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**The need for novel strategies to analyze the dynamic pattern of worker's health over time and the consequences for sustained employability**

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## *The need for novel strategies to analyze the dynamic pattern of worker's health over time and the consequences for sustained employability*

In most occupational populations common chronic diseases, such as chronic obstructive pulmonary disease, asthma, depression, and low-back pain and other musculoskeletal disorders, contribute substantially to the work-related burden of disease (1). These common health problems often have an episodic nature with strong fluctuations in severity of complaints, expressed by recurrent episodes interspersed with periods free from complaints. Longitudinal studies among nurses and construction workers with annual follow-up measurements have documented a high prevalence of low-back pain, but also high annual recurrence and recovery rates (2, 3). These studies illustrate the dynamic patterns of musculoskeletal diseases in occupational populations, whereby some workers have persistent pain and other workers have incidental complaints or remain completely free from health problems during prolonged periods. Similar patterns have also been observed for other chronic diseases, such as respiratory disorders and depressive symptoms (4, 5).

There is an abundance of longitudinal studies on the effects of work-related factors on various diseases and their consequences for sustained employability. Typically, independent variables are collected at enrolment of workers into the study and are used to estimate their relative contribution to the incidence of health problems, sickness absence, or disability during the follow-up period. Such an analysis seldom addresses the time-varying patterns of working conditions and disease responses. A dynamic pattern of disease over time will prompt different questions, such as: “when does work trigger the onset of an episode of disease?”; “do the same work-related factors that determine onset of disease also play a role in aggravation of this disease?”; “when will an episode of disease cause sickness absence?”; and “how will chronic diseases and repeated sickness absence influence the capacity of workers to maintain their work ability and participation in the workforce?”.

There is rapidly emerging evidence that, for many diseases, the interplay of work, disease, and work capacity has a dynamic pattern during the life course of a worker. This dynamic pattern has important implications for our understanding of how strenuous working conditions contribute to the occurrence of disease and consequent sickness absence and disability. For musculoskeletal disorders, there are strong indications that work-related factors play a different role in different stages of disease and consequences for work performance. For example, a recent study showed that mechanical load predicted the persistence of knee pain over a 12-year period (6), whereas another study on shoulder and neck complaints suggested that awkward postures were more important for onset than recurrence of complaints (7). A study among predominantly female industrial workers reported that work-related physical and psychosocial factors were associated with low-back pain but not with sickness absence (8). In contrast, a study among mostly female personnel in healthcare showed that, among those workers with substantial back and neck pain, heavy physical work was an important predictor for long-term sickness absence (9). These contradictory findings can partly be explained by the inability of classical analytical methods to capture the dynamics of time-varying health states, since each adverse health event is regarded as completely independent from previous episodes of that event. The importance of this problem was recently demonstrated by Navarro and colleagues (10) through a survival analysis with repeated measurements in a cohort of hospital workers with an 8-year follow-up. The hazard rates of recurrent episodes of sickness absence for musculoskeletal, respiratory, and mental and behavioral disorders were substantially higher

than the hazard rates of initial sickness absences, suggesting that different factors play a role in onset and aggravation of these diseases.

When repeated observations over time are available, newly developed strategies allow us to study how and when work-related factors influence patterns of change in an individual's health. Two strategies have become increasingly popular to address the dynamic pattern of the interplay of determinants, health, and consequences over time: (i) the life-course approach with latent and pathways models that focus on estimating trajectories over time and determinants of trajectory shapes and trajectory group membership, and (ii) multi-state models for changes in health states over time that provide probabilities of transition among health states and explain differences among individuals during the course of a disease.

The usefulness of the life-course approach with trajectory analysis has been demonstrated in recent studies. In a longitudinal study among Finnish municipal employees with 5 measurements during 28 years of follow-up, group-based trajectory modeling was used to identify 5 distinct trajectories of development of work ability over time, partly influenced by mental and physical workload during midlife (11). The same technique was used on six repeated measurements during a two-year follow-up of workers with a traumatic limb injury and distinguished three return-to-work trajectories with different patterns of individual and work-related characteristics (12). An exemplary study with exceptional use of register-based information demonstrated convincingly through growth-curve trajectories that mental health improved after disability retirement, especially for workers with mental disorders, but no change was observed among old-age pensioners (13).

Multi-state models for changes in health states over time have been very useful to demonstrate the impact of exposure at work over a complete working career on disease and associated disability, for example for mechanical load and low-back pain among healthcare workers (14) and flour dust and occupational asthma among bakers (15). Another interesting application of multi-state models is the description of the course of disease using probabilities for transitions from being healthy to becoming disabled via sickness absence during a specified period of time. This approach is especially of interest in situations with recurrent events, such as sickness absence, and competing risks, for example becoming unemployed or disabled. In this issue of the Journal, Pedersen and colleagues (16) present a fine example of a multi-state model on sickness absence, unemployment, and disability in the Danish workforce. A large register for sickness absence and social benefits covering 52 months provided detailed information on the dynamic pattern between 4 possible states: sickness absence, dutiful employment, unemployment, and disability pension. The use of a Cox proportional hazards model with multi-states enabled the researchers to provide a comprehensive description of the different transitions among the four distinguished states and to analyze the factors that influenced these transitions. A traditional survival analysis would be limited to the risks of sickness absence, unemployment, and disability, without addressing the opposite routes of returning to work and re-entering paid employment and the particular role of sickness absence in the pathways of displacement from the workforce.

The study of Pedersen and colleagues is unique in the sense that multiple routes of (temporary) displacement from the workforce are quantified. Among men and women, the presence of a chronic disease is an important risk factor for sickness absence [hazard ratios (HR) of 4.11 and 4.18, respectively] and disability pension (HR of 3.76 and 4.79, respectively), but not for unemployment (HR of 0.62 and 0.56, respectively). This striking difference between unemployment and disability implies that both routes of displacement act to some extent as communicating vessels, whereby some workers with a chronic disease who face unemployment are eligible for a disability pension. In most European countries, the presence of a chronic disease is a risk factor for exit from paid employment through disability as well as unemployment (17).

Another interesting finding of the Pedersen et al study is that chronic disease is not a barrier for re-entering paid employment among unemployed women (HR 0.99), whereas unemployed men with a chronic disease have an even higher probability to find a paid job again (HR 1.15). A longitudinal study

in 11 European countries showed that a chronic health problem was a relevant barrier with odds ratios varying between 0.3 (Belgium) and 0.9 (Germany, Portugal) (18). Pedersen and colleagues (16) point out that the Danish flexicurity model aims to include persons with a chronic disease in the labor market. This particular feature of the Danish welfare state seems also responsible for a comparable health status between workers in precarious jobs and those with permanent positions, whereas in other welfare regimes precarious employment is an important determinant of health inequalities (19). However, it remains an intriguing observation that the presence of a chronic disease plays a different role for men and women in re-entering the labor market, which may suggest differential opportunities.

Recent studies in the *Scandinavian Journal of Work, Environment & Health* have applied novel analytical methods for longitudinal studies to determine how and when work-related factors influence patterns of change in an individual's health. The results of these studies present valuable new insights into the mechanisms of sustainable employability. This knowledge will certainly contribute to interventions, programs, and national regulations to support workers to continue working longer in good health.

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