



UNIVERSITATEA DE MEDICINĂ ȘI FARMACIE
“CAROL DAVILA” din BUCUREȘTI



UNIVERSITY OF MEDICINE AND PHARMACY
“CAROL DAVILA”, BUCHAREST
DOCTORAL SCHOOL
FIELD: MEDICINE

PhD THESIS

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**ASSESSMENT OF DISABILITY SEVERITY IN
DECONDITIONED POST-COVID-19 PATIENTS
ENROLLED IN A MEDICAL REHABILITATION
PROGRAM
PhD THESIS SUMMARY**

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1. Introduction. Current Research Context

Over recent decades, medicine has undergone a major paradigm shift, driven by the increasingly apparent limitations of the traditional biomedical model, which focuses almost exclusively on disease, diagnosis, and survival. Although the approach has been pivotal in advancing etiological treatments and reducing mortality across a wide range of acute conditions, it has proven insufficient for capturing the true impact of illness on patients' lives, particularly in the setting of chronic disease, multimorbidity, and survival after severe acute events. [1-6].

Progressively, the focus has shifted toward the functional dimension of health. Accordingly, functioning and disability can no longer be regarded as mere downstream consequences of disease; rather, they have become major clinical indicators with independent explanatory and predictive value [7–10]. This orientation is also reflected at the institutional level through the World Health Organization's adoption of the International Classification of Functioning, Disability and Health (ICF) as an integrative conceptual framework for describing health status. [11].

According to the ICF, health is not defined solely by the absence of disease, but by an individual's level of functioning within a real-life context, shaped by the interaction between biological status, personal factors, and environmental factors. [11,12]. Consequently, a condition may be considered biologically resolved, yet the patient may continue to experience significant functional limitations that compromise autonomy, work capacity, social participation, and overall quality of life. [13-16].

This discrepancy between “biological resolution” and “functional recovery” constitutes one of the central challenges of contemporary rehabilitation medicine. It became particularly evident during the COVID-19 pandemic, which not only produced a substantial burden of severe acute disease but also left a significant number of patients with persistent symptoms, functional disability, and multisystem involvement in the post-acute phase and over the longer term. [17-22].

The WHO “Rehabilitation 2030” initiative underscores the need to embed rehabilitation as an essential component of modern health systems, both during the acute phase and in the management of medium and long-term sequelae [23]. Within this framework, rehabilitation can no longer be regarded as a secondary, late-stage intervention,

but rather as a clinical and organizational strategy aimed at preventing and reducing disability. [23-25].

2. Importance of the Topic. Timeliness and Clinical Relevance

Traditionally, health system performance and patient outcomes have been assessed using indicators such as mortality and morbidity. While indispensable, these metrics do not capture the practical realities of everyday life, an individual's capacity to perform activities, manage daily living, and participate in social life [26,27].

Global Burden of Disease studies have shown that a substantial proportion of the overall population-level impact of disease is driven not by deaths, but by years lived with disability (YLD) [28,29]. This finding fundamentally reshapes the hierarchy of goals in medical care, conferring strategic importance on interventions aimed at preserving or restoring functioning [28-30].

In this context, rehabilitation medicine occupies a central role. Its purpose is not to eradicate disease, but to mitigate its functional consequences and maximize the patient's level of autonomy [31-33]. However, clinical practice indicates that functional loss is not determined solely by the index disease, but by a constellation of secondary mechanisms—among which deconditioning plays a major role [34-37].

Deconditioning is a complex syndrome characterized by a global decline in functional capacity resulting from inactivity, immobilization, acute illness, or prolonged systemic stress. From a pathophysiological standpoint, it encompasses loss of muscle mass and strength, reduced aerobic capacity, impaired balance and coordination, and decreased exercise tolerance [34,38,39].

In the hospital setting, particularly during prolonged admissions or critical illness, these changes can develop rapidly and progress at an accelerated pace. The literature indicates that even relatively short periods of immobilization may lead to clinically meaningful functional decline, especially in older adults and in patients with limited functional reserve [40-42].

Clinically, deconditioning extends beyond a transient reduction in physical performance. It is associated with increased dependence on external assistance, prolonged recovery trajectories, and a reduced likelihood of returning to a satisfactory level of autonomy. In this sense, deconditioning can be viewed as an “amplifier” of disability,

capable of transforming a initially limited impairment into a complex and persistent functional profile [34,36,43].

The COVID-19 pandemic has given this issue a new dimension and unprecedented visibility. Beyond its acute impact on mortality and the strain placed on health systems, the pandemic has produced a large cohort of patients who, after the acute phase, have remained with persistent functional limitations [17-22]. Symptoms such as chronic fatigue, exercise intolerance, muscle weakness, subtle cognitive disturbances, exertional dyspnea, and reduced capacity for socio-occupational reintegration have been frequently reported both in patients with severe disease and in a substantial proportion of those with moderate forms [44-49].

Similarly, patients hospitalized for other conditions during the pandemic were exposed to an increased risk of deconditioning due to immobilization, restrictions on mobilization, and disruption of usual care pathways [50-52]. Accordingly, post-COVID disability and post-hospitalization disability can no longer be viewed as marginal phenomena; they should be addressed as major public health issues, with implications for quality of life, socio-occupational reintegration, and the sustainability of health systems [53-55].

3. Assessment Instruments: Need for Standardization

Despite the clear importance of disability as a clinical outcome, both medical practice and the literature reveal substantial variability in the instruments used to assess functioning. This methodological heterogeneity limits comparability across studies and complicates the integration of findings into coherent evidence-based practice models [56-59].

For this reason, the WHO has promoted the ICF framework not only as a classification system, but also as a common language for describing functioning [11,12]. Building on this conceptual framework, standardized instruments such as WHODAS 2.0 and, more recently, ClinFIT COVID-19 have been developed, enabling disability to be quantified in a way that is comparable across diseases, clinical contexts, and health systems [60-63].

In particular, ClinFIT COVID-19 was designed to assess patients' functional severity across the full continuum of care, encompassing the acute, post-acute, and long COVID phases. Conceptually anchored in the ICF, the instrument draws on functional categories relevant to post-COVID syndromes, with emphasis on domains such as energy, exercise tolerance, respiratory function, pain, sleep, cognitive functions, and mobility [61-64].

The combined use of a clinician-rated instrument (ClinFIT COVID-19) enables a more comprehensive characterization of disability by integrating the objective clinical perspective with the subjective patient perspective [60,65]. This approach is regarded in the contemporary literature as a methodological standard in rehabilitation, as disability cannot be reduced to a single dimension, and discrepancies between clinical assessment and the patient's lived experience may lead to incomplete interpretations [66-68].

4. Rationale and Positioning of the Thesis

Within this context, the present PhD thesis aims to examine functioning and disability as major clinical outcomes of medical care, particularly in the COVID-19 and post-pandemic setting, with a focus on the relationship between deconditioning, disability severity, and response to rehabilitation.

The research is framed from an integrative perspective grounded in the biopsychosocial model of health and the ICF conceptual framework. A central element of this approach is the repositioning of disability not as a static consequence of disease, but as a dynamic process, shaped by the stage of infection and by the interplay between biological, functional, and contextual factors.

This repositioning is supported by the international literature, which advances functioning as a health indicator and as a tool for guiding rehabilitation interventions [7-10,23,69]. The present work also aligns with current trends advocating the integrated use of patient experience measures (PREMs), patient-reported outcomes (PROMs), and dynamic physiological biomarkers within a unified analytical framework [70-72].

The thesis leverages real-world clinical data from a multicenter cohort, including patients recruited from a multidisciplinary emergency hospital, a dedicated post-COVID assessment center, and a national infectious diseases institute. It further proposes a longitudinal approach to the evaluation of deconditioned patients, both with and without a prior history of COVID-19.

5. Central Hypothesis and Research Objectives

5.1. Central Hypothesis

The central hypothesis of this research is that the level of functional disability in deconditioned patients is driven primarily by the severity of deconditioning rather than by the initial diagnosis. In addition, it is posited that a structured medical rehabilitation program

yields a significant, clinically meaningful improvement in functioning and disability, measurable using standardized instruments aligned with the ICF framework (ClinFIT COVID-19).

In particular, functional deconditioning is considered a major mediating mechanism between disease and disability, and reducing its severity through therapeutic intervention is expected to decrease disability relatively independently of the initial etiology of the acute episode.

5.2. Scientific objectives

Based on this hypothesis, the research pursues the following objectives::

1. Quantitative and clinical characterization of the baseline levels of disability and deconditioning in patients enrolled in the rehabilitation program, using standardized ICF-based instruments (ClinFIT COVID-19).
2. Analysis of the relationship between the severity of functional deconditioning and the level of disability, in order to test deconditioning as a major determinant of loss of functional autonomy.
3. Evaluation of the impact of the medical rehabilitation program on functioning and disability by comparing scores at baseline (T0) and at the end of the intervention (T1).
4. Integration of the findings into a coherent conceptual model in which disability is interpreted as a functional expression of deconditioning, rather than solely as a direct effect of the underlying disease.

6. Overall Thesis Structure and Scientific Logic

The thesis is structured into two main components:

1. **The general section**, which develops the conceptual and clinical foundations of functioning, disability, and deconditioning, and positions the research within the context of the international literature.
2. **The original section (author's contributions)**, which includes the overall methodology, cohort description, statistical analysis, and presentation of results across the three studies.

Specifically, the research is organized around three complementary directions, reflecting distinct, yet interconnected, levels of evaluating medical care and its impact on the patient:

- the experiential and perceptual level of the hospitalized patient (satisfaction with care);
- the clinical and functional level of disability and global rehabilitation;
- the fine-grained dynamic and physiological level, focusing on nonlinear mechanisms of post-COVID-19 respiratory rehabilitation.

This structure is consistent with contemporary recommendations in rehabilitation medicine, which advocate integrating organizational indicators, functional outcomes, and dynamic biomarkers within a unified interpretative framework [70-72].

7. Chapter 1 – Conceptual and Clinical Foundations (Synthesis)

Chapter 1 presents the conceptual foundation required to interpret disability as a major clinical outcome [1-6,11].

Deconditioning is described not as a minor secondary phenomenon, but as a major mechanism of functional decline, present across multiple pathologies and amplified in the context of prolonged hospitalization, critical illness, and immobilization [34-42]. Thus, functional loss is not driven directly by the initial lesion, but by the downstream cascade of inactivity-related consequences: sarcopenia, reduced cardiorespiratory capacity, impaired postural control, balance disturbances, and an increased risk of falls [38-42].

Rehabilitation intervention is described as a process aimed at restoring autonomy and reducing disability by addressing the pathophysiological mechanisms underlying deconditioning [31-33].

Another major focus of the chapter is the operationalization of functioning using ICF-derived instruments. The thesis argues that standardized assessment is an indispensable prerequisite for cross-study comparability, progress monitoring, and integrating findings into evidence-based practice [56-59]. Within this context, the ClinFIT COVID-19 instrument is introduced as a novel element and will be used in the thesis's original studies [60-64].

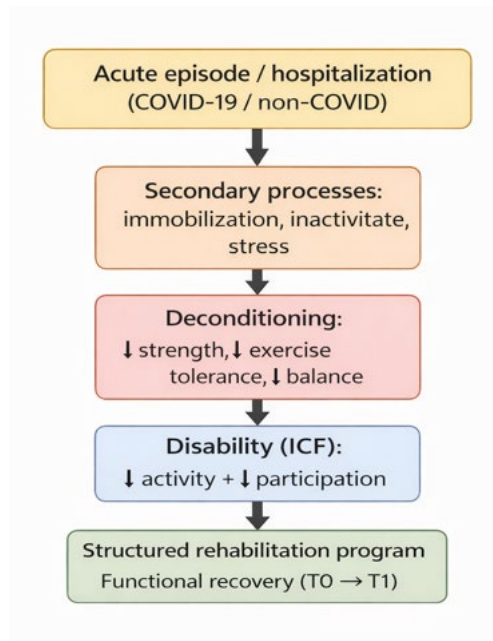


Figure 1 – Integrative conceptual model: disease → deconditioning → disability → rehabilitation

7.1. Chapter 2 – Disability and COVID-19 in the Literature Context

The thesis emphasizes that the pandemic was not only an epidemiological crisis, but also an event that accelerated the transition toward a functioning-oriented approach to medicine, highlighting the extent of post-hospitalization and post-viral disability [17-22].

The bibliometric analysis presented in the chapter confirms the rapid expansion of post-COVID scientific output, both in volume and in methodological diversity, with increasing emphasis on persistent disability, long-term rehabilitation, and socio-occupational reintegration [6-12,49-55].

The thesis is positioned at the intersection of the relatively limited body of studies that combine standardized clinical assessment with patient-reported evaluation and the small number of investigations that treat deconditioning as a central mechanism. It proposes an integrated, longitudinal approach to deconditioned patients, both with and without a prior history of COVID-19.

Table 1. Major directions in the post-COVID literature on disability and rehabilitation

1.	Long COVID and persistent symptoms	Fatigue, dyspnea, pain, cognitive disturbances, exercise intolerance	Supports the need for functional assessment and long-term monitoring
2	Assessment of functioning and disability (ICF-based)	ICF, ClinFIT COVID-19, WHODAS 2.0, standardized instruments, functional domains	Supports the use of a common language and validated instruments
3	Post-COVID rehabilitation and multimodal programs	Physiotherapy, occupational therapy, respiratory rehabilitation, physical reconditioning	Underpins the pre–post interventional design (T0–T1)
4	Pathophysiology and systemic mechanisms	Inflammation, pulmonary, cardiovascular, and neurological involvement, sarcopenia, dysautonomia	Explains clinical heterogeneity and the need for a multidisciplinary approach
5	Socio-occupational impact and reintegration	Return to work, quality of life, social participation, occupational disability	Supports inclusion of the “participation” dimension and functioning as a major outcome
6	Health systems and post-pandemic care organization	Continuum of care, telemedicine, community rehabilitation, integrated services	Justifies analyzing quality of care and functional management
7	Functional biomarkers and innovative methods	Dynamic analysis, variability, fractality, digital monitoring	Supports Study 3 and the nonlinear model for optimizing recovery

8. Chapter 3 – Working Hypotheses and Research Objectives

The research hypotheses and objectives serve as a structural pivot within the architecture of the thesis, enabling the transition from the conceptual grounding (general section) to the methodological and analytical work (original section). Within the logic of an empirically oriented doctoral thesis, the explicit formulation of hypotheses and objectives is not a merely formal step; it is an essential prerequisite for internal coherence, appropriate variable selection, and the valid interpretation of results [73-76].

The thesis is grounded in the premise that modern health assessment must systematically incorporate indicators of functioning and disability, as biomedical parameters in isolation are insufficient to capture the true impact of disease on autonomy and participation [77-79]. In this context, COVID-19 acted as a catalyst that exposed the limitations of the classical model and accelerated the shift toward a functioning-oriented approach to medicine, in which rehabilitation becomes a strategic component of the health system [80-82].

8.1. General research hypothesis

The overall hypothesis of the thesis is formulated as follows:

The quality of medical care influences both the patient's perceived experience during the acute phase of hospitalization and subsequent functional outcomes, while deconditioning and the dynamic rigidification of physiological systems represent central mechanisms of post-hospitalization disability; integrating functional assessment with dynamic biomarkers enables optimization of the rehabilitation process.

This hypothesis is consistent with the recent literature, which frames functioning as a central clinical outcome in post-COVID rehabilitation. It emphasizes that functional impairments may persist across the entire post-infectious trajectory, regardless of the initial severity of disease, and that the disability profile is shaped by the interaction between biological injury and deconditioning processes [83-88].

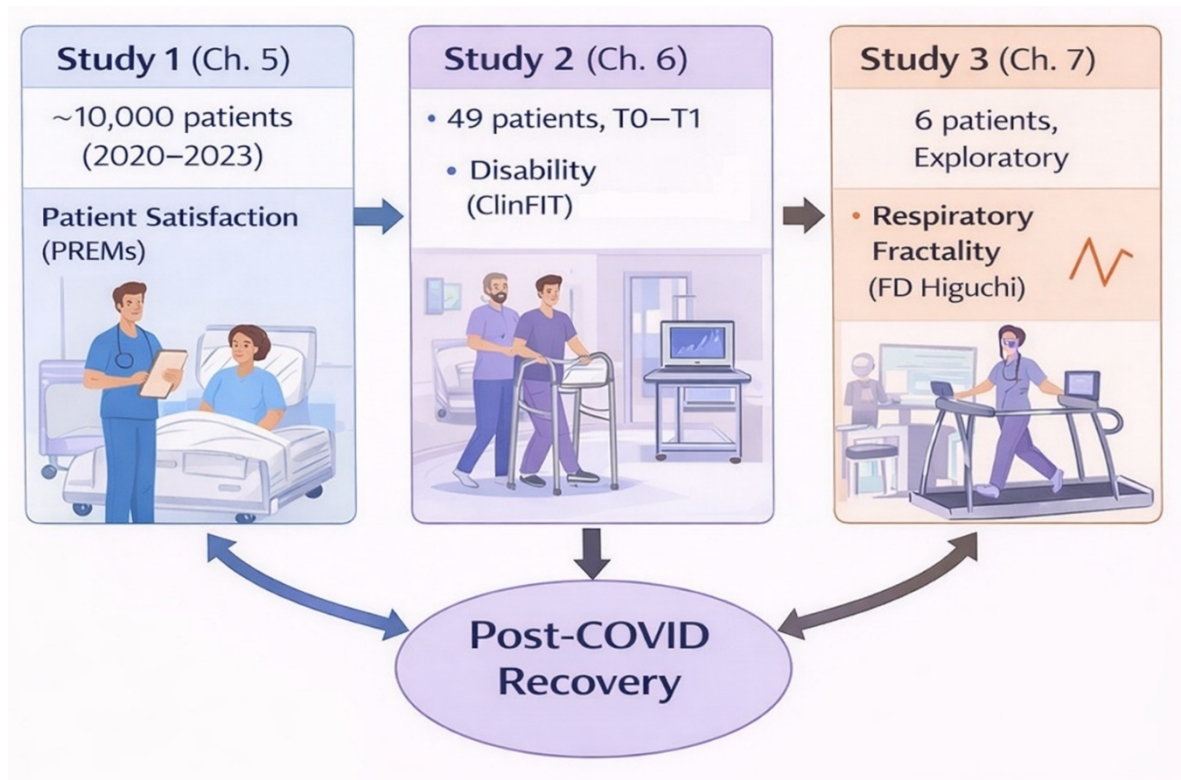


Figure 3 – Multimodal research architecture: three complementary studies across the continuum of care

The figure depicts the thesis’s integrative logic: from patient experience and in-hospital quality of care (Study 1), to functional outcomes and the role of deconditioning in disability (Study 2), and finally to a fine-grained physiological level (Study 3), where respiratory recovery is interpreted as a nonlinear adaptive process that can be monitored using complexity-based biomarkers.

8.2. Study-specific hypotheses and objectives

Consistent with the delineation of the three studies, the thesis formulates distinct hypotheses and objectives:

- *Study 1 (Chapter 5)*: Inpatient satisfaction during the COVID-19 pandemic (2020–2023) reflects both the perceived quality of medical care and the organizational constraints imposed by the pandemic context; significant differences are expected across care dimensions and across pandemic periods.

- *Study 2 (Chapter 6)*: In deconditioned patients with disability enrolled in a structured rehabilitation program, disability level is driven primarily by the severity of

deconditioning rather than the initial etiology; rehabilitation is expected to yield significant, clinically meaningful improvements in functioning.

- *Study 3 (Chapter 7)*: Post-COVID respiratory rehabilitation is a nonlinear adaptive process; fractal analysis of the respiratory signal enables the identification of functional rigidification and supports optimization of interventions through adaptive guidance.

9. Chapter 4 – General Research Methodology (Synthesis)

This chapter defines the overarching methodological framework of the thesis, with the purpose of ensuring coherence across the three studies.

9.1. Study type and overall design

The thesis is conceived as a multimodal investigation with a mixed design, integrating observational approaches, longitudinal clinical methods, and exploratory techniques based on dynamic and fractal analysis. The complexity of the phenomena under study, patient satisfaction, functioning, disability, and physiological recovery, cannot be adequately characterized through a single study type or a single set of indicators.

9.2. Institutional setting, study period, and study population

The research was conducted in multicenter hospital-based clinical settings dedicated to the care of COVID-19 patients and to the rehabilitation of individuals with complex pathology and post-hospitalization sequelae. The investigated period spans 2020–2023, corresponding to the main phases of the pandemic and the post-acute interval, with a subsequent extension to support the assessment of functional and respiratory recovery.

This temporal continuity enables an integrated analysis of patient experience, functional outcomes, and physiological recovery mechanisms within a “continuum of care” framework.

The study population is clinically heterogeneous but conceptually unified: patients who experienced a hospitalization episode during the COVID-19 period or underwent post-hospitalization rehabilitation.

9.3. Data management and quality control

The thesis describes the implementation of standardized procedures for data entry and storage, identification and handling of missing values, verification of errors and outliers, and documentation of all processing steps. These procedures are intended to ensure the

traceability and reproducibility of the analyses, an essential requirement in research based on real-world institutional data.

9.4. Common statistical methods and general research variables

The statistical methods used across the thesis, common to all three studies, include descriptive analyses, parametric and non-parametric tests, correlation analyses, regression models, longitudinal analyses, and effect size estimation. Statistical significance was set at $p < 0.05$.

Variables were defined and operationalized to support an integrated analysis across three dimensions: patient experience, functioning and disability, and the physiological mechanisms of recovery.

Internal validity is supported through standardization and the use of validated instruments, while external validity is constrained by the specific institutional context. The observational nature of Study 1, the lack of randomization in Studies 2 and 3, and the use of self-reported measures represent acknowledged methodological limitations, which are addressed critically in the thesis.

10. Chapter 5 - Study 1: Quality of Medical Care During the COVID-19 Pandemic (Patient Perspective)

10.1. Introduction and rationale

The first study of the thesis examines patient satisfaction as a central indicator of the quality of medical care. The thesis argues that patient satisfaction is not a peripheral construct, but a core component of quality, with direct implications for compliance, treatment adherence, and trust in the health system.

A substantial body of international research shows that negative patient experience during hospitalization can influence subsequent patterns of healthcare utilization and may even affect certain clinical outcomes over the medium and long term [89-92]. In the pandemic context, this dimension becomes particularly salient because social isolation imposed on patients, communication barriers created by personal protective equipment, staff overload, and generalized uncertainty can profoundly shape the subjective experience of hospitalization, even when the technical quality of care remains adequate.

Accordingly, the thesis describes the systematic assessment of inpatient satisfaction as an indirect indicator of organizational functioning and of an institution's capacity to maintain quality standards under conditions of extreme pressure.

10.2. Operational hypotheses and objectives (Study 1)

For Study 1, four major operational hypotheses are formulated:

H1.1. There are significant differences in satisfaction levels across different dimensions of care (communication, staff attitude, organization, conditions, safety).

H1.2. Patient satisfaction differs significantly across the distinct phases of the pandemic (2020–2023), reflecting organizational changes and fluctuations in health system pressure.

H1.3. Relational dimensions of care (communication, empathy, availability) contribute more to overall satisfaction than strictly organizational or hotel-related dimensions.

H1.4. Overall satisfaction is significantly associated with perceptions of safety and clinical competence.

The overall objective of the study is to assess satisfaction among hospitalized COVID-19 patients during 2020–2023 and to analyze the multidimensional structure of satisfaction in relation to the organizational and relational context of medical care.

The specific objectives include:

- Determining the overall level of satisfaction;
- Separate analysis of the main dimensions (communication, attitude, organization, hotel conditions, safety);
- Comparing satisfaction across different phases of the pandemic;
- Identifying the dimensions that contribute most to overall satisfaction;
- Exploring the relationship between overall satisfaction and specific characteristics of the hospitalization experience

10.3. Materials and methods (Study 1)

Study 1 is an observational, retrospective, and analytical study that assesses the satisfaction of patients hospitalized in a multidisciplinary hospital during the COVID-19 pandemic, over the period 2020–2023. The study is situated within the paradigm of patient-centered care and patient experience, which recognizes satisfaction as a relevant indicator of healthcare quality.

Methodologically, the study is based on an analysis of the standardized inpatient satisfaction questionnaire routinely used for continuous hospitalization at the Central Military Emergency University Hospital “Dr. Carol Davila” in Bucharest, during March 2020 to June 2023.

Cohort

More than 10,000 valid questionnaires were analyzed, collected semiannually from most hospital departments. The very large sample size provides high statistical robustness and enables both a cross-sectional description of patients’ perceptions of care quality and a longitudinal analysis of how these perceptions evolved across different phases of the pandemic..

10.4. Indicators used (satisfaction structure)

Patient satisfaction is analyzed multidimensionally across distinct domains, capturing relational dimensions as well as organizational and safety-related aspects. The thesis explicitly treats overall satisfaction as an aggregated outcome, while placing particular emphasis on the domain-specific profile, as it enables the identification of strengths and areas of vulnerability in care delivery within a pandemic context.

Tabel 2 - Structure of the satisfaction domains analyzed in Study 1 (2020–2023)

Domain	Clinical/organizational meaning
Communication	clarity of information, staff accessibility
Attitude	empathy, respect, availability
Organization	waiting times, patient flow, coordination, logistics
Hotel conditions	cleanliness, comfort, meals
Safety	trust in clinical care, perceived protection

11. Main results

The results of Study 1 are interpreted in an integrative framework in which patient satisfaction is analyzed as an expression of the hospital’s organizational functioning under conditions of extreme pressure.

The thesis emphasizes that patient experience was overall positive and stable even during severe pandemic phases, and that the human dimension of care (attitude, communication, therapeutic relationship) represents the central pillar of perceived quality.

A key finding is that patient satisfaction correlates with relevant organizational indicators and should not be regarded as a purely subjective construct.

The thesis also discusses the existence of a significant negative correlation between overall satisfaction and readmission rates, suggesting that a better hospital experience may contribute to a better understanding of the therapeutic plan, increased compliance, continuity of care, and early addressing of issues.

In this context, patient satisfaction is interpreted not only as a descriptive indicator but also as a potential tool for managing the quality and efficiency of the healthcare system.

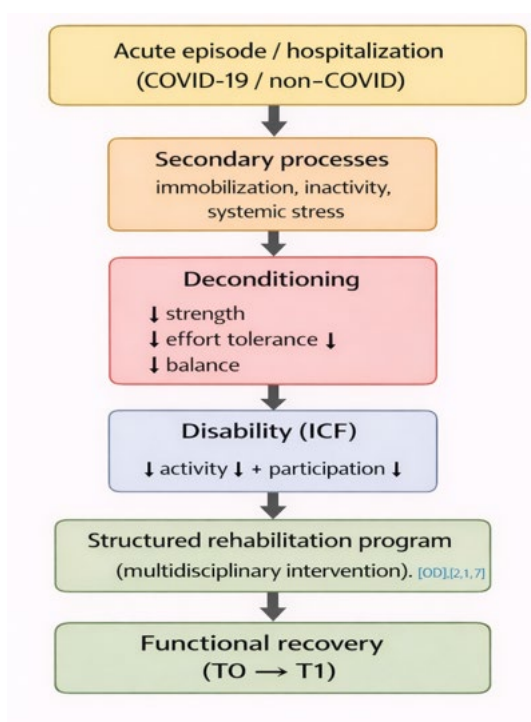


Figure 2 – Integrative ICF-based conceptual model

12. Study 1 – Results and Integrative Interpretation (Summary for Abstract)

12.1. Key insights from the longitudinal analysis (2020–2023)

Analysis of approximately 10,000 valid questionnaires indicates an overall positive and stable patient experience throughout the analyzed period, including during phases of

high pandemic pressure, with trends of improvement in later stages as the system adapted organizationally.

A robust finding is that the human dimension of care (communication, empathy, availability, attitude) serves as the central pillar of overall satisfaction, surpassing the influence of strictly hotel/organizational dimensions in shaping the final evaluation.

12.2. Satisfaction as a functional indicator for quality management

The thesis highlights a particularly relevant finding for hospital management: the significant negative correlation between overall satisfaction and readmission rates, suggesting that patient experience can influence post-discharge behaviors and outcomes (compliance, continuity of care, early intervention).

In addition, the thesis emphasizes that the lack of a significant correlation between complications and readmissions may reflect the multifactorial nature of readmissions (comorbidities, socio-economic factors, access to outpatient care, post-discharge care organization), confirming the systemic complexity of care quality and the limitations of simplistic interpretations of isolated indicators.

12.3. Organizational implications

High correlations between certain departments suggest the existence of organizational subcultures or "centers of good practice," with implications for internal standardization and knowledge transfer. Based on these observations, the thesis derives strategic recommendations: investment in human resources yields maximum returns on patient experience; satisfaction monitoring should be used as a real tool for quality management; crisis preparedness must include communication and psychological support, while maintaining the therapeutic relationship under restrictive conditions.

13. Study 2 – Deconditioning, Disability, and Rehabilitation

13.1. Rationale and objective

Study 2 is a longitudinal clinical study involving 49 patients with deconditioning and functional disability enrolled in a structured rehabilitation program. The general objective is to assess the role of deconditioning as a central mechanism of disability and analyze the impact of rehabilitation on the recovery trajectory, using standardized instruments anchored in the ICF (ClinFIT COVID-19). Additionally, the study aims to correlate the functional

domains proposed by ClinFIT with those in the FIM (Functional Independence Measure) to quantify the degree of disability, as part of the author's original contributions.

13.2. Key hypothesis

The central hypothesis of the study is that the level of disability is primarily determined by the severity of deconditioning and the impairment of functional domains, and that the rehabilitation program leads to a significant and clinically relevant improvement (T0 → T1), measurable through ClinFIT and the correlation between ClinFIT and FIM—introducing the novel element called ClinFIM COVID-19. Based on the published study using ClinFIT COVID-19 to analyze dysfunction in post-COVID-19 patients [64], a correlation was made between cognitive/psychological domains and motor/physical domains. The ClinFIM motor score showed a significant association with the duration of post-COVID symptoms, suggesting that patients with a longer symptomatic course have a lower level of functional autonomy.

Methodology

Assessment tools were applied to evaluate the domains of functioning, activities of daily living, exercise capacity, and fatigability for descriptive statistics. Patients were assessed at T0 (the initiation of the predefined rehabilitation program in the department where they were hospitalized) and at T1 (the completion of the rehabilitation program and discharge).

13.3. Results

The largest effect sizes were identified in the domains of mobility, personal autonomy, and exercise tolerance—domains that represent priority targets for medical rehabilitation interventions.

In contrast, the domains associated with chronic pain, persistent fatigability, and emotional functions exhibited a more variable response to intervention, suggesting the need for complementary therapeutic strategies and a multidisciplinary approach over the longer term.

These results support the idea that post-COVID recovery is a staged process, with certain functional domains showing a more rapid potential for improvement, while others require prolonged interventions and continuous monitoring.

During the acute phase, the most frequently affected domains were exercise tolerance, respiratory functions, and respiratory muscle functions, as well as mobility and walking activities. These limitations reflect the direct impact of acute infection, hypoxemia, and immobilization associated with hospitalization, and are often correlated with the need for oxygen therapy and assistance with daily activities..

In the post-acute phase, the functional profile highlighted the persistence of exercise intolerance, muscle strength impairment, and joint mobility limitations, alongside difficulties in performing activities of daily living. This stage is characterized by incomplete spontaneous recovery, with functional limitations remaining significant, particularly in the domains of activity and autonomy.

In patients with long COVID, the initial evaluation revealed a reconfiguration of disability, with an increased prevalence of chronic pain, fatigability, sleep disturbances, and impairment of emotional and cognitive functions. Additionally, participation restrictions, especially in professional activities and social life, were more frequent and severe compared to other phases of the disease.

14. Study 3 – Post-COVID Respiratory Recovery: Nonlinear Dynamics and Fractal Analysis

14.1. Rationale and objective

Study 3 is a longitudinal exploratory study involving 6 patients, focused on optimizing post-COVID-19 respiratory rehabilitation through the integration of nonlinear dynamics and fractal analysis as biomarkers of functional adaptation. The thesis argues that traditional assessment based solely on spirometric parameters may be insufficiently sensitive to fine functional changes, while complexity biomarkers can capture the "rigidification" or "regaining" of respiratory variability as a sign of recovery.

14.2. Methodological hypothesis

Respiratory rehabilitation is interpreted as a nonlinear adaptive process; fractal analysis of the respiratory signal allows for the identification of transitions between pathological and functional states and can adaptively guide therapeutic interventions, with the potential to optimize the duration and efficiency of recovery.

15. Summary Conclusions

Overall, the thesis provides an integrated approach to post-hospitalization and post-COVID rehabilitation, demonstrating that:

- Functioning and disability must be treated as major clinical outcomes;
- Deconditioning represents a cross-cutting mechanism of disability, relatively independent of the acute episode's etiology;
- A structured rehabilitation program leads to significant improvements in functioning (measurable in a standardized way);
- Integrating patient experience indicators with functional indicators and dynamic biomarkers can enhance quality management and personalize rehabilitation

16. Author's Original Contributions

The author's original contributions are measurable and explicitly developed within the thesis, as follows:

1) Integration of the ICF framework in the analysis of care quality and post-COVID recovery

The author positioned functioning as a major clinical indicator, using the ICF framework to interpret both disability and the recovery trajectory, surpassing traditional approaches that focus exclusively on biological parameters..

2) Articulation of an integrative perspective between patient satisfaction and functional outcomes

The thesis proposes an approach that correlates PREMs (patient experience indicators) with functional (PROMs/clinical) outcomes, supporting the notion that quality of care assessment should simultaneously include both organizational and functional dimensions..

3) Conducting a large-scale longitudinal observational study on patient satisfaction during COVID-19 (2020–2023)

Study 1 represents one of the most comprehensive institutional satisfaction analyses in the pandemic context, based on real-world data, with direct relevance for quality management.

4) Applying a pre–post interventional design to assess the impact of medical recovery

Study 2 uses a longitudinal clinical design (T0–T1) to demonstrate the effect of rehabilitation on functioning and disability within a real-world practice setting, utilizing validated instruments.

5) Introducing fractal analysis of the respiratory signal as a dynamic biomarker of post-COVID recovery

Study 3 proposes the use of Higuchi's fractal dimension as a sensitive marker of respiratory recovery, complementing classic parameters (FVC, FEV1, DLCO, SpO₂ during exertion).

6) Proposing a nonlinear conceptual model for optimizing respiratory recovery

The nonlinear conceptual model (Figure 7.5) interprets recovery as a transition between attractors, with therapeutic interventions as "external forces" capable of modifying the stability of dynamic regimes, providing a coherent framework for personalized interventions.

7) Providing results with direct applicability in quality care management

The results of Study 1 and Study 2 are explicitly formulated in an applied key: integrating patient satisfaction into quality management and using standardized functional tools in the triage and planning of rehabilitation.

8) Highlighting the relationship between the evolutionary stages of COVID-19 and specific patterns of functional impairment

The thesis demonstrates that the phases of the disease (acute, post-acute, long COVID) are associated with distinct patterns of functional impairment, with direct implications for staged rehabilitation programs and the organization of post-pandemic medical services.

17. Strengths, Limitations, and Future Directions

17.1. Study strengths

The thesis highlights the following major strengths:

- use of large datasets derived from real-world clinical practice;
- a longitudinal approach to the investigated phenomena;
- integration of innovative methods (nonlinear dynamics, fractal analysis) in the assessment of recovery;
- a multicenter design.

17.2. Limitations

The main limitations are related to:

- the small sample size of the exploratory study;
- the need for prospective validation of fractal biomarkers in real-world cohorts.

17.3. Future research directions

- Based on the findings, the proposed future directions include:
- expanding fractal analysis studies to larger samples and longer follow-up periods;
- integrating fractal indicators with standardized ICF-based instruments and PROMs;
- developing adaptive rehabilitation protocols guided by dynamic biomarkers;
- investigating the relationship between patient satisfaction and long-term functional outcomes.

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