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Classification and Review of Factors Influencing Return-to-Work Timelines After Occupational Injuries

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Abstract: ***The article presents a comprehensive classification and critical review of factors influencing return-to-work (RTW) timelines after occupational injuries, from an interdisciplinary perspective and using predictive modeling. The research relevance is driven not only by the socio-economic magnitude of the issue, but also by an increasing need for evidence-based strategies to manage work sustainability. The objective is to systematize and classify biological, psychological, organizational, and regulatory determinants shaping the duration of work disability, and to compare traditional clinical approaches with contemporary predictive analytics tools. The novelty lies in integrating the conceptual model of the Arena for Work Disability Prevention with modern machine-learning methods, thereby constructing a holistic, multi-level schema of influences that range from individual attitudes and psychophysiological resources to institutional regulators and macroeconomic conditions. The main findings demonstrate that disability duration emerges from the interaction of four circuits: personal, workplace, healthcare, and regulatory. It is shown that graded RTW programs, cognitive-behavioral and organizational interventions, and coordinated participation by the physician, employer, and insurer can shorten the average time-to-work resumption by several weeks. The article is intended for researchers in occupational medicine and rehabilitation, occupational safety professionals, healthcare managers, and developers of digital solutions for predictive monitoring of work sustainability.***

Keywords: return to work, occupational injuries, work disability, biopsychosocial factors

1. Introduction

RTW after occupational injury is regarded as a key indicator of both individual and societal resilience: annual direct and indirect costs of accidents in the United States alone exceed USD 176 billion, comparable to expenditures on primary prevention of cardiovascular diseases and reflected in the structure of the national gross domestic product [1]. A meta-analysis of 16 cohorts showed that approximately 80% of injured workers return to employment after an average of 102 days; however, variance in timelines remains high and depends on a constellation of biopsychosocial factors, as evidenced by a wide 95% confidence interval (67–88%) [2].

For the worker, timely RTW entails preserved financial stability, social status, and a reduced risk of pain chronification; for the employer, reduced replacement costs, retention of corporate memory, and increased reputational reliability; for the healthcare system, decreased burden on rehabilitation services and more rational resource allocation. Thus, disability duration is not merely a medical outcome but a point of intersection among three autonomous yet interconnected subsystems: the individual, the enterprise, and the public health institution.

Precise terminology is necessary to avoid conceptual ambiguity and to ensure study comparability. RTW is defined as the safe and sustainable resumption of an employee's duties after a period of temporary work disability, and the event is considered accomplished only if it is maintained for at least 4 weeks without regression. Work disability encompasses any limitation in the ability to perform job functions due to injury or illness, irrespective of legal disability status. It serves as an integrative indicator of functional deficit in the social plane. Graded return to work (graded RTW) denotes gradual increases in working hours or task scope according to a pre-agreed schedule; such programs are recognized as effective in preventing skill loss and accelerating full recovery, particularly in musculoskeletal injuries [3].

Using these definitions creates a shared semantic field, enabling the comparison of disparate studies and the construction of an integrated model of determinants examined below. Within such a model, RTW timelines are not static magnitudes but dynamic functions sensitive to personal, clinical, organizational, and regulatory parameters, underscoring the necessity of an interdisciplinary approach and consistent accounting for multi-level factors.

2. Literature Survey

Research on RTW after occupational injuries has evolved from descriptive observations to systemic models unifying clinical, psychosocial, and organizational determinants. According to the meta-analysis by Santos et al. [2], the mean duration of temporary disability after injury is about 102 days; however, variability is driven by numerous factors linked to both health status and workplace context. Kools and Koning [3] showed that graded RTW shortens disability duration and lowers the risk of reinjury, marking a shift from passive observation to the pursuit of actionable interventions.

Further theoretical development is associated with the Arena for Work Disability Prevention model proposed by Loisel and adapted by Dijkstra et al. [4]. This model structures recovery within four interrelated spheres, personal, professional, medical, and institutional, demonstrating that RTW is determined not by isolated factors but by their interaction. De Boer et al. [5] confirmed the importance of such cross-level linkages in oncology populations, showing that

organizational support and employer flexibility substantially influence work outcomes.

The studies by Cullen et al. [6] and Maas et al. [7] refined evidence on the effectiveness of comprehensive interventions and graded RTW programs in musculoskeletal and pain-related conditions, consolidating the multidisciplinary approach as the foundation of current RTW practice. Concurrently, Heikkala et al. [8] and Gjengedal et al. [9] developed and validated screening instruments, the Örebro questionnaire and the RTW-SE self-efficacy scale, respectively, enabling the identification of risk groups based on psychological and behavioral characteristics.

A machine learning era for RTW prediction has emerged. In two RTW prediction studies, the gradient-increasing approach outperformed regression models [10], as did the ensemble approach [11]. These studies also demonstrated that clinical, demographic and occupational variables interact in a non-linear fashion in terms of their relation to RTW. These studies suggest a move away from descriptive and regression methods toward predictive analytics for personalized RTW approaches.

3. Problem Definition

The problem lies in the substantial variability in RTW timelines after occupational injuries, despite comparable clinical outcomes. The meta-analysis by Santos et al. [2] estimated average disability duration at approximately 102 days, yet dispersion remains high owing to personal, psychosocial, and organizational influences [4]. The absence of a unified classification and comparable prognostic models hampers risk assessment and rehabilitation planning. There is a need to systematize the determinants and to construct an integrated model combining clinical, behavioral, and contextual parameters to predict RTW timelines accurately.

4. Methodology

The investigation of factors influencing RTW timelines after occupational injuries was based on a systematic analysis of scientific publications, meta-reviews, industry reports, and clinical registries published between 2015 and 2025. Theoretical foundations drew on concepts of work reintegration and disability prevention models, including Loisel's Arena for Work Disability Prevention, which was used to classify determinants at the individual, workplace, healthcare system, and regulatory environment levels.

The methodology comprised three sequential stages. First, a systematic search of PubMed, Scopus, and Web of Science was conducted using the keywords return-to-work, occupational injury, predictive factors, graded return, and machine learning. After deduplication and filtering for full-text and peer-reviewed status, 68 publications were selected, of which 32 contained quantitative measures of disability duration.

Second, content analysis was conducted, categorizing factors into biological, psychological, organizational, and institutional domains. Particular emphasis was placed on meta-analyses and cohort studies that defined average RTW timelines and variance across worker populations from different sectors. Cross-comparison of RTW models highlighted key variables: age, injury severity, self-efficacy, employer flexibility, and complexity of insurance procedures.

Third, findings were synthesized into a comparative table of factors and their relative influence, alongside a classification scheme illustrating the cascading impact of personal and contextual parameters. To assess modern prognostic tools, a review of validated scales and machine-learning algorithms applied to registry data was undertaken.

This design ensured a comprehensive understanding of multi-level influences and enabled comparison between traditional clinical and contemporary digital methods for predicting RTW timelines after injury.

5. Results and Discussion

Recognition that prolonged work absence is seldom determined by injury alone, but instead emerges at the intersection of biological, behavioral, and institutional forces, has become a turning point in the study of work disability. The Arena for Work Disability Prevention model proposed by P. Loisel encapsulates this multilayered nature. It shifted the emphasis from treating disease to preventing social loss of function and, over two decades, has become the methodological scaffold for most modern reviews, as evidenced by its central role in a 2023 mapping of factors preserving employment among industrial workers [4].

According to the model illustrated in Figure 1, the trajectory of an injured worker is shaped by the interaction of four subsystems.

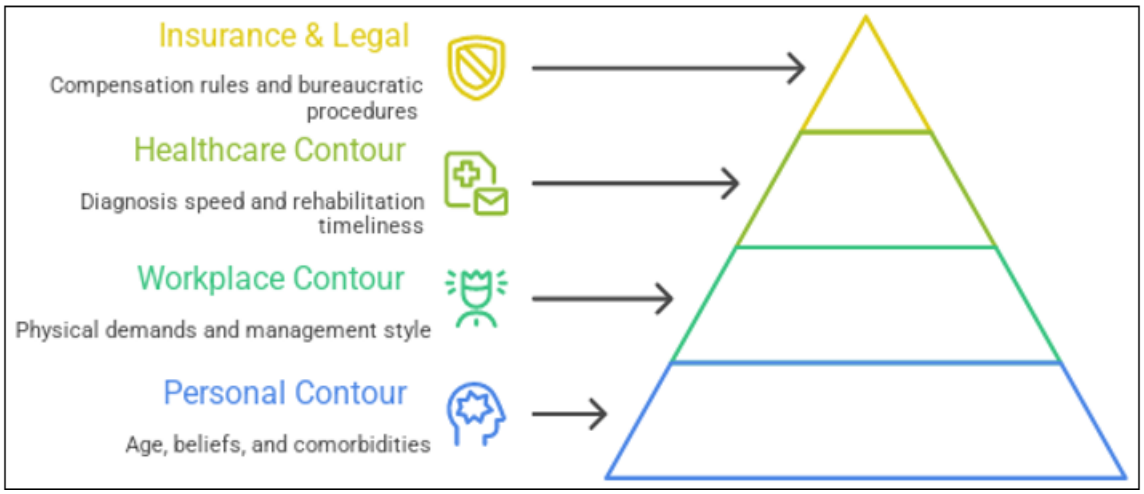

Figure 1: Worker Recovery Model [5]

The personal circuit comprises age, recovery expectancy, and comorbidities, forming the baseline potential for return. The workplace circuit aggregates physical demands, leadership style, and readiness to modify tasks; notably, recent mapping identified it as the most frequent locus of determinants delaying RTW. The healthcare circuit sets the tempo through speed of diagnostics, interdisciplinarity, and timely rehabilitation. In contrast, the insurance-legal environment, via compensation rules and bureaucratic procedures, can either accelerate or prolong the process. By depicting these four spheres as concentric layers, the model underscores that no actor operates in a vacuum, and even minor communication failures, e.g., between a physician and an employer, can delay disability by weeks [5].

Empirical data corroborate the model's synergistic nature: multi-component programs simultaneously targeting medical care, work organization, and service coordination reduced sick-leave duration by an average of three weeks compared with mono-focus interventions, with the most pronounced effect in musculoskeletal injuries [6]. A specific example of such coordination is graded RTW: cohorts in which working hours increased according to a pre-negotiated schedule exhibited higher probabilities of sustainable RTW after 6 months of temporary disability, as confirmed by a Canadian study that employed proportional-hazards models [7].

The logical framework derived from the Arena describes a cascade of influences: personal resources define baseline vulnerability, but the subsequent trajectory is set by sequential decisions within the treating team and enterprise management; these decisions, in turn, are constrained or facilitated by regulatory norms. Consequently, time-to-return is a dynamic function in which an event at any level, whether a delay in issuing a medical certificate or the absence of adapted tasks, initiates a deviation chain that elevates the risk of chronification. Understanding this nonlinearity highlights the importance of early cross-sector dialogue and provides a methodological basis for further determinant analysis.

Explaining why some workers return markedly earlier than others requires decomposing multi-level influences into ordered yet interpenetrating strata. At the core lie demographic characteristics, age, educational capital, family role distribution, and even migration experience, which serve as initial settings, shaping physiological reserve, cognitive flexibility, and access to informal support networks. A more seasoned specialist, socialized professionally over the years, often negotiates temporary workload reductions, whereas a newcomer, not yet embedded in the organizational fabric, encounters higher barriers.

Next are clinical parameters. Injury type, depth of tissue damage, and concomitant chronic conditions chart the recovery course. Displaced fractures, multiple soft-tissue tears, and complicated infections each dictate their own regenerative pace and pain baseline upon which motor activity is rebuilt. Fatigue, pronounced nociceptive signaling, and consultative pauses between subspecialists lengthen the disability corridor even when outward appearance seems encouraging.

The psychological layer enters concurrently but acts more subtly. Confidence in recovery, cognitive attributions such as the worst always happens, fear of reinjury, and habitual coping strategies form an inner dialogue that either propels progress or retards it. For one worker, a hint of support suffices to initiate muscle training; for another, even advanced rehabilitation devices will not help while anxiety saturates the mental field. Behavioral patterns, avoidance of movement or, conversely, competitive haste to return, modulate pain perception and actual functional status.

Encircling the individual is the workplace milieu. Mechanical load, noise, microclimate, shift rhythm, and, crucially, managerial culture and willingness to adopt flexible solutions define the field in which a potential rehabilitation resident either loses skills or gradually scales their workload. When management offers adapted duties, shortened shifts, or remote participation in project meetings, the RTW line straightens; when the injured employee encounters silence or mistrust, each day of postponement begets the next.

The subsequent ring consists of medical and rehabilitation interventions. Prompt initiation of physiotherapy, interdisciplinary case conferences, telemedicine platforms, and a carefully titrated graded schedule have repeatedly demonstrated the capacity to compress the interval between injury and stable workplace presence. Effectiveness, however, depends on precision in load titration and regular

feedback; without these, the risk of relapse or chronic pain rises, reverting the process to its starting point.

Finally, the outermost circle comprises insurance and macroeconomic mechanisms. Compensation rules, bureaucratic complexity of benefit payments, availability of partial-work programs, regional unemployment, and sectoral market conditions can either catalyze or slow RTW. Where insurance norms encourage early, even partial, work engagement, the worker and employer are more readily able to reach a compromise. In contexts of scarce vacancies or strict documentation requirements, each certificate becomes a bottleneck, jamming the entire process.

A multilayered picture thus emerges, as shown in Figure 2, where personal parameters set the starting point, clinical and psychological factors shape early dynamics, organizational factors determine trajectory quality, and institutional factors define the corridor within which that trajectory is feasible. Stratification into levels serves analytic convenience; in reality, boundaries are permeable, and any factor's impact depends on resonance with all others.

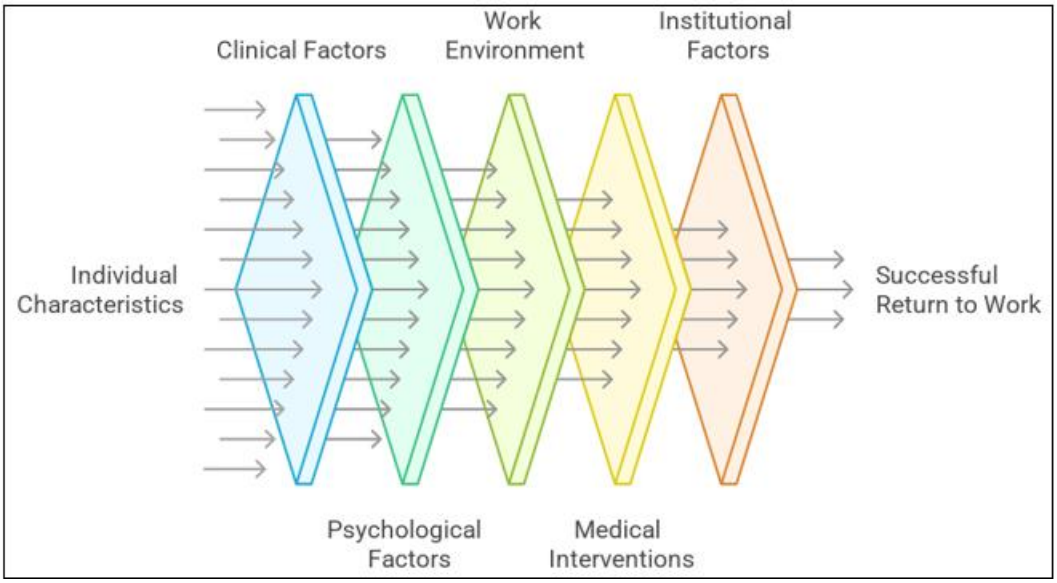

Figure 2: Factors Influencing Return to Work

Given the multi-level nature of traumatic work disability and the need for early risk stratification, research is shifting from factor description to quantitative prediction tools. The Örebro Musculoskeletal Pain Screening Questionnaire remains a senior screening method, summing pain intensity, catastrophizing, and recovery expectations: a composite score above fifty identifies workers whose probability of remaining on sick leave beyond six weeks increases nearly fourfold, with an area under the curve of seventy-seven percent, moderate prognostic strength [8]. The RTW Self-Efficacy scale complements psychological assessment; in a cohort receiving cognitive-behavioral therapy, a threshold of 4.6 distinguished those who were stably employed one year later from those who remained partly employed, with sensitivity of 68% and specificity of 72%, confirming the predictive value of subjective confidence [9].

Although both instruments are compact and feasible at first contact, their static structures limit their ability to capture nonlinearity. To model complex interdependencies among demographics, employment history, and medical data, machine learning methods are increasingly being applied. A recent literature review showed that gradient ensembles and stochastic trees have become standard in large-registry analyses, with key gaps in integrating unstructured sources, such as rehabilitation diary text [10]. A typical example is a gradient-boosting model trained on 685,000 records from a German pension fund: with an accuracy of 83% and an AUC of 88%, it substantially outperformed logistic regression; the top five predictors included prior sick-leave duration, employment tenure, and discharge functional status, while pandemic effects were minimal [11].

Clinical application of these predictions enables stratification immediately after initial assessment: a high Örebro score or low self-efficacy triggers multidisciplinary management, while a registry-based algorithm updates daily RTW probability and helps clinicians adjust load programs. Insurers use the same computational cores to allocate compensation and dynamically incentivize graded RTW; transparency in predictor selection remains essential for stakeholder trust. Together, first-generation scales and high-dimensional digital models form a continuum in which in-office screening and big-data analytics reinforce each other, delivering more precise, individualized RTW forecasts.

The orchestration of measures to shorten the path from injury to sustainable employment begins with graded RTW. When schedules are designed so that initial days entail a fraction of the usual workload, then scale up in small increments, the body adapts without pain flare-ups or secondary anxiety. At the same time, the employer tests functional balance without risk of reinjury. Where task characteristics allow partial duty, a partial-disability mode prevents complete social disengagement and sustains professional identity, especially critical for knowledge-intensive roles.

Remote technologies have moved rehabilitation beyond clinic walls. Video consultations, sensor bracelets, and mobile applications that capture range of motion integrate into hybrid

programs alternating in-person sessions with home monitoring. This format reduces logistical costs, accelerates feedback, and enables fine-grained real-time load adjustment. An additional effect is enhanced self-regulation: when workers visualize step counts or joint amplitude, subjective ownership of the process increases.

The psychological component remains a hidden driver. Cognitive-behavioral therapy helps patients identify automatic catastrophic thoughts and replace them with functional appraisals. Motivational interviewing increases intrinsic readiness to engage in a program of graded effort. Together, they alleviate fear or the experience of reinjury, lower the anxiety-pain threshold, and unjam a significant rate-limiting barrier in late recovery, where the body tolerates loading but the mind remains a protective brake.

Where psychology prepares the ground, engineering supplies the material substrate. Reconfiguring the workstation to individual anthropometry, implementing lift assists, altering load-transfer trajectories, and optimizing lighting and microclimate transform the production floor from a risk field into a training ground for pain regression. Ergonomic solutions amplify graded RTW effects: each well-placed handrail or adjustable chair reduces stress on the injured segment, allowing rehabilitation plans to proceed uninterrupted and thereby advancing full work engagement. Rehabilitation strategies to accelerate RTW are presented in Figure 3.

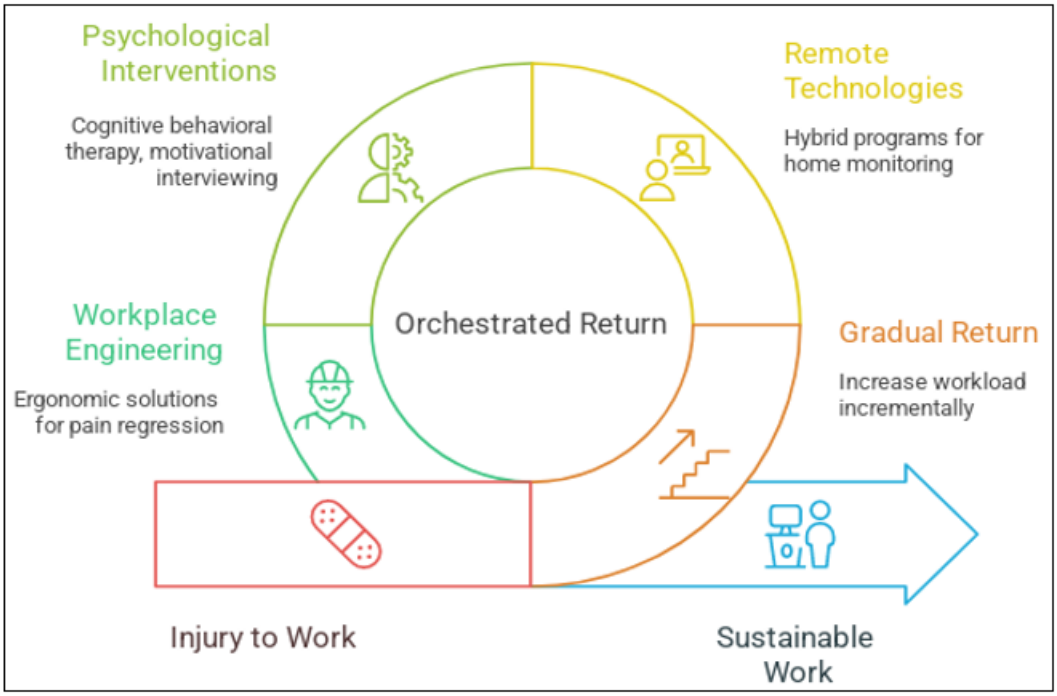

Figure 3: Orchestrated Return to Sustainable Work

The viability of these strategies depends on consistent clinical adoption. At the first visit, clinicians should shift their perspective from an isolated injury to a probable RTW trajectory, using brief questionnaires to identify psychosocial barriers and aligning plans with actual job demands. Prescriptions extend beyond physiotherapy orders to embedding each procedure within graded-return milestones, pre-agreeing timepoints with a rehabilitation coordinator. The coordinator functions as a nexus: maintaining continuous contact via video consults, collecting trajectories of pain and activity from wearables, and convening interdisciplinary meetings upon deviation. Eschewing generic restriction lists in favor of concrete functional goals streamlines stakeholder communication and shortens the period of latent uncertainty when a worker is ostensibly ready yet apprehensive to return.

For enterprises, preserving social contact during sick leave is pivotal. A brief supportive message from a supervisor, an invitation to join daily team stand-ups remotely, and opportunities to perform feasible, non-core tasks foster belonging while testing real capacities. Human resources, informed by current medical guidance, match adapted posts and reserve equipment per ergonomist recommendations: adjustable desks, vibration-dampening devices, and assistive lifts. During graded return, a transparent calendar matters: employees know the dates for shift expansion and the criteria for revision, which dampens anticipatory anxiety and reduces the risk of self-limitation.

Insurers and regulators set the external rules. The fewer bureaucratic barriers to reimbursing physiotherapy and partial employment, the more likely employers are to invest in workplace modifications, and the more likely workers are to take early steps without fearing benefit loss. Rapid approval rules for rehabilitation plans, the ability to combine benefits with part-time work, and unified digital registries for progress tracking build predictability for all parties. Regulators, when setting tariffs, account for evidence of reduced sick-leave duration under multidisciplinary approaches and incentivize such programs by offering lower insurance premiums. Medical logic, corporate priorities, and financial mechanisms thus converge on a single point: timely and sustainable RTW.

6. Conclusion

The results of this review indicate that RTW time frames following an occupational injury can be modeled as a complex, nonlinear system in which biological, psychological, organizational, and institutional factors interact in non-additive ways, mutually amplifying and attenuating one another. RTW is a complex, non-linear process that cannot be defined simply as a single event (that is, as a medical endpoint), but rather as the interface between physical recovery, cognitive readiness, and social infrastructure for return to work. Attempts to forecast timelines from clinical data alone inevitably lose precision, whereas models incorporating psychosocial and contextual determinants demonstrate substantially higher explanatory power.

At the center of this multi-level structure stands the individual, not only as a biological organism but as a subject of expectations, fears, and social ties. Baseline recovery mindset, perceptions of fairness in compensation, and communication quality with the employer form a cognitive contour that shapes subsequent dynamics. The outer layers, the organization of work, the healthcare system, and the insurance-legal environment, create the field in which individual efforts are either amplified or dampened. Even minimal discontinuities between levels, such as delays in medical certification or absence of adapted workposts, can trigger chains of postponement that convert temporary disability into chronicity.

Analysis of current models indicates that the most effective interventions synchronize actions across subsystems. Multidisciplinary programs combining clinical treatment, psychological support, and workplace modification reduce sick-leave duration by several weeks on average and increase the likelihood of sustainable RTW. These findings confirm the systemic nature of the phenomenon and demonstrate that success depends less on the intensity of any single intervention than on the temporal and functional coordination of the whole.

The shift from factor description to predictive tools is a key direction in contemporary research. First-generation screening scales, such as the Örebro questionnaire and self-efficacy indices, have proven capable of identifying high-risk groups; only integration of these data with machine-learning models, however, opens the path to truly individualized forecasts. Leveraging large registry datasets enables not only estimation of RTW probability but also its dynamic recalculation as new data arrive, transforming prediction from a one-time act into a continuous analytic process.

Accordingly, rehabilitation timeframes after occupational injuries reflect the maturity of the entire work-sustainability governance system. The greater the coordination, transparency, and trust among participants, the shorter the path from injury to resumption of professional activity. Future research should refine non-linear interrelations across model levels, expand predictive bases with behavioral data, and develop adaptive intervention protocols capable of altering RTW trajectories in real time. Only such an approach allows RTW to be viewed not as a statistical metric but as a complex indicator of the social and professional resilience of modern society.

7. Future Scope

Future development in predicting RTW timelines after occupational injuries is linked to integrating multi-level data and expanding analytic approaches. The integration of clinical, psychosocial and organizational prognoses into the same digital platform, with dynamic forecasting that captures the unfolding reality of rehabilitation, is also promising.

Furthermore, using behavioral and telemetry data, such as those gathered from wearables, has improved our ability to measure relevant variables like physical activity or recovery. Creation of interdisciplinary databases and international registries build a platform for sharing experiences and comparisons of RTW models between countries and sectors, improving the evidence transferability.

The principal limitation of current research is data heterogeneity and divergent criteria for sustainable RTW, which call for the development of unified evaluation standards. The advantage of modern approaches lies in their ability to integrate heterogeneous data and generate flexible, personalized predictions that surpass those of traditional linear models, bringing the RTW process closer to adaptive recovery management.

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