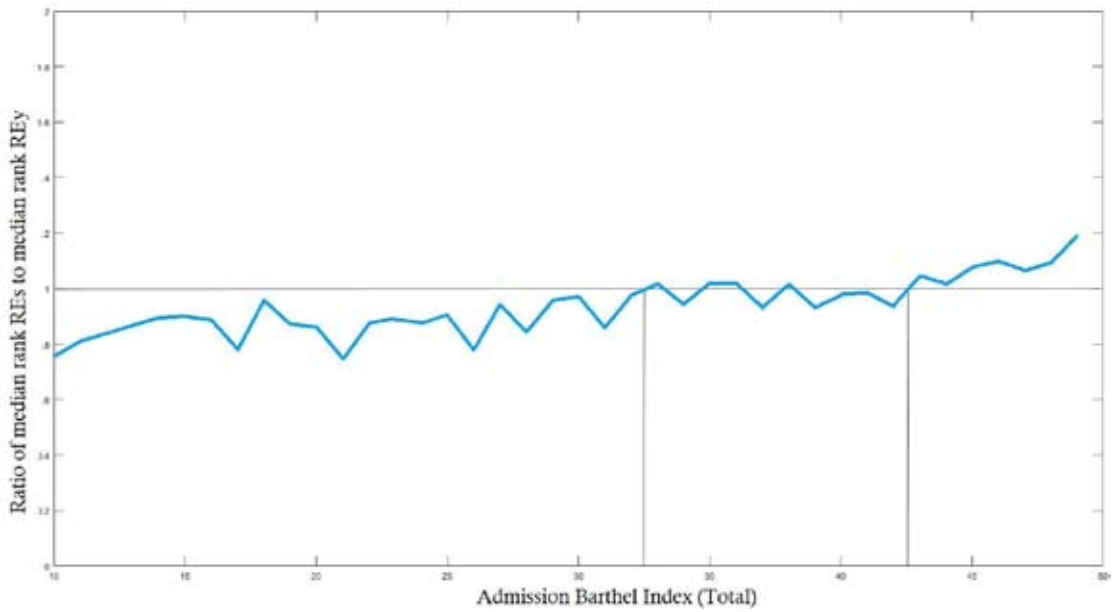


Figure 1 - Median rank ratio of the REs to REY value against BI scores.

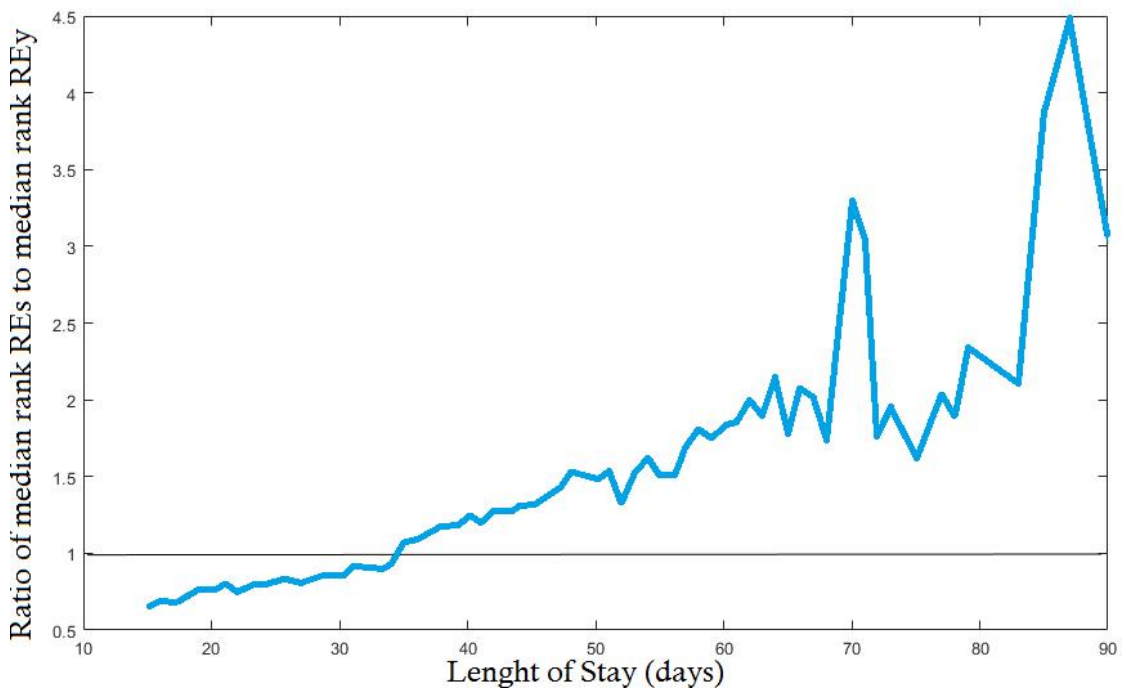


Figure 2 - Median rank ratio of the REs to REY value against LOS.

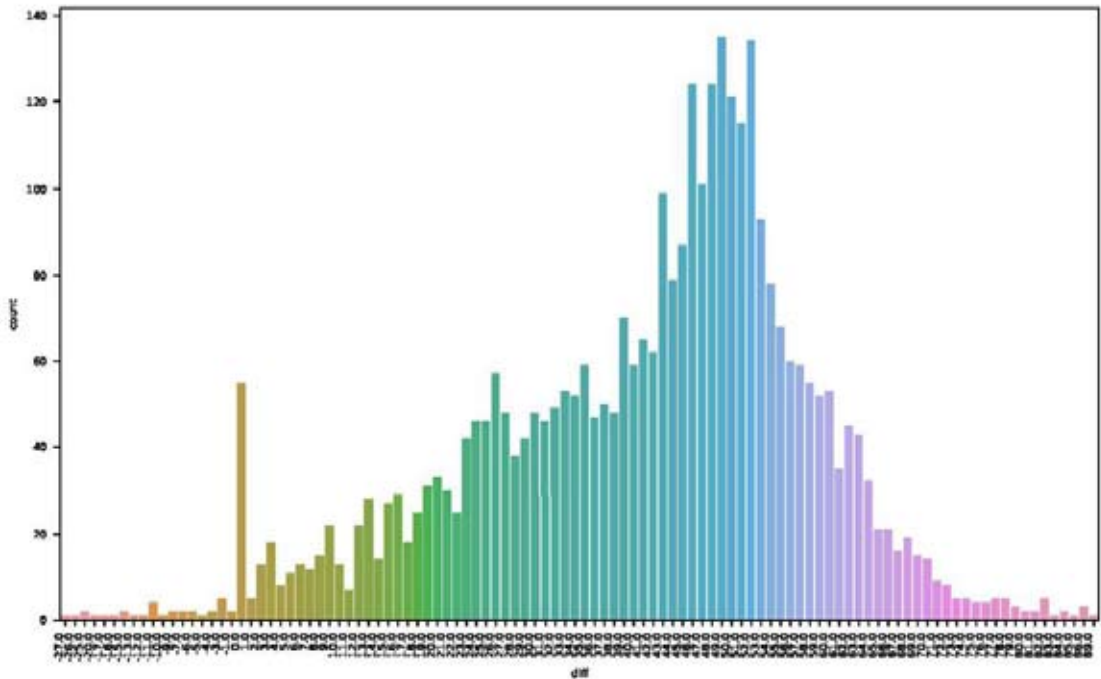


Figure 3 - Difference between discharge and hospitalization BI values ( $\Delta B$ ).

were calculated. Table 1 summarizes the characteristics of the study sample.

We calculated the median rank ratio of the REs to REy against BI scores (Fig. 1) and days of stay (Fig. 2). Analysing the figures, the relationship appeared positive with REs, but negative with REy, when the median ranks of REs to REy were plotted against BI. When the median ranks were plotted based on the length of stay, the relationship was positive with REs, but negative with REy.

In Fig. 1 the median rank ratio of the REs to REy value were 1 in the range of BI scores from 32 to 42. In Fig. 2 the median rank ratio of the REs to REy value were 1 for a Length of Stays corresponding to 33 days.

## Discussion

Our study is inspired by the first study, to our knowledge, to examine the factors

associated with REs and REy and to report exchange relationships between REs and REy in relation to the functional status of admission and duration of hospital rehabilitation in elderly disabled (7), which also supported previous findings in the literature that advanced age, cognitive impairment and comorbid burden were independently associated with lower REs or REy (15-17).

The aim of our study was to evaluate the trade-off between REs and REy with respect to the BI admission score and the LOS as already reported in some studies in the literature, for example Koh et al. (12) did a similar study for patients with stroke.

Rodà F et al, in 2019 (18), in a consensus conference, using the Delphi method, aimed to define the adequacy of the criteria for admission of intensive rehabilitation (first attempt in Italy). The total number of 31 experts was invited to participate, but

only 16 completed the entire survey. The authors conclude that this low participation rate unfortunately demonstrates the lack of awareness among rehabilitation professionals in Italy, which is therefore a further signal both of the lack of scientific evidence on the subject and of the need to reach a consensus on the criteria of admission to this type of hospitalization.

Piscitelli D et al., in 2018 (19), carried out a review, with the aim to explore the evidence regarding the feasibility, effectiveness, cost, safety and patient satisfaction through direct access than other organizational models. The authors have shown that direct access to physiotherapy treatments is feasible both clinically and economically, despite the limited evidence of the studies examined. Patients showed fewer physiotherapy treatments, doctor visits, imaging tests, non-steroidal anti-inflammatory drugs, secondary care, and showed greater satisfaction with the control group.

Many researchers use LOS for a hospital stay as the denominator for REy; this is acceptable provided the functional scoring is performed close to the date of admission and discharge. However, if the first functional measurement was performed many days after admission or the last functional assessment was performed many days before date of discharge, REy may be spuriously high if LOS was used in the denominator. Hence, it may be more accurate to use the number of days between the date of first and last functional measurement as the denominator for REy instead of LOS, as conducted by Koh et al. (5).

However, the current Italian laws require that BI be evaluated at the time of acceptance.

Our results (Fig. 1) show that a low score for BI was related to a low effectiveness (REs) but to a high efficiency (REy). In fact the Figure implies that a patient with a worse functional state at admission achieved a faster functional recovery and they achieve

a lower functional gain compared to a patient with a better functional state at the time of admission. Instead, a patient with a longer LOS was associated with better efficacy and worse efficiency, compared to a patient with a shorter LOS.

According to our results, the ideal range BI scores (Ratio=1) at admission, which optimized both REs and REy for patients, is 32 to 42 units. Our ideal value of LOS that optimized both REs and REy in our patients, was 32 days. Both our results differ from what was described by Chow. As for BI scores, in our case the ideal range is located at lower values than Chow; this data could be due to the criteria of admission to the intensive rehabilitation departments (cod. 56) in force in Italy which foresee a BI between 10 and 49 (20). Some institutions and governments have admission criteria or maximum duration of stay for inpatient rehabilitation funding eligibility. While unnecessary prolongation of inpatient rehabilitation may be inefficient, premature termination of sub-acute stroke rehabilitation because of financial constraints may limit maximal functional recovery (12).

## Conclusion

In Our study we calculated the Trade-offs between REs and REy with respect to admission BI score and LOS in a population of 3,466 patients affected by orthopedic (1,707) and neurological (1,759) diseases. Every member of the healthcare team should be aware of such trade-offs when they make decisions about rehabilitation services.

**Ethics approval and consent to participate:** Since March 2012 the Italian Data Protection Authority (Garante per la protezione dei dati personali) declared that hospitals classified as IRCCSs can perform retrospective studies without the approval of the local EC, since only a formal communication is needed. Such communication has been registered by the EC of the IRCCS San Raffaele

Pisana of Rome on 18/07/2018, code number: 7/18. This waived the need of participants' informed consent.

**Consent for publication:** All authors gave their consent for the manuscript publication.

**Availability of data and material:** The authors are available to send data to those who request it.

**Competing interests:** The authors have declared that no competing interests exist.

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## Riassunto

### *Trade-Off con Efficacia ed Efficienza riabilitativa in un campione di disabili italiani in un'unità di riabilitazione post-acute*

**Background.** I centri di riabilitazione intensiva, noti in Italia come "codice 56", ammettono i pazienti che necessitano di un ricovero dopo un episodio acuto. Diversi Indici di riabilitazione sono stati proposti come outcome al fine di misurare il tasso di miglioramento conseguente ad un programma di riabilitazione. La misura più utilizzata al fine di misurare le prestazioni nelle attività di vita quotidiana è l'Indice Barthel modificato. Gli Indici di impatto della riabilitazione, basati sull'indice di Barthel modificato sono l'efficacia e l'efficienza riabilitativa.

**Obiettivo.** Lo scopo del nostro studio era valutare il trade-off tra l'efficacia e l'efficienza riabilitativa rispetto al punteggio di ammissione dell'Indice di Barthel e alla durata del ricovero e i range ideali che ottimizzavano entrambi gli indici.

**Metodi.** Abbiamo valutato retrospettivamente i dati di tutti i pazienti ammessi all'unità di riabilitazione intensiva dell'Istituto di Ricovero e Cura a Carattere Scientifico San Raffaele Pisana di Roma, da gennaio 2006 a marzo 2018. Gli outcome primari del nostro studio erano l'Efficacia e l'Efficienza riabilitativa durante la degenza ospedaliera.

**Risultati.** È stato analizzato un database di 3.466 pazienti e sono stati calcolati gli indici di Efficacia e di Efficienza Riabilitativa. Abbiamo calcolato il coefficiente di rango mediano tra Efficacia ed Efficienza Riabilitativa rispetto ai punteggi dell'Indice di Barthel. Il coefficiente di rango medio di Efficacia e Efficienza Riabilitativa era 1 nell'intervallo dei

punteggi dell'Indice di Barthel da 32 a 42. Il coefficiente di rango medio di Efficacia Riabilitativa e di Efficienza Riabilitativa era 1 per una durata di ricovero corrispondente a 33 giorni.

**Conclusioni.** Nel nostro studio sono stati calcolati i trade-off tra Efficacia ed Efficienza Riabilitativa rispetto al punteggio di ammissione dell'Indice di Barthel e alla durata della degenza in una popolazione di 3.466 pazienti affetti da patologie ortopediche (1.707) e neurologiche (1.759). Ogni componente del Team sanitario dovrebbe essere consapevole di tali trade-off quando prende decisioni attinenti al servizio di riabilitazione.

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Corresponding author: Francesco Agostini, MD, Department of Anatomical and Histological Sciences, Legal Medicine and Orthopedics, Sapienza University of Rome, Piazzale Aldo Moro 5, 00185, Rome, Italy  
e-mail: francescoagostini.ff@gmail.com