Employment Outcomes after Critical Illness

Han Su

A dissertation

submitted in the partial fulfillment of the

requirements for the degree of

Doctor of Philosophy

University of Washington

2020

Reading Committee:

Hilaire Thompson, Chair

Elizabeth Bridges

Catherine Hough

Program Authorized to Offer Degree:

School of Nursing

University of Washington

ABSTRACT

Employment Outcomes after Critical Illness

Han Su

Chair of the Supervisory Committee:

Hilaire Thompson, Professor

Department of Biobehavioral Nursing and Health Informatics

Employment outcomes following hospitalization are essential to assess for working-age patients, as they directly link to a person's functional recovery, social reintegration, and economic status. Research shows that one-third of previously employed intensive care unit (ICU) survivors are jobless for up to 5 years following hospital discharge. Those who return to work (RTW) earn less compared to their pre-illness annual income. Furthermore, there is a marked rise in the need for Medicare and Medicaid as the source of health insurance in this population post-discharge. In the past few decades, several models have been proposed to describe the process and potential factors that influence patients' responses to RTW across various populations, though not specifically for critical illness. Thus, in this dissertation, I proposed a conceptual model of RTW following critical illness based on Bronfenbrenner's ecological model and RTW models for other populations and tested this model using multiple approaches.

By using systematic review, meta-analysis, and meta-regression, I revealed that time and level of disability policy support are factors associated with the proportion of ICU survivors who RTW. In subsequent papers I focused on critically ill patients with acute respiratory distress

syndrome (ARDS). By conducting a secondary analysis using data from the ARDS Network Long-Term Outcomes Study (ALTOS) together with the Occupational Information Network (O*NET) system, I reveal that Pre-ARDS workload was not associated with post-ARDS RTW. However, several other factors were found to be negatively associated with RTW. These factors included critical illness characteristics, post-ARDS functional impairment, pain, fatigue, and imbalance in work ability, and not working at prior follow-up time. Using structural equation modeling and mediation analysis, I revealed that disease severity had the most considerable effect on RTW at 6 months, followed by functional abilities. Work at 6 months had the most substantial impact on RTW at 12 months, followed by disease severity and functional abilities at both 6- and 12-months follow-up. Work at 6 months, functional abilities at 6 and 12 months, and pre-ARDS workload are mediators to RTW in the ARDS population and are potentially modifiable. Thus, interventions that address early RTW with adequate work accommodation, improvement in function and symptom management, and workload/work modification reduction could assist ARDS survivors RTW.

TABLE OF CONTENTS

LIST OF TABLES

CHAPER 2

CHAPER 3

CHAPER 4

CHAPER 5

LIST OF FIGRES

CHPAER 1

CHAPER 2

CHAPER 3

CHAPER 4

CHAPER 5

LIST OF SUPPLEMENTAL CONTENT

CHAPER 2

CHAPER 3

CHAPER 4

CHAPER 5

Chapter 1. Introduction

Employment outcomes following hospitalization are essential to assess for working-age patients, as they directly link to a person's functional recovery, social role, and economic status. Failure to return to work (RTW) following illness or injury is often, both theoretically and operationally, equated with work disability.[1] In the past three decades, several models have been proposed to describe the process and potential factors that influence human responses to work and the development of work disability across various populations,[2] though not specifically for critical illness. These include biomedical, social construction, and biopsychosocial models. In the biomedical model, disability is produced by a medical condition, which causes deviation in an individual's normal biomedical function or structure. [1,3] The main purpose of rehabilitation in this model is focused on restoring health status through health care. However, in the social construction model, disability is viewed as a combination of activities, relationships, individual attributes, and conditions arising mainly from the social environment.[3] Thus, disability depends on a societal response in a given context. Biopsychosocial models approach disability from both the social and the biomedical paradigms and emphasize that dynamic interactions of body, mind, and environment affect the results of rehabilitation. The International Classification of Functioning, Disability, and Health (ICF)/the expanded ICF model,[4] cancer and work model,[5] as well as the readiness for return to work model are examples of biopsychosocial approaches to work disability.[6]

In order to gain a deeper understanding of employment outcomes as well as the barriers and facilitators for RTW in intensive care unit (ICU) survivors, I proposed a conceptual model of RTW following critical illness (Figure 1) based on the Bronfenbrenner's ecological model,[7] expanded ICF model, [4] cancer and work model, [5] and the readiness for return to work model. [8] In this model, I propose that not only personal demographic factors and critical illness-related

characteristics, but also functional ability after hospitalization, pre-illness workload, policy, and time might influence and individual's return to work following critical illness.

The conceptual model of RTW following critical illness

Adapted from the expended ICF model, [4] workload refers to the minimal physical, cognitive, interpersonal, and emotional ability that a specific job requires to perform it. These characteristics come from the macro, meso, and micro levels of work environments. The macro level environments relate to the country or global context that is involved, such as legislation, technological and economic developments, and the labor market. The meso-level environmental factors are related to the company involved, such as organizational culture and organizational regulations. The micro-level workplace environment includes the specific job of the person, terms of employment, task/role content, and working conditions. [4]

Personal factors describe the interrelationship between personal demographic factors, critical illness-related factors, and functional ability after critical illness. The functional ability is a combination of physical (i.e., how much weight can a person lift), cognitive, interpersonal and emotion functional ability (i.e., can a person deal with pressure or stress). [4] Aligned with the expanded ICF model, the critical illness RTW framework suggests that to prevent malfunction, injury, and disease, there must be a balance between the physical, cognitive, interpersonal and emotional workload caused by external factors (work-related and non-work-related) as well as the physical, cognitive, interpersonal and emotional functional ability of the person. [4]

Another essential factor is the chronosystem. RTW is a dynamic process, with the person on sick leave progressing through multiple phases, encompassing a range of actions, and interacting with various parties towards RTW. Yong (2005) categorized RTW into four stages: off of work, re-entering the workforce, maintenance, and advancement stage. In off of work stage, the

individual focuses on the recovery process, starts to consider returning to work, makes plans to RTW, and actively seeking information regarding an RTW and testing their ability to do so. In re-entering the workforce stage, the individual employee puts the plan into action and goes back to work in some capacity. They will continue to be responsive to help from external sources and motivated to initiate and follow through on targeted behavioral changes. In the Maintenance stage, individuals use and maintain specific skills and social support to deal with situations that can trigger a relapse and interfere with successful RTW. Individuals can ‘‘relapse back’’ to a previous stage at any point. In the advancement stage, individuals might seek or attain an advancement. However, some individuals might not have a desire for promotion. At each stage, some individual ICU survivors might face different issues, disabilities, and challenges. Thus, the interrelationship between variables might change based on different time points. For example, critical illness-related factors might play an important role in the off of work stage. The match between work-related load and functioanl ability is most important in the re-entering the workforce stage. It is crucial to provide occupational and clinical interventions that match the phase of disability to help and facilitate RTW. [8]

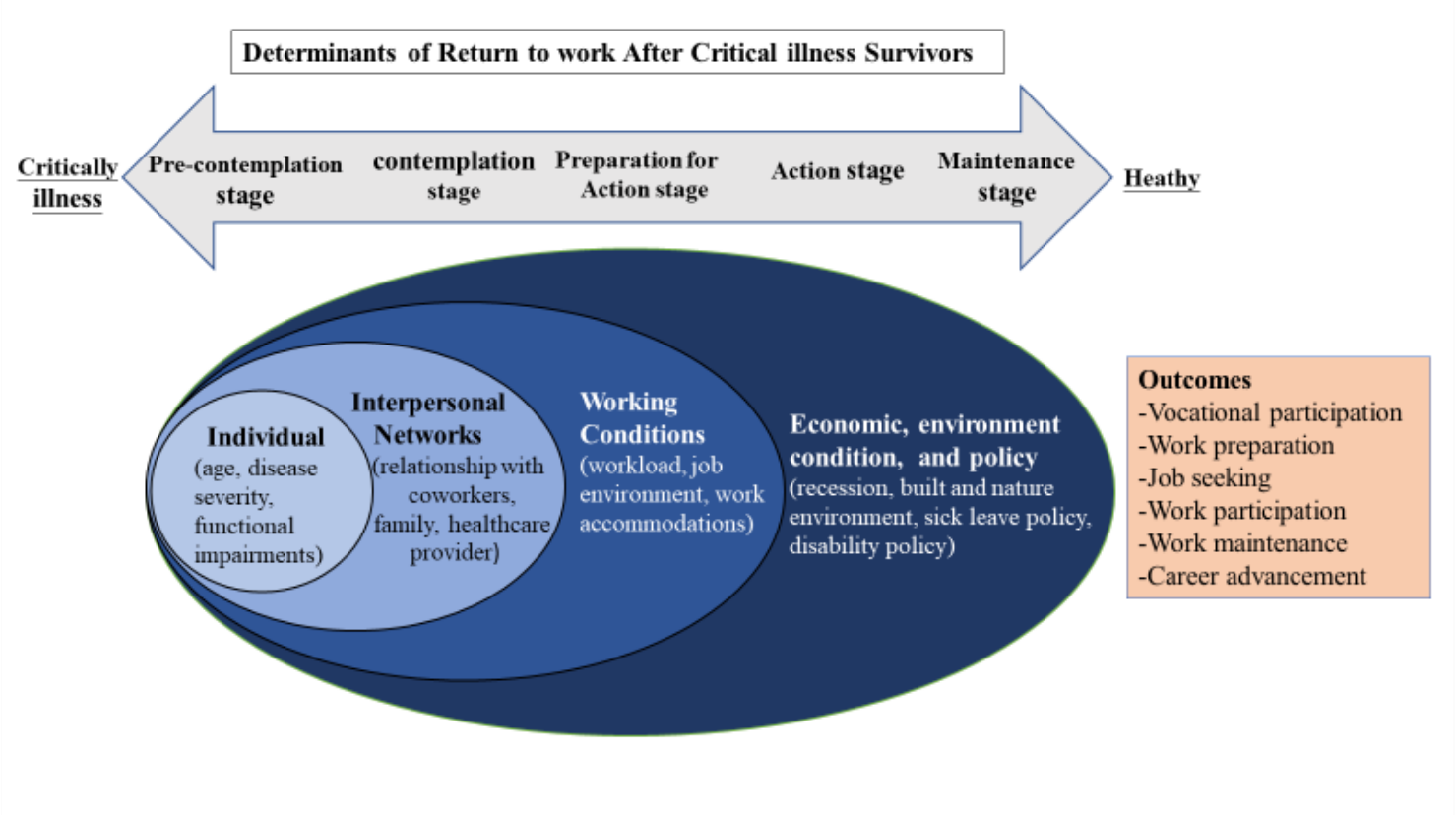


Figure 1. The conceptual model of critical illness RTW

Dissertation Elements

The dissertation aims to examine the proposed model, which included the following specific aims:

1) review current knowledge about RTW in ICU population and test the associations among time, level of disability policy support, and RTW;
2) Examine the association among individual's pre-illness workload, post-illness functional ability, and RTW at 6 and 12 months after discharge;
3) Examine whether a mismatch in post-illness functional ability and pre-illness workload associated with lower odds of RTW at 6- and 12-months post-illness;
4) Test, compare, and contrast the conceptual framework presented in Figure 1 to assess how a) critical illness-related factors, b) post-illness functional ability, and c) pre-illness workload, relate to each other (which are direct effects vs. indirect effects) to influence RTW after critical illness at 6- and 12-months post-discharge.

Each chapter in the dissertation is formatted in the style of its either published or prospective journal. A brief overview of each chapter is as follows:

Chapter 2. Factors Associated with Employment Outcome after Critical Illness: Systematic Review, Meta-analysis, and Meta-Regression

In chapter 2, we conducted a systematic review and meta-analysis to understand the current state of knowledge regarding RTW in adults following critical illness. Furthermore, we examined the association between temporary factors, level of policy support, and employment outcomes in ICU survivors by using meta-regression.

Chapter 3: Relationship between pre-Acute Respiratory Distress Syndrome (ARDS) workload, functional ability after discharge and return to work

By using Data from the ARDS Network Long-Term Outcomes Study (ALTOS) and the U.S. Occupational Information Network (O*NET), we examined the association between pre-illness workload, functional ability post-illness, pain interference, fatigue symptoms, and employment outcomes at 6 and 12 months following ARDS.

Chapter 4. Mismatch between pre-illness job workload and post-ARDS functional ability is associated with return to work

The balance between the physical, cognitive, interpersonal, and emotional workload as well as the physical, cognitive, interpersonal, and emotional functional ability of the person is essential to prevent work related injury and disease.

By using the ALTOS dataset and O*NET, we examined the relationship between the mismatch between pre-illness job workload/post-ARDS functional ability and employment outcomes.

Chapter 5. Relationships between workload, critical illness factors, and functional ability on return to work following ARDS: Application of a structural equation model and mediation analysis.

By using structural equation modeling and mediation analysis, we tested the fit of part of the conceptual model of RTW following critical illness, as well as interrelationships between patient's disease characteristics, pre-ARDS workload, post-ARDS functional impairments, and employment outcomes. The ALTOS dataset and O*NET were used in this analysis.

Chapter 6. Conclusion

Chapter 6 discusses the main findings of this line of research and its relevance for clinical practice to support positive employment outcomes after critical illness. It also describes limitations of the dissertation and remaining gaps for future research. Finally, the conceptual model is revisited.

Reference:

1. Schultz IZ, Stowell AW, Feuerstein M, Gatchel RJ. Models of return to work for musculoskeletal disorders. *Journal of occupational rehabilitation.* 2007;17(2):327-352.
2. Waddell G. Biopsychosocial analysis of low back pain. *Baillieres Clin. Rheumatol.* 1992;6(3):523-557.
3. Smart JF, Smart DW. Models of disability: Implications for the counseling profession. *Journal of Counseling & Development.* 2006;84(1):29-40.
4. Heerkens Y, Engels J, Kuiper C, Van Der Gulden J, Oostendorp R. The use of the ICF to describe work related factors influencing the health of employees. *Disability and rehabilitation.* 2004;26(17):1060-1066.
5. Feuerstein M, Todd BL, Moskowitz MC, et al. Work in cancer survivors: a model for practice and research. *Journal of Cancer Survivorship.* 2010;4(4):415-437.
6. Feuerstein M. A multidisciplinary approach to the prevention, evaluation, and management of work disability. *Journal of occupational rehabilitation.* 1991;1(1):5-12.
7. Bronfenbrenner U. Ecological models of human development. *Readings on the development of children.* 1994;2(1):37-43.
8. Franche R-L, Krause N. Readiness for return to work following injury or illness: conceptualizing the interpersonal impact of health care, workplace, and insurance factors. *Journal of occupational rehabilitation.* 2002;12(4):233-256.

Chapter 2: Factors Associated with Employment Outcome after Critical Illness: Systematic Review, Meta-analysis, and Meta-Regression

Han Su, MSN, RN
PhD candidate, University of Washington School of Nursing, Seattle, Washington.

Nathan J. Dreesmann, BSN, RN
PhD candidate, University of Washington School of Nursing, Seattle, Washington.

Catherine L. Hough, MD, MS
Professor of Medicine in the Division of Pulmonary and Critical Care Medicine, Oregon Health & Science University, Portland, OR, USA

Elizabeth Bridges, PhD, RN, CCNS
Professor, Department of Biobehavioral Nursing and Health Informatics
University of Washington, Seattle, Washington.

Hilaire J. Thompson, PhD, RN, ARNP
Joanne Montgomery Endowed Professor, Department of Biobehavioral Nursing and Health Informatics
University of Washington, Seattle, Washington.

Corresponding Author
Han Su
University of Washington School of Nursing
Box 357266
1959 NE Pacific St.
Seattle, WA 98195
206-616-5641
hansu21@uw.edu

Abstract

Aims: To synthesize data on prevalence and risk factors for return to work (RTW) in ICU survivors.

Design: Systematic review and meta-analysis.

Data Sources: PUBMED, CINAHL, EMBASE, and PsycINFO databases were searched from 2000 and Feb 2020.

Review Methods: Peer-reviewed articles that included adult ICU survivors and employment outcomes. Two investigators independently reviewed articles following the PRISMA protocol. Pooled prevalence for RTW was calculated across all studies. Meta-regression analyses were performed to assess the association between disability policies, temporal factors, and unemployment following critical illness.

Results: Twenty-eight studies met the inclusion criteria. The proportion (95% CI) of RTW following critical illness was 29% (0.20,0.42) within 3 months, 59% (0.50,0.70) at 4 to 6 months, 56% (0.50,0.62) at 7 to 12 months, 63% (0.54,0.72) 13 to 24 months, 58% (0.37,0.91) at 25 to 36 months, 58% (0.42,0.81) at 37 to 48 months, and 44% (0.25,0.76) at 49 to 60 months. Time and level of disability policy support are factors associated with the proportion of ICU survivors who RTW. There is a 20% increase (95%CI:0.06,0.33) in the proportion of individuals who RTW per year. However, the average rate of increase decelerates by 4% (-0.07, -0.1) per year. In countries with high support policies, the proportion of RTW is 32% higher compared to countries with low support policies (0.08,0.24). However, as subsequent years pass, the additional proportion of individuals RTW in high support countries declines (β=-0.06, CI: -0.1, -0.02).

Conclusions: Unemployment is common in ICU survivors. Countries with policies that give higher support for disabled workers have a higher RTW proportion to 3 years following ICU admission. However, from 3 to 5 years, there is a transition to countries with lower support policies having better employment outcomes.

Impact: Nurses can function as public advocates to facilitate policy change. Further policy analysis is warranted.

Key words: Critical illness; Intensive Care Units; Return to work; Employment; Policy; Outcome measure, Nursing

Introduction

Millions of survivors of critical illness are being discharged to their communities annually as intensive unit care (ICU) mortality declines and admissions increase (Needham et al., 2012). Five to fifteen years following ICU discharge, many survivors still suffer from physical and cognitive impairment or psychiatric symptoms (Cox et al., 2009; Desai, Law, & Needham, 2011; Griffiths et al., 2013; Iwashyna, Ely, Smith, & Langa, 2010). These impairments may contribute to unemployment or underemployment in ICU survivors. Return to work (RTW) status in ICU survivors is an important issue to explore for several reasons. First, it is a global societal and healthcare issue, given nearly one-third of previously employed ICU survivors never RTW across 5-years of follow-up post-discharge (Kamdar et al., 2018). This represents substantial lost earnings to the individual, and a marked rise in need for government-funded health care coverage (Kamdar et al., 2017; Kamdar et al., 2018). Moreover, the meaning of employment is not merely about financial benefits, but is essential to one's identity and self-esteem (Oppermann, 2004). Prolonged unemployment has been found to link to poor health and higher mortality (Garcy & Vagero, 2012; Hiswals, Marttila, Malstam, & Macassa, 2017; Roelfs, Shor, Davidson, & Schwartz, 2011).

Background

Two systematic review and meta-analyses (Kamdar et al., 2020; McPeake et al., 2019) have explored the issue of RTW following critical illness. The primary focus of the meta-analysis by McPeake and colleages was to examine the impact of RTW on psychosocial and financial outcomes using a one year time horizon. In their review, they noted that age, gender, and hospital length of stay (LOS) were risk factors for RTW following critical illness (McPeake et al., 2019), but did not examine if an actual association exists. The article by Kamdar and colleages published earlier this year extended knowledge in this area finding that approximately 33%, 60%, 66% of

previously employed ICU survivors could RTW at 3, 12 and 60 months following hospital discharge, respectively. Moreover, Kamdar et al. found using meta-analysis methods that there were no significant differences between either patient primary diagnosis (e.g., ARDS) or global geographic region of sample and RTW outcomes (Kamdar et al., 2020). While the papers by McPeake and Kamdar strengthen our knowledge of the impact of critical illness and highlight some potential factors associated with RTW, gaps in our knowledge remain. Notably, in order to design rehabilitation programs that best facilitate ICU survivors RTW, it is crucial to not only identify associations of predictive factors, but also the magnitude of such associations. Moreover, RTW after critical illness is a long-term, dynamic process that encompasses personal and policy factors, as well as chronosystems (i.e., events and transitions that occur during one's life) (Franche & Krause, 2002; Heerkens, Engels, Kuiper, Van der Gulden, & Oostendorp, 2004; Schultz, Stowell, Feuerstein, & Gatchel, 2007) and these interactions on RTW need to be explored further.

The review

Aim

We conducted a systematic review, meta-analysis, and meta-regression to assess (1) the proportion of persons RTW following critical illness to 5 years post-discharge, (2) risk factors associated with unemployment within ICU survivors as well as their magnitude. This analysis focused on examining personal, chronological, and disability policy-level risk factors.

Design

This review is a systematic review, meta-analysis, and meta-regression. We followed the PRISMA guidelines to report our systematic review and meta-analysis. The protocol for this systematic review was registered with PROSPERO CRD42018100752.

Search methods

A systematic literature search was conducted in PubMed, EMBASE, CINAHL Complete, and PsycINFO from 1/1/2000 through 2/1/2020 to identify relevant articles. We did not inclue papers published prior to 2000 because in the past two decades improvements in critical care medicine have resulted in a higher survival rate in this population. As such, articles that were published before 2000 may not reflect the outcome of ICU survivors now. The search strategy is provided as Table 1 in appendix.

We included full-text, peer-reviewed research papers that met the following inclusion criteria: (1) study population consisted of adult (>16 years) survivors of critical illness; who were (2) employed before critical illness; (3) article was written in English; (4) reported RTW or employment-related factors as an outcome variable; and (5) provided the proportion of RTW at a specific follow-up time point. We excluded studies meeting any of the following criteria: (1) primary focus on patients with a diagnosis of burn injury, suicide attempt, acute myocardial infarction, traumatic brain injury, stroke, trauma, or out of hospital cardiac arrest (These populations were excluded as the pathophysiology of illness/injury or trajectory of recovery are distinctly different); (2) articles that only provided mean or median time to RTW; (3) abstracts, case reports, letter to editors, book chapters, and dissertations. The reference lists of identified articles were also searched for appropriate studies.

Two blinded authors reviewed all citations and articles identified by literature search. The titles, abstracts, and complete articles were reviewed to determine the final studies for inclusion.

Search outcome

The literature search identified 1463 articles for evaluation (Figure 1). From initial title and abstract screening, 47 abstracts met the initial eligibility criteria after being reviewed. On full-text review, three were excluded because of wrong publication type, four were removed because they

did not measure pre-ICU employment, one was removed due to a research design issue, two were removed for analyzing a duplicate dataset, eight were removed due to without a specific follow-up time point. This left 28 papers in the final sample.

Quality apprasial

To assess the quality of eligible studies, we used the Newcastle Ottawa Scale (NOS)(GA Wells,nd). The total score ranges from 0 to 8, and studies having less than 3 points are identified as being at high risk of bias (Rotenstein et al., 2016).

Data abstraction

The data extraction was performed by the first author , using a form that included publication year, country, data on participants, study methods, potential risk factors for un- or underemployment, and propotion of RTW. We contacted authors who published their reports up to February 2020 and received additional information for six studies (Adhikari et al., 2009; Cheung et al., 2006; Griffiths et al., 2013; Herridge et al., 2003; Herridge et al., 2011; Sevin et al., 2018). A second reviewer verified papers for accuracy of extracted data. Disagreements at all stages of the selection process were resolved by consensus or in consultation with the senior author (H.T.) .

Data synthesis

Meta-analysis

The pooled proportion of RTW was estimated by pooling data from the 28 studies (Table 1). We used random-effects meta-analyses that accounted for between-study heterogeneity. Data were pooled from seven follow-up time points: within 3 months, 4 to 6 months, 7 to 12 months, 13 to 24 months, 25 to 36 months, 37 to 48 months, and 49 to 60 months. Heterogeneity between study was assessed using the I^2 statistic. I^2 values of 25%, 50%, and 75% indicate small, moderate, and

large amounts of heterogeneity, respectively (Higgins, Thompson, Deeks, & Altman, 2003). Meta-analysis was performed using R version 4.3.3 "metafor" package.

Meta-regression

Twelve of 28 studies were longitudinal follow-up studies (Table 1). We conducted several preliminary data analyses to examine whether linear mixed-effects models (LMMs) or generalized linear mixed models (GLMMs) approaches were more suitable for our data. Since 1) our models did not violate the assumptions of linearity, normality, and homogeneous errors; and 2) the same results were found using LMMs and GLMMs, we report our final models using LMMs(Chen, Cheng, Berkout, & Lindhiem, 2017).

Based on the result of our meta-analysis, we modeled follow-up time as a linear and a quadratic term, age and ICU LOS as continuous variables, and disability policy as dichotomous variable.The association between proportion of RTW, follow-up time, and disability policy were analyzed in 28 articles. The preliminary analysis which included the mean age and ICU LOS for each study, follow-up time, disability policy, and an interaction term between disability policy and follow-up time. We only tested the interaction term between disability policy and linear term of follow-up time due to collinearity. Preliminary analysis shows that mean age and ICU LOS are not associated with the proportion of RTW in both univariable and multivariable analysis. As we had identical results with and without adjustment for mean age and ICU LOS we do not report these variables in our final model (Table 2 in appendix).

Only 12 articles provided information regarding age, gender, and ICU LOS for the subpopulation that was employed before illness. Due to this relatively small sample size, we examined the association between proportion of RTW, age, gender, and ICU LOS using partial correlation adjusting for follow-up time rather than meta-regression. Publication bias was

investigated using funnel plots and the Egger test (Egger, Davey Smith, Schneider, & Minder, 1997; Sterne & Egger, 2001).

Measurement of disability policy

To test whether sickness and disability policies play a role in RTW following critical illness, we used the disability policy typologies published by the Organisation for Economic Co-operation and Development for both compensation and integration policies (OECD, 2010). The compensation dimension is a quantification of the country's policies regarding monetary support for disabled workers. The scores range from 0 to 50. The higher the compensation score is, the more generous the country is viewed. The Integration dimension is a quantification of policies to support vocational training available to the disabled. The scores range from 0 to 50. The higher the integration score, the more the country's labor market provides supports to reengage disabled individuals in the labor market. For this analysis, we defined countries as high or low policy support countries. Those in the "low" category had both compensation and integration scores lower than the median score of the eligible studies. All the others were classified as a high policy support country (Figure. 1 in the appendix).

Results

The results are presented as findings from systematic review followed by the results from the meta-analysis and metaregression for each subheading.

Study characteristics

Table 1 presents the basic characteristics of the 28 studies included studies. On assessment for bias, no study was found to have a NOS score less than 3 points. Of the 28 studies, 27 were cohort studies and one was randomized control trial. A total of 8168 patients reported employment before their illness and were assessed between 1 and 60 months after discharge. Eighteen studies included

patients admitted to medical and surgical ICU with any diagnosis, four included patients admitted to medical ICU only. Six articles only included ARDS patients. Ten studies were done in North America, 13 in Europe, and 5 in Oceania.

Proportion of ICU survivors RTW

This systematic review demonstrated that multiple approaches have been used to measure employment outcomes following critical illness (Table 2). For this study, we defined our main outcome measure as ‘‘return to any job: yes/no’’. Based on this definition, the point proportion of RTW ranged from 15% to 98% among the eligible studies. The average proportion of previously employed survivors RTW across each study and follow-up time point is 54% (Table 4, Model 1). The proportion (95% CI; I^2) of previously employed survivors RTW was 29% (0.20,0.42; 78%) within 3 months, 59% (0.50,0.70; 96%) at 4 to 6 months, 56% (0.50,0.62; 78%) at 7 to 12 months, 63% (0.54,0.72; 73%) 13 to 24 months, 58% (0.37,0.91; 94%) at 25 to 36 months, 58% (0.42,0.81; 89%) at 37 to 48 months, and 44% (0.25,0.76; 95%) at 49 to 60 months. The I^2 statistics were ranged from 73-96%, indicating large between-study heterogeneity (Figure 2).

Risk Factors Associated with ICU survivors RTW

Results from our systematic review shows that follow-up time, critical illness-related factors, and demographic factors may be potential barriers or facilitators to ICU survivors RTW (Table 3). Using meta-regression and adjusting for different policy levels, we found that there is a 20% increase (95 % CI; P: 0.06,0.33; 0.004) in the proportion of individuals RTW per year on average. However, the average rate of increase decelerated by 4% (-0.01, -0.01; 0.003) per year (Table 4-Model 3 and Figure 2). Using partial correlation, we found no correlation between ICU LOS (r:0.08, P:0.73), age (r:0.13, P:0.59), gender (r:-0.07, P:0.77) and proportion of RTW after adjusting for follow-up time.

Disability policy and RTW in ICU survivors

The average proportion of previously employed ICU survivors RTW for high and low policy support countries are 58% and 46% (Table 4-Model 2), respectively. Using meta-regression, the proportion of RTW following critical illness in a country with high support policies is 32% higher compared to low support policy countries (β; 95 %CI; P:0.16; 0.08,0.24;<0.0001) after adjusting for follow-up time (Table 4-Model 3). Furthermore, there is a negative impact on the proportion of individuals who RTW in high support policies countries with passage of time with a 12% decreased proportion in RTW with each additional year compared to those in low support policies countries (-0.06; -0.1, -0.02; 0.006). Over five years of follow-up, countries with high support policies have a higher proportion of persons RTW compared to low support countries until the end of year two (Figure 3). However, at year three, countries with lower policy support begin to have a higher proportion of individuals RTW (Figure 3).

Assessment of publication bias and sensitivity analysis

Visual inspection of the funnel plot of studies reporting on proportion of RTW revealed no significant asymmetry (Figure 2 in the appendix). There was no evidence of publication bias by using the Egger test (P=0.19).

Discussion

Unemployment is common in ICU survivors who were previously working, given that 46% of individuals failed to RTW within 5 years of critical illness. The pooled proportion of ICU survivors who RTW was similar to that reported in prior meta-analyses(Kamdar et al., 2020; McPeake et al., 2019), but substantially lower than that previously reported for other populations, including cancer survivors (76.2%) (de Boer, Taskila, Ojajarvi, van Dijk, & Verbeek, 2009), mild TBI (56%, 83%, and 89% at 1-, 6-, and 12-months, respectively) (Bloom et al., 2018), and

coronary artery disease (76% between 6 to 36 months) (Zangger et al., 2018). Furthermore among those ICU survivors who RTW, the proportion of persons RTW is lower at 49 to 60 months (44%) than prior time points, demonstrating that there is a significant proportion who can not maintain their position in the workforce. The high proportion of ICU survivors' unemployment and inability to maintain work reiterates the need for supportive interventions and policies in rehabilitation and post-discharge phases.

The process of RTW is multi-phase, encompassing the period of being off of work, re-entering the workforce, maintaining within the workforce, and then advancement (Young et al., 2005). Planning to resume work and making necessary preparations are the key components during the out-of-work phase (Young et al., 2005). Work reentry, reassess work capacity, and performance are the key milestones for the re-entry phase (Young et al., 2005). Our review found that employment outcome measures within the ICU population have primarily focused on the re-entry phase of RTW. Only 6 out of 28 articles identified mentioned outcomes related to the out-of-work phase, and none mentioned those related to maintenance or advancement phases of RTW. This is problematic for understanding and supporting the ICU survivors RTW, since each phase has different challenges and milestones; thus, different measurements should be applied. Furthermore, recovery following critical illness likely has a different trajectory and time course for different individuals. For ICU survivors, it is crucial to find what factors facilitate or hinder RTW issues across different individuals and phases. This information is needed to enable health care providers to provide personalized occupational and clinical interventions to the appropriate phase of recovery to foster RTW. Given the high prevalence of unemployment (46%) in ICU survivors identified in this meta-regression research that address these gaps, particularly related to the out-of- work phase should be a priority.

Interestingly, our meta-regression showed that disability policy differences contributed significantly to variance in the proportion of RTW in ICU survivors. Policies that provide more monetary disability benefits and encourage more reengagement in the labor market were associated with a higher RTW proportion in ICU survivors. Our finding is similar to previous studies in population of persons with low back pain and chronic illness (Anema et al., 2009; Holland et al., 2011). Moreover, we found that the association between the proportion of individuals RTW varied by different policy levels as time passed. Countries with high support policies had better RTW outcomes to year three, but low support policy countries had a higher proportion of RTW from years three to five. Thus, national or state-level policies should be reviewed, and changes considered. Policies that are flexible, providing higher supports earlier on and incorporate individual recovery trajectory and disease stage might help ICU survivors RTW. At this time, nurses can function as public advocates to facilitate policy change as they understand the clinical aspects of critical illness-related complications and how such sequelae impact ICU survivors' function and employment. Further policy analysis should be conducted to investigate which plans and length of support makes the most impact.

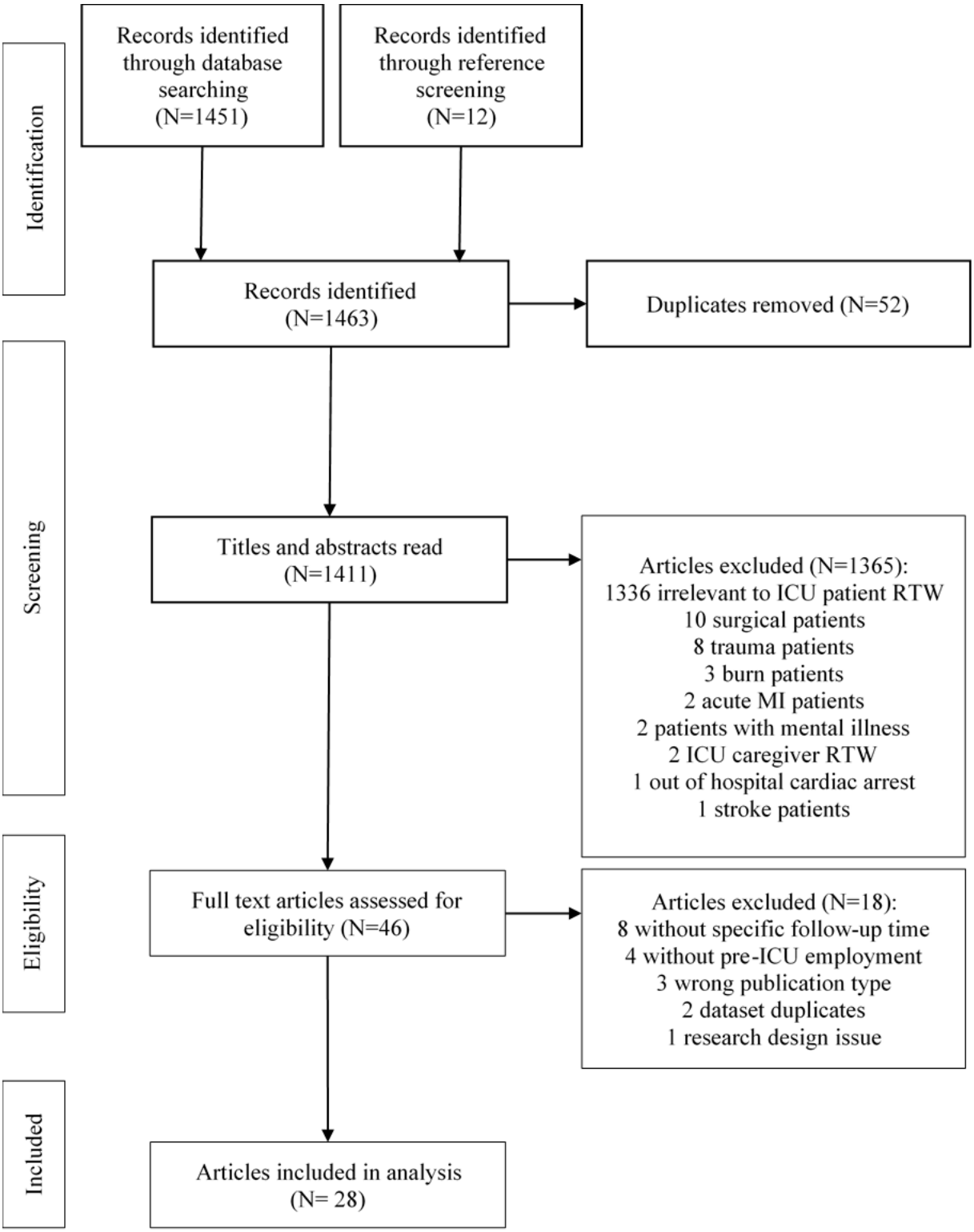
This study has some limitations. First, there was substantial heterogeneity in the meta-analysis which cannot be fully explained by time since discharge or definition of RTW. Second, only a few studies measure employment as their primary outcome, which limited our ability to examine potential risk factors for employment outcomes in ICU survivors using meta-regression. We only had enough data to explore the association between age, ICU length of stay, and proportion of RTW, but were not able to explore the role of disease severity, physical impairment, psychologic symptoms, or cognitive function after critical illness. These factors should be examined in future meta-analyses as adequate data becomes available. Third, there may be cross-country differences

ICU admission and utilization (e.g., age, disease severity, etc.) that could account for some of the differences seen in the policy analyses. However, we do not have enough data to adjust for these factors as covariates, and future meta-analyses should examine these relationships as adequate data becomes available. Fourth, bias might be introduced to this study since some of the studies included in this paper have a significant loss to follow-up. Participants may have been lost to follow up because of death, rehospitalization, or loss of interest in the study (healthy bias) which might lead to overestimation or underestimation of the proportion of RTW in this population. Finally, we excluded studies of patients after TBI, out of hospital arrest, and cardiac surgery; therefore, our results do not apply to these populations.

CONCLUSION

Unemployment is common in ICU survivors. The differences in disability policies as well as time associated with the proportion of individuals RTW following ICU. One's employment and contribution to the workforce are critical to individual self-concept as well as society. As such, the negative impact of critical illness on employment outcomes is a public health concern and more attention to this issue is needed. Future studies would benefit from longitudinal designs. Furthermore, additional policy analysis is warranted to determine the trade-off between different policy plans and outcomes.

Figure 1. Study Identification and Selection Process



RTW: return to work; OHCA: out of hospital cardiac arrest; ICU: intensive care unit

Figure 2. Forest plot

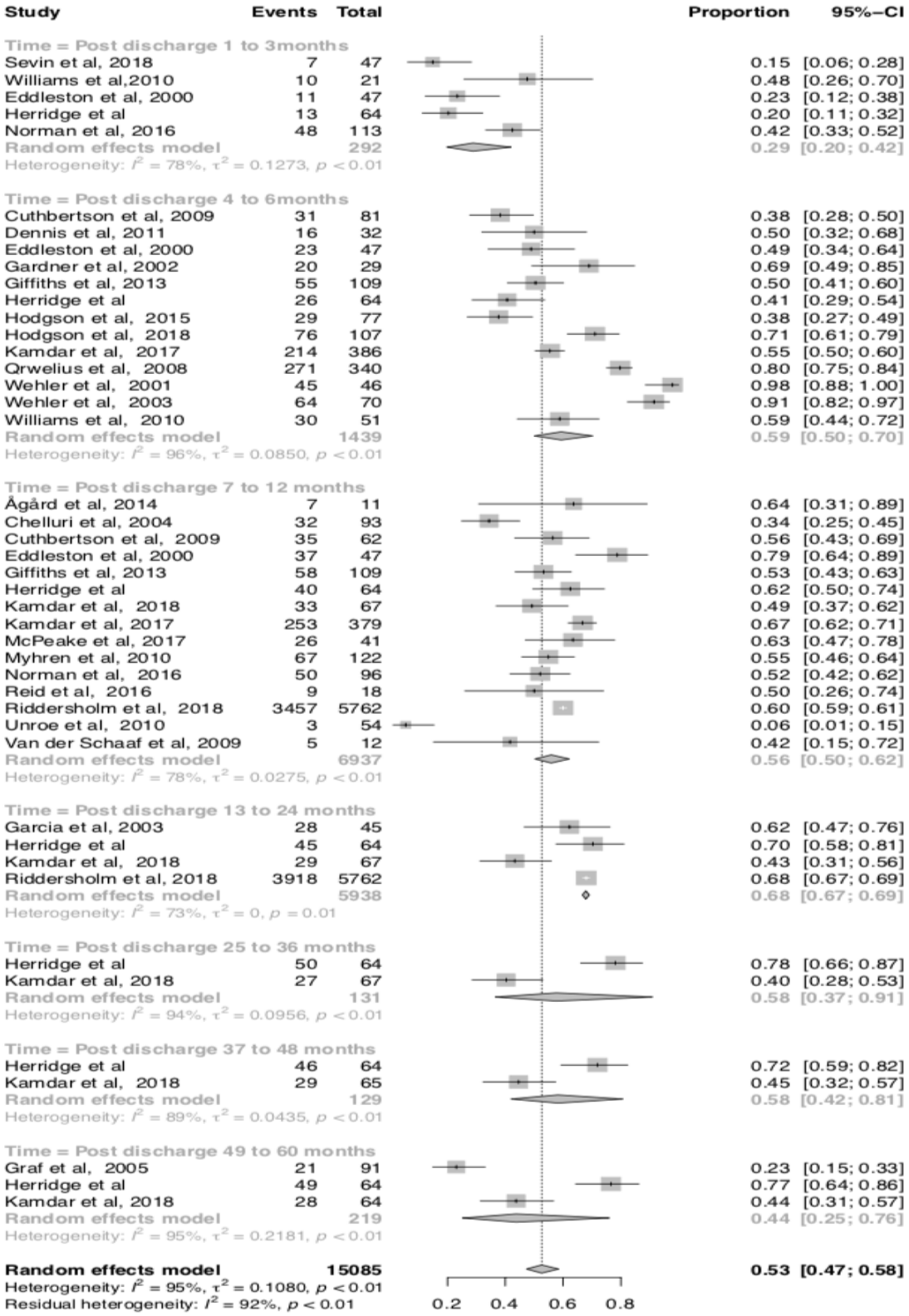
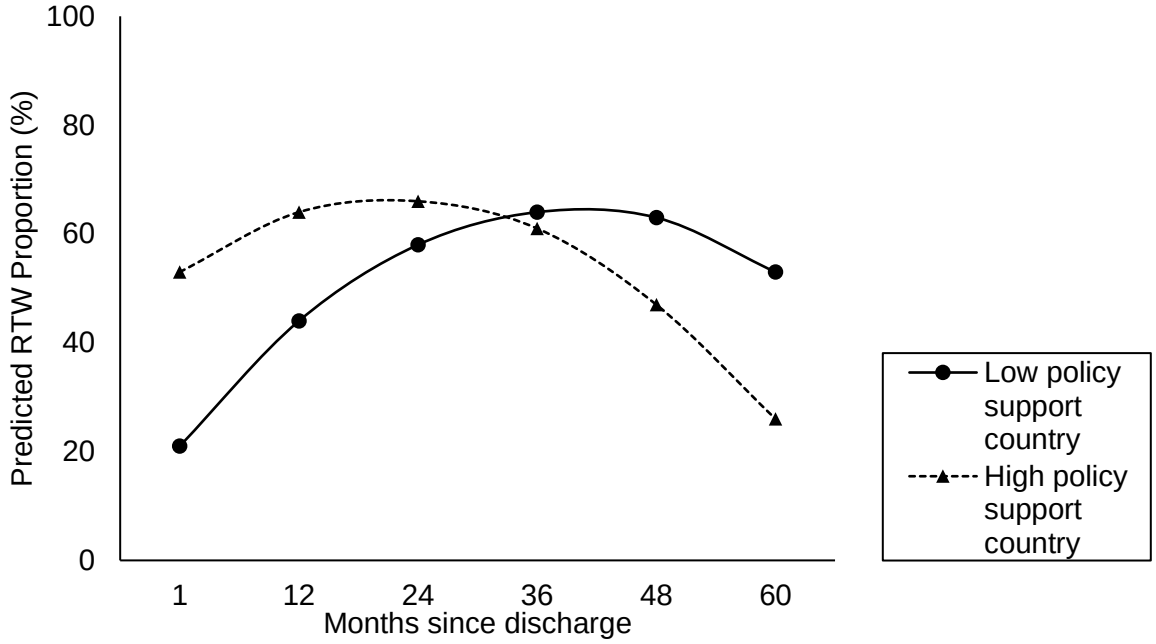


Figure 3. Model-implied trajectories of return to work (RTW) proportions as a function of months since baseline for countries with different policy support levels



RTW: return to work; High policy support countries include Denmark, Germany, Norway, Sweden, United Kingdom, Belgium, Australia, and the Netherlands. Low policy support countries included Canada and United States.

Table 1. Study, patient characteristics, and return to work (RTW) outcome

Author (year) / Country	Study Design	Participants Sample size. Age gender ICU criteria Mean ± SD or Median (IQR)	Timing of assessment	Significant Findings	High risk of bias [c]
Mixed ICU					
Ågård et al, (2014)/ Denmark	Cohort study	11 Age: 56 (35-70) M/F: 11/7 ICU LOS: 11(5-74) Post ICU ward LOS: 10 (2-63)	Pre-ICU 12M	8 F/T, 3 P/T 1 F/T, 6 P/T, 3 RTW[p].	No
Eddleston et al, (2000) / UK	Cohort study	143 Age: 49±11.57 M/F: 68/75 APACHE II: 18.79±6.15 ICU LOS: 3.8(11.47,13.17) D	Pre-ICU 3M 6M 12M	47 employed 11 RTW[a] 23 RTW 37 RTW[a]	No
Garcia et al, (2003) / Belgium	Cohort study	96 Age: 60 (42–75) M/F: 61/35 APACHE II: 9 (6.25–12) ICU LOS: 3(3-6) D Hospital LOS: 20.5(14-40.8) D	Pre ICU 18M	45 employed 28 RTW[a]	No
Gardner et al, (2002) / Australia	Cohort study	93 Age: 55.4± 18.4, APACHE II: 11.7 ±7.3 ICU LOS: 4.1±8.1D	Pre-ICU 6M	29 20 RTW[a] / 7 RTW[p]	No
Griffiths et al, (2013) / UK	Cohort study	293 Age: 62 (52–71) M/F: 192/101 APACHEII >18: 127 (43%) <=18: 156 (53%) ICU LOS: 8 (5-16) D Hospital LOS: 29 (17-47) D	Pre-ICU 6M 12M	103 55 RTW[a] 58 RTW[a] ↑State financial support. ↓income	No
Hodgson et al, (2015) /Australia and New Zealand	Cohort study	192 Age: 58.0 ± 15.8 M/F: 117/75 APACHEII: 19.1±7.6 ICU LOS: 11 (6 -17) D MV day: 8 (5 -14) D Hospital LOS: 24 (16-42) D	Pre-ICU 6M	77 employed 29 RTW[a] /25 RTW[p]	No
Van der Schaaf et al, (2009) / the Netherlands	Cohort study	47 Age: 58.0±15	Pre-ICU 12M	12 employed 5 RTW[a]	No

		M/F: 29/18 APACHEII: 17±7 ICU LOS: 9 (6 -14) D			
Hodgson et al, (2018) / Australia	Cohort study	107 Age: 52.5±15.9 M/F: 78/29 Hospital LOS: 17(10.9-30) D ICU LOS: 6.5(3.5-11) D APACHEII: 16.8±7.9	Pre-ICU 6M	107 employed 76 RTW[a] (29 RTW[p])	No
McPeake et al, (2017) / Scotland	Cohort study	**Intervention group** 40 Age: 51 (43–57) M/F: 25/15 ICU LOS: 15 (9-27) D APACHEII: 23 (19–27) **Control group** 52 Age: 46.5 (40–52) M/F: 31/22 ICU LOS: 3 (1-10) D APACHEII: 14 (9–19)	Pre ICU 12M	44 employed 26 RTW[a]	No
Norman et al., (2016) / USA	Cohort study	115 Age: 53(44-60) M/F: 69/44	Pre ICU 3M 12M	113employed 48 RTW[a] 50 RTW[a]	No
Riddersholm et al, (2018) / Denmark	Cohort study	5762 Age: 49.8(37.9-57.6) M/F: 3671/2091 ICU LOS: 7(4-14) D Hospital LOS: 27(14-62) D SAP II: 36.4±16.4	Pre ICU 12M 24M	5762 employed 3457 RTW[a] 3818 RTW[a] 29% unable to sustain in work within 1Y after RTW; Patient who stayed in workforce for a median 3.3Y; ↓income	No
Unroe et al, (2010) /USA	Cohort study	126 Age: 55±16 M/F: 76/50 APACHE II: 19 (15-24) ICU LOS: 26 (22-42) D Hospital LOS: 39 (28-57) D	Pre ICU 12M	54 3 RTW[a]	No
Chelluri et al, (2004) /USA	Cohort study	359 Median Age: 53 M/F: 203/156	Pre ICU 12M	93 32 RTW[a]	No

Williams et al, (2010) / Australia	Cohort study	112 Age: 54 (36-68) M/F: 67/45 APACHEII: 19 (14–24) ICU LOS: 2 (1-4) D	Pre ICU 6M Pre ICU 2M	51 30 RTW[a] 21 10	No
Reid et al, (2016) / Australia	Cohort study	39 Age: 54 (36-68) M/F: 30/9 APACHEII: 20±1.4 ICU LOS: 10.2 (4.9-20.3) D Hospital LOS: 23.9(13.3-67.7) D	Pre ICU 12M	18 9 RTW[a]	No
Qrwelius et al, (2008) / Sweden	Cohort study	497 Age: 42± 15.7 M/F: 274/223	Pre ICU 6M	340 271 Sick leave: 121	No
Myhren et al, (2010) /Norway	Cohort study	194 Age: 49.1± 15.2 M/F: 117/77 SAPH II: 37.1 (35.2-38.9) ICU LOS: 12.5 (10.2-14.3) D	Pre ICU 12M	122 67 RTW[a]	No
Cuthbertson et al, (2009) / UK	RCT	**Intervention group** 143 Age: 59 (46–49) M/F: 86/57 ICU LOS: 2.9 (1.7-9.5) D APACHEII: 19 (15–24) **Control group** 143 Age: 60 (46–71) M/F: 86/57 ICU LOS: 3.1 (1.2-7.5) D APACHEII: 19 (15–24)	Pre ICU 6M 12M	81 employed 31 RTW[a] 35 RTW[a]	No
ARDS					
Herridge et al, (2011), Adhikari et al, (2009), Herridge et al, (2003), Cheung et al, (2006) / Canada	Cohort study	117 Age: 45 (36-58) M/F: 66/51 APACHEII: 23 (17-27) MV days: 21 (12-40) D ICU LOS: 25 (15-45) D Hospital LOS: 48 (27-77) D	Pre-ICU 3M 6M 12 M 24M 36M 48M 60M	64 employed 13 RTW[a]; 10 RTW[p] 26 RTW[a]; 23 RTW[p] 40 RTW[a]; 31 RTW[p] 45 RTW[a]; 36 RTW[p] 50 RTW[a] 46 RTW[p] 46 RTW[a]; 41 RTW[p] 49 RTW[a]; 46 RTW[p] ↑Health care cost;	No

				Majority of patients RTW 2 y after ICU discharge	
Kamdar et al, (2017) / USA	Cohort study	386 Age: 45±13 M/F: 215/171 APACHEIII: 83±26 MV days: 11±10 D Hospital LOS: 22±16 D ICU LOS:15±13 D	Pre-ICU 6M 12M	386 RTW[a] 214 RTW[a] 253 RTW[a] 79 experienced a major occupation change ↑ Medicare/Medicaid, ↓Income ↓Effectiveness at work	No
Kamdar et al, (2018) / USA	Cohort study	67 Age: 46(39- 54) M/F: 42/25 APACHEII: 23(18-28) MV days: 9 (5-17) D Hospital LOS: 23(16-35) D ICU LOS: 14(9-22) D	Pre ICU 12 M 24M 36M 48M 60M	67 RTW[a] 33 RTW[a] 29 RTW[a] 27 RTW[a] 29 RTW[a] 28 RTW[a] ↑ Medicare/Medicaid ↓Income ↓Effectiveness at work 36% unable to sustain in work within 5Y after RTW	No
Medical ICU					
Wehler et al, (2001) / Germany	Cohort study	185 Age: 56±18 M/F: 108/82 APARCH II:19±10 MV %: 45% ICU LOS: 9±16 D	Pre-ICU 6M	46 employed 45 RTW[p]	No
Wehler et al, (2003) / Germany	Cohort study	318 Age: 57±17 M/F: 108/82 APARCH II: 18±10 ICU LOS: 11.4±19 D	Pre-ICU 6M	70 64 RTW[p]	No
Graf et al, (2005) / Germany	Cohort study	303 Age: 62 ± 12 M/F: 216/87 SAPS II: 26 ± 13 MV %: 53% ICU LOS: 3.7 ± 4.7D Hospital LOS: 15 ± 13	Pre-ICU 5Y	91 21 RTW[a]	No

C.M. Sevin et al, (2018) / USA	Cohort study	62 Age: 49.5 (36,57) M/F: 34/28 SOFA: 10 (7,12) Hospital LOS:18(12,28) D ICU LOS: 8 (5,21) D	Pre-ICU 1M	47 7 RTW[a]	No

Legend: High risk of bias[c]: The total score of Newcastle Ottawa Scale (NOS) less than 3 points are identified as being at high risk of bias. ICU: intensive care unit, LOS: length of stay, M: male, F: Female, SD: standard deviation, IQR: interquartile range, RTW[a]: return to any work, RTW[p]: return to prior work, F/T: full time, P/T: part time, Y: year M: month, W:week, D: day, h: hours,(N): no association, SIP68 :sickness impact profile, WHODAS: The World Health Organization Disability Assessment Schedule, PTSS-10: Post-Traumatic Stress Symptom Scale -10, HADS: Hospital Anxiety and Depression Scale, BDI-II: Beck Depression Inventory II , APACHE II: Acute Physiology and Chronic Health Evaluation, MV: mechanical ventilation, ARDS: Acute respiratory distress syndrome, AKI: acute kidney injury, RRT: renal replacement therapy, SF-36: 36-Item Short Form Survey, SOFA: sequential organ failure assessment, ECLA : extracorporeal lung assist, ECMO: extracorporeal membrane oxygenation, SAPS II : Simplified Acute Physiology Score II, PTSD: post-traumatic stress disorder

Table 2. Return to Work (RTW) Outcomes Used in Identified Studies

Phase	Dimensions	Outcomes	Number of references	Reference
Off of work	Work preparation	Undertaking vocational rehabilitation	3	(Griffiths et al., 2013; Herridge et al., 2003; van der Schaaf, Beelen, Dongelmans, Vroom, & Nollet, 2009)
		Job retraining	1	(Herridge et al., 2003)
		Receiving disability benefits	3	(Kamdar et al., 2017; Kamdar et al., 2018; Riddersholm, Christensen, Kragholm, Christiansen, & Rasmussen, 2018)
Re-entry	Work participation	Time to RTW	5	(Adhikari et al., 2009; Cheung et al., 2006; Herridge et al., 2003; Herridge et al., 2011; Kamdar et al., 2017)
		Return to any job	28	(Adhikari et al., 2009; Agard, Lomborg, Tonnesen, & Egerod, 2014; Chelluri et al., 2004; Cheung et al., 2006; Cuthbertson et al., 2009; Dennis, Hebden-Todd, Marsh, Cipriano, & Parsons, 2011; Depuydt et al., 2016; Eddleston, White, & Guthrie, 2000; Gardner & Sibthorpe, 2002; Graf, Wagner, Graf, Koch, & Janssens, 2005; Griffiths et al., 2013; Herridge et al., 2003; Herridge et al., 2011; C. Hodgson et al., 2015; C. L. Hodgson et al., 2018; Kamdar et al., 2017; Kamdar et al., 2018; McPeake et al., 2017; Myhren, Ekeberg, & Stokland, 2010; Norman et al., 2016; Orwelius, Nordlund, Nordlund, Edell-Gustafsson, & Sjoberg, 2008; Reid et al., 2016; Riddersholm, Christensen, Kragholm, Christiansen, & Rasmussen, 2018; Sevin et al., 2018; Unroe et al., 2010; van der Schaaf, Beelen, Dongelmans, Vroom, & Nollet, 2009; Wehler et al., 2003; Wehler et al., 2001; Williams, Leslie, Brearley, & Dobb, 2010).
		RTW without change job duties or working hours	12	(Adhikari et al., 2009; Agard, Lomborg, Tonnesen, & Egerod, 2014; Cheung et al., 2006; Gardner & Sibthorpe, 2002; Herridge et al., 2011; Higgins, Thompson, Deeks, & Altman, 2003; C. Hodgson et al., 2015; C. L. Hodgson et al., 2018; Kamdar et al., 2017; Kamdar et al., 2018; Wehler et al., 2003; Wehler et al., 2001)
		Work effectiveness	4	(C. L. Hodgson et al., 2018; Kamdar et al., 2017; Riddersholm et al., 2018; van der Schaaf et al., 2009)
		Productivity (Sick leave/ Income loss)	6	(Agard et al., 2014; Griffiths et al., 2013; Kamdar et al., 2017; Kamdar et al., 2018; Riddersholm et al., 2018; van der Schaaf et al., 2009)
	Work durability	RTW sustainability	2	(Kamdar et al., 2018; Riddersholm et al., 2018)
		Job loss after RTW/ resignation	2	(Kamdar et al., 2018; Riddersholm et al., 2018)
	Monetarily orientated	Health care costs	3	(Herridge et al., 2003; Kamdar et al., 2017; Kamdar et al., 2018)

Definition of abbreviations: RTW: return to work

Table 3. Factors Associated with Return to Work (RTW) Outcomes by Study

Type of Factor	Associated with RTW: Positive association	Associated with RTW: Negative association	Not associated with RTW
Critical illness related factors			
High APACHE II/III			(Gardner & Sibthorpe, 2002; Kamdar et al., 2017; Kamdar et al., 2018)
High SOFA			(Kamdar et al., 2018)
High SAPS II scores			(Riddersholm, Christensen, Kragholm, Christiansen, & Rasmussen, 2018)
Increasing LOS of hospital/ICU stay		(Kamdar et al., 2017; Riddersholm et al., 2018)	(Kamdar et al., 2018)
Increased time of MV support		(Kamdar et al., 2017; Kamdar et al., 2018; Riddersholm et al., 2018)	
Coma or delirium days in hospital		(Kamdar et al., 2018)	(Norman et al., 2016)
Numbers of organs requiring support		(Riddersholm et al., 2018)	
Post-critical illness factors			
Cognitive impairment		(Eddleston, White, & Guthrie, 2000; Herridge et al., 2003; Norman et al., 2016)	(Norman et al., 2016)
PTSD		(Cheung et al., 2006; Herridge et al., 2003)	
Depression		(Adhikari et al., 2009; Cheung et al., 2006; Herridge et al., 2003)	(Norman et al., 2016)
Physical impairment		(Cheung et al., 2006; Herridge et al., 2011; Norman et al., 2016)	(Norman et al., 2016)
Impaired Functional ability (SF-36, SIP-68 or WHODAS)		(Kamdar et al., 2018; Norman et al., 2016; van der Schaaf, Beelen, Dongelmans, Vroom, & Nollet, 2009)	
Discharge to skilled facility		(Kamdar et al., 2017; Kamdar et al., 2018)	
Poor sleep pattern after hospitalization		(Eddleston et al., 2000)	
Sociodemographic factors			
Age		(Kamdar et al., 2017)	(Kamdar et al., 2018)
Race (white)	(Kamdar et al., 2017)		(Kamdar et al., 2018)
Gender (male)	(Kamdar et al., 2017)	(Eddleston et al., 2000)	(Kamdar et al., 2018)
Years of education	(Norman et al.,2016)		(Kamdar et al., 2018)
Personal attitude	(Herridge et al.,2011)		

Definition of abbreviations: ICU: intensive care unit, LOS: long of stay, PTSD, SIP-68: sickness impact profile, WHODAS: The World Health Organization Disability Assessment Schedule, APACHE II: Acute Physiology and Chronic Health Evaluation, MV: mechanical ventilation, SF-36: 36-Item Short Form Survey, SAPS II: Simplified Acute Physiology Score, SOFA: sequential organ failure assessment, PTSD: Posttraumatic stress disorder

Table 4. Multilevel Model Results for Proportion of Return to Work (RTW)

Fixed Effects	Model 1 (Across all Timepoints)				Model 2 (Across all Timepoints)				Model 3 (Baseline + Growth Model)			
	Coeff	*(SE)*	*CI*	*p*	*Coeff*	*(SE)*	*CI*	*p*	*Coeff*	*(SE)*	*CI*	*P*
Intercept (Mean RTW)	0.54	(0.03)	(0.48, 0.60)	***	0.52	(0.03)	(0.44, 0.58)	***	0.37	(0.05)	(0.26, 0.48)	***
High Policy Support Country					0.06	(0.03)	(0.00, 0.15)		0.16	(0.04)	(0.08, 0.24)	***
Linear Change per Month since 1-Month Post-Discharge									0.20	(0.06)	(0.06, 0.33)	**
Linear Change * High Policy									-0.06	(0.02)	(-0.1, -0.02)	**
Quadratic Change (Deceleration) since 1-Month Post-Discharge									-0.04	(0.01)	(-0.07, -0.01)	**
Random Effects	*Var*				*Var*				*Var*			
Intercept (Mean Change)												
Between-study	0.00				0.01				0.01			
Within-study (residual)	0.04				0.03				0.01			
Model Information												
No. Parameters	3				4				7			
Deviance	-20				-24				-39			
Bayesian information criterion	-9				-8				-13			

Note. N = 44 observations within 28 studies; R lme4 used to estimate models; R lmerTest used to approximate Sattherthwaite *df* for coefficient *t*-tests. Maximum Likelihood estimates shown. Policy support effect coded. High policy support countries include Denmark, Germany, Norway, Sweden, United Kingdom, Belgium, Australia, and the Netherlands, coded as 1. Low policy support countries included Canada and United States, coded as -1.
*p < .05, **p < .01, ***p < .00

References

Adhikari, N. K. J., McAndrews, M. P., Tansey, C. M., Matte, A., Pinto, R., Cheung, A. M., Herridge, M. S. (2009). Self-reported symptoms of depression and memory dysfunction in survivors of ARDS. *Chest, 135*(3), 678-687. doi:10.1378/chest.08-0974

Agard, A. S., Lomborg, K., Tonnesen, E., & Egerod, I. (2014). Rehabilitation activities, out-patient visits and employment in patients and partners the first year after ICU: a descriptive study. *Intensive Crit Care Nurs, 30*(2), 101-110. doi:10.1016/j.iccn.2013.11.001

Anema, J. R., Schellart, A. J., Cassidy, J. D., Loisel, P., Veerman, T. J., & van der Beek, A. J. (2009). Can cross country differences in return-to-work after chronic occupational back pain be explained? An exploratory analysis on disability policies in a six country cohort study. *J Occup Rehabil, 19*(4), 419-426. doi:10.1007/s10926-009-9202-3

Bloom, B., Thomas, S., Ahrensberg, J. M., Weaver, R., Fowler, A., Bestwick, J., Pearse, R. (2018). A systematic review and meta-analysis of return to work after mild Traumatic brain injury. *Brain Inj, 32*(13-14), 1623-1636. doi:10.1080/02699052.2018.1532111

Chelluri, L., Im, K. A., Belle, S. H., Schulz, R., Rotondi, A. J., Donahoe, M. P., Pinsky, M. R. (2004). Long-term mortality and quality of life after prolonged mechanical ventilation. *Crit Care Med, 32*(1), 61-69. doi:10.1097/01.0000098029.65347.F9

Chen, K., Cheng, Y., Berkout, O., & Lindhiem, O. (2017). Analyzing Proportion Scores as Outcomes for Prevention Trials: a Statistical Primer. *Prev Sci, 18*(3), 312-321. doi:10.1007/s11121-016-0643-6

Cheung, A. M., Tansey, C. M., Tomlinson, G., Diaz-Granados, N., Matte, A., Barr, A., Herridge, M. S. (2006). Two-year outcomes, health care use, and costs of survivors of acute respiratory distress syndrome. *Am J Respir Crit Care Med, 174*(5), 538-544. doi:10.1164/rccm.200505-693OC

Cox, C. E., Docherty, S. L., Brandon, D. H., Whaley, C., Attix, D. K., Clay, A. S., Tulsky, J. A. (2009). Surviving critical illness: acute respiratory distress syndrome as experienced by patients and their caregivers. *Crit Care Med, 37*(10), 2702-2708. doi:10.1097/CCM.0b013e3181b6f64a

Cuthbertson, B. H., Rattray, J., Campbell, M. K., Gager, M., Roughton, S., Smith, A., Waldmann, C. (2009). The PRaCTICaL study of nurse led, intensive care follow-up programmes for improving long term outcomes from critical illness: a pragmatic randomised controlled trial. *BMJ, 339*, b3723. doi:10.1136/bmj.b3723

de Boer, A. G., Taskila, T., Ojajarvi, A., van Dijk, F. J., & Verbeek, J. H. (2009). Cancer survivors and unemployment: a meta-analysis and meta-regression. *Jama, 301*(7), 753-762. doi:10.1001/jama.2009.187

Dennis, D. M., Hebden-Todd, T. K., Marsh, L. J., Cipriano, L. J., & Parsons, R. W. (2011). How do Australian ICU survivors fare functionally 6 months after admission? *Crit Care Resusc, 13*(1), 9-16.

Depuydt, P., Oeyen, S., De Smet, S., De Raedt, S., Benoit, D., Decruyenaere, J., & Derom, E. (2016). Long-term outcome and health-related quality of life in difficult-to-wean patients with and without ventilator dependency at ICU discharge: a retrospective cohort study. *BMC Pulm Med, 16*(1), 133. doi:10.1186/s12890-016-0295-0

Desai, S. V., Law, T. J., & Needham, D. M. (2011). Long-term complications of critical care. *Crit Care Med, 39*(2), 371-379. doi:10.1097/CCM.0b013e3181fd66e5

Eddleston, J. M., White, P., & Guthrie, E. (2000). Survival, morbidity, and quality of life after discharge from intensive care. *Crit Care Med, 28*(7), 2293-2299. doi:10.1097/00003246-200007000-00018

Egger, M., Davey Smith, G., Schneider, M., & Minder, C. (1997). Bias in meta-analysis detected by a simple, graphical test. *Bmj, 315*(7109), 629-634. doi:10.1136/bmj.315.7109.629

Franche, R. L., & Krause, N. (2002). Readiness for return to work following injury or illness: conceptualizing the interpersonal impact of health care, workplace, and insurance factors. *J Occup Rehabil, 12*(4), 233-256. doi:10.1023/a:1020270407044

GA Wells, B. S., D O'Connell, J Peterson, V Welch, M Losos, P Tugwell, (nd) The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses. . Retrieved from http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp

Garcy, A. M., & Vagero, D. (2012). The length of unemployment predicts mortality, differently in men and women, and by cause of death: a six year mortality follow-up of the Swedish 1992-1996 recession. *Soc Sci Med, 74*(12), 1911-1920. doi:10.1016/j.socscimed.2012.01.034

Gardner, A., & Sibthorpe, B. (2002). Will he get back to normal? Survival and functional status after intensive care therapy. *Intensive Crit Care Nurs, 18*(3), 138-145. doi:10.1016/s0964-3397(02)00002-2

Graf, J., Wagner, J., Graf, C., Koch, K. C., & Janssens, U. (2005). Five-year survival, quality of life, and individual costs of 303 consecutive medical intensive care patients--a cost-utility analysis. *Crit Care Med, 33*(3), 547-555. doi:10.1097/01.ccm.0000155990.35290.03

Griffiths, J., Hatch, R. A., Bishop, J., Morgan, K., Jenkinson, C., Cuthbertson, B. H., & Brett, S. J. (2013). An exploration of social and economic outcome and associated health-related quality of life after critical illness in general intensive care unit survivors: a 12-month follow-up study. *Crit Care, 17*(3), R100. doi:10.1186/cc12745

Heerkens, Y., Engels, J., Kuiper, C., Van der Gulden, J., & Oostendorp, R. (2004). The use of the ICF to describe work related factors influencing the health of employees. *Disabil Rehabil, 26*(17), 1060-1066. doi:10.1080/09638280410001703530

Herridge, M. S., Cheung, A. M., Tansey, C. M., Matte-Martyn, A., Diaz-Granados, N., Al-Saidi, F., Slutsky, A. S. (2003). One-year outcomes in survivors of the acute respiratory distress syndrome. *N Engl J Med, 348*(8), 683-693. doi:10.1056/NEJMoa022450

Herridge, M. S., Tansey, C. M., Matte, A., Tomlinson, G., Diaz-Granados, N., Cooper, A., Cheung, A. M. (2011). Functional disability 5 years after acute respiratory distress syndrome. *N Engl J Med, 364*(14), 1293-1304. doi:10.1056/NEJMoa1011802

Higgins, J. P., Thompson, S. G., Deeks, J. J., & Altman, D. G. (2003). Measuring inconsistency in meta-analyses. *Bmj, 327*(7414), 557-560. doi:10.1136/bmj.327.7414.557

Hiswals, A. S., Marttila, A., Malstam, E., & Macassa, G. (2017). Experiences of unemployment and well-being after job loss during economic recession: Results of a qualitative study in east central Sweden. *J Public Health Res, 6*(3), 995. doi:10.4081/jphr.2017.995

Hodgson, C., Bellomo, R., Berney, S., Bailey, M., Buhr, H., Denehy, L., Webb, S. (2015). Early mobilization and recovery in mechanically ventilated patients in the ICU: a bi-national, multi-centre, prospective cohort study. *Crit Care, 19*, 81. doi:10.1186/s13054-015-0765-4

Hodgson, C. L., Haines, K. J., Bailey, M., Barrett, J., Bellomo, R., Bucknall, T., Jamie Cooper, D. J. (2018). Predictors of return to work in survivors of critical illness. *J Crit Care, 48*, 21-25. doi:10.1016/j.jcrc.2018.08.005

Holland, P., Nylen, L., Thielen, K., van der Wel, K. A., Chen, W. H., Barr, B., Whitehead, M. (2011). How do macro-level contexts and policies affect the employment chances of chronically ill and disabled people? Part II: The impact of active and passive labor market policies. *Int J Health Serv, 41*(3), 415-430. doi:10.2190/HS.41.3.b

Iwashyna, T. J., Ely, E. W., Smith, D. M., & Langa, K. M. (2010). Long-term cognitive impairment and functional disability among survivors of severe sepsis. *Jama, 304*(16), 1787-1794. doi:10.1001/jama.2010.1553

Kamdar, B. B., Huang, M., Dinglas, V. D., Colantuoni, E., von Wachter, T. M., Hopkins, R. O., & Needham, D. M. (2017). Joblessness and Lost Earnings after Acute Respiratory Distress Syndrome in a 1-Year National Multicenter Study. *Am J Respir Crit Care Med, 196*(8), 1012-1020. doi:10.1164/rccm.201611-2327OC

Kamdar, B. B., Sepulveda, K. A., Chong, A., Lord, R. K., Dinglas, V. D., Mendez-Tellez, P. A., Needham, D. M. (2018). Return to work and lost earnings after acute respiratory distress syndrome: a 5-year prospective, longitudinal study of long-term survivors. *Thorax, 73*(2), 125-133. doi:10.1136/thoraxjnl-2017-210217

Kamdar, B. B., Suri, R., Suchyta, M. R., Digrande, K. F., Sherwood, K. D., Colantuoni, E., Hopkins, R. O. (2020). Return to work after critical illness: a systematic review and meta-analysis. *Thorax, 75*(1), 17-27. doi:10.1136/thoraxjnl-2019-213803

McPeake, J., Mikkelsen, M. E., Quasim, T., Hibbert, E., Cannon, P., Shaw, M., Haines, K. J. (2019). Return to Employment after Critical Illness and Its Association with Psychosocial Outcomes. A Systematic Review and Meta-Analysis. *Ann Am Thorac Soc, 16*(10), 1304-1311. doi:10.1513/AnnalsATS.201903-248OC

McPeake, J., Shaw, M., Iwashyna, T. J., Daniel, M., Devine, H., Jarvie, L., Quasim, T. (2017). Intensive Care Syndrome: Promoting Independence and Return to Employment (InS:PIRE). Early evaluation of a complex intervention. *PLoS One, 12*(11), e0188028. doi:10.1371/journal.pone.0188028

Myhren, H., Ekeberg, O., & Stokland, O. (2010). Health-related quality of life and return to work after critical illness in general intensive care unit patients: a 1-year follow-up study. *Crit Care Med, 38*(7), 1554-1561. doi:10.1097/CCM.0b013e3181e2c8b1

Needham, D. M., Davidson, J., Cohen, H., Hopkins, R. O., Weinert, C., Wunsch, H., Harvey, M. A. (2012). Improving long-term outcomes after discharge from intensive care unit: report from a stakeholders' conference. *Crit Care Med, 40*(2), 502-509. doi:10.1097/CCM.0b013e318232da75

Norman, B. C., Jackson, J. C., Graves, J. A., Girard, T. D., Pandharipande, P. P., Brummel, N. E., Ely, E. W. (2016). Employment Outcomes After Critical Illness: An Analysis of the Bringing to Light the Risk Factors and Incidence of Neuropsychological Dysfunction in ICU Survivors Cohort. *Crit Care Med, 44*(11), 2003-2009. doi:10.1097/ccm.0000000000001849

OECD. (2010). *Sickness, Disability and Work: Breaking the Barriers, A Synthesis of Findings across OECD Countries*. Paris.

Oppermann, J. D. (2004). Interpreting the meaning individuals ascribe to returning to work after traumatic brain injury: a qualitative approach. *Brain Inj, 18*(9), 941-955. doi:10.1080/02699050410001671919

Orwelius, L., Nordlund, A., Nordlund, P., Edell-Gustafsson, U., & Sjoberg, F. (2008). Prevalence of sleep disturbances and long-term reduced health-related quality of life after critical care: a prospective multicenter cohort study. *Crit Care, 12*(4), R97. doi:10.1186/cc6973

Reid, D. B., Chapple, L. S., O'Connor, S. N., Bellomo, R., Buhr, H., Chapman, M. J., Deane, A. M. (2016). The effect of augmenting early nutritional energy delivery on quality of life and employment status one year after ICU admission. *Anaesth Intensive Care, 44*(3), 406-412. doi:10.1177/0310057x1604400309

Riddersholm, S., Christensen, S., Kragholm, K., Christiansen, C. F., & Rasmussen, B. S. (2018). Organ support therapy in the intensive care unit and return to work: a nationwide, register-based cohort study. *Intensive Care Med, 44*(4), 418-427. doi:10.1007/s00134-018-5157-1

Roelfs, D. J., Shor, E., Davidson, K. W., & Schwartz, J. E. (2011). Losing life and livelihood: a systematic review and meta-analysis of unemployment and all-cause mortality. *Soc Sci Med, 72*(6), 840-854. doi:10.1016/j.socscimed.2011.01.005

Rotenstein, L. S., Ramos, M. A., Torre, M., Segal, J. B., Peluso, M. J., Guille, C., Mata, D. A. (2016). Prevalence of Depression, Depressive Symptoms, and Suicidal Ideation Among Medical Students: A Systematic Review and Meta-Analysis. *Jama, 316*(21), 2214-2236. doi:10.1001/jama.2016.17324

Schultz, I. Z., Stowell, A. W., Feuerstein, M., & Gatchel, R. J. (2007). Models of return to work for musculoskeletal disorders. *J Occup Rehabil, 17*(2), 327-352. doi:10.1007/s10926-007-9071-6

Sevin, C. M., Bloom, S. L., Jackson, J. C., Wang, L., Ely, E. W., & Stollings, J. L. (2018). Comprehensive care of ICU survivors: Development and implementation of an ICU recovery center. *J Crit Care, 46*, 141-148. doi:10.1016/j.jcrc.2018.02.011

Sterne, J. A., & Egger, M. (2001). Funnel plots for detecting bias in meta-analysis: guidelines on choice of axis. *J Clin Epidemiol, 54*(10), 1046-1055. doi:10.1016/s0895-4356(01)00377-8

Unroe, M., Kahn, J. M., Carson, S. S., Govert, J. A., Martinu, T., Sathy, S. J., Cox, C. E. (2010). One-year trajectories of care and resource utilization for recipients of prolonged mechanical ventilation: a cohort study. *Ann Intern Med, 153*(3), 167-175. doi:10.7326/0003-4819-153-3-201008030-00007

van der Schaaf, M., Beelen, A., Dongelmans, D. A., Vroom, M. B., & Nollet, F. (2009). Functional status after intensive care: a challenge for rehabilitation professionals to improve outcome. *J Rehabil Med, 41*(5), 360-366. doi:10.2340/16501977-0333

Wehler, M., Geise, A., Hadzionerovic, D., Aljukic, E., Reulbach, U., Hahn, E. G., & Strauss, R. (2003). Health-related quality of life of patients with multiple organ dysfunction: individual changes and comparison with normative population. *Crit Care Med, 31*(4), 1094-1101. doi:10.1097/01.Ccm.0000059642.97686.8b

Wehler, M., Martus, P., Geise, A., Bost, A., Mueller, A., Hahn, E. G., & Strauss, R. (2001). Changes in quality of life after medical intensive care. *Intensive Care Med, 27*(1), 154-159. doi:10.1007/s001340000769

Williams, T. A., Leslie, G. D., Brearley, L., & Dobb, G. J. (2010). Healthcare utilisation among patients discharged from hospital after intensive care. *Anaesth Intensive Care, 38*(4), 732-739. doi:10.1177/0310057x1003800417

Young, A. E., Roessler, R. T., Wasiak, R., McPherson, K. M., van Poppel, M. N., & Anema, J. R. (2005). A developmental conceptualization of return to work. *J Occup Rehabil, 15*(4), 557-568. doi:10.1007/s10926-005-8034-z

Zangger, G., Zwisler, A. D., Kikkenborg Berg, S., Kristensen, M. S., Gronset, C. N., Uddin, J., Thygesen, L. C. (2018). Psychometric properties of HeartQoL, a core heart disease-specific health-related quality of life questionnaire, in Danish implantable cardioverter defibrillator recipients. *Eur J Prev Cardiol, 25*(2), 142-149. doi:10.1177/2047487317733074

Appendix
Table1. Search strategy

Database	Search term	Items found
PubMed	Search (((((("Respiratory Distress Syndrome" OR ARDS OR "Acute Lung Injury" OR "Critical Illness" OR "Critical Care" OR "Intensive Care Units" NOT "Burn Units" NOT "Intensive Care Units, Pediatric" NOT "Recovery Room")) OR ((((("Respiratory Distress Syndrome, Adult"[Mesh] OR "Acute Lung Injury"[Mesh] OR "Critical Illness"[Mesh]) OR "Critical Care"[Mesh]) OR "Intensive Care Units"[Mesh]) NOT "Burn Units"[Mesh]) NOT "Intensive Care Units, Pediatric"[Mesh]) NOT "Recovery Room"[Mesh]))) AND ((((("Return to Work"[Mesh] OR "Employment"[Mesh] OR "return to work" OR employ* OR job*))) NOT (("Workforce"[Mesh]) OR "Health Workforce"[Mesh])))))) NOT Review[Publication Type] Sort by: Best Match Filters: Publication date from 2000/01/01 to 2020/02/19; English; Adult: 19+ years	1319
CINAHL Complete	((MH "Job Re-Entry") OR "return to work" OR (MH "Employment Status") OR "employ" OR (MH "Employment+") OR "employment") AND((MH "Critical Illness") OR "critical illness" OR (MH "Critically Ill Patients") OR (MH "Respiratory Distress Syndrome, Acute") OR "ARDS") **Limiters** - Published Date: 20000101-20200219 **Narrow by SubjectAge:** - all adult **Narrow by Language:** - English	39
Embase	('Intensive care unit'/de OR 'Critically ill patient'/de OR adult respiratory distress syndrome'/de) AND ('employment'/de OR 'return to work'/de) AND(2001:py OR 2002:py OR 2003:py OR 2004:py OR 2005:py OR 2006:py OR 2007:py OR 2008:py OR 2009:py OR 2010:py OR 2011:py OR 2012:py OR 2013:py OR 2014:py OR 2015:py OR 2016:py OR 2017:py OR 2018:py OR 2019:py OR 2020:py) AND([adult]/lim OR[aged]/lim OR [middle aged]/lim OR[very elderly]/lim OR [young adult]/lim)	35
PsychINFO	((MH "Job Re-Entry") OR "return to work" OR (MH "Employment Status") OR "employ" OR (MH "Employment+") OR "employment") AND((MH "Critical Illness") OR "critical illness" OR (MH "Critically Ill Patients") OR (MH "Respiratory Distress Syndrome, Acute") OR "ARDS") **Limiters** - Published Date: 20000101-20200219 **Narrow by SubjectAge:** - adulthood (18 & older) **Narrow by Language:** - English	8

Table 2. Multilevel Model Results for Proportion of Return to Work (RTW)

Fixed Effects	Model 4 (Across all Timepoints)			
	Coeff	*(SE)*	*CI*	*p*
Intercept (Mean RTW)	0.87	(0.45)	(-0.05, 1.82)	
ICU LOS	-0.002	(0.007)	(-0.02,0.01)	
Age	-0.009	(0.009)	(-0.03, 0.008)	
High Policy Support Country	0.19	(0.08)	(0.05, 0.32)	*
Linear Change per Month since 1-Month Post-Discharge	0.21	(0.07)	(0.06, 0.35)	**
Linear Change * High Policy	-0.06	(0.02)	(-0.1, -0.01)	*
Quadratic Change (Deceleration) since 1-Month Post-Discharge	-0.04	(0.01)	(-0.07, -0.01)	**
Random Effects	*Var*			
Intercept (Mean Change)				
Between-study	0.5			
Within-study (residual)	0.1			
Model Information				
No. Parameters	9			
Deviance	-34			
Bayesian information criterion	-1.2			

Note. ICU LOS= intensive unit care length of stay. N = 44 observations within 28 studies; R lme4 used to estimate models; R lmerTest used to approximate Sattherthwaite *df* for coefficient *t*-tests. Maximum Likelihood estimates shown. Policy support effect coded. High policy support countries include Denmark, Germany, Norway, Sweden, United Kingdom, Belgium, Australia, and the Netherlands, coded as 1. Low policy support countries included Canada and United States, coded as -1.

*$p < .05$, **$p < .01$, ***$p < .00$

Figure 1**.** Disability Policy Orientation Across the OECD

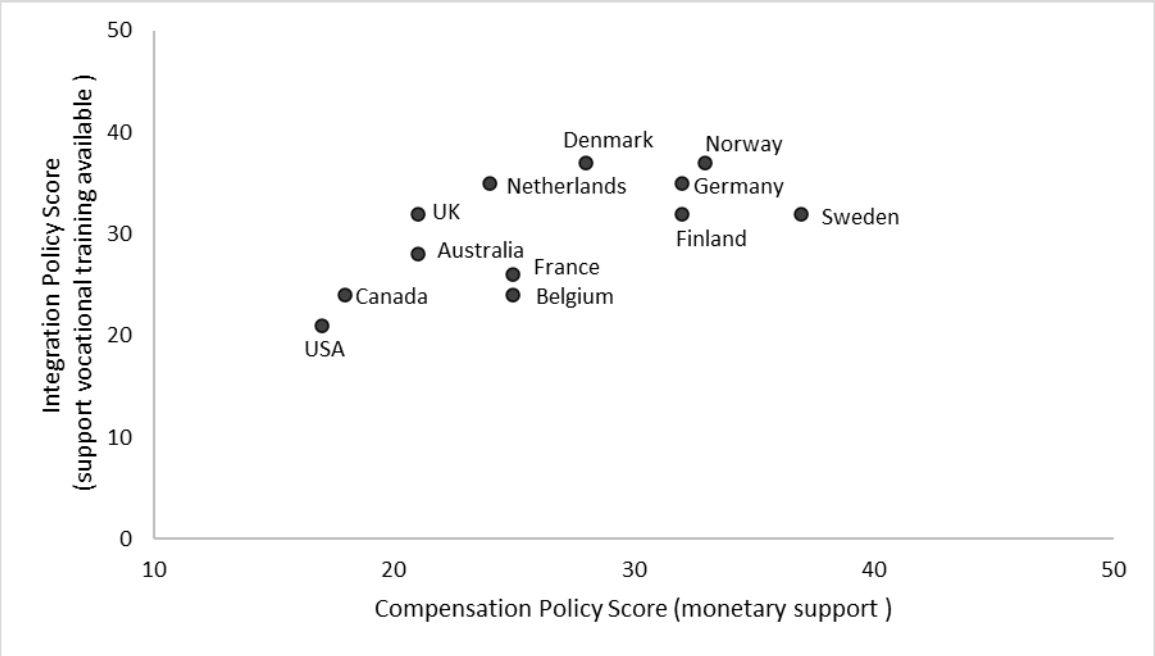
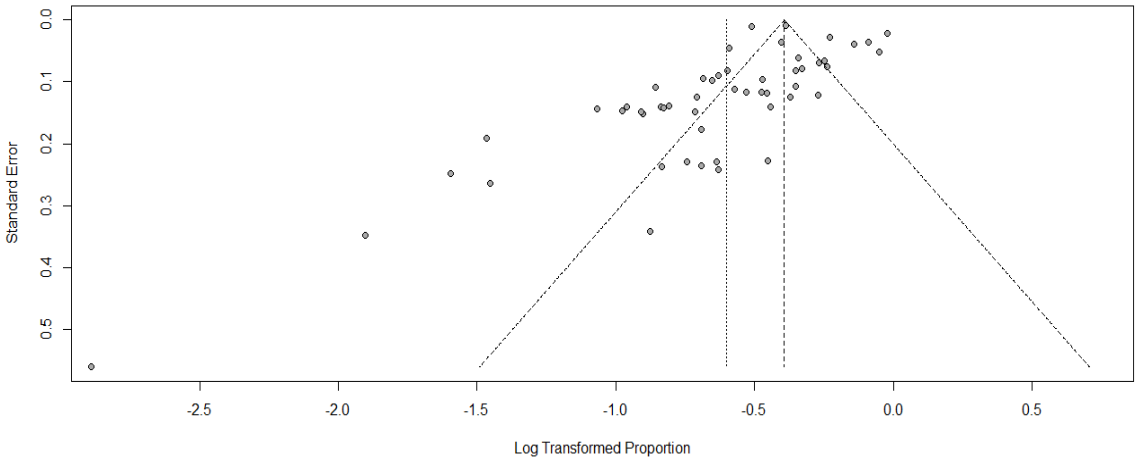


Figure 2**.** Assessment publication bias by funnel plot for the 28 studies



Legend: There was no asymmetry, suggesting the absence of significant publication bias (Egger's test

Chapter 3. Association of Job Characteristics and Functional Impairments on Return to Work after Acute Respiratory Distress Syndrome

Short Title: **Job, Function, and Work Status after ARDS**

Han Su, RN, MSN[1], Hilaire J. Thompson, PhD, RN, ARNP[1,2],
Susanne May, PhD[3], Victor D. Dinglas, MPH[4,5], Catherine L. Hough, MD, MS[6],
Megan M. Hosey, PhD[4,5,7], Ramona O. Hopkins, PhD[8,9,10],
Biren B. Kamdar*, MD, MBA, MHS[11], Dale M. Needham*, FCPA, MD, PhD[4,5,7]

1. School of Nursing, University of Washington, Seattle, WA, USA
2. Harborview Injury Prevention and Research Center, Seattle, WA, USA
3. Department of Biostatistics, University of Washington, Seattle, WA, USA
4. Division of Pulmonary and Critical Care Medicine, Johns Hopkins University School of Medicine, Baltimore, MD, USA
5. Outcomes After Critical Illness and Surgery (OACIS) Group, Johns Hopkins University School of Medicine, Baltimore, MD, USA
6. Pulmonary and Critical Care Medicine, Oregon Health & Science University, Portland, OR, USA
7. Department of Physical Medicine and Rehabilitation, Johns Hopkins University School of Medicine, Baltimore, MD, USA
8. Neuroscience Center and Psychology Department, Brigham Young University, Provo, UT USA
9. Pulmonary and Critical Care Medicine, Intermountain Health Care, Murray, UT USA
10. Center for Humanizing Critical Care, Intermountain Medical Center, Murray, UT USA
11. Division of Pulmonary, Critical Care, Sleep Medicine and Physiology, University of California, San Diego, La Jolla, CA, USA

*Contributed equally as co-senior authors

Corresponding Author:
Han Su, MSN, RN
Box 357266 Seattle, WA 98195-7266
Email: hansu21@uw.edu; Fax: 206-543-4771

Conflict of Interest Statement: On behalf of all authors, the corresponding author states that there are no conflicts of interest.

Funding information: This research was supported by the ALTA, EDEN, OMEGA and SAILS trials (NHLBI contracts HHSN268200536165C to HHSN268200536176C and HHSN268200536179C) and the Hester McLaws Dissertation Research Award.

No prior abstract publication/presentation.

Abbreviation List

ARDS: acute respiratory distress syndrome

ALTOS: ARDS Network Long-term Outcomes Study

CI: confidence interval

SD: standard deviation

OR: odds ratio

O*NET: The U.S. Occupational Information Network

RTW: Return to work

ICU: Intensive care unit

LOS: length of stay

MMSE: Mini-Mental State Examination

SF-36: Short Form-36

MH: Mental health subscale of SF-36

SF: Social functioning subscale of SF-36

PF: Physical function subscale of SF-36

FACIT-F: Functional Assessment of Chronic Illness Therapy–Fatigue Scale

PTSD: Post-traumatic stress disorder

Abstract

Background: Joblessness is common after ARDS, but related risk factors are not fully understood.

Research Question: What is the association between survivors' pre-ARDS workload and post-ARDS functional impairment, pain, and fatigue with their return to work (RTW) status at 6- and 12-month follow-up?

Study Design and Methods: The U.S. Occupational Information Network (O*NET) was used to determine pre-ARDS workload for participants in the ARDS Network Long-Term Outcomes Study (ALTOS). Post-ARDS functional impairment was assessed using the Mini-Mental State Examination and SF-36 Physical Functioning, Social Functioning, and Mental Health sub-scales, and categorized as either: no impairments, only psychosocial impairment, physical with low psychosocial impairment, or physical with high psychosocial impairment. Post-ARDS pain and fatigue were assessed using the SF-36 pain item and FACIT-fatigue scale, respectively. Logistic regression analysis was used to evaluate the associations between pre-ARDS workload, post-ARDS functional impairment, and symptoms of pain and fatigue with RTW at 6 and 12 months post-ARDS.

Results: Pre-ARDS workload was not associated with post-ARDS RTW. However, as compared to survivors with no functional impairments, those with only psychosocial impairments had lower odds of RTW (6-month: Odds Ratio 0.64, 95% Confidence Interval [0.30-1.37]; 12-month: 0.12 [0.05-0.27]), as were those with physical impairments with low or high psychosocial impairments (low: 0.28 [0.15-0.54]; 0.12 [0.06-0.27], and high: 0.13 [0.06-0.27]; 0.02 [0.01-0.07]). At 6- and 12-months, pain (0.15 [0.09-0.25]; 0.18 [0.10-0.33]) and fatigue (0.20 [0.12-0.33]; 0.16 [0.09-0.29]) also were negatively associated with RTW.

Interpretation: For previously employed survivors of ARDS, post-ARDS psychosocial and physical impairments, pain, and fatigue were negatively associated with RTW at both 6 and 12 months, while pre-ARDS workload was not associated. These findings are important for designing and implementing vocational interventions for ARDS survivors.

Keywords: Intensive care unit, Outcomes, Employment, Functional ability, Symptom

After hospitalization, return to work (RTW) is important for previously-employed patients, and is positively associated with functional recovery and economic status.[1] However, previously-employed survivors of acute respiratory distress syndrome (ARDS) commonly experience joblessness, affecting 44-51% and 23-56% at 1- and 5-year follow-up, respectively.[2-4] Hence, greater understanding of occupational and patient factors associated with post-ARDS employment outcomes is urgently needed. Among ARDS survivors, existing patient and hospitalization factors associated with joblessness include: older age, non-White race, chronic health conditions, prolonged mechanical ventilation, longer intensive care unit (ICU) and hospital lengths of stay.[2,5] However, there are few studies evaluating joblessness with ARDS survivors' post-hospitalization status, including aspects of their physical, cognitive, and mental health status.[6,7]

In other patient populations, post-hospitalization joblessness is associated pre-hospitalization workload (the minimal ability required to perform a specific job[8]) and post-hospitalization functional impairment (e.g., physical, psychological, interpersonal, and cognitive impairment) and symptoms (e.g., pain and fatigue). [9-12] These findings need greater evaluation to understand their generalizablity to ARDS survivors and to assist in designing vocational interventions. Hence, our primary objective was to separately evaluate the associations of (a) pre-ARDS job workload, (b) post-ARDS functional impairment, and symptoms of (c) pain and (d) fatigue with RTW at 6 and 12 months after ARDS. As an exploratory objective, we also examined the association of these factors, in combination, with RTW at 6 and 12 months.

Methods

Overview and Participants

This evaluation was conducted as a secondary data analysis of the ARDS Network Long-Term Outcomes Study (ALTOS)[13,14] ALTOS is prospective cohort study that evaluated 6- and 12-month outcomes of participants from randomized trials conducted by the National Institutes of Health (NIH) ARDS Network. Participants were enrolled from 43 hospitals during the period of 2008 to 2014.[15-18] For this analysis, participants in the ARDS Network parent studies were excluded if they: 1) reported no employment before hospitalization for ARDS; 2) died or retired during the follow-up period; 3) had incomplete functional assessments; or 4) were missing employment outcome data during follow-up. As required to associate specific jobs with employment workload, we also excluded survivors who had a job title that: (1) could not be matched within the Occupational Information Network (O*NET) dataset (n=2), or (2) was classified as having both low physical and psychosocial workloads (due to a sample size too small for meaningful statistical analysis (n=4)). Approval for ALTOS was obtained from the institutional review boards of all participating study sites.

Demographic and ICU Variables

Demographic and ICU variables were collected in the parent study, including age, sex, race, ethnicity, Acute Physiology and Chronic Health Evaluation III (APACHE III) severity of illness score,[19] duration of mechanical ventilation, and ICU and hospital lengths of stay (LOS).

Primary Outcome: Return to Work

In the parent study, a previously developed employment questionnaire [2,5,20] was administered to survivors (or their proxies) at 6 and 12 months after ARDS. This indepth questionnaire included questions regarding pre-ARDS job title and current employment status

(i.e., working or not working). For statistical analysis, the primary outcome was evaluated at both 6- and 12-months, and modelled as a binary variable indicating if the ARDS survivor was working versus not working at the respective time point.

Pre-ARDS Workload Phenotype Exposure Variable

To estimate survivors' pre-ARDS workload, we matched their pre-ARDS job title, from their ALTOS employment questionnaire, [2,5,20] with the O*NET system[21]. O*NET is a regularly updated US Department of Labor database that provides, in detail, specific domains (i.e., abilities, interests, knowledge, skills, work activities, work context, and work values) of nearly 1,000 occupations (www.onetcenter.org). Each domain contains several standardized descriptors, on a 1-5 scale, with higher scores identifying attributes more vital for specific occupations.[21] In our study, descriptor scores >2 indicated a high workload (www.onetonline.org/help/online/scales). As impairments in memory, attention, and executive function are frequently reported cognitive issues in ICU survivors,[22] we used the descriptors 'memorization and complex problem-solving' to capture cognitive workload. Additionally, we used descriptors 'level of competition' and 'social perceptiveness' to capture survivors' emotional and interpersonal workload, respectively. We then collapsed cognitive, emotional, and interpersonal workloads into a single variable, psychosocial workload, to identify jobs that had a high level of demand in this area (range 0-3, with a higher number indicating greater demands). Finally, we used the descriptor 'performing general physical activities' to capture survivors' physical workload.

Using these psychosocial and physical workload data, we defined three pre-ARDS workload phenotypes based on actual RTW patterns observed in ALTOS: 1) only high psychosocial workload (i.e., an O-Net descriptor score >2 in $\geq$1 of psychosocial category [i.e.,

cognitive, emotional, and/or interpersonal]; e.g., telemarketer or software developer), 2) high physical (descriptor score >2) and low psychosocial (descriptor score >2 in ≤1 category) workload (e.g., custodian or grocery store clerk), and 3) high physical and psychosocial (descriptor score >2 in >1 category) workload (e.g., nurse or basketball coach).

Functional Impairment Exposure Variable

Functional impairment, an outcome encompassing psychosocial impairment (comprised of cognitive, emotional, interpersonal impairment) and physical impairment, was measured at 6 and 12 months post-ARDS. More specifically, cognitive function was measured by the Mini-Mental State Examination (MMSE),[23] with a score <24 indicating cognitive impairment.[24] Emotional, interpersonal, and physical impairment were measured by Short Form 36 (SF-36) mental health (MH), social functioning (SF), and physical function (PF) subscales, respectively. Each normalized subscale ranges from 0 to 100 (mean [SD] = 50 [10]), with a higher score indicating better status,[25] and emotional, interpersonal, and physical impairments, respectively, defined as MH, SF, and PF normalized scores ≤40. Using these variables, we defined 4 post-ARDS functional impairment phenotypes based on observed RTW patterns: 1) no functional impairment, 2) only psychosocial impairments, 3) physical and low psychosocial impairment, and 4) physical and high psychosocial impairment.

Pain and Fatigue Exposure Variables

Pain and fatigue symptoms were measured at 6 and 12 months post-ARDS. Pain was evaluated by the pain interference question of the SF-36. This question asks the individual to rate the extent to which pain interferes with normal work, with responses ranging from 'Not at all', 'A little bit', 'Moderate', 'Quite a bit' to 'Extremely',[25] with responses of 'Moderate' or higher defined as experiencing pain. Fatigue was measured by Functional Assessment of Chronic

Illness Therapy- Fatigue Scale (FACIT-F), which measures an individual's level of fatigue during their usual daily activities over the past week. A transformed score (range 0 – 100) ≤68 was defined as experiencing fatigue.[26]

Statistical Analysis

We summarized data using means and standard deviations for continuous variables, and proportions for categorical variables. We compared data using Student's *t* tests for continuous variables, and Chi-squared or Fisher's Exact tests, as appropriate, for categorical variables.

For the primary objective, we used logistic regression to separately evaluate the associations of each of the following variables with RTW at each of 6 and 12 months: pre-ARDS workload phenotype, functional impairment phenotype, pain, and fatigue. For the secondary objective, we included all factors (pre-ARDS workload, and 6-month functional impairments, pain, and fatigue) in two separate multivariable logistic regression models evaluating the association with RTW at 6 months (Model 1: a cross-sectional analysis) and at 12 months (Model 2: a prospective analysis (i.e. exposure factors evaluated at the 6-month time point, and the RTW outcome evaluated at 12-month time point). We did not evaluate a model using both exposure and outcome variables at the 12-month time point due to the small number of ARDS survivors in several cells within the multivariable regression model. The following covariates were included in all regression models, chosen *a priori* based on prior publications:[2,5] age, sex, race, APACHE III, and hospital LOS. In all models, multicollinearity was evaluated using variance inflation factors (VIF) and was not detected (i.e., all VIF <10). All analyses were performed using R statistical software. A 2-sided p-value <0.05 denoted statistical significance, with no adjustment for multiple comparisons.

Results

Patient characteristics

A total of 326 and 284 previously-employed survivors, respectively, were included in our 6 and 12-month post-ARDS analyses (Figure 1). There were no significant differences in demographic or ICU factors among survivors who did or did not meet inclusion criteria for the 6-month analysis. However, as compared to those included, survivors excluded from the 12-month analysis tended to have longer mechanical ventilation duration and LOS (eTable 1).

RTW, Impairments and Symptoms

At 6 and 12 months after ARDS, respectively, 171 (52%) and 161 (57%) previously employed survivors had returned to work, with 191 (59%) and 150 (53%) reporting impairments (i.e. physical and/or psychosocial), 200 (61%) and 158 (56%) reporting fatigue, and 131 (40%) and 97 (34%) reporting pain (Table 1). Among survivors with psychosocial impairments, 33%, 54%, and 44% reported cognitive, emotional, and interpersonal impairments at 6 months, respectively, and 48%, 71%, and 33% reported these impairments at 12 months. Those who were not working tended to be older and non-White, with longer LOS and mechanical ventilation duration, and reporting greater impairments (physical and/or psychosocial) and symptoms (fatigue and/or pain).

Post-ARDS functional impairment at 6 and 12 months was associated with not returning to work at 6 and 12 months post-ARDS, respectively. At 6-month post-ARDS, compared to survivors with no functional impairment, those with only psychosocial impairment did not have a significantly lower odds of RTW (OR [CI]: 0.64 [0.30, 1.37], P=0.25), while those with physical

impairment, either with low psychosocial impairment (0.28 [0.15, 0.54], P<0.001) or high psychosocial impairment (0.13 [0.06, 0.27], P<0.001) had lower odds of working (Table 2).

Evaluations of return to work at 12-month follow-up demonstrated similar or stronger associations compared to the findings at 6-month follow-up (Table 2). Most notably, at 12- versus 6-month follow-up, there was a stronger association of survivors exhibiting only psychosocial impairments (compared to survivors without impairment) not returning to work (0.41 [0.18, 0.95], P=0.04).

Pre-ARDS Workload and RTW

Six-month RTW status did not differ by pre-ARDS workload phenotype. At 12 months after ARDS, those individuals with a high physical but low psychosocial workload had a significantly lower percentage of survivors RTW (p=0.04; Table 1). In the adjusted logistic regression model, pre-ARDS workload was not associated with survivors' RTW at 6 and 12 months after ARDS (Table 2).

In multivariable regression models simultaneously evaluating all factors (Table 3), the associations with RTW attenuated for all functional impairment, pain and fatigue variables. Pain (0.25 [0.12, 0.49], P<0.001) and fatigue (0.49 [0.24, 1.01] P=0.052) symptoms at 6 months had strong negative associations with return to work at 6 months, while physical impairments at 6 months, with either low or high psychosocial impairments (0.34 [0.14, 0.83], p 0.02 and 0.15 [0.05, 0.45], p <0.001) had strong negative associations for return to work at 12-months.

Discussion

At 6 months after ARDS, only 52% of previously-employed survivors of ARDS had RTW; with improvement to only 57% at 12 month follow-up. More than half of survivors had

psychosocial and physical impairments at 6- and 12-month follow-up, with substantial symptoms of pain and fatigue commonly reported. Notably, individually each of these impairments and symptoms were negatively associated with working at both 6- and 12-month follow-up, while patients' pre-ARDS occupational workload was not associated. When simultaneously evaluating all impairments and symptoms, pain and fatigue at 6 months each had strong negative associations with working at 6 months, while physical with psychological impairments at 6 months had strongest negative associations with subsequently working at 12 months.

To our knowledge, this is the most comprehensive study, to-date, to examine the association of pre-hospitalization workload, along with post-ARDS functional impairments and symptoms on return to work status at 6 and 12 month follow-up. While our results suggest no association between pre-ARDS workload and return to work at 6- and 12-months after ARDS, studies in other populations have yielded both negative[10,27-29] and positive [28,30,31] results. As a potential explanation, previous studies explored the association of workload and RTW as single domain (e.g., physical or cognitive). However, we assessed workload using multiple domains, categorizing them into different phenotypes. Additionally, we evaluated job workload using detailed O*NET descriptors, while prior studies relied on self-report[27] or job content questionnaires.[29] However, there is potential for measurement error in our mapping of survivors' pre-ARDS work with O*NET descriptors that could have attenuated a potential association.

Consistent with prior studies in ARDS[6,7] and general ICU[1,32] populations, we found that post-ARDS functional impairments (particularly the combination of physical and psychosocial impairments) were negatively associated with RTW at 6 and 12 months. While prior RTW studies examined function as a single domain (e.g., physical, emotional or cognitive),[1,7] we

observed that the majority of survivors reported multiple functional impairments, motivating our approach to analyze function in the context of co-occurring, rather than singular, impairments.

Interestingly, survivors with only psychosocial impairments (compared to those without impairment) had a relatively weak negative association with RTW at 6 months post-ARDS. In this analysis, 50-70% of psychosocial impairments were related to emotional functional impairment (i.e., SF-36 MH score <40).[33] This finding is consistent with prior reports demonstrating that anxiety,[34] depression,[35] and post-traumatic stress symptoms[36,37] are common and often co-occur[38-40] in ICU survivors. Potentially, the severity of these symptoms do not impair the ability to work at 6 months post-ARDS. Alternatively, compared to physical impairments, they may be underrecognized or underestimated by survivors, their employers and/or disability providers in terms of their relevant impairments for RTW. However, given that psychosocial impairments at 6 months, alone or when combined with physical impairments, were negatively associated with RTW at 12 months after ARDS, specific emphasis on early recognition and management of psychosocial impairments (i.e., cognitive, interpersonal and mental health issues) may be important in assisting with subsequent RTW.

Approximately one-third and one-half of survivors, respectively, reported pain and fatigue symptoms that were negatively associated with RTW at 6- and 12-months. Similar symptoms contributing to functional disability and RTW have been shown in low back pain/radiculopathy,[41] cancer,[42-45] and heart failure[46] populations. In ICU[47,48] and ARDS[49] survivors, such symptoms commonly co-exist with physical, cognitive, and mental impairments. Hence, in post-ICU follow-up clinics, early recognition of pain and/or fatigue symptoms may help prompt a broad exploration of other impairments, and a multidisciplinary and proactive

management approach to assist with RTW efforts and potentially reduce chronic and ongoing symptoms in ARDS survivors.

This study had many strengths, including its multicenter longitudinal design, relatively large sample size of previously-employed ARDS survivors, high participant retention rate, and detailed evaluation of pre-ARDS workload and post-ARDS impairments and symptoms with return to work. However, our study also has several limitations. For instance, as an observational study, we cannot make causal inferences between impairments, pain, fatigue, and return to work. Moreover, baseline status for these factors is lacking in order to inform which impairments and symptoms are new or worse after ARDS. In addition, we used the SF-36 and MMSE to measure aspects of functional impairment, which do fully capture functional ability in comparison to physical performance-based tests or more detailed cognitive test batteries.[50] Moreover, functional capacity evaluations, work ability indices, and work limitation questionnaires could be applied in future research to build on the findings of this evaluation. Finally, we dichotomized workload, impairments and symptoms, rather than analyzing as continuous variables. This approach can lead to loss of information. However, given the novelty and complexity of these analyses, this approach was used for purposes of feasibility and for assisting in easy interpretation of findings. Moreover, in using O*NET, dichotomization is consistent with the system's standard scoring[21].

Interpretation

Almost half of previously-employed ARDS survivors had not returned to work at 6 months, with only modest improvement at 12-months. Moreover, at 12 months, 53% reported physical or psychosocial impairments, and 34% and 56% reported pain and fatigue symptoms, respectively. These impairments and symptoms were negatively associated with return to work, while

survivors' pre-ARDS workload phenotype was not. These findings are important for designing and implementing vocational rehabilitation interventions to help address a crisis of joblessness among ARDS survivors.

Figure 1. Patient Flow chart

Legend:
Definition of abbreviations: ARDS= Acute respiratory distress syndrome; O*NET= The U.S. Occupational Information Network.

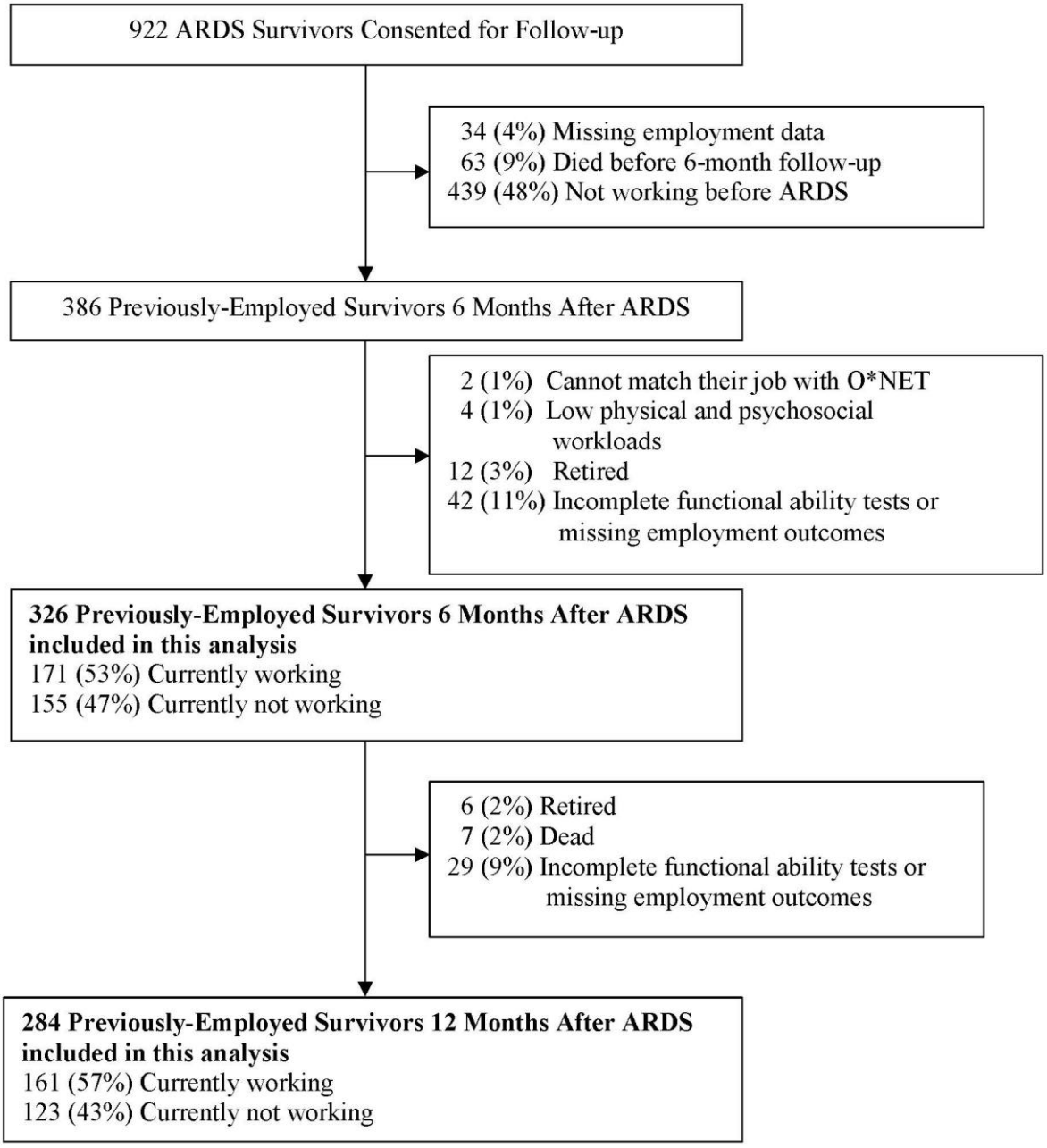


Table 1. Demographic and ICU Variables, by Employment Status at 6 and 12 Months After ARDS*						
Variable	Working at 6 months (n=171)	Not working at 6 months (n=155)	$p^{\dagger}$	Working at 12 months (n=161)	Not working at 12 months (n=123)	$p^{\dagger}$
Demographic factors						
Age, mean (SD), years	44 (13)	46 (12)	0.16	44 (12)	47 (12)	0.04
Female	69 (40)	76 (49)	0.12	64 (40)	61 (50)	0.12
White race	143 (84)	114 (74)	0.03	138 (86)	87 (71)	0.002
Hispanic ethnicity	12 (7)	17 (11)	0.25	11 (7)	13 (11)	0.28
ICU Factors						
APACHE III severity of illness	84 (26)	85 (27)	0.75	82 (25)	85 (27)	0.39
ARDS primariy risk factor:						
Pulmonary	119 (70)	102 (66)	0.48	106 (66)	90 (73)	0.20
Sepsis	27(16)	31 (20)	0.39	27 (17)	19 (16)	0.87
Others	25 (15)	25 (16)	0.76	28 (17)	17 (14)	0.51
Mechanical ventilation, mean (SD) days	9 (8)	13 (12)	<0.001	9 (9)	12 (12)	0.02
ICU LOS, mean (SD) days	12 (9)	17 (12)	<0.001	12 (9)	15 (12)	0.005
Hospital LOS, mean (SD) days	18 (11)	27(17)	<0.001	19 (13)	24 (16)	0.005
Pre-ARDS Workload£						
High psychosocial workload only	63 (37)	57 (37)	0.99	62 (39)	42 (34)	0.45
High physical & low psychosocial workload	34 (20)	38 (25)	0.35	28 (17)	34 (28)	0.04
High physical & high psychosocial workload	74 (43)	60 (39)	0.43	71 (44)	47 (39)	0.39
Functional Impairment after ARDS¥						
No impairment	99 (58) §	36 (23) §	<0.001	113 (71) ‡	21 (17) ‡	<0.001
Only psychosocial impairments	30 (17) §	18 (12) §	0.16	18 (11) ‡	24 (20) ‡	0.062
Physical & low psychosocial impairment	28 (16) §	50 (32) §	0.001	24 (15) ‡	37 (30) ‡	0.002
Physical & high psychosocial impairment	14 (8) §	51 (33) §	<0.001	6 (4) ‡	41 (34) ‡	<0.001
Symptoms after ARDS						
Pain	33 (19) §	98 (63) §	<0.001	30 (19) ‡	67 (55) ‡	<0.001
Fatigue	74 (44) §	126 (81) §	<0.001	61 (38) ‡	97 (85) ‡	<0.001

* Data presented as n (%) unless otherwise noted and may not add to 100% due to rounding

† Calculated by Student's *t* test for continuous variables and Chi-squared or Fisher exact tests, as appropriate, for categorical variables

£ Psychosocial workload combines cognitive, emotional, and interpersonal workload categories, with a job exhibiting low (<2 categories), or high (≥2 categories) number of these categories

¥ Psychosocial impairment combines cognitive, emotional, and interpersonal impairment categories, with survivors having impairments in low (<2 categories), or high (≥2 categories) number of these categories.

§ Analyzed using functional impairments, pain, and fatigue at 6 months.
‡ Analyzed using functional impairments, pain, and fatigue at 12 months.

Definition of abbreviations: SD = standard deviation; ARDS = Acute respiratory distress syndrome; COPD = Chronic obstructive pulmonary disease; APACHE III = Acute Physiology and Chronic Health Evaluation III; ICU = intensive care unit; LOS = length of stay.

Table 2. Separate Adjusted Associations of Return to Work after ARDS with Each of Pre-ARDS Workload Phenotypes, Functional Impairments, Pain, and Fatigue*

		Working at 6 months		Working at 12 months	
		OR (95% CI)	***p***	**OR (95% CI)**	***p***
Pre-ARDS Workload£	Only high psychosocial workload	Reference		Reference	
	High physical & low psychosocial workload	0.81 (0.42, 1.56)	0.58	0.59 (0.29, 1.18)	0.13
	High physical & high psychosocial workload	0.97 (0.56, 1.68)	0.66	1.04 (0.50, 1.62)	0.73
Functional impairments at 6 months ¥	No impairment	Reference		Reference	
	Only psychosocial impairments	0.64 (0.30, 1.37)	0.25	0.41 (0.18, 0.95)	0.04
	Physical & low psychosocial impairment	0.28 (0.15, 0.54)	<0.001	0.15 (0.07, 0.32)	<0.001
	Physical & high psychosocial impairment	0.13 (0.06, 0.27)	<0.001	0.06 (0.02, 0.13)	<0.001
Pain at 6 months		0.15 (0.09, 0.25)	<0.001	0.17 (0.10, 0.31)	<0.001
Fatigue at 6 months		0.20 (0.12, 0.33)	<0.001	0.16 (0.09, 0.29)	<0.001
Functional impairments at 12 months ¥	No impairment			Reference	
	Only psychosocial impairment			0.12 (0.05, 0.27)	<0.001
	Physical & low psychosocial impairment			0.12 (0.06, 0.27)	<0.001
	Physical & high psychosocial impairment			0.02 (0.01, 0.07)	<0.001
Pain at 12 months				0.18 (0.10, 0.33)	<0.001
Fatigue at 12 months				0.16 (0.09, 0.29)	<0.001

* Each bolded row reports the results of a separate multivariable logistic regression model evaluating the association of working status with the variable named in that row, adjusted for age, sex, race, APACHE III, and hospital length of stay.

£ Psychosocial workload combines cognitive, emotional, and interpersonal workload categories, with a job exhibiting low (<2 categories), or high (≥2 categories) number of these categories.

¥ Psychosocial impairment combines cognitive, emotional, and interpersonal impairment categories, with survivors having impairments in low (<2 categories), or high (≥2 categories) number of these categories.

Table 3. Combined Adjusted Association of Return to Work After ARDS with All of Pre-ARDS Workload Phenotypes, Functional Impairments, Pain, and Fatigue†

		Model 1† Working at 6 months		Model 2† Working at 12 months	
		OR (95% CI)	*p*	OR (95% CI)	*p*
Pre-ARDS Workload£	Only high psychosocial workload	Reference		Reference	
	High physical & low psychosocial workload	0.66 (0.31, 1.39)	0.27	0.43 (0.19, 0.98)	0.04
	High physical & high psychosocial workload	1.20 (0.64, 2.23)	0.58	1.12 (0.56, 2.22)	0.76
Functional abilities at 6 months¥	No impairment	Reference		Reference	
	Only psychosocial impairment	1.30 (0.54, 3.09)	0.56	0.75 (0.30, 1.93)	0.56
	Physical & low psychosocial impairment	0.80 (0.35, 1.79)	0.58	0.34 (0.14, 0.83)	0.02
	Physical & high psychosocial impairment	0.59 (0.22, 1.59)	0.29	0.15 (0.05, 0.45)	<0.001
Pain interference at 6 months¶		0.25 (0.12, 0.49)	<0.001	0.50 (0.23, 1.07)	0.07
Fatigue at 6 months¶		0.49 (0.24, 1.01)	0.05	0.44 (0.19, 1.04)	0.06

† Multivariable logistic regression models were used to evaluate the association of pre-ARDS workload and patient status at 6 months with return to work at 6 months (Model 1: a cross-sectional analysis) and with return to work at 12 months (Model 2: a prospective analysis). Both models are adjust for adjusted for age, sex, race, APACHE III, and hospital length of stay.

£ Psychosocial workload combines cognitive, emotional, and interpersonal workload categories, with a job exhibiting low (<2 categories), or high (≥2 categories) number of these categories.

¥ Psychosocial impairment combines cognitive, emotional, and interpersonal impairment categories, with survivors having impairments in low (<2 categories), or high (≥2 categories) number of these categories.

Acknowledgments

1. Guarantor Statement: HS, HJT and DMN are the guarantors of the content of the manuscript.
2. Author Contributions: HS conceived the work. HS performed the statistical analyses and data interpretation, and wrote the initial draft of the manuscript. HJT and SM supervised the analysis. HJT, SM, CTH, VDD, MMH, ROH, BBK and DMN contributed substantially to the study design, data interpretation and critically revised the manuscript for important intellectual content. All authors gave final approval of the submitted version of the manuscript and agreed to be accountable for the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.
3. Financial/nonfinancial Disclosures: This research was supported by the ALTA, EDEN, OMEGA and SAILS trials (NHLBI contracts HHSN268200536165C, HHSN268200536176C and HHSN268200536179C) and the Hester McLaws Dissertation Research Award to HS.
4. Role of the sponsors: None
5. Other contributions: NA

References

1. Hodgson CL, Haines KJ, Bailey M, et al. Predictors of return to work in survivors of critical illness. *Journal of critical care.* 2018;48:21-25.
2. Kamdar BB, Minxuan H, Dinglas VD, et al. Joblessness and Lost Earnings after Acute Respiratory Distress Syndrome in a 1-Year National Multicenter Study. *American Journal of Respiratory & Critical Care Medicine.* 2017;196(8):1012-1020.
3. Herridge MS, Tansey CM, Matte A, et al. Functional disability 5 years after acute respiratory distress syndrome. *The New England journal of medicine.* 2011;364(14):1293-1304.
4. Kamdar BB, Suri R, Suchyta MR, et al. Return to work after critical illness: a systematic review and meta-analysis. *Thorax.* 2020;75(1):17.
5. Kamdar BB, Sepulveda KA, Chong A, et al. Return to work and lost earnings after acute respiratory distress syndrome: A 5-year prospective, longitudinal study of long-term survivors. *Thorax.* 2018;73(2):125-133.
6. Herridge MS, Cheung AM, Tansey CM, et al. One-Year Outcomes in Survivors of the Acute Respiratory Distress Syndrome. *New England Journal of Medicine.* 2003;348(8):683-693.
7. Rothenhäusler HB, Ehrentraut S, Stoll C, Schelling G, Kapfhammer HP. The relationship between cognitive performance and employment and health status in long-term survivors of the acute respiratory distress syndrome: Results of an exploratory study. *General Hospital Psychiatry.* 2001;23(2):90-96.
8. Heerkens Y, Engels J, Kuiper C, Van der Gulden J, Oostendorp R. The use of the ICF to describe work related factors influencing the health of employees. *Disability and rehabilitation.* 2004;26(17):1060-1066.
9. Fraser R, Machamer J, Temkin N, Dikmen S, Doctor J. Return to work in traumatic brain injury (TBI): A perspective on capacity for job complexity. *Journal of Vocational Rehabilitation.* 2006;25:141-148.
10. Cancelliere C, Donovan J, Stochkendahl MJ, et al. Factors affecting return to work after injury or illness: best evidence synthesis of systematic reviews. *Chiropr Man Therap.* 2016;24(1):32-32.
11. Feuerstein M, Todd BL, Moskowitz MC, et al. Work in cancer survivors: a model for practice and research. *J Cancer Surviv.* 2010;4(4):415-437.
12. Schultz IZ, Stowell AW, Feuerstein M, Gatchel RJ. Models of return to work for musculoskeletal disorders. *Journal of occupational rehabilitation.* 2007;17(2):327-352.
13. Dinglas VD, Hopkins RO, Wozniak AW, et al. One-year outcomes of rosuvastatin versus placebo in sepsis-associated acute respiratory distress syndrome: prospective follow-up of SAILS randomised trial. *Thorax.* 2016;71(5):401-410.
14. Needham DM, Dinglas VD, Bienvenu OJ, et al. One year outcomes in patients with acute lung injury randomised to initial trophic or full enteral feeding: prospective follow-up of EDEN randomised trial. *Bmj.* 2013;346:f1532.
15. Matthay MA, Brower RG, Carson S, et al. Randomized, placebo-controlled clinical trial of an aerosolized beta(2)-agonist for treatment of acute lung injury. *American journal of respiratory and critical care medicine.* 2011;184(5):561-568.
16. Rice TW, Wheeler AP, Thompson BT, et al. Initial trophic vs full enteral feeding in patients with acute lung injury: the EDEN randomized trial. *Jama.* 2012;307(8):795-803.

17. Rice TW, Wheeler AP, Thompson BT, deBoisblanc BP, Steingrub J, Rock P. Enteral omega-3 fatty acid, gamma-linolenic acid, and antioxidant supplementation in acute lung injury. *Jama.* 2011;306(14):1574-1581.
18. Truwit JD, Bernard GR, Steingrub J, et al. Rosuvastatin for sepsis-associated acute respiratory distress syndrome. *The New England journal of medicine.* 2014;370(23):2191-2200.
19. Knaus WA, Wagner DP, Draper EA, et al. The APACHE III prognostic system. Risk prediction of hospital mortality for critically ill hospitalized adults. *Chest.* 1991;100(6):1619-1636.
20. Radford K, Phillips J, Drummond A, et al. Return to work after traumatic brain injury: cohort comparison and economic evaluation. *Brain injury.* 2013;27(5):507-520.
21. Development. NCfON. O*NET OnLine. www.onetonline.org.
22. Hopkins RO, Brett S. Chronic neurocognitive effects of critical illness. *Curr Opin Crit Care.* 2005;11(4):369-375.
23. Newkirk LA, Kim JM, Thompson JM, Tinklenberg JR, Yesavage JA, Taylor JL. Validation of a 26-point telephone version of the Mini-Mental State Examination. *J Geriatr Psychiatry Neurol.* 2004;17(2):81-87.
24. Pfoh ER, Chan KS, Dinglas VD, et al. Cognitive screening among acute respiratory failure survivors: a cross-sectional evaluation of the Mini-Mental State Examination. *Crit Care.* 2015;19(1):220.
25. Ware J, Kosinski MA, Dewey J. How to Score Version 2 of the SF-36® Health Survey. *Lincoln, QualityMetric Incorporated.* 2000.
26. Butt Z, Lai J-S, Rao D, Heinemann AW, Bill A, Cella D. Measurement of fatigue in cancer, stroke, and HIV using the Functional Assessment of Chronic Illness Therapy - Fatigue (FACIT-F) scale. *J Psychosom Res.* 2013;74(1):64-68.
27. Kearney J, Dyson K, Andrew E, Bernard S, Smith K. Factors associated with return to work among survivors of out-of-hospital cardiac arrest. *Resuscitation.* 2020;146:203-212.
28. Walker WC, Marwitz JH, Kreutzer JS, Hart T, Novack TA. Occupational categories and return to work after traumatic brain injury: a multicenter study. *Arch Phys Med Rehabil.* 2006;87(12):1576-1582.
29. Haveraaen LA, Skarpaas LS, Aas RW. Job demands and decision control predicted return to work: the rapid-RTW cohort study. *BMC Public Health.* 2017;17(1):154.
30. Lombardi AV, Jr., Nunley RM, Berend KR, et al. Do patients return to work after total knee arthroplasty? *Clin Orthop Relat Res.* 2014;472(1):138-146.
31. Haveraaen L, Skarpaas L, Berg J, Aas RW. Do psychological job demands, decision control and social support predict return to work three months after the end of a return-to-work (RTW) programme? The rapid-RTW cohort study. *Work* 2015;53.
32. Norman BC, Jackson JC, Graves JA, et al. Employment Outcomes After Critical Illness: An Analysis of the Bringing to Light the Risk Factors and Incidence of Neuropsychological Dysfunction in ICU Survivors Cohort. *Critical care medicine.* 2016;44(11):2003-2009.
33. Pfoh ER, Chan KS, Dinglas VD, et al. The SF-36 offers a strong measure of mental health symptoms in survivors of acute respiratory failure. A tri-national analysis. *Annals of the American Thoracic Society.* 2016;13(8):1343-1350.
34. Nikayin S, Rabiee A, Hashem MD, et al. Anxiety symptoms in survivors of critical illness: a systematic review and meta-analysis. *Gen Hosp Psychiatry.* 2016;43:23-29.

35. Rabiee A, Nikayin S, Hashem MD, et al. Depressive Symptoms After Critical Illness: A Systematic Review and Meta-Analysis. *Critical care medicine.* 2016;44(9):1744-1753.
36. Righy C, Rosa RG, da Silva RTA, et al. Prevalence of post-traumatic stress disorder symptoms in adult critical care survivors: a systematic review and meta-analysis. *Crit Care.* 2019;23(1):213.
37. Parker AM, Sricharoenchai T, Raparla S, Schneck KW, Bienvenu OJ, Needham DM. Posttraumatic stress disorder in critical illness survivors: a metaanalysis. *Critical care medicine.* 2015;43(5):1121-1129.
38. Bienvenu OJ, Friedman LA, Colantuoni E, et al. Psychiatric symptoms after acute respiratory distress syndrome: a 5-year longitudinal study. *Intensive Care Med.* 2018;44(1):38-47.
39. Huang M, Parker AM, Bienvenu OJ, et al. Psychiatric Symptoms in Acute Respiratory Distress Syndrome Survivors: A 1-Year National Multicenter Study. *Crit.Care Med.* 2016;44(5):954-965.
40. Bienvenu OJ, Colantuoni E, Mendez-Tellez PA, et al. Cooccurrence of and Remission From General Anxiety, Depression, and Posttraumatic Stress Disorder Symptoms After Acute Lung Injury: A 2-Year Longitudinal Study. *Critical care medicine.* 2015;43(3).
41. Steenstra IA, Munhall C, Irvin E, et al. Systematic Review of Prognostic Factors for Return to Work in Workers with Sub Acute and Chronic Low Back Pain. *Journal of occupational rehabilitation.* 2017;27(3):369-381.
42. Barsevick AM, Whitmer K, Nail LM, Beck SL, Dudley WN. Symptom cluster research: conceptual, design, measurement, and analysis issues. *J Pain Symptom Manage.* 2006;31(1):85-95.
43. Dong ST, Butow PN, Costa DSJ, Lovell MR, Agar M. Symptom Clusters in Patients With Advanced Cancer: A Systematic Review of Observational Studies. *Journal of Pain and Symptom Management.* 2014;48(3):411-450.
44. Dorland HF, Abma FI, Van Zon SKR, et al. Fatigue and depressive symptoms improve but remain negatively related to work functioning over 18 months after return to work in cancer patients. *J Cancer Surviv.* 2018;12(3):371-378.
45. Spelten ER, Verbeek JH, Uitterhoeve AL, et al. Cancer, fatigue and the return of patients to work-a prospective cohort study. *Eur J Cancer.* 2003;39(11):1562-1567.
46. Herr JK, Salyer J, Lyon DE, Goodloe L, Schubert C, Clement DG. Heart failure symptom relationships: a systematic review. *J Cardiovasc Nurs.* 2014;29(5):416-422.
47. Wintermann GB, Rosendahl J, Weidner K, Strauß B, Hinz A, Petrowski K. Self-reported fatigue following intensive care of chronically critically ill patients: a prospective cohort study. *J Intensive Care.* 2018;6:27.
48. Spadaro S, Capuzzo M, Valpiani G, et al. Fatigue in intensive care survivors one year after discharge. *Health Qual Life Outcomes.* 2016;14(1):148.
49. Neufeld KJ, Leoutsakos JS, Yan H, et al. Fatigue Symptoms during the First Year after ARDS. *Chest.* 2020.
50. Chan KS, Aronson Friedman L, Dinglas VD, et al. Are physical measures related to patient-centred outcomes in ARDS survivors? *Thorax.* 2017;72(10):884-892.

Online Supplement

Association of Job Characteristics and Functional Impairment on Return to Work after Acute Respiratory Distress Syndrome

Han Su, MSN, Hilaire J. Thompson, PhD, Susanne May, PhD,
Victor D. Dinglas, MPH, Catherine L. Hough, MD,
Megan M. Hosey, PhD, Ramona O. Hopkins, PhD,
Biren B. Kamdar, MD, MBA, MHS, Dale M. Needham, MD, PhD

eTable 1-Baseline and Intensive Care Data at 6 and 12 Months after ARDS*

Variable	All Survivors (N=386)	Included at 6 months (n=326)	Excluded at 6 months (n=60)‡	$p^{\$}$	Included at 12 months (n=284)	Excluded at 12 months (n=42)¶	$p^{\$}$
Baseline status							
Age, mean (SD), year	45 (13)	45 (13)	46 (13)	0.84	45 (13)	46 (15)	0.67
Female	171 (44)	145 (45)	26 (43)	0.89	124 (44)	20 (48)	0.74
White race	308 (80)	257 (79)	51 (85)	0.38	225 (79)	32 (76)	0.69
Intensive care							
Baseline APACHE III	83 (26)	84 (26)	80 (28)	0.35	83 (26)	89 (28)	0.19
Mechanical ventilation, mean (SD) days	12 (10)	12 (11)	10 (10)	0.52	11 (11)	14 (11)	0.06
ICU LOS, mean (SD), day	14 (11)	14 (11)	15 (13)	0.52	14 (10)	18 (13)	0.04
Hospital LOS, mean (SD), day	23 (16)	22 (15)	25 (20)	0.33	21 (15)	27 (19)	0.06

*Data presented as n (%) unless otherwise noted. Percentages may not total 100% due to rounding.

‡ Two participants excluded as jobs could not be matched in O*NET, 4 due to low physical and psychosocial workloads, 12 retired, and 42 incomplete functional impairment data or missing employment outcomes.

¶ Six and 7 participants excluded due to retirement and death, respectively, and 29 due to incomplete functional ability tests or missing employment outcomes

$ Differences were calculated by Student's *t* test for continuous variables and Chi-squared test or Fisher exact tests, as appropriate, for categorical variables.

Definition of abbreviations: SD = standard deviation; ARDS = Acute respiratory distress syndrome; COPD = Chronic obstructive pulmonary disease; APACHE III = Acute Physiology and Chronic Health Evaluation III; ICU = intensive care unit; LOS = length of stay.

Chapter 4. **Association of imbalance between job workload and functional ability with return to work in ARDS survivors**

Han Su, RN, MSN[1], Ramona O. Hopkins, PhD[2,3,4], Biren B. Kamdar, MD, MBA, MHS[5], Susanne May, PhD[6], Victor D. Dinglas, MPH[7,8], Kurt L. Johnson, PhD[9], Megan M. Hosey, PhD[7,8,10], Catherine L. Hough, MD, MS[11], Dale M. Needham, FCPA, MD, PhD[7,8,10], Hilaire J. Thompson, PhD, RN, ARNP[1, 12]

1. School of Nursing, University of Washington, Seattle, Washington, USA
2. Neuroscience Center and Psychology Department, Brigham Young University, Provo, Utah USA
3. Pulmonary and Critical Care Medicine, Intermountain Health Care, Murray, Utah USA
4. Center for Humanizing Critical Care, Intermountain Medical Center, Murray, Utah USA
5. Division of Pulmonary, Critical Care, Sleep Medicine and Physiology, University of California, San Diego, La Jolla, California, USA
6. Department of Biostatistics, University of Washington, Seattle, Washington, United States
7. Division of Pulmonary and Critical Care Medicine, Johns Hopkins University School of Medicine, Baltimore, MD, USA
8. Outcomes After Critical Illness and Surgery (OACIS) Group, Johns Hopkins University, Baltimore, MD, USA
9. Department of Rehabilitation Medicine, University of Washington, Seattle, WA, USA
10. Department of Physical Medicine and Rehabilitation, Johns Hopkins University School of Medicine, Baltimore, MD, USA
11. Division of Pulmonary and Critical Care Medicine, Oregon Health & Science University, Portland, OR, USA
12. Harborview Injury Prevention and Research Center, Seattle, WA, USA

Corresponding Author:
Han Su, MSN, RN.
Box 357266 Seattle, WA 98195-7266
Email: hansu21@uw.edu; Fax: 206-543-4771

Word count: 2129

Abstract

Background: Inability to return to work (RTW) is common after acute respiratory distress syndrome (ARDS). Mismatch in an individual's job workload and their functional ability, termed work ability imbalance, is negatively associated with return to work, but has not been evaluated in ARDS survivors.

Object: We examine associations between work ability imbalance at 6 months and RTW at 6 and 12 months, as well as ability to sustain employment in ARDS survivors.

Methods: Previously employed participants from the ARDS Network Long-Term Outcomes Study (N=341) were evaluated. Pre-ARDS workload was determined based on the US Occupational Information Network classification. Post-ARDS functional ability was assessed using self-reported SF-36 physical functioning, social functioning, and mental health sub-scales, and Mini-Mental State Examination. ARDS survivors were categorized into four work ability imbalance categories: none, psychosocial, physical, and both psychosocial and physical.

Results: Almost 90% of ARDS survivors had a physical and/or psychosocial work ability imbalance at both 6- and 12-months follow-up. As compared to survivors with no imbalance at 6 months, those with both physical and psychosocial imbalance had lower odds of RTW (6-month: OR 0.34, 95% CI [0.14, 0.87]; 12-months: 0.22 [0.10-0.69]). Thirty-eight (19%) of those who ever RTW were subsequently jobless at 12 months.

Conclusion: Interventions aimed at rebalancing ARDS survivors' work ability by addressing physical and psychosocial aspects of their functional ability and workload should be explored as part of efforts to improve return to work, maintain employment, and reduce the financial impact of joblessness.

Keywords: Intensive care unit, ARDS, Employment, Work Ability, Sustained employment

Key Messages

What is the key question?

- Is work ability imbalance (i.e., a mismatch in an individual's job workload and their functional ability) negatively associated with return to work in ARDS survivors?

What is the bottom line?

- Analyses of data from a multi-center, national study in the USA demonstrated that among 341 previously employed ARDS survivors, an imbalance in both physical and psychosocial work ability at 6 months was strongly associated with not working at 6 and 12 months post-ARDS (adjusted Odds Ratio (95% Confidence Interval): 0.34 (0.14, 0.87) and 0.22 (0.10-0.69), respectively).

Why read on?

- The result of this study suggests that interventions aimed at rebalancing ARDS survivors' work ability by modifying their functional ability and target both physical and psychosocial aspects of workload could improve employment outcomes.

INTRODUCTION

In previously employed acute respiratory distress syndrome (ARDS) survivors, a delay or inability to return to work (RTW) is common, leading to a substantial financial burden for patients, families, and society.[1-3] Demographic factors, socio-economic status, and chronic health conditions are associated with joblessness in previously-employed survivors of ARDS and other critical illnesses.[2] Intensive care unit (ICU)-related factors, such as disease severity and length of stay (LOS),[1 4] along with post-ICU impairments (including physical, cognitive, and psychological impairment, pain, and fatigue) are also negatively associated with RTW.[5 6]

"Work ability," defined as a match between the physical, psychological, social, and environmental workload of an individual's job and their functional ability,[7 8] is a crucial factor for RTW within the fields of rehabilitation and occupational medicine.[9] To facilitate successful RTW, employers and healthcare providers must assess an employee's work ability to understand the required vocational rehabilitation and workplace accommodations.[7] A job with a high physical and/or psychosocial workload, together with an employee's impaired functional ability, creates an imbalance in work ability (Figure 1).[10] Imbalance in work ability is associated with prolonged absence from work, job loss, reduced productivity, work-related injuries, early retirement, development of chronic health conditions, and increased mortality.[11-15] However, whether an imbalance in work ability is associated with RTW in ARDS survivors is unclear. Hence, our primary objective was to evaluate the association between imbalance in work ability and RTW at 6 and 12 months post-ARDS. As a secondary objective, we evaluated patterns of work ability imbalance with sustained employment between 6 and 12 month follow-up.

METHODS

Overview and Participants

The ARDS Network Long-Term Outcomes Study (ALTOS), a multicenter prospective cohort study, was the basis for the present study. ALTOS evaluated 6- and 12-month outcomes in ARDS patients from 2008 to late 2014. To be eligible for this evaluation, participants had to: 1) have full- or part-time employment before ARDS; 2) survive to 12-month follow-up; 3) have complete data on employment outcome and functional ability; and 4) have a job title that could be matched with the Occupational Information Network (O*NET) dataset. Approval for ALTOS was obtained from the Institutional Review Boards of all participating study sites.

Evaluating Workload Phenotype and Functional Ability

The cognitive, emotional, interpersonal, and physical workload of survivors' pre-ARDS employment was estimated by matching survivor's job title with the Occupational Information Network (O*NET; www.onetonline.org/). O*NET, a validated database developed and updated by the US Department of Labor Administration, includes nearly 1000 occupations. Each occupation is measured by descriptors that describe and rate specific domains (abilities, interests, knowledge, skills, work activities, work context, and work values). Each descriptor is rated on a 1-5 scale; a higher value indicating a higher importance for that specific occupation. We defined descriptor scores ≤ 2 and >2 as low and high workload, respectively, as per O*NET recommendations (www.onetonline.org/help/online/scales). For this study, we used memorization and complex problem-solving O*NET descriptors to represent cognitive workload. Social perceptiveness, level of competition, and performing general physical activity O*NET descriptors were used to represent participants' interpersonal workload, emotional workload, and physical workload, respectively.

Cognitive, emotional, interpersonal, and physical functional abilities were measured at 6- and 12-months post-ARDS. Cognitive ability was measured by the Mini-Mental State Exam (MMSE) with a score <24 indicating cognitive impairment.[16] Emotional, interpersonal, and physical abilities were measured by the SF-36 mental health (MH), social functioning (SF), and physical function (PF) subscales, respectively,[17] with a normalized score $\leq$40 indicating reduced functional ability.

Primary Exposure: Imbalance in Work Ability

Imbalance in work ability, a binary variable, was defined as an ARDS survivor whose job had high workload demands, but the survivor had low functional ability in that area (e.g., physical imbalance was defined as a high physical workload, but SF-36 PF score $\leq$40). Based on actual RTW patterns observed in ALTOS, we collapsed cognitive, emotional, and interpersonal areas into psychosocial imbalance in work ability (defined as at least one imbalance in the three areas). Moreover, we categorized imbalance in work ability into four main categories: 1) no imbalance, 2) psychosocial work ability imbalance, 3) physical work ability imbalance, 4) imbalance in both physical and psychosocial work abilities.

Primary Outcome: Return to Work

A previously developed employment questionnaire[18] was used to collect pre-ARDS employment information along with employment status at 6 and 12 months post-ARDS. Return to work was defined as being employed prior to ARDS and working at the time of the study follow-up assessment, completed at each of 6 and 12 months after ARDS. Retirement in the first year after ARDS was classified as no RTW in the primary analysis, with a sensitivity analysis excluding newly retired survivors. ARDS survivors who ever RTW during 12-month follow-up and were currently working at the 12-month assessment were classified as having “sustained

employment;" those who ever RTW, but were not working at 12 months were classified as "non-sustained employment."

Covariates: Baseline Patient- and ICU–Related Variables

Based on prior literature,[1 2 4] the following relevant covariates were considered for this analysis: baseline demographic factors (i.e., age, sex, race, and ethnicity) and ICU-related factors (i.e., Acute Physiology and Chronic Health Evaluation III [APACHE III] severity of illness score, duration of mechanical ventilation, and ICU and hospital length of stay [LOS]).

Statistical Analyses

We summarized continuous and categorical variables using means (standard deviations) and counts (proportions), respectively. We compared data using Student's *t*-tests for continuous variables, and Chi-squared or Fisher's Exact tests for categorical variables, as appropriate. For the primary study objective, logistic regression models were used to evaluate the association between imbalance in work ability and RTW status (binary variable: working versus not working) at each of 6 and 12-month follow-up. As age, sex, race, APACHE III score, and hospital length of stay were associated with RTW in ARDS patients in prior work,[1 2 4] we adjusted for these variables in the regression models. All analyses were performed using R statistical software (R Development Core, Vienna, Austria). A 2-sided p-value <0.05 was considered statistically significant.

RESULTS

Patient characteristics

A total of 341 and 301 previously employed survivors were included in our analyses at 6 and 12-month follow-up, respectively (Figure 2 and Table 1). There were no significant differences in demographic, APACHE III score, and hospital length of stay among survivors who did versus did not meet inclusion criteria for the 6- and 12- month analyses (eTable 1). However, survivors who did not meet inclusion criteria at 12-month follow-up had a significantly longer ICU LOS.

Mismatch in work ability and RTW

Among previously employed survivors, 172 (50%) and 164 (54%) had RTW at 6- and 12-month follow-up, respectively. Among those with RTW at 6- and 12-month follow-up, 310 (91%) and 271 (90%) had physical and/or psychosocial imbalance in work ability (Table 1), respectively. Compared to ARDS survivors with no imbalance at 6 months, those with imbalance in both physical and psychosocial work ability had a decreased adjusted odds ratio (aOR) for RTW at both 6 months (aOR [CI]: 0.33 [0.13, 0.82], P = 0.02) and 12 months (0.22 [0.07, 0.65], <0.006). However, there was no significant association for those with an imbalance in only physical or only psychosocial work ability at both follow-up periods (Table 2).

Imbalance in work ability and sustained RTW

Among the 204 individuals who ever RTW for 12 months follow-up, 38 (19%) were not working at 12 months. Of these individuals, 13 (34%) had an imbalance in both physical and psychosocial work ability at 12-month follow-up. In comparison, of those 166 (83%) individuals who had sustained employment, only 39 (23%) had an imbalance in both physical and psychosocial work ability.

DISCUSSION

In this multicenter study of 341 previously employed ARDS survivors, 50% and 46% did not RTW at 6- and 12-month follow-up, respectively. Notably, >90% of those unable to RTW had imbalance in physical and/or psychosocial work ability. Significantly, having an imbalance in both physical and psychosocial work ability at 6 months was associated with not working at both 6- and 12-month follow-up. Among those who RTW at 6 months, 17% were jobless at 12 months.

Consistent with other studies that examined patients with cancer, musculoskeletal, cardiovascular or mental health disorders; older adults; and healthy workers,[11-14] we found that imbalance in work ability was negatively associated with RTW. While work ability is multi-dimensional, most previous studies used the Work Ability Index as a total score.[8] In contrast, the present study measured different dimensions of work ability and found that combined physical and psychosocial imbalance was negatively associated with RTW during the first-year of follow-up. Thus, within the first year after ARDS, rehabilitation interventions and workplace accommodations should be designed to target both physical and psychosocial aspects versus a single dimension.

In this study, we found that approximately 50% of ARDS survivors did not RTW, and of those who did RTW, 17% could not sustain employment at 12-month follow-up. The inability to RTW and to have sustained employment are associated with permanent disability and loss of workforce productivity.[19] In the United States, the estimated losses attributed to illness-related inability to RTW due was $1.5 trillion, representing 8.5% of the Gross Domestic Product (GDP).[20] However, these financial consequences are relatively understudied in ICU populations.

Financial toxicity, defined as the financial burden and subsequent distress related to medical care, has a negative effect on ARDS survivor's emotional, physical, and social recovery.[3] The loss of additional years of income due to joblessness can add to financial toxicity after ARDS. Hence, studies are warranted examining ARDS survivors' ability to sustain employment and the direct and indirect impacts of joblessness.

Healthcare providers can support ARDS survivors to rebalance work ability by increasing an individual's functional ability and advocating for workload modification (Figure 1). Interventions that target both functional recovery and modification of workload have promising results for improving employment outcomes in non-ICU populations.[21 22] For instance, education, physical rehabilitation,[23] and cognitive-behavioral therapy[24 25] can improve functional abilities. Workplace assessment/accommodations [26] and ergonomic assessments/interventions[27] have successfully modified workload to help balance with functional abilities.

In ICU survivors, most research has focused on interventions to increase individuals' functional ability,[28-31] with only emerging evaluations of any impact on survivors' employment status.[32-35] Preliminary data on programs that examined work-related outcomes include the intensive care unit recovery center (ICU-RC) at Vanderbilt University Medical Center in the US,[34 35] the PRaCTICaL program in the United Kingdom,[32] and InS:PIRE[33] in Scotland. All three programs are multidisciplinary and include debriefing the ICU stay, screening for physical and psychological morbidities with referrals (if needed), and medication review/reconciliation. The PRaCTICaL randomized trial had clinic appointments at 2-3 and 9-months after ICU discharge; this delayed timing may have contributed to the intervention's non-significant findings[32] A unique aspect of the InS:PIRE intervention is peer support that had a positive influence based on qualitative evaluation of the program.

Future studies should consider multi-component approaches to reduce incongruity between workload and functional ability. Such approaches can include: (1) peer support to help survivors set realistic goals and identify practical strategies to support RTW; (2) multidisciplinary healthcare consultation, including a vocational rehabilitation specialist, to improve patients' symptom management, self-efficacy, self-care, and coping skills; and (3) job coach or return-to-work coordinator to engage with employers and patients to facilitate workplace accommodations aimed at modifying workload, increasing environmental adjustment, and maximizing function in the workplace.[36 37] Embedding cost-effectiveness analyses within such interventional studies is important to help create a business case for such programs.

This study has important strengths, including its assessment of functional ability, job workload, work status, and work ability from a multicenter national study with 341 previously employed ARDS survivors. However, our study also has limitations. First, we used SF-36 PF and MH subscales to assess functional ability, rather than performance-based physical assessments or specific psychological screening tools or diagnostic assessments. However, in ARDS survivors, the SF-36 MH subscale has moderate to strong correlation with recommended psychological screening tools for ICU survivors.[38] Similarly, the SF- 36 PF subscale strongly correlates with the 6-minute walk test physical performance measure.[39] Second, our study did not explicitly evaluate the potential influence of an individual's values, motivation, and workplace accommodations, which are associated with employment outcomes after ARDS.[5 26] Third, our study only evaluated survivors over 6- and 12-month follow-up; thus, associations of mismatch in work ability with long-term employment outcomes are unknown. Lastly, since this study specifically evaluated ARDS survivors, the results may not be generalizable to other ICU survivors.

CONCLUSION

Among ARDS survivors, the inability to RTW or sustain employment are common over 12-month follow-up. An imbalance in both physical and psychosocial work ability is negatively associated with RTW. To promote rehabilitation efforts in previously employed ARDS survivors, these findings support the need to assess work ability early in the course of recovery. Further, there is a need to design and test interventions that evaluate and optimize individuals' physical and psychosocial functional abilities and job workload simultaneously.

Figure 1. Proposed Interventions to Reduce Imbalance in Work Ability

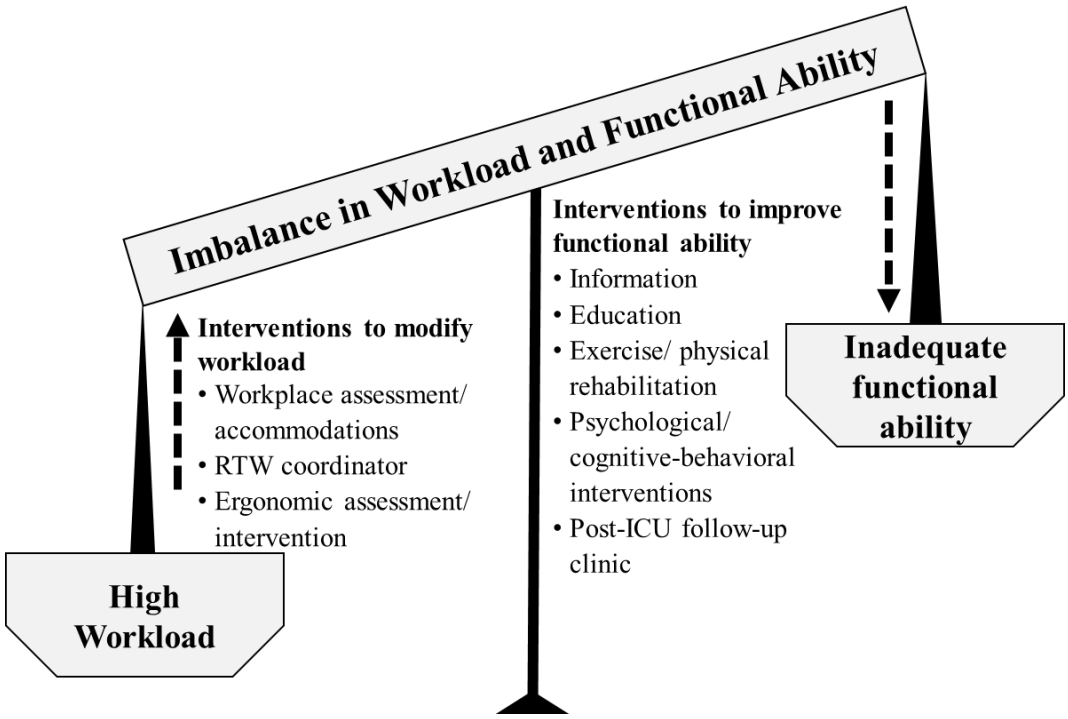


Figure 2. Study Participant Flow Chart

Abbreviations: ARDS= Acute respiratory distress syndrome; O*NET= The US Occupational Information Network.

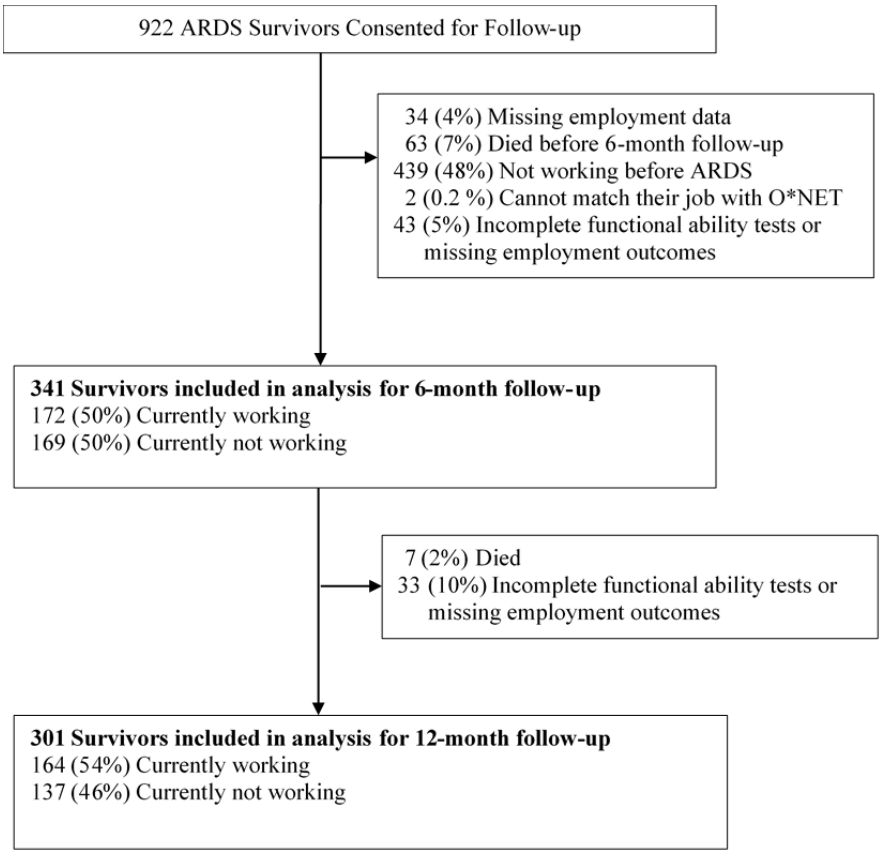


Table 1. Demographic and ICU Variables, by Employment Status at 6 and 12 Months After ARDS

Variable	6-month follow-up Working (n=172)	6-month follow-up Not working (n=169)	*p*†	12-month follow-up Working (n=164)	12-month follow-up Not working (n=137)	*p*†
Demographic factors						
Age, mean (SD)	44 (13)	47 (13)	0.03	44 (13)	48 (13)	0.004
Female	69 (40)	82 (49)	0.13	64 (39)	68 (50)	0.07
White race	144 (84)	127 (75)	0.05	141 (86)	99 (72)	0.005
Hispanic Ethnicity	12 (7)	19 (11)	0.19	11 (7)	15 (11)	0.22
ICU Factors						
APACHE III, mean (SD)	83 (25)	84 (27)	0.73	82 (25)	84 (27)	0.50
ARDS risk factor						
Pulmonary	120 (70)	112 (66)	0.76	107 (65)	99 (72)	0.43
Sepsis	27(16)	31 (18)		28 (17)	19 (14)	
Other	25 (15)	26 (15)		29 (18)	19 (14)	
ICU LOS, mean (SD) days	12 (9)	17 (12)	<0.001	12 (9)	16 (12)	0.009
Hospital LOS, mean (SD) days	18 (12)	27 (18)	<0.001	19 (13)	25 (17)	0.003
Imbalance in work ability						
No imbalance	20 (12) §	11 (7) §	0.02	20 (12) ‡	10 (7) ‡	0.003
Only psychosocial imbalance	84 (49) §	74 (44) §		76 (46) ‡	54 (39) ‡	
Only physical imbalance	28 (16) §	20 (12) §		30 (18) ‡	15 (11) ‡	
Both physical and psychosocial imbalance	40 (23) §	64 (38) §		38 (23) ‡	58 (42) ‡	

Data presented as n (%) unless otherwise noted; percentages may not add to 100% due to rounding

† Calculated by Student's *t*-test for continuous variables and Chi-squared or Fisher exact tests, as appropriate, for categorical variables.

§ Data at 6 months.

‡ Data at 12 months.

Abbreviations: SD. = standard deviation; ARDS = Acute respiratory distress syndrome; APACHE III = Acute Physiology and Chronic Health Evaluation III; ICU = intensive care unit; LOS = length of stay.

Table 2. Adjusted Associations of Survivors' Imbalance in Work Ability and Employment Status

		Working at 6 months (N=341)		Working at 12 months (N=301)	
		OR (95% CI)	***P***	**OR (95% CI)**	***p***
Imbalance in work ability at 6 months	No imbalance	Reference		Reference	
	Only physical imbalance	0.76 (0.28, 2.11)	0.60	0.85 (0.25, 2.82)	0.78
	Only psychosocial imbalance	0.58 (0.24, 1.39)	0.23	0.37 (0.13, 1.05)	0.06
	Both physical and psychosocial imbalance	0.33 (0.13, 0.82)	0.02	0.22 (0.07, 0.65)	0.006

*Logistic regression model, adjusting for age, race, hospital length of stay, and APACHE III

Contributors: HS conceived the work. HS performed the statistical analyses and data interpretation and wrote the initial draft of the manuscript. HJT and SM supervised the analysis. ROH, BBK, SM, VDD, CLH, KLJ, MMH, DMN and HJT contributed substantially to the study design, data interpretation and critically revised the manuscript for important intellectual content. All authors gave final approval of the submitted version of the manuscript and agreed to be accountable for the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Competing of interests: None declared.

Funding: HS is supported by The Hester McLaws Dissertation Research Award from University of Washington. This research was supported by the ALTA, EDEN, OMEGA and SAILS trials (NHLBI contracts HHSN268200536165C to HHSN268200536176C and HHSN268200536179C), N01HR56170, R01HL091760, 3R01HL091760-02S1.

Acknowledgment: We acknowledgment that Emma Gause, PhD of the Harborview Injury Prevention and Research Center assisted with verification of R code syntax.

Patient consent for publication: Not required.

Ethics approval: The university's institutional review boards of all participating sties approved this study.

Reference:

1. Kamdar BB, Sepulveda KA, Chong A, et al. Return to work and lost earnings after acute respiratory distress syndrome: A 5-year prospective, longitudinal study of long-term survivors. *Thorax* 2018;73(2):125-33.
2. Kamdar BB, Suri R, Suchyta MR, et al. Return to work after critical illness: a systematic review and meta-analysis. *Thorax* 2020;75(1):17. doi: 10.1136/thoraxjnl-2019-213803
3. Hauschildt KE, Seigworth C, Kamphuis LA, et al. Financial Toxicity After Acute Respiratory Distress Syndrome: A National Qualitative Cohort Study. *Critical care medicine* 2020;48(8):1103-10.
4. Kamdar BB, Minxuan H, Dinglas VD, et al. Joblessness and Lost Earnings after Acute Respiratory Distress Syndrome in a 1-Year National Multicenter Study. *American Journal of Respiratory & Critical Care Medicine* 2017;196(8):1012-20.
5. Herridge MS, Cheung AM, Tansey CM, et al. One-year outcomes in survivors of the acute respiratory distress syndrome. *The New England journal of medicine* 2003;348(8):683-93. doi: 10.1056/NEJMoa022450 [published Online First: 2003/02/21]
6. Hodgson CL, Haines KJ, Bailey M, et al. Predictors of return to work in survivors of critical illness. *Journal of critical care* 2018;48:21-25. doi: https://doi.org/10.1016/j.jcrc.2018.08.005
7. Soer R, van der Schans CP, Geertzen JH, et al. Normative values for a functional capacity evaluation. *Arch Phys Med Rehabil* 2009;90(10):1785-94. doi: 10.1016/j.apmr.2009.05.008 [published Online First: 2009/10/06]
8. Ilmarinen J. The Work Ability Index (WAI). *Occupational Medicine* 2007;57(2):160-60. doi: 10.1093/occmed/kqm008
9. Tengland PA. The concept of work ability. *Journal of occupational rehabilitation* 2011;21(2):275-85. doi: 10.1007/s10926-010-9269-x [published Online First: 2010/11/06]
10. Tuomi K, Ilmarinen J, Seitsamo J, et al. Summary of the Finnish research project (1981—1992) to promote the health and work ability of aging workers. *Scandinavian Journal of Work, Environment & Health* 1997;23:66-71.
11. Beier ME, Torres WJ, Fisher GG, et al. Age and job fit: The relationship between demands–ability fit and retirement and health. *Journal of Occupational Health Psychology* 2020;25(4):227-43. doi: 10.1037/ocp0000164
12. von Bonsdorff MB, Seitsamo J, Ilmarinen J, et al. Work ability in midlife as a predictor of mortality and disability in later life: a 28-year prospective follow-up study. *Cmaj* 2011;183(4):E235-E42.
13. de Boer AGEM, Verbeek JHAM, Spelten ER, et al. Work ability and return-to-work in cancer patients. *British Journal of Cancer* 2008;98(8):1342-47. doi: 10.1038/sj.bjc.6604302
14. Reeuwijk KG, Robroek SJW, Hakkaart L, et al. How work impairments and reduced work ability are associated with health care use in workers with musculoskeletal disorders, cardiovascular disorders or mental disorders. *Journal of occupational rehabilitation* 2014;24(4):631-39. doi: 10.1007/s10926-013-9492-3
15. Fraade-Blanar LA, Sears JM, Chan KC, et al. Relating Older Workers' Injuries to the Mismatch Between Physical Ability and Job Demands. *J Occup Environ Med* 2017;59(2):212-21. doi: 10.1097/jom.0000000000000941 [published Online First: 2017/02/07]

16. Pfoh ER, Chan KS, Dinglas VD, et al. Cognitive screening among acute respiratory failure survivors: a cross-sectional evaluation of the Mini-Mental State Examination. *Crit Care* 2015;19(1):220. doi: 10.1186/s13054-015-0934-5 [published Online First: 2015/05/06]
17. Ware J, Kosinski MA, Dewey J. How to Score Version 2 of the SF-36® Health Survey. *Lincoln, QualityMetric Incorporated* 2000
18. Radford K, Phillips J, Drummond A, et al. Return to work after traumatic brain injury: cohort comparison and economic evaluation. *Brain injury* 2013;27(5):507-20. doi: 10.3109/02699052.2013.766929 [published Online First: 2013/03/12]
19. Brenner H, Ahern W. Sickness absence and early retirement on health grounds in the construction industry in Ireland. *Occupational and Environmental Medicine* 2000;57(9):615. doi: 10.1136/oem.57.9.615
20. Rasmussen B, Sweeny K, Sheehan P. Economic costs of absenteeism, presenteeism and early retirement due to ill health: A focus on South Africa. *Report to the US Chamber of Commerce* 2017
21. Carroll C, Rick J, Pilgrim H, et al. Workplace involvement improves return to work rates among employees with back pain on long-term sick leave: a systematic review of the effectiveness and cost-effectiveness of interventions. *Disability and rehabilitation* 2010;32(8):607-21. doi: 10.3109/09638280903186301 [published Online First: 2010/03/09]
22. van Vilsteren M, van Oostrom SH, de Vet HC, et al. Workplace interventions to prevent work disability in workers on sick leave. *Cochrane Database Syst Rev* 2015(10):Cd006955. doi: 10.1002/14651858.CD006955.pub3 [published Online First: 2015/10/06]
23. Kuoppala J, Lamminpää A, Husman P. Work health promotion, job well-being, and sickness absences--a systematic review and meta-analysis. *J Occup Environ Med* 2008;50(11):1216-27. doi: 10.1097/JOM.0b013e31818dbf92 [published Online First: 2008/11/13]
24. Nazarov S, Manuwald U, Leonardi M, et al. Chronic Diseases and Employment: Which Interventions Support the Maintenance of Work and Return to Work among Workers with Chronic Illnesses? A Systematic Review. *Int J Environ Res Public Health* 2019;16(10) doi: 10.3390/ijerph16101864 [published Online First: 2019/05/30]
25. Nieuwenhuijsen K, Faber B, Verbeek JH, et al. Interventions to improve return to work in depressed people. *Cochrane Database Syst Rev* 2014(12):Cd006237. doi: 10.1002/14651858.CD006237.pub3 [published Online First: 2014/12/04]
26. Nevala N, Pehkonen I, Koskela I, et al. Workplace accommodation among persons with disabilities: A systematic review of its effectiveness and barriers or facilitators. *Journal of occupational rehabilitation* 2015;25(2):432-48.
27. Hoe VC, Urquhart DM, Kelsall HL, et al. Ergonomic interventions for preventing work-related musculoskeletal disorders of the upper limb and neck among office workers. *Cochrane Database of Systematic Reviews* 2018(10)
28. Geense WW, van den Boogaard M, van der Hoeven JG, et al. Nonpharmacologic Interventions to Prevent or Mitigate Adverse Long-Term Outcomes Among ICU Survivors: A Systematic Review and Meta-Analysis. *Critical care medicine* 2019;47(11):1607-18. doi: 10.1097/ccm.0000000000003974 [published Online First: 2019/08/30]

29. Rosa RG, Ferreira GE, Viola TW, et al. Effects of post-ICU follow-up on subject outcomes: A systematic review and meta-analysis. *Journal of critical care* 2019;52:115-25. doi: 10.1016/j.jcrc.2019.04.014 [published Online First: 2019/04/30]
30. Mehlhorn J, Freytag A, Schmidt K, et al. Rehabilitation interventions for postintensive care syndrome: a systematic review. *Critical care medicine* 2014;42(5):1263-71. doi: 10.1097/ccm.0000000000000148 [published Online First: 2014/01/15]
31. Jensen JF, Thomsen T, Overgaard D, et al. Impact of follow-up consultations for ICU survivors on post-ICU syndrome: a systematic review and meta-analysis. *Intensive Care Med* 2015;41(5):763-75. doi: 10.1007/s00134-015-3689-1 [published Online First: 2015/03/04]
32. Cuthbertson BH, Rattray J, Campbell MK, et al. The PRaCTICaL study of nurse led, intensive care follow-up programmes for improving long term outcomes from critical illness: a pragmatic randomised controlled trial. *BMJ (Clinical research ed)* 2009;339:b3723. doi: 10.1136/bmj.b3723 [published Online First: 2009/10/20]
33. McPeake J, Shaw M, Iwashyna TJ, et al. Intensive Care Syndrome: Promoting Independence and Return to Employment (InS:PIRE). Early evaluation of a complex intervention. *PLoS ONE* 2017;12(11)
34. Sevin CM, Bloom SL, Jackson JC, et al. Comprehensive care of ICU survivors: Development and implementation of an ICU recovery center. *Journal of critical care* 2018;46:141-48.
35. Bloom SL, Stollings JL, Kirkpatrick O, et al. Randomized Clinical Trial of an ICU Recovery Pilot Program for Survivors of Critical Illness. *Critical care medicine* 2019;47(10):1337-45. doi: 10.1097/ccm.0000000000003909 [published Online First: 2019/08/07]
36. Schandelmaier S, Ebrahim S, Burkhardt SC, et al. Return to work coordination programmes for work disability: a meta-analysis of randomised controlled trials. *PloS one* 2012;7(11):e49760.
37. Bohatko-Naismith J, James C, Guest M, et al. The role of the Australian workplace return to work coordinator: essential qualities and attributes. *Journal of occupational rehabilitation* 2015;25(1):65-73.
38. Pfoh ER, Chan KS, Dinglas VD, et al. The SF-36 Offers a Strong Measure of Mental Health Symptoms in Survivors of Acute Respiratory Failure. A Tri-National Analysis. *Annals of the American Thoracic Society* 2016;13(8):1343-50. doi: 10.1513/AnnalsATS.201510-705OC
39. Chan KS, Aronson Friedman L, Dinglas VD, et al. Are physical measures related to patient-centred outcomes in ARDS survivors? *Thorax* 2017;72(10):884. doi: 10.1136/thoraxjnl-2016-209400

ONLINE SUPPLEMENT

Association of imbalance between job workload and functional ability with return to work in ARDS survivors

Han Su, RN, MSN[1], Ramona O. Hopkins, PhD[2,3,4], Biren B. Kamdar, MD, MBA, MHS[5], Susanne May, PhD[6], Victor D. Dinglas, MPH[7,8], Kurt L. Johnson, PhD[9], Megan M. Hosey, PhD[7,8,10], Catherine L. Hough, MD, MS[11], Dale M. Needham, FCPA, MD, PhD[7,8,10], Hilaire J. Thompson, PhD, RN, ARNP[1, 12]

1. School of Nursing, University of Washington, Seattle, Washington, USA
2. Neuroscience Center and Psychology Department, Brigham Young University, Provo, Utah USA
3. Pulmonary and Critical Care Medicine, Intermountain Health Care, Murray, Utah USA
4. Center for Humanizing Critical Care, Intermountain Medical Center, Murray, Utah USA
5. Division of Pulmonary, Critical Care, Sleep Medicine and Physiology, University of California, San Diego, La Jolla, California, USA
6. Department of Biostatistics, University of Washington, Seattle, Washington, United States
7. Division of Pulmonary and Critical Care Medicine, Johns Hopkins University School of Medicine, Baltimore, MD, USA
8. Outcomes After Critical Illness and Surgery (OACIS) Group, Johns Hopkins University, Baltimore, MD, USA
9. Department of Rehabilitation Medicine, University of Washington, Seattle, WA, USA
10. Department of Physical Medicine and Rehabilitation, Johns Hopkins University School of Medicine, Baltimore, MD, USA
11. Division of Pulmonary and Critical Care Medicine, Oregon Health & Science University, Portland, OR, USA
12. Harborview Injury Prevention and Research Center, Seattle, WA, USA

eTable 1-Baseline and intensive care data at 6 and 12 months after ARDS

Variable	6-month follow-up			12-month follow-up		
	Included (n=341)	Excluded (n=45) ‡	*p* †	Included (n=301)	Excluded (n=40) ¶	*p* †
Age, mean (SD)	46 (13)	42 (11)	0·09	46 (13)	45 (16)	0·66
Female	151 (44)	20 (44)	0·99	132 (44)	19 (48)	0·74
White race	271 (80)	37 (82)	0·84	240 (80)	31 (78)	0·68
Hispanic Ethnicity	31 (9)	2 (4)	0·30	25 (9)	6 (13)	0·33
ICU Factors						
APACHE III	84 (26)	80 (28)	0·36	83 (26)	89 (28)	0·26
ICU LOS, mean (SD), day	14 (11)	14 (13)	0·98	14 (11)	18 (12)	0·03
Hospital LOS, mean (SD), day	22 (16)	24 (19)	0·60	22 (15)	26 (18)	0·11

Data presented as n (%) unless otherwise noted; percentages may not add to 100% due to rounding

† Calculated by Student's *t*-test for continuous variables and Chi-squared or Fisher exact tests, as appropriate, for categorical variables.

Abbreviations: SD. = standard deviation; ARDS = Acute respiratory distress syndrome; APACHE III = Acute Physiology and Chronic Health Evaluation III; ICU = intensive care unit; LOS = length of stay.

eTable 2. Sensitivity Testing: Adjusted Associations of Individual Survivors' Imbalance in Work Ability and Working Status where Retirement Treated as Missing Data

		Working at 6 months		Working at 12 months	
		OR (95% CI)	***p***	**OR (95% CI)**	***p***
Imbalance in work ability at 6 months	No imbalance	Reference		Reference	
	Only physical imbalance	0.77 (0.28, 2.11)	0.62	0.85 (0.25, 2.81)	0.78
	Only psychosocial imbalance	0.66 (0.27, 1.59)	0.35	0.43 (0.15, 1.24)	0.12
	Both physical and psychosocial imbalance	0.35 (0.14, 0.87)	0.02	0.23 (0.08, 0.68)	0.008

*Regression model adjusts for age, race (White vs. non-White), hospital length of stay, and APACHE III

Chapter 5. Interrelationships between Workload, Disease Severity, and Functional Ability on Return to Work following ARDS: A Longitudinal Structural Equation Model and Mediation Analysis

Han Su,[1] Hilaire J. Thompson,[1,2] Kenneth Pike,[1] Biren Kamdar,[3] Victor Dinglas,[4,5] Elizabeth Bridges,[1] Dale Needham[4,5,6] & Ramona Hopkins[7,8,9]

13. School of Nursing, University of Washington, Seattle, Washington, USA
14. Harborview Injury Prevention and Research Center, Seattle, WA, USA
15. Division of Pulmonary, Critical Care, Sleep Medicine and Physiology, University of California, San Diego, La Jolla, California, USA
16. Division of Pulmonary and Critical Care Medicine, Johns Hopkins University School of Medicine, Baltimore, MD, USA
17. Outcomes After Critical Illness and Surgery (OACIS) Group, Johns Hopkins University School of Medicine, Baltimore, MD, USA
18. Department of Physical Medicine and Rehabilitation, Johns Hopkins University School of Medicine, Baltimore, MD, USA
19. Neuroscience Center and Psychology Department, Brigham Young University, Provo, Utah USA
20. Pulmonary and Critical Care Medicine, Intermountain Health Care, Murray, Utah USA
21. Center for Humanizing Critical Care, Intermountain Medical Center, Murray, Utah USA

Corresponding Author:
Han Su, MSN, RN
Box 357266 Seattle, WA 98195-7266
Email: hansu21@uw.edu; Fax: 206-543-4771

Conflict of Interest Statement: On behalf of all authors, the corresponding author states that there are no conflicts of interest.

Funding information: This research was supported by the ALTA, EDEN, OMEGA and SAILS trials (NHLBI contracts HHSN268200536165C to HHSN268200536176C and HHSN268200536179C), N01HR56170, R01HL091760, 3R01HL091760-02S1, and the Hester McLaws Dissertation Research Award.
No prior abstract publication/presentation.

Abstract

Inability to as well as delayed return to work (RTW) are common in previously employed acute respiratory distress syndrome (ARDS) survivors. Pre-illness workload, disease severity, and post-illness functional abilities affect survivors' employment outcomes after ARDS. We conducted a secondary data analysis using the ARDS Network Long-Term Outcomes Study (ALTOS) to examine each factor's interrelationships across 6 and 12-months of follow-up. ALTOS was a nationwide prospective cohort study that enrolled patients with ARDS from 43 hospitals in the United States from 2008-2014. Longitudinal structural equation model and mediation analyses were applied. The U.S. Occupational Information Network (O*NET) was used to determine pre-ARDS workload, Mini-Mental State Examination, and SF-36 were used to measure post-ARDS functional abilities. Our study revealed that disease severity had the largest effect on RTW at 6 months followed by functional abilities. While work at 6 months had the most substantial impact on RTW at 12 months followed by disease severity and functional abilities at both 6- and 12-months follow-up. Pre-ARDS interpersonal workload affected RTW at 6 and 12 months post-ARDS, however the effects were small. Work at 6 months, functional abilities at 6 and 12 months, and pre-ARDS workload are mediators to RTW in the ARDS population and are potentially modifiable. Thus, interventions that address early RTW with adequate work accommodation, improvement in function, and reduction in workload/work modification could assist ARDS survivors RTW.

Keywords: Intensive care unit, ARDS, Employment, Impairment, Job characteristics

1. Introduction

The success of return to work (RTW) and maintenance in employment is a major concern for previous employed acute respiratory distress syndrome (ARDS) survivors (Dinglas et al., 2018). Failure to RTW following illness or injury is often, both theoretically and operationally, equated with work disability (Schultz, Stowell, Feuerstein, & Gatchel, 2007). In previously employed ARDS survivors, work disability is prevalent; 44% cannot RTW the first year after ARDS (Kamdar et al., 2017; Kamdar et al., 2020).

Several models have been proposed to describe the process and potential factors that influence human responses to work and the development of work disability in the past several decades (Feuerstein et al., 2010; Heerkens, Engels, Kuiper, Van der Gulden, & Oostendorp, 2004; Waddell, 1992). According to those models, employment outcomes can be affected directly or indirectly by multiple elements such as medical status, functional ability, pre-illness workload, family, and social support, as well as healthcare resource utilization (Feuerstein et al., 2010; Heerkens et al., 2004; Waddell, 1992). Functional ability includes multiple domains, such as cognition and physical ability. Similarly, a job's workload is comprised of a combination of cognitive, physical, psychological, and interpersonal components. Furthermore, the work environment, sick leave policies, and economic factors are also proposed to affect employment outcomes after illness or injury (Feuerstein et al., 2010). Many factors have been associated with survivors' employment outcomes after ARDS, including age, gender, race, pre-admission health status, and critical illness-related factors (Kamdar et al., 2017). However, there is limited information on the interrelationships among these elements and their association with employment outcomes.

Understanding modifiable risk factors for RTW and whether the relationships among these factors directly or indirectly cause ARDS survivors' employment outcomes could inform future interventions. Thus, this study aims to identify potentially modifiable risk factors and their interrelationships for RTW, focusing on patient's disease characteristics, pre-ARDS workload, and post-ARDS functional impairments. Return to work at 6- and 12-months post-ARDS are the primary outcomes of interest. Four parallel models (one each for cognitive workload/cognitive ability, physical workload/physical ability, psychological workload/psychological ability, and interpersonal workload/interpersonal ability) were constructed and tested (Figure 1).

2. Methods

2.1. Overview and Participants

Data from the National Institutes of Health-funded ARDS Network Long-Term Outcomes Study (ALTOS) were used for this secondary data analysis. ALTOS is a nationwide prospective cohort study that enrolled patients with ARDS from 43 hospitals in the United States from 2008 to late 2014 (Matthay et al., 2011; Rice et al., 2011; Rice et al., 2012; Truwit et al., 2014). Telephone-based assessments were used to evaluate participants' 6 and 12-month outcomes after ARDS diagnosis. For this analysis, participants in the parent study were included for analysis if they 1) reported full- or part-time employment before hospitalization for ARDS; 2) did not die or retire during the follow-up period; 3) had complete employment outcome data during follow up; 4) job title could be matched with the Occupational Information Network (O*NET) dataset. Approval for the parent study was obtained from the Institutional Review Boards of all participating study sites.

2.2. Demographic and Illness-related Variables

Demographic and illness-related factors were collected by chart review in the parent study. Demographic variables obtained included age, gender, race, and ZIP Code. Median household income was approximated from the individual's 5-digit ZIP Code according to the 2006-2010 United States Census Bureau report ("Zip Code Characteristics: Mean and Median Household Income,"). Illness-related characteristics included the intensive care unit (ICU) length of stay (LOS), and hospital LOS, the Acute Physiology and Chronic Health Evaluation III (APACHE III, range 0-299, higher scores correspond to more severe disease and higher risk of death) (Knaus et al., 1991).

2.3. Pre-ARDS workload

Pre-ARDS workload refers to the minimal cognitive, interpersonal, psychological, or physical ability that a specific job requires in order to perform it. We matched participants' pre-ARDS job title with the O*NET version 24.2 (Development.) to estimate participants' pre-ARDS workload. The O*NET dataset contains skills rating for 968 occupations. Each occupation is measured by several descriptors. Each descriptor in O*NET is associated with a 1-5 scale with higher values indicating a descriptor more critical to the job. For each occupation, the number of descriptors used to measure cognitive, interpersonal, psychological, and physical workload in our study were 21, 6, 2, and 9, respectively (e Table 1).

2.4. Post-ARDS functional abilities and employment outcome

Post-ARDS interpersonal, psychological, and physical abilities were measured by the Short Form 36 (SF-36) survey social functioning (SF), psychological health (MH), and physical function (PF) subscales at 6- and 12-months post-ARDS, respectively. SF, MH, PF normalized subscales range from 0 to 100 (mean = 50, standard deviation = 10), with a higher score indicating better status (Ware, Kosinski, & Dewey, 2000). Cognitive ability was measured at 6-

and 12-months post-ARDS by the Mini-Mental State Examination (MMSE), which score ranges from 0 to 30, with higher scores indicating higher cognitive function (Newkirk et al., 2004). For this study, employment outcome was defined as the individual can or cannot RTW and was gathered by self-report or proxy using a previously developed questionnaire at 6 and 12 months post-ARDS (Radford et al., 2013).

2.5. Analysis

2.5.1. Structural equation modeling (SEM)

Descriptive analysis of participants' characteristics and employment outcomes at 6- and 12-month post-ARDS was conducted using SPSS 26 (IBM Corp, Antioch, NY). We proposed four longitudinal models (cognitive, psychological, interpersonal, and physical) to test the interrelationship among pre-ARDS functional abilities, disease severity, post-ARDS functional abilities, and RTW at 6- and 12-month post-ARDS. We used a longitudinal SEM approach using maximum likelihood estimation to test these models. This allowed us to: 1) obtain efficient and unbiased estimates of longitudinal measures; 2) to incorporate latent variables with multiple indicators in the model; 3) accommodate unbalanced samples and missing data through full information maximum likelihood estimation; 4) treated one variable as outcome and predictor simultaneously. There are two steps in SEM; the first is to test the measurement model; the second is to test the structural model.

First, we specified and tested measurement models using the latent variable with its corresponding manifest or measured variables (indicators). The measurement model of patients' illness-related characteristics, cognitive, physical, psychological, and interpersonal workload was estimated individually using confirmatory factor analysis (CFA). For the disease severity measurement model, ICU LOS, APACHE III, and ward/floor LOS were tested. For the

measurement model of pre-ARDS cognitive, interpersonal, psychological, and physical workloads, 21 cognitive descriptors, 6 social skills descriptors, 2 stress-related descriptors, and 9 physical descriptors from the O*NET system were tested, respectively (e Table 1). Each measurement model was finalized based on factor loadings and the acceptable model fit indices (Kline, 2016; Pituch & Stevens, 2016).

Following the development of the measurement models, four structural models were then specified and tested individually according to the proposed model of associations among disease severity, pre-ARDS workload, post-ARDS functional abilities, and post-ARDS RTW at 6- and 12-months. We adjusted for age, gender, race, and median household income in all models. The goodness of fit of each measurement and structural models were examined by indices, including the comparative of fit index (CFI), the Tucker-Lewis index (TLI), root mean square error of approximation (RMSEA), and standardized root means square residual (SRMR). The acceptable standards for these indices are RMSEA<0.08, SRMR <0.08, CFI>0.9, and TLI > 0.9 (Hooper, Coughlan, & Mullen, 2007; Kline, 2016; Pituch & Stevens, 2016).

2.5.2. Mediation analysis

To further examine the interrelationship among each variable, we conducted several mediation analyses. We used post-ARDS functional abilities at 6 and 12 months, and work at 6 months as mediators between disease severity, pre-ARDS workload, and work at 12 months. For each model (cognitive, psychological, interpersonal, and physical), we tested a) the direct effect, b) the indirect effect (measured by the pathway that goes through the intermediary variables/mediators), and c) the total effect (the sum of direct and indirect effects) on each predictor and work at 6 and 12-months. Longitudinal SEM and mediation analyses were performed using Mplus version 8 (Muthén & Muthén) with the weighted least squares estimator

using a probit link as outcome measures was binary. All confidence intervals and p-values were estimated using bootstrap resampling with 10000 resamples.

3. Results

3.1. Participant characteristics

A total of 329 ARDS survivors were included in this study. Demographic characteristics, pre-ARDS workload, disease severity, and post-ARDS functional abilities and employment outcome of the sample are presented in Table 1. Fifty-two percent (n=171) and 55% (n=182) of the sample returned to work at 6- and 12 months post-ARDS, respectively.

3.2. Longitudinal Structural equation modeling and mediation analysis

The correlation among each latent variable in the measurement models and model fit indices were summary in eFigure 1. The standardized path results and model fit indices of all structural models are summarized in Figure 1 and Tables 2-5. All measurement models and structural models fit the data well (Figure 1 footnotes and eFigure 1). Values of standardized path coefficients (β) >0.50, 0.30, and 0.10 indicate a large, medium, and small effect, respectively (Cohen, 1992).

3.2.1. Return to work at 6 months

Disease severity had a total effect on work at 6 months in the cognitive (standardized path coefficients $\beta = -0.51$, $p < 0.001$), psychological (-0.52, <0.001), interpersonal (-0.51, <0.001), and physical model (-0.52, <0.001, (Tables 2-5). More than 90% of these total effects come from direct effects in cognitive (-0.48, <0.001), psychological (-0.52, <0.001), and interpersonal models (-0.44, <0.001, Figure 1). While in the physical model, 26 % of the total effect was mediated by physical ability at 6 months (-0.15, <0.001) (Table 5). Functional ability had a direct effect on work at 6 months in psychological (0.42, <0.001), interpersonal (0.40, <0.001), and

physical model (0.43, <0.001), but not in the cognitive model (Figure 2). In general, disease severity is the most critical factor affecting work at 6 months in all models, followed by functional abilities at 6 months. Workload had a direct effect on work at 6 months only in the interpersonal model (0.22, 0.001).

3.2.2. Return to work at 12 months

Disease severity had a total effect on work at 12 months in cognitive (-0.32, 0.001), psychological (-0.33, 0.001), interpersonal (-0.32, 0.001), and physical models (-0.33, 0.001) (Table2-5). However, 61-78% of the total effects were mediated through work at 6 months in cognitive (-0.39,0.008), psychological (-0.40, 0.03), and interpersonal models (-0.33, 0.05) (Tables 2-4). While in the physical model, 42%, 11%, and 16% of the total effect were mediated through work at 6 months (-0.30, 0.05), ability at 6 month and work at 6 months (-0.11, 0.05), and ability at 6 and 12 months (-0.11, 0.001), respectively (Table 5).

Cognitive (0.26, 0.001), psychological (0.44, <0.001), interpersonal (0.44, <0.001), and physical ability (0.47, <0.001) at 6 months had a total effect on work at 12 months (Tables 2-5). In psychological, interpersonal, and physical models, 44-66% and 27-34% of the total effects were mediated by work at 6 months and ability at 12 months, respectively (Tables 3-5, Figure 1). Cognitive (0.14, 0.06), psychological (0.33, <0.002), interpersonal (0.22, 0.03), and physical ability (0.33, <0.007) at 12 months had direct effects on work at 12 months. Work at 6 months had a total effect on work at 12 months in all four models [cognitive model (0.82, <0.001), psychological model (0.79, <0.001), interpersonal model (0.79, <0.001), physical model (0.80, <0.001)]. Direct effects accounted for 91-96 % of the total effects in all four models (Tables 2-5 and Figure 1).

In general, work at 6 months is the most critical factor affecting work at 12 months, followed by functional ability at 6 months, functional ability at 12 months, and disease severity. Further, work at 6 months primarily mediated the effect between both functional ability at 6 and disease severity and work at 12 months. In the interpersonal model workload had a total effect on work at 12 months (0.16, 0.03);72% of the total effect was mediated by work at 6 months (Table 4).

4. Discussion

In this nationwide longitudinal prospective study of 329 previously employed ARDS survivors, 45% did not RTW at 12-months follow-up. Working at 6 months was directly affected by disease severity and functional abilities at 6 months in three of four models (psychological, interpersonal, and physical). In these models, working at 12 months was indirectly affected by disease severity and ability at 6 months (mediated through work at 6 months), and directly affected by working at 6 months and functional ability at 12 months. In the cognitive model, only disease severity affected work at 6 months.

Consistent with previous studies in general ICU, injury, and illness populations, the present study revealed that higher disease severity, functional impairment, and not working during the previous follow-up period negatively affected individuals' subsequent employment outcomes (Awan et al., 2020; Cancelliere et al., 2016; Kamdar et al., 2020). Furthermore, the present study disentangled relationships between workload, disease severity, and functional abilities on RTW across 6 and 12 months. Our findings suggest that work at 6 months, functional abilities at 6 and 12 months are potential targets for improving ARDS survivors RTW at 12 months, given that those factors mediated many pathways. Thus, interventions focused on improving cognitive ability, such as cognitive rehabilitation (Jackson et al., 2012; Wilcox et al., 2013) at 6 months might facilitate RTW at 12 months in ARDS survivors with a high cognitive

workload job (e.g., chief executive officer, software engineer). Likewise, interventions targeting improving psychological, interpersonal, and/or physical ability at 6 and 12 months might facilitate ARDS survivors with a high job workload in the corresponding domain RTW. These interventions include cognitive-behavioral and psychological interventions, as well as exercise/physical rehabilitation (Nazarov et al., 2019; Nieuwenhuijsen et al., 2014).

Interestingly, we revealed that relationships among different variables differed by models and follow-up time. In the ARDS population, disease severity affects RTW at both 6 and 12 months in all models. However, disease severity had a more profound effect on work at 6 months (β around -0.5) than 12 months (β around -0.3). Additionally, disease severity is the most critical factor affecting work at 6 months, followed by functional abilities. While work at 6 months becomes the most crucial factor effecting work at 12 months, followed by functional abilities at 6 and then 12 months. These findings have implications for post-ICU management. In the first six months, the clinician might focus primarily on monitoring survivors' disease severity and comorbidities, followed by improving functional abilities. Early RTW interventions might be considered in this stage if the situation allows. From 6 to 12 months, the clinician would maintain focus on improving functional abilities while providing additional support to facilitate RTW.

Being employed at the 6-month follow-up is the strongest predictor for RTW in ARDS survivors at 12 months in all models. A similar association had been found in TBI patients; however, the association did not exist after two years post-TBI (Awan et al., 2020). Instead, the odds of RTW decrease rapidly with an increasing duration of sickness absence (van Duijn et al., 2010b). In this regard, RTW can be perceived as proactive treatment (Horppu, Martimo, Viikari-Juntura, Lallukka, & MacEachen, 2016). Early RTW (< 6 weeks) with work modification has

shown promising results (i.e., reducing sickness absence) in some populations, especially in musculoskeletal disorders (Martimo et al., 2010; Shiri et al., 2011; van Duijn et al., 2010a; van Vilsteren et al., 2015). Thus, early RTW might be another intervention to improve employment outcomes in ARDS survivors. However, the optimal components, timing, and implementation of ARDS survivors' early RTW interventions still needs further elucidation.

Surprisingly, those individuals with higher interpersonal workload jobs had a higher odd of working at 6 and 12 months post-ARDS than those with lower interpersonal workloads. One potential explanation is that pre-illness workload may be a marker for premorbid interpersonal, communication, or personality traits more conducive to successful RTW after illness, such as strong communication and interpersonal function ability skills, cognitive reserve, and mental flexibility (Douglas, Bracy, & Snow, 2016; Stern, 2009; Walker, Marwitz, Kreutzer, Hart, & Novack, 2006). Another potential explanation is that jobs with high interpersonal workload are able to provide employees with more accommodations (Walker et al., 2006), supporting RTW.

The present paper has numerous strengths, including a sample of 329 previously employed ARDS survivors, a detailed evaluation of pre-ARDS workload and post-ARDS impairments with work status. Moreover, we included all the variables measured at the different timeframes in one model. However, our study also has several limitations. For instance, in the cognitive model we found no direct effect between ability and work at either 6- or 12- month. A potential explanation for this finding is that agreement between MMSE and comprehensive neuropsychological test batteries in detecting cognitive impairment was previously fair to moderate in the ARDS population (E. R. Pfoh et al., 2015). Furthermore, the variability in MMSE score in the ALTOS study was relatively small (SD 2), and as such, may lack sensitivity as a single measure. Previous studies have recommended combining an additional measure of

executive function to the MMSE in order to improve the detection of cognitive impairment (Kim et al., 2014). Additionally, we used the SF-36 to measure physical and psychological impairment rather than performance-based outcome measurements. However, the SF-36 PF (Chan et al., 2017) and MH subscales (Elizabeth R Pfoh et al., 2016) have a high correlation with the 6-minute walk and mental health symptoms measured by the Hospital Anxiety and Depression Scale and Impact of Events Scale, respectively. Third, we only studied ARDS survivors to 12 months; thus, we do not know whether the relationships identified hold after the first-year of follow-up. Fourth, we analyzed cognitive, psychological, interpersonal, and physical models independently. As such, we may have underestimated the effect of functional ability on RTW because we did not consider interaction effects and the resulting multi-dimensional disability in ARDS survivors.

5.Conclusion

Work disability is common in the first-year post-ARDS. Disease severity, functional abilities (psychological, interpersonal, and physical) at 6 months, and pre-ARDS interpersonal workload had a large, medium, and small effect on work at 6 months, respectively. While work at 6 months, disease severity and functional (cognitive, psychological, interpersonal, and physical) abilities at both 6- and 12-months follow-up, and interpersonal workload had a respective large, medium, and small effect on work at 12 months. Within those factors, work at 6 months, functional abilities at 6 and 12 months, and pre-illness workload are modifiable mediators of post-ARDS employment outcomes at 12 months. Thus, interventions that address early RTW with enhancing functional abilities, adequate work accommodation, and reducing workload by work modification could facilitate improved employment outcomes in ARDS survivors.

Table 1. Baseline, Pre-ARDS workload, Illness-related factors, and Post-ARDS functional abilities and employment outcome data (N=329).

	Mean (SD)
Demographics	
Female, N (%)	182 (55)
Age	45 (13)
White race, N (%)	263 (80)
Pre-ARDS workload	Appendix
Illness-related Variables	
APACHE III	83 (26)
ICU LOS (days)	14 (10)
Ward/Floor LOS (days)	8 (9)
Employment Outcome	
Working at six months, n (%)	171 (52)
Working at twelve months, n (%)	182 (55)
Post-ARDS Functional abilities at six months £	
Cognitive ability	26 (2)
Psychological ability	47 (13)
Interpersonal ability	43 (14)
Physical ability	41 (13)
Post-ARDS Functional abilities at twelve months £	
Cognitive ability	26 (2)
Psychological ability	47 (14)
Interpersonal ability	45 (13)
Physical ability	43 (13)

*Data are presented as mean (SD) unless otherwise noted and % may not total 100% due to rounding.

£ Post-ARDS functional ability included cognitive, interpersonal, psychological, and physical abilities measured by Mini-Mental State Examination, Short Form-36 (SF-36) survey social functioning, SF-36 psychological health, and SF- 36 physical function subscales, respectively. Definition of abbreviations: SD= standard deviation; ARDS= Acute respiratory distress syndrome; APACHE III = Acute Physiology and Chronic Health Evaluation III; ICU= intensive care unit; LOS= length of stay.

Table 2 Standardized Total, Direct, and Indirect Effects on Cognitive Workload, Disease Severity, Cognitive Ability, and Work at 6- and 12-months post-ARDS

Work at 6 months	Disease severity	Ability at 6 months	-0.01	0.39	-0.01	0.39	-0.50	<0.001	-0.51	<0.001
	Workload	Ability at 6 months	0.02	0.26	0.02	0.26	0.11	0.14	0.13	0.08
	Ability at 6 months						0.13	0.17	0.13	0.17
Work at 12 months	Disease severity	Work at 6 months	-0.39	0.008						
		Ability at 6 months	-0.01	0.51						
		Ability and work at 6 months	-0.01	0.41						
		Ability at 12 months	0.006	0.76	-0.43	0.005				
		Work at 6 and ability at 12 months	-0.02	0.33						
		Ability at 6- and 12- months	-0.006	0.39						
		Ability at 6, work at 6, and ability at 12 months	<0.001	0.53						
							0.11	0.46	-0.32	0.001
	Workload	Work at 6 months	0.09	0.18						
		Ability at 6 months	0.02	0.25						
		Ability and work at 6 months	0.02	0.29						
		Ability at 12 months	0.006	0.57	0.13	0.05				
		Work at 6 and ability at 12 months	0.003	0.39						
		Ability at 6- and 12- months	0.008	0.19						
		Ability at 6, work at 6, and ability at 12 months	0.001	0.49						
							-0.003	0.96	0.13	0.06
	Work at 6 months	Ability at 12 months	0.03	0.22	0.03	0.22	0.79	<0.001	0.82	<0.001
	Ability at 6 months	Work at 6 months	0.10	0.20						
		Ability at 12 months	0.06	0.09	0.16	0.07				
		Work at 6 and ability at 12 months	0.004	0.42						
							0.10	0.20	0.26	0.001
	Ability at 12 months						0.14	0.06	0.14	0.06

¶ Standardized path coefficients, β, is on probit scale. One probit is approximate to 1.7 logits (Hardy & Bryman, 2004).
ǂ All confidence intervals and p-value were estimated using bootstrap resampling with 10000 resamples.
£ Post-ARDS cognitive abilities were measured by mini-psychological state examination. The pre-ARDS workload was measured by the O*Net system
Definition of abbreviations: ARDS= Acute respiratory distress syndrome.

Table 3 Standardized Total, Direct, and Indirect Effects on Psychological workload, Disease Severity, Psychological Ability, and Work at 6- and 12-months post-ARDS

Work at 6 months	Disease severity	Ability at 6 months	0.008	0.85	0.008	0.85	-0.53	<0.001	-0.52	<0.001
	Workload	Ability at 6 months	0.03	0.22	0.03	0.22	0.03	0.70	0.06	0.42
	Ability at 6 months						0.42	<0.001	0.42	<0.001
Work at 12 months	Disease severity	Work at 6 months	-0.40	0.03	-0.39	0.04	0.06	0.75	-0.33	0.001
		Ability at 6 months	-0.002	0.91						
		Ability and work at 6 months	0.006	0.87						
		Ability at 12 months	0.02	0.65						
		Work at 6 and ability at 12 months	-0.02	0.67						
		Ability at 6- and 12- months	0.004	0.85						
		Ability at 6, work at 6, and ability at 12 months	<0.001	0.96						
	Workload	Work at 6 months	0.02	0.72	0.05	0.44	0.003	0.96	0.05	0.46
		Ability at 6 months	-0.009	0.54						
		Ability and work at 6 months	0.02	0.31						
		Ability at 12 months	-0.003	0.84						
		Work at 6 and ability at 12 months	0.001	0.84						
		Ability at 6- and 12- months	0.02	0.26						
		Ability at 6, work at 6, and ability at 12 months	0.001	0.68						
	Work at 6 months	Ability at 12 months	0.03	0.57	0.03	0.57	0.76	<0.001	0.79	<0.001
	Ability at 6 months	Work at 6 months	0.32	0.003	0.56	<0.001	-0.13	0.31	0.44	<0.001
		Ability at 12 months	0.23	0.006						
		Work at 6 and ability at 12 months	0.01	0.62						
	Ability at 12 months						0.33	0.002	0.33	0.002

¶ Standardized path coefficients, β, is on probit scale. One probit is approximate to 1.7 logits (Hardy & Bryman, 2004).
ǂ All confidence intervals and p-value were estimated using bootstrap resampling with 10000 resamples.
£ Post-ARDS cognitive abilities were measured by mini-psychological state examination. The pre-ARDS workload was measured by the O*Net system
Definition of abbreviations: ARDS= Acute respiratory distress syndrome.

Table 4 Standardized Total, Direct, and Indirect Effects on Interpersonal Workload, Disease Severity, Interpersonal Ability, and Work at 6- and 12-months post-ARDS

Work at 6 months	Disease severity	Ability at 6 months	-0.05	0.12	-0.05	0.12	-0.46	<0.001	-0.51	<0.001
	Workload	Ability at 6 months	0.01	0.57	0.01	0.57	0.22	<0.001	0.23	0.001
	Ability at 6 months						0.40	<0.001	0.40	<0.001
Work at 12 months	Disease severity	Work at 6 months	-0.33	0.05	-0.38	0.04	0.06	0.76	-0.32	0.001
		Ability at 6 months	-0.001	0.97						
		Ability and work at 6 months	-0.04	0.18						
		Ability at 12 months	0.05	0.44						
		Work at 6 and ability at 12 months	-0.03	0.46						
		Ability at 6- and 12- months	-0.02	0.25						
		Ability at 6, work at 6, and ability at 12 months	-0.004	0.43						
	Workload	Work at 6 months	0.16	0.03	0.17	0.04	-0.009	0.92	0.16	0.03
		Ability at 6 months	<0.001	0.98						
		Ability and work at 6 months	0.009	0.61						
		Ability at 12 months	-0.02	0.30						
		Work at 6 and ability at 12 months	0.02	0.39						
		Ability at 6- and 12- months	0.004	0.61						
		Ability at 6, work at 6, and ability at 12 months	0.001	0.70						
	Work at 6 months	Ability at 12 months	0.07	0.29	0.07	0.29	0.72	<0.001	0.79	<0.001
	Ability at 6 months	Work at 6 months	0.29	0.002	0.43	<0.001	0.005	0.96	0.44	<0.001
		Ability at 12 months	0.12	0.04						
		Work at 6 and ability at 12 months	0.03	0.28						
	Ability at 12 months						0.22	0.03	0.22	0.03

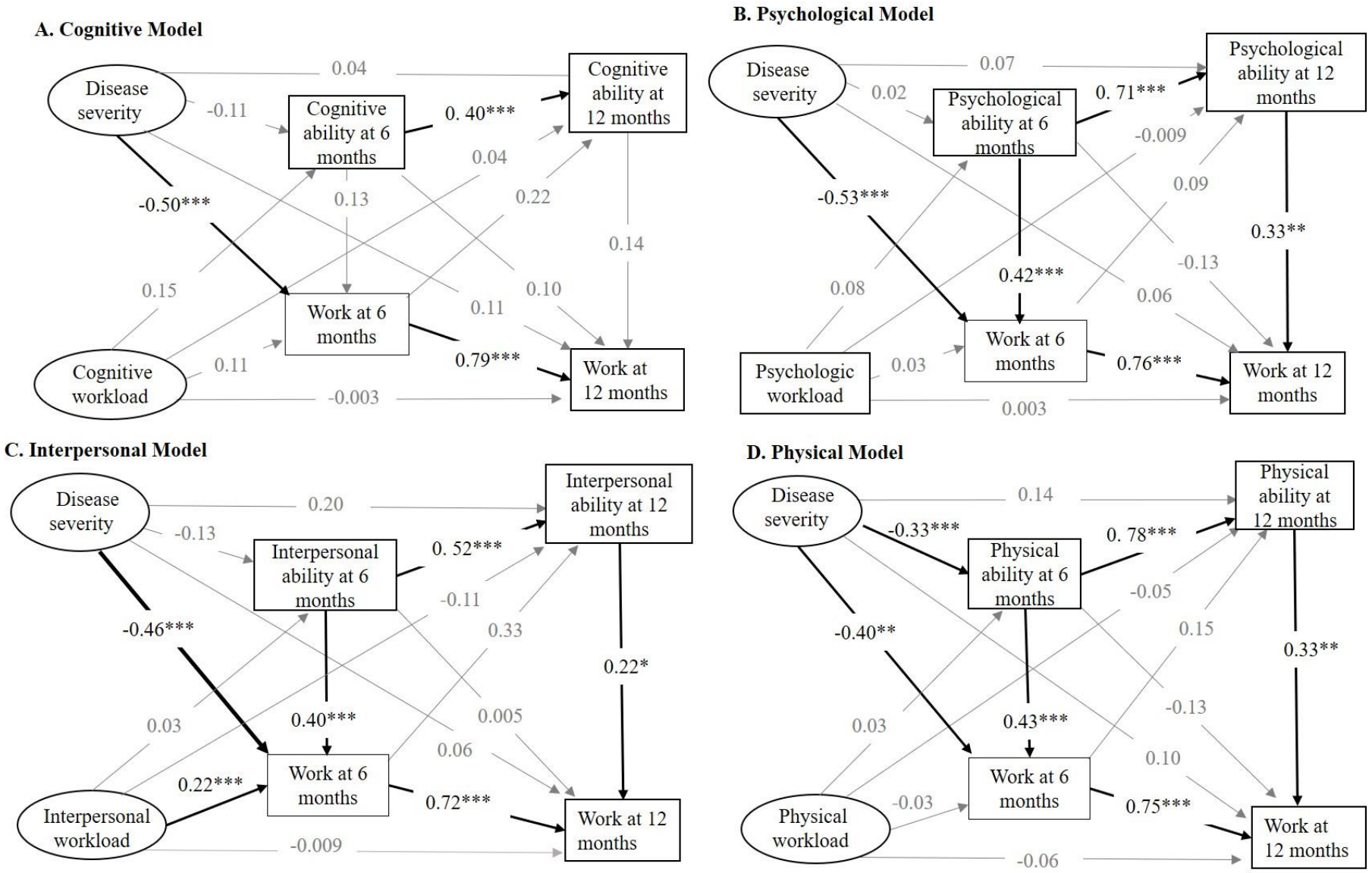
¶ Standardized path coefficients, β, is on probit scale. One probit is approximate to 1.7 logits (Hardy & Bryman, 2004).
ǂ All confidence intervals and p-value were estimated using bootstrap resampling with 10000 resamples.
£ Post-ARDS cognitive abilities were measured by mini-psychological state examination. The pre-ARDS workload was measured by the O*Net system
Definition of abbreviations: ARDS= Acute respiratory distress syndrome.

Table 5 Standardized Total, Direct, and Indirect Effects on Physical Workload Disease Severity, Physical Ability, and Work at 6- and 12-months post-ARDS

Work at 6 months	Disease severity	Ability at 6 months	-0.14	<0.001	-0.14	<0.001	-0.40	0.001	-0.54	<0.001
	Workload	Ability at 6 months	0.01	0.54	0.01	0.54	-0.03	0.62	-0.02	0.80
	Ability at 6 months						0.43	<0.001	0.43	<0.001
Work at 12 months	Disease severity	Work at 6 months	-0.30	0.05	-0.43	0.01	0.10	0.55	-0.33	0.001
		Ability at 6 months	0.04	0.36						
		Ability and work at 6 months	-0.08	0.05						
		Ability at 12 months	0.05	0.21						
		Work at 6 and ability at 12 months	-0.02	0.30						
		Ability at 6- and 12- months	-0.11	0.001						
		Ability at 6, work at 6, and ability at 12 months	-0.007	0.12						
	Workload	Work at 6 months	-0.02	0.65	-0.03	0.67	-0.06	0.31	-0.09	0.22
		Ability at 6 months	-0.004	0.70						
		Ability and work at 6 months	0.01	0.56						
		Ability at 12 months	-0.02	0.22						
		Work at 6 and ability at 12 months	-0.002	0.68						
		Ability at 6- and 12- months	0.008	0.58						
		Ability at 6, work at 6, and ability at 12 months	0.001	0.60						
	Work at 6 months	Ability at 12 months	0.05	0.13	0.05	0.13	0.75	<0.001	0.80	<0.001
	Ability at 6 months	Work at 6 months	0.32	<0.001	0.60	<0.001	-0.13	0.31	0.47	<0.001
		Ability at 12 months	0.25	0.01						
		Work at 6 and ability at 12 months	0.02	0.09						
	Ability at 12 months						0.33	0.007	0.33	0.007

¶ Standardized path coefficients, β, is on probit scale. One probit is approximate to 1.7 logits (Hardy & Bryman, 2004).
ǂ All confidence intervals and p-value were estimated using bootstrap resampling with 10000 resamples.
£ Post-ARDS cognitive abilities were measured by mini-psychological state examination. The pre-ARDS workload was measured by the O*Net system
Definition of abbreviations: ARDS= Acute respiratory distress syndrome.

Figure 1 Path models of hypothesized effects of patients' pre-ARDS workload, disease severity, post-ARDS ability, and employment outcome.



Footnote:
£. Cognitive, interpersonal, psychological, and physical abilities were measured by Mini-mental State Examination, Short Form 36 survey social functioning, psychological health, and physical function, respectively. Cognitive, interpersonal, psychological, and physical workloads were measured by the O*Net system.
ǂ. All confidence intervals p-value were estimated using bootstrap resampling with 10000 resamples. All pathway coefficients were Standardized.
Definition of abbreviations: APACHE III = Acute Physiology and Chronic Health Evaluation III; ICU= intensive care unit; LOS= length of stay. CFI = comparative fit index; TLI= Tucker-Lewis index; Oval represented latent variables. Square represented manifest or measured variables.
* $p < .05$, ** $p < .01$, *** $p < .001$, Black line= statistically significant, gray line= statistically non-significant.

For simplicity, covariance and error variances are not shown in the figures.

A, Based on R^2 estimates (p-value), the model accounts for 34% (0.002) of the variance in RTW at 6 months, and 70% (<0.001) of the variance in RTW at 12 months. CFI:0.987; TLI: 0.976; RMSEA: 0.023; SRMR: 0.038.

B, Based on R^2 estimates (p-value), the model accounts for 50% (<0.001) of the variance in RTW at 6 months, and 73% (<0.001) of the variance in RTW at 12 months. CFI: 0.984; TLI: 0.950; RMSEA: 0.038; SRMR: 0.032

C, Based on R^2 estimates (p-value), the model accounts 51% (<0.001) of the variance in RTW at 6 months, and 71% (<0.001) of the variance in RTW at 12 months. CFI: 0.993; TLI :0.985; RMSEA: 0.019; SRMR:0.036.

D. Based on R^2 estimates (p-value), the model accounts for 48% (<0.001) of the variance in RTW at 6 months, and 72% (<0.001) of the variance in RTW at 12 months. CFI:0.999; TLI :0.998; RMSEA: 0.007; SRMR: 0.025.

References:

Awan, N., DiSanto, D., Juengst, S. B., Kumar, R. G., Bertisch, H., Niemeier, J., . . . Wagner, A. K. (2020). Interrelationships Between Post-TBI Employment and Substance Abuse: A Cross-lagged Structural Equation Modeling Analysis. *Arch Phys Med Rehabil, 101*(5), 797-806. doi:10.1016/j.apmr.2019.10.189

Cancelliere, C., Donovan, J., Stochkendahl, M. J., Biscardi, M., Ammendolia, C., Myburgh, C., & Cassidy, J. D. (2016). Factors affecting return to work after injury or illness: best evidence synthesis of systematic reviews. *Chiropractic & manual therapies, 24*(1), 32-32. doi:10.1186/s12998-016-0113-z

Chan, K. S., Aronson Friedman, L., Dinglas, V. D., Hough, C. L., Shanholtz, C., Ely, E. W., . . . Needham, D. M. (2017). Are physical measures related to patient-centred outcomes in ARDS survivors? *Thorax, 72*(10), 884-892. doi:10.1136/thoraxjnl-2016-209400

Cohen, J. (1992). A power primer. *Psychological bulletin, 112*(1), 155.

Development., N. C. f. O. N. O*NET OnLine. Retrieved from www.onetonline.org

Dinglas, V. D., Chessare, C. M., Davis, W. E., Parker, A., Friedman, L. A., Colantuoni, E., . . . Needham, D. M. (2018). Perspectives of survivors, families and researchers on key outcomes for research in acute respiratory failure. *Thorax, 73*(1), 7. doi:10.1136/thoraxjnl-2017-210234

Douglas, J. M., Bracy, C. A., & Snow, P. C. (2016). Return to Work and Social Communication Ability Following Severe Traumatic Brain Injury. *J Speech Lang Hear Res, 59*(3), 511-520. doi:10.1044/2015_jslhr-l-15-0025

Feuerstein, M., Todd, B. L., Moskowitz, M. C., Bruns, G. L., Stoler, M. R., Nassif, T., & Yu, X. (2010). Work in cancer survivors: a model for practice and research. *J Cancer Surviv, 4*(4), 415-437. doi:10.1007/s11764-010-0154-6

Hardy, M., & Bryman, A. (2004). Regression Models for Categorical Outcomes. In *In Handbook of Data Analysis* (pp. 258). London: SAGE Publications.

Heerkens, Y., Engels, J., Kuiper, C., Van der Gulden, J., & Oostendorp, R. (2004). The use of the ICF to describe work related factors influencing the health of employees. *Disabil Rehabil, 26*(17), 1060-1066. doi:10.1080/09638280410001703530

Hooper, D., Coughlan, J., & Mullen, M. (2007). Structural Equation Modeling: Guidelines for Determining Model Fit. *The Electronic Journal of Business Research Methods, 6*.

Horppu, R., Martimo, K.-P., Viikari-Juntura, E., Lallukka, T., & MacEachen, E. (2016). Occupational Physicians' Reasoning about Recommending Early Return to Work with Work Modifications. *PLoS ONE, 11*(7), e0158588-e0158588. doi:10.1371/journal.pone.0158588

Jackson, J., Ely, E. W., Morey, M. C., Anderson, V. M., Siebert, C., Denne, L., . . . Janz, D. (2012). Cognitive and physical rehabilitation of ICU survivors: results of the RETURN randomized, controlled pilot investigation. *Crit Care Med, 40*(4), 1088.

Kamdar, B. B., Minxuan, H., Dinglas, V. D., Colantuoni, E., von Wachter, T. M., Hopkins, R. O., . . . Huang, M. (2017). Joblessness and Lost Earnings after Acute Respiratory Distress Syndrome in a 1-Year National Multicenter Study. *American Journal of Respiratory & Critical Care Medicine, 196*(8), 1012-1020. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=cin20&AN=125698161&site=ehost-live

Kamdar, B. B., Suri, R., Suchyta, M. R., Digrande, K. F., Sherwood, K. D., Colantuoni, E., . . . Hopkins, R. O. (2020). Return to work after critical illness: a systematic review and meta-analysis. *Thorax, 75*(1), 17. doi:10.1136/thoraxjnl-2019-213803

Kim, J. W., Lee, D. Y., Seo, E. H., Sohn, B. K., Choe, Y. M., Kim, S. G., . . . Woo, J. I. (2014). Improvement of Screening Accuracy of Mini-Mental State Examination for Mild Cognitive Impairment and Non-Alzheimer's Disease Dementia by Supplementation of Verbal Fluency Performance. *Psychiatry Investig, 11*(1), 44-51. doi:10.4306/pi.2014.11.1.44

Kline, R. B. (2016). *Principles and practice of structural equation modeling, 4th ed*. New York, NY, US: Guilford Press.

Knaus, W. A., Wagner, D. P., Draper, E. A., Zimmerman, J. E., Bergner, M., Bastos, P. G., . . . et al. (1991). The APACHE III prognostic system. Risk prediction of hospital mortality for critically ill hospitalized adults. *Chest, 100*(6), 1619-1636. doi:10.1378/chest.100.6.1619

Martimo, K. P., Shiri, R., Miranda, H., Ketola, R., Varonen, H., & Viikari-Juntura, E. (2010). Effectiveness of an ergonomic intervention on the productivity of workers with upper-extremity disorders--a randomized controlled trial. *Scand J Work Environ Health, 36*(1), 25-33. doi:10.5271/sjweh.2880

Matthay, M. A., Brower, R. G., Carson, S., Douglas, I. S., Eisner, M., Hite, D., . . . Thompson, B. T. (2011). Randomized, placebo-controlled clinical trial of an aerosolized beta(2)-agonist for treatment of acute lung injury. *Am J Respir Crit Care Med, 184*(5), 561-568. doi:10.1164/rccm.201012-2090OC

Nazarov, S., Manuwald, U., Leonardi, M., Silvaggi, F., Foucaud, J., Lamore, K., . . . Rothe, U. (2019). Chronic Diseases and Employment: Which Interventions Support the Maintenance of Work and Return to Work among Workers with Chronic Illnesses? A Systematic Review. *Int J Environ Res Public Health, 16*(10). doi:10.3390/ijerph16101864

Newkirk, L. A., Kim, J. M., Thompson, J. M., Tinklenberg, J. R., Yesavage, J. A., & Taylor, J. L. (2004). Validation of a 26-point telephone version of the Mini-Mental State Examination. *J Geriatr Psychiatry Neurol, 17*(2), 81-87. doi:10.1177/0891988704264534

Nieuwenhuijsen, K., Faber, B., Verbeek, J. H., Neumeyer-Gromen, A., Hees, H. L., Verhoeven, A. C., . . . Bültmann, U. (2014). Interventions to improve return to work in depressed people. *Cochrane Database Syst Rev*(12), Cd006237. doi:10.1002/14651858.CD006237.pub3

Pfoh, E. R., Chan, K. S., Dinglas, V. D., Cuthbertson, B. H., Elliott, D., Porter, R., . . . Needham, D. M. (2016). The SF-36 offers a strong measure of mental health symptoms in survivors of acute respiratory failure. A tri-national analysis. *Annals of the American Thoracic Society, 13*(8), 1343-1350.

Pfoh, E. R., Chan, K. S., Dinglas, V. D., Girard, T. D., Jackson, J. C., Morris, P. E., . . . Hopkins, R. O. (2015). Cognitive screening among acute respiratory failure survivors: a cross-sectional evaluation of the Mini-Mental State Examination. *Crit Care, 19*(1), 220. doi:10.1186/s13054-015-0934-5

Pituch, K. A., & Stevens, J. (2016). *Applied multivariate statistics for the social sciences : analyses with SAS and IBM's SPSS*.

Radford, K., Phillips, J., Drummond, A., Sach, T., Walker, M., Tyerman, A., . . . Jones, T. (2013). Return to work after traumatic brain injury: cohort comparison and economic evaluation. *Brain Inj, 27*(5), 507-520. doi:10.3109/02699052.2013.766929

Rice, T. W., Wheeler, A. P., Thompson, B. T., deBoisblanc, B. P., Steingrub, J., & Rock, P. (2011). Enteral omega-3 fatty acid, gamma-linolenic acid, and antioxidant supplementation in acute lung injury. *Jama, 306*(14), 1574-1581. doi:10.1001/jama.2011.1435

Rice, T. W., Wheeler, A. P., Thompson, B. T., Steingrub, J., Hite, R. D., Moss, M., . . . Rock, P. (2012). Initial trophic vs full enteral feeding in patients with acute lung injury: the EDEN randomized trial. *Jama, 307*(8), 795-803. doi:10.1001/jama.2012.137

Schultz, I. Z., Stowell, A. W., Feuerstein, M., & Gatchel, R. J. (2007). Models of return to work for musculoskeletal disorders. *J Occup Rehabil, 17*(2), 327-352.

Shiri, R., Martimo, K. P., Miranda, H., Ketola, R., Kaila-Kangas, L., Liira, H., . . . Viikari-Juntura, E. (2011). The effect of workplace intervention on pain and sickness absence caused by upper-extremity musculoskeletal disorders. *Scand J Work Environ Health, 37*(2), 120-128. doi:10.5271/sjweh.3141

Stern, Y. (2009). Cognitive reserve. *Neuropsychologia, 47*(10), 2015-2028. doi:10.1016/j.neuropsychologia.2009.03.004

Truwit, J. D., Bernard, G. R., Steingrub, J., Matthay, M. A., Liu, K. D., Albertson, T. E., . . . Thompson, B. T. (2014). Rosuvastatin for sepsis-associated acute respiratory distress syndrome. *N Engl J Med, 370*(23), 2191-2200. doi:10.1056/NEJMoa1401520

van Duijn, M., Eijkemans, M. J., Koes, B. W., Koopmanschap, M. A., Burton, K. A., & Burdorf, A. (2010a). The effects of timing on the cost-effectiveness of interventions for workers on sick leave due to low back pain. *Occupational and Environmental Medicine, 67*(11), 744. doi:10.1136/oem.2009.049874

van Duijn, M., Eijkemans, M. J., Koes, B. W., Koopmanschap, M. A., Burton, K. A., & Burdorf, A. (2010b). The effects of timing on the cost-effectiveness of interventions for workers on sick leave due to low back pain. *Occupational and Environmental Medicine, 67*(11), 744-750.

van Vilsteren, M., van Oostrom, S. H., de Vet, H. C. W., Franche, R. L., Boot, C. R. L., & Anema, J. R. (2015). Workplace interventions to prevent work disability in workers on sick leave. *Cochrane Database of Systematic Reviews*(10). doi:10.1002/14651858.CD006955.pub3

Waddell, G. (1992). Biopsychosocial analysis of low back pain. *Baillieres Clin Rheumatol, 6*(3), 523-557. doi:10.1016/s0950-3579(05)80126-8

Walker, W. C., Marwitz, J. H., Kreutzer, J. S., Hart, T., & Novack, T. A. (2006). Occupational categories and return to work after traumatic brain injury: a multicenter study. *Arch Phys Med Rehabil, 87*(12), 1576-1582. doi:10.1016/j.apmr.2006.08.335

Ware, J., Kosinski, M. A., & Dewey, J. (2000). How to Score Version 2 of the SF-36® Health Survey. *Lincoln, QualityMetric Incorporated*.

Wilcox, M. E., Brummel, N. E., Archer, K., Ely, E. W., Jackson, J. C., & Hopkins, R. O. (2013). Cognitive dysfunction in ICU patients: risk factors, predictors, and rehabilitation interventions. *Crit Care Med, 41*(9), S81-S98.

Zip Code Characteristics: Mean and Median Household Income. Retrieved from https://www.psc.isr.umich.edu/dis/census/Features/tract2zip/

Online supplements

Interrelationships between Workload, Disease Severity, and Functional Ability on Return to Work following ARDS: A Longitudinal Structural Equation Model and Mediation Analysis

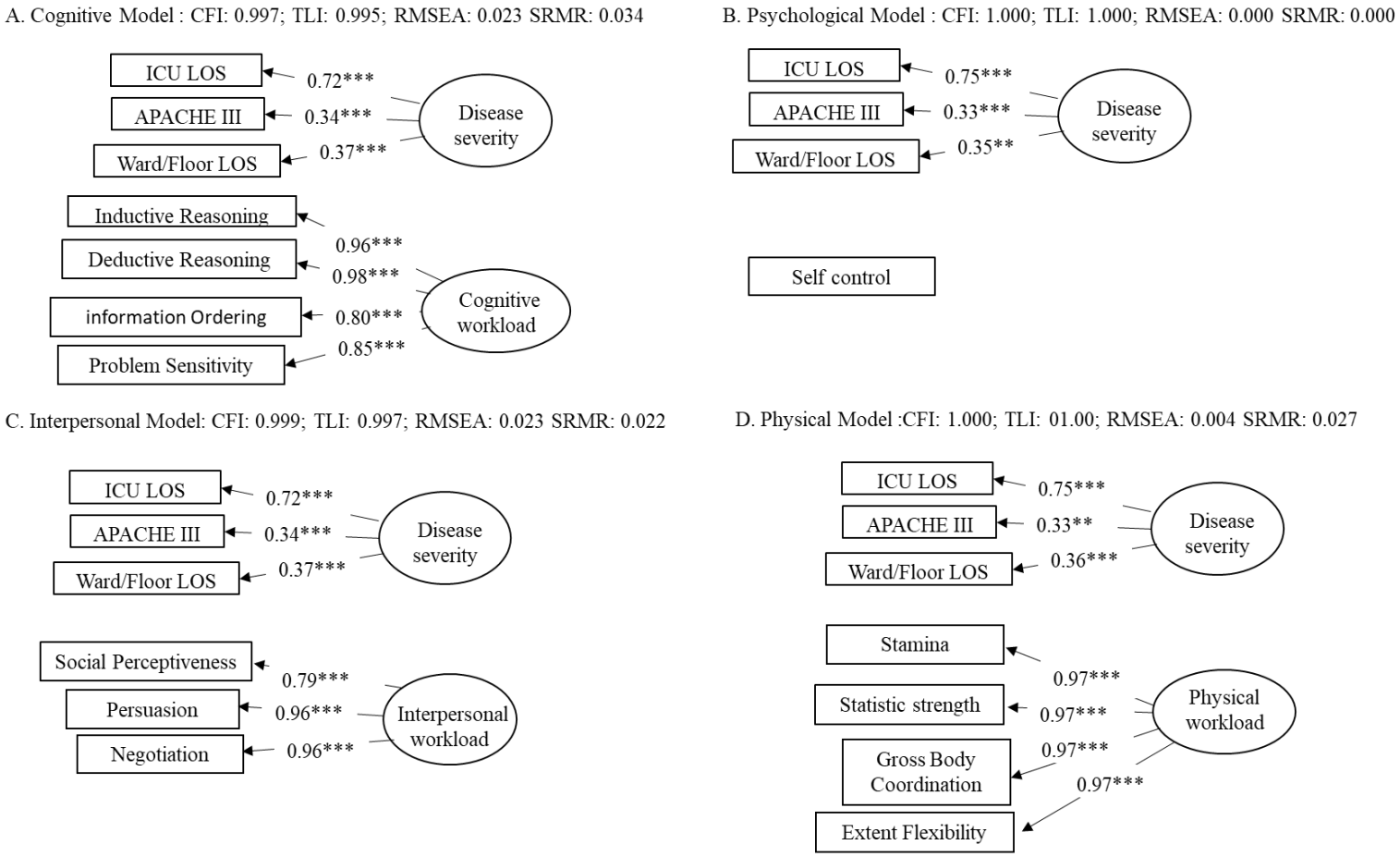
Han Su,[1] Hilaire J. Thompson,[1,2] Kenneth Pike,[1] Biren Kamdar,[3] Victor Dinglas,[4,5] Elizabeth Bridges,[1] Dale Needham[4,5,6] & Ramona Hopkins[7,8,9]

1. School of Nursing, University of Washington, Seattle, Washington, USA
2. Harborview Injury Prevention and Research Center, Seattle, WA, USA
3. Division of Pulmonary, Critical Care, Sleep Medicine and Physiology, University of California, San Diego, La Jolla, California, USA
4. Division of Pulmonary and Critical Care Medicine, Johns Hopkins University School of Medicine, Baltimore, MD, USA
5. Outcomes After Critical Illness and Surgery (OACIS) Group, Johns Hopkins University School of Medicine, Baltimore, MD, USA
6. Department of Physical Medicine and Rehabilitation, Johns Hopkins University School of Medicine, Baltimore, MD, USA
7. Neuroscience Center and Psychology Department, Brigham Young University, Provo, Utah USA
8. Pulmonary and Critical Care Medicine, Intermountain Health Care, Murray, Utah USA
9. Center for Humanizing Critical Care, Intermountain Medical Center, Murray, Utah USA

Table 1. D**escriptors used to measure cognitive, interpersonal, psychological, and physical workload** (N=329).

Pre-ARDS workload	O*NET Descriptor	Mean (standard deviation)
Physical workload	Dynamic Flexibility	1.2 (0.23)
	Dynamic Strength	2.0 (0.57)
	Explosive Strength	1.4 (0.38)
	Extent Flexibility	2.2 (0.76)
	Gross Body Coordination	2.0 (0.60)
	Gross Body Equilibrium	1.8 (0.53)
	Stamina	2.1 (0.68)
	Static Strength	2.3 (0.78)
	Trunk Strength	2.5 (0.67)
Interpersonal workload	Coordination	4.2 (0.37)
	Instructing	2.8 (0.58)
	Negotiation	2.6 (0.56)
	Persuasion	2.8 (0.56)
	Service Orientation	3.1 (0.56)
	Social Perceptiveness	3.2 (0.47)
Cognitive workload	Category Flexibility	3.0 (0.34)
	Deductive Reasoning	3.3 (0.47)
	Flexibility of Closure	2.7 (0.40)
	Fluency of Ideas	2.7 (0.54)
	Inductive Reasoning	3.2 (0.46)
	Information Ordering	3.2 (0.36)
	Mathematical Reasoning	2.4 (0.52)
	Memorization	2.3 (0.39)
	Number Facility	2.4 (0.46)
	Oral Comprehension	3.7 (0.41)
	Oral Expression	3.6 (0.49)
	Originality	2.6 (0.56)
	Perceptual Speed	2.6 (0.39)
	Problem Sensitivity	3.4 (0.46)
	Selective Attention	3.0 (0.27)
	Spatial Orientation	1.5 (0.63)
	Speed of Closure	2.4 (0.36)
	Time Sharing	2.6 (0.35)
	Visualization	2.6 (0.49)
	Written Comprehension	3.3 (0.57)
	Written Expression	3.1 (0.63)
Psychological workload	Self-control	4.1 (0.42)
	Stress tolerance	4.0 (0.42)

Figure 1 Measurement models: cognitive, psychosocial, interpersonal, and physical model



Footnote:
£. Cognitive, interpersonal, psychological, and physical workloads were measured by the O*Net system.
ǂ. All confidence intervals and p-value were estimated using bootstrap resampling with 10000 resamples.
Definition of abbreviations: APACHE III = Acute Physiology and Chronic Health Evaluation III; ICU= intensive care unit; LOS= length of stay. CFI = comparative fit index; TLI= Tucker-Lewis index; RMSEA = root mean square error of approximation; SRMR = standardized room mean residual. * $p < .05$, ** $p < .01$, *** $p < .001$.
For simplicity, covariance and error variances are not shown in the figures.

Chapter 6. Conclusions

Return to work (RTW) is an essential outcome for previously employed survivors in the critical care unit (ICU) since it represents a person's recovery of functional ability, social role, and economic status. However, currently, there is no established conceptual model to guild clinical practice and research on how to facilitate ICU survivors RTW. The present dissertation aimed to address this gap by testing part of a proposed model for critical illness patients RTW using existing literature, data from the ARDS Network Long-term Outcomes Study (ALTOS), and the U.S. Occupational Information Network (O*NET) system.

In chapter 2 of this dissertation, through a systematic review and meta-analysis, 56% of previously employed ICU survivors did not RTW 5 years post ICU stay. Time and disability policy support were identified as factors associated with the proportion of previously employed ICU survivors who RTW. Meta-regression found there is a 20% increase in the proportion of individuals who RTW per year. However, the average growth rate slows by 4% per year. In countries with high support policies, the RTW proportion is 32% higher compared to countries with low support policies. However, as the subsequent years pass, the additional proportion of individuals RTW in high support countries declines.

Chapters 3, 4, and 5 of this dissertation involved secondary data analyses from the ALTOS study and the O*NET system. In chapters 3 and 4, we found that post-ARDS functional impairments, pain and fatigue symptoms, and mismatch in work ability, were negatively associated with post-ARDS RTW at 6- and 12-months. Interestingly, while pre-ARDS workload alone was not associated with RTW, this relationship became significant when examining the match between workload and ability (specifically mismatch in work ability). This finding suggests that context matters. For example, an individual with a specific functional impairment

might not find RTW problematic if he/she has a low workload job in that domain. However, it would be problematic with a high workload job.

In chapter 5 of this dissertation, through cross-lagged structural equational modeling and mediation analyses, disease severity was found to have the largest effect on RTW at 6 months, followed by functional abilities. For RTW at 12 months, work at 6 months had the most substantial impact, followed by disease severity and functional abilities at both 6- and 12-months follow-up. Work at 6 months, functional abilities at 6 and 12 months, and pre-ARDS workload are mediators to RTW in the ARDS population and are potentially modifiable.

Taken together, the papers forming this dissertation show that inability to RTW is common in previously employed ICU survivors. Additionally, we confirmed prior findings that disease severity, gender, and age affected RTW after ARDS.1-5 This dissertation also extends prior knowledge by identifying time since discharge, policy support, post-ARDS functional impairments, mismatch in work ability, pain and fatigue symptoms, and not working during the previous follow-up period were factors that affected ICU survivors RTW. Moreover, the relationships among different factors varied by various workloads, functional abilities, and follow-up times. Among the factors identified as influencing RTW following ARDS, post-illness functional impairments and mismatched in work ability, and not working during the previous follow-up period are potentially modifiable.

Implications of the dissertation for clinical practice include: 1) post-ICU management should integrate needs at different follow-up times. In the first six months, the clinician might focus primarily on monitoring survivors' disease severity and comorbidities, followed by improving functional abilities. From 6 to 12 months, clinicians would move to paying more attention to facilitating RTW while continuing to focus on improving functional abilities; 2)

Early recognition of pain and fatigue symptoms may help prompt a broad exploration of other impairments and inability to RTW; 3) multidisciplinary interventions that address pain and fatigue symptom management, early RTW with adequate work accommodation, enhancing functional abilities, and reducing workload by work modification could facilitate improved employment outcomes in ICU survivors. Areas identified from the dissertation as important for future research include 1) the need for additional policy analysis and cost effectiveness analysis to determine the trade-off between different policy plans and employment outcomes; 2) a need to further elucidate the optimal components, timing, and implementation of multidisciplinary interventions for improving ARDS survivors' employment outcomes.

Reference

1. Kamdar BB, Suri R, Suchyta MR, et al. Return to work after critical illness: a systematic review and meta-analysis. Thorax. 2020;75(1):17.
2. Kamdar BB, Minxuan H, Dinglas VD, et al. Joblessness and Lost Earnings after Acute Respiratory Distress Syndrome in a 1-Year National Multicenter Study. American Journal of Respiratory & Critical Care Medicine. 2017;196(8):1012-1020.
3. Herridge MS, Cheung AM, Tansey CM, et al. One-year outcomes in survivors of the acute respiratory distress syndrome. The New England journal of medicine. 2003;348(8):683-693.
4. Hodgson CL, Haines KJ, Bailey M, et al. Predictors of return to work in survivors of critical illness. Journal of critical care. 2018; 48:21-25.
5. Riddersholm S, Christensen S, Kragholm K, Christiansen CF, Rasmussen BS. Organ support therapy in the intensive care unit and return to work: a nationwide, register-based cohort study. Intensive Care Medicine. 2018:1-10.