Finnish Institute of Occupational Health

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ABSTRACT

The characteristics and flexibility of working hours are changing rapidly in all the Nordic countries. Working hours are becoming more boundaryless among the higher socioeconomic groups, whereas every fifth employee still works shifts. Nordic countries share similar working life structures and bases for working hour regulations. The overall aim of the NordForsk-funded 'Working hours, Health, Well-being and Participation in Working life' project (WOW, 2015–2021) was to develop evidence-based models and solutions related to working hours to support health and work participation in the Nordic countries.

The specific aims of WOW were to investigate the societal and socio-economical differences and trends of Nordic working hour patterns using representative national and European data to identify policy-relevant trends and vulnerable groups for targeted interventions. Secondly, we studied the effects of shift work and working time autonomy on health, incident chronic diseases, work-life balance and work participation using five prospective cohort studies in Denmark, Finland, Norway and Sweden. Finally, ten intervention and two diary-based studies were carried out to create and test different organizational and individual level countermeasures related to working hours in shift work, boundaryless expert work, and safety-critical 24/7 industries to generate criteria and tools to improve health, well-being and work participation.

Through its high number of cohort and intervention studies, to date, WOW has produced over 100 scientific publications in international journals. The main findings indicate that compared to other European countries, Nordic countries have shorter average working hours and more working time control. However, they also have many differences. Earlier research has shown that working over 55 hours per week is associated with an increased risk of chronic health problems. These results were not replicated in Scandinavia in terms of chronic health and occupational injuries, possibly due to the lower number of people working such long weekly hours. However, reduced working hours, namely six-hour workdays or 30-hour weeks, with retained salary, has shown beneficial effects on subjective health, sleep and well-being.

The WOW studies have lent new support to the associations between exposure to night shift work and several acute and chronic conditions such as the increased risk of fatigue and insomnia, occupational injuries, rheumatoid arthritis, type-2 diabetes, hypertension, miscarriage, and hypertension and preeclampsia during pregnancy,

as well as short and long sickness absence and disability pensions. We have found mixed results regarding the association between night shift work and breast cancer, mortality and dementia, and no support for an association between night shift work and prostate cancer. The cohort and diary studies on working time control showed beneficial associations with work-life balance, mental and physical health, and sickness absence.

The intervention studies showed that self-rostering, the use of participative shift scheduling among hospital employees, and the use of stress therapy among managers had positive effects on work-life balance and work participation. The use of rapidly forward-rotating 12-hour shift systems in industry showed beneficial effects on perceived health compared to 8-hour shift systems. In 24/7 safety-critical industries, the use of fatigue risk management systems was a promising way to reduce fatigue, in addition to the use of some working hour regulations or single countermeasures such as the use of training or nap breaks. In shift work, the appropriateness of bright light therapies likely depends on the number of consecutive night shifts, making this strategy difficult in quickly rotating shift work, which is common in the Nordic countries. Shift workers with insomnia may benefit from different non-pharmacological insomnia interventions performed by occupational health services.

The WOW project has produced and updated cross-national working time recommendations, especially in terms of night shift work, flexible working hours and individual coping with unsocial working hours.

TIIVISTELMÄ

Työaikojen joustavuus ja ominaispiireet muuttuvat nopeasti kaikissa Pohjoismaissa. Samalla kun työtyöaikojen joustot ovat kasvaneet ylemmissä sosioekonomissa ryhmissä, joka viides työntekijä tekee edelleen aikaan ja paikkaan sidottua vuorotyötä. NordForskin rahoittaman ”Työajat, terveys, työhyvinvointi ja työelämään osallistuminen (WOW)” tutkimusprojektin tavoitteena oli kehittää työaikoihin liittyviä uusia toimintamalleja ja ratkaisuja terveyden ja työhön osallistumisen parantamiseksi Pohjoismaissa.

WOW-hankkeen yksityiskohtaisina tavoitteina oli tutkia työaikoihin liittyviä yhteiskunnallisia ja sosiaalisia eroja ja kehityssuuntia hyödyntäen sekä kansallisia että Euroopan laajuisia edustavia aineistoja keskeisten työaikoihin liittyvien muutosten ja tutkimustarpeiden tunnistamiseksi. Toiseksi tutkimme vuorotyön ja työaikoihin liittyvien vaikutusmahdollisuuksien vaikutuksia terveyteen, kroonisten sairauksien ilmaantuvuuteen, työn ja muun elämän yhteensovittamiseen ja työelämään osallistumiseen hyödyntäen viittä etenevää tutkimuskohorttia Tanskassa, Suomessa, Norjassa ja Ruotsissa. Lisäksi selvitimme kymmenen interventio- ja kahden päiväkirjatutkimuksen avulla työaikoihin liittyvien organisatoristen ja yksilöllisten kehittämistoimenpiteiden ja muutosten yhteyksiä terveyteen, työhyvinvointiin ja työhön osallistumiseen. Nämä hankkeet liittyivät vuorotyöhön, turvallisuuskriittisiin aloihin, julkisen sektorin ammatteihin ja asiantuntijatyöhön.

Johtuen käyttämistämme useista laajoista tutkimuskohorteista ja aliprojekteista, hanke on tuottanut jo yli 100 tieteellistä julkaisua. Päätulosten mukaan keskimääräinen työaika on Pohjoismaissa lyhyempi ja työaikoihin liittyvät vaikutusmahdollisuudet paremmat kuin muissa Euroopan maissa. Toisaalta työaikojen liittyvissä muutoksissa oli Pohjoismaiden välillä myös selviä eroja. Aiempien havaintojen perusteella erityisesti yli 55 tunnin viikkotyöaika lisää vakavien terveysongelmien riskiä. Pohjoismaissa tehdyt tutkimuksemme eivät tukeneet tätä havaintoa kroonisten sairauksien ja työtapaturmien osalta, mahdollisesti johtuen hyvin pitkiä työaikoja tekevien pienestä osuudesta Pohjoismaissa. Toisaalta siirtyminen normaalista työajasta kuuden tunnin työpäivään tai 30-tunnin työviikkoon, palkan pysyessä ennallaan, paransi koettua terveyttä ja työhyvinvointia.

WOW tutkimukset vahvistivat aiempia havaintoja yötyötä sisältävän vuorotyön vaikutuksista moniin akuutteihin ja kroonisiin terveysriskeihin kuten unihäiriöihin ja väsymykseen, työtapaturmiin, reumaan, tyypin-2 diabetekseen, verenpainetautiin,

raskauden ajan terveysriskeihin ja raskauden keskeytymiseen, sekä lyhyiden ja pitkien sairauspoissaolojen riskiin, ja riskiin joutua työkyvyttömyyseläkkeelle. Yötyötä sisältävän vuorotyö ei lisännyt eturauhassyövän riskiä. Tutkimustulokset yötyön yhteydestä rintasyöpään, dementiaan ja kuolleisuuteen olivat ristiriitaisia aineistoista ja altistumisen kestosta riippuen. Hyvät työaikoihin liittyvät vaikutusmahdollisuudet olivat useissa tutkimuksissa yhteydessä työn ja muun elämän parempaan yhteensovittamiseen, parempaan koettuun terveyteen, ja vähäisempiin sairauspoissaoloihin.

Interventiotutkimukset työaikoihin liittyvien vaikutusmahdollisuuksien parantamisesta vuorosuunnitteluohjelmistojen kautta sekä esimiesten stressinhallintakoulutus vaikuttivat myönteisesti työn ja muun elämän tasapainoon sekä sairauspoissaoloihin. Nopeasti kiertävään 12 tunnin vuorojärjestelmään siirtyminen oli yhteydessä parempaan koettuun terveyteen teollisuudessa hitaammin kiertäviin 8 tunnin järjestelmiin verrattuna. Turvallisuuskriittisissä vuorotyöammateissa väsymyksen hallintajärjestelmät osoittautuivat lupaaviksi keinoksi vähentää väsymystä työaikasäädösten ja eräiden yksilötason keinojen, kuten liikunnan ja lyhyiden nokosten, lisäksi. Kirkasvalohoitojen soveltuvuus vuorotyöhön näyttää riippuvan peräkkäisten yövuorojen lukumäärästä, vaikeuttaen hoitojen soveltuvuutta nopeasti kiertävää vuorotyötä tekeville. Unettomuuden lääkkeettömillä hoitokeinoilla voitiin vähentää vuorotyöläisten unettomuutta työterveyshuollossa.

WOW hanke on tuottanut ja päivittänyt vuorotyöhön ja työaikajoustoihin liittyviä terveyssuosituksia, sekä koonnut suosituksia hyvistä yksilöllistä keinoista vuorotyön haittojen vähentämiseksi.

SAMMANFATTNING

Arbetstiderna i de nordiska länderna genomgår en snabb förändring. Samtidigt som flexibel arbetstid är vanligare inom de högre socioekonomiska grupperna, arbetar var femte arbetstagare skift och är därmed bunden till ett arbetstidsschema och till arbetsplatsen. Målsättningen för forskningsprojektet ”Arbetstider, hälsa, välbefinnande i arbetet och deltagande i arbetslivet (WOW)” som finansierats av NordForsk var att utveckla nya arbetstidsmodeller och lösningar med syfte att förbättra hälsan och deltagande i arbetslivet inom Norden.

WOW-projektets specifika mål var att undersöka samhälleliga och sociala skillnader och trender gällande arbetstider. För att kunna beskriva centrala aspekter kopplade till arbetstider i de nordiska länderna utnyttjades nationellt och europeiskt representativa data. Vi undersökte också vilken påverkan skiftarbete och möjligheter att påverka arbetstiderna hade på hälsa, balansen mellan arbete och fritid och deltagande i arbetslivet genom att utnyttja fem prospektiva kohortstudier i Danmark, Finland, Norge och Sverige. Dessutom undersökte vi sambandet mellan organisatoriska och individuella förebyggande åtgärder, inklusive förändringar gällande schemaläggning, och hälsorelaterade utfall samt deltagande i arbetslivet. Projektet omfattade tio interventions- och två dagboksundersökningar. Interventionsstudierna handlar om skiftarbete, säkerhetskritiska branscher, yrken inom den offentliga sektorn och expert-arbete.

Till följd av många omfattande undersökningskohorter och delprojekt har projektet redan gett upphov till mer än 100 vetenskapliga publikationer. Ett av huvudresultaten är att den genomsnittliga arbetstiden i Norden är kortare jämfört med andra EU-länder, och möjligheterna att påverka arbetstiderna bättre än i övriga europeiska länder. Däremot fanns det tydliga skillnader bland de nordiska länderna i förändringar som berör arbetstider. På basis av tidigare fynd ökar risken för allvarliga hälsoproblem i synnerhet då arbetstiden överskrider 55 veckotimmar. Projektets undersökningar som gjorts i de nordiska länderna stöder däremot inte ett samband mellan +55 veckotimmar, kroniska sjukdomar och arbetsolycksfall. Detta kan möjligen bero på att endast en liten del av arbetstagarna i Norden har mycket långa arbetstider. Samtidigt innebar en minskning av arbetsdagen till sex timmars arbetstid eller 30-timmars arbetsvecka, med bibehållen lön, att den upplevda hälsan förbättrades.

WOW-undersökningarna bekräftade tidigare fynd om skiftarbete där nattarbete ingår och akuta och kroniska hälsorisker, t.ex. sömnstörningar och trötthet, arbetsolycksfall,

reumatism, typ 2-diabetes, högt blodtryck, hälsorisker under graviditet och missfall, risk för långvarig och kortvarig sjukfrånvaro och risk för förtidspension. Skiftarbete som innehåller nattarbete ökade inte risken för prostatacancer. Forskningsresultaten som berörde sambandet mellan nattarbete och bröstcancer, demens och dödlighet var motstridiga, vilket förmodligen beror på metodologiska olikheter mellan studierna, t. ex. varierade exponeringstiden för nattarbete mellan undersökningarna. I flera undersökningar observerades samband mellan goda möjligheter att påverka arbetstider och bättre balans mellan arbetet och privatlivet, bättre upplevd hälsa och minskad sjukfrånvaro.

Interventionsstudierna visade att en förbättring av möjligheterna att påverka arbetstiderna med stöd av datoriserade schemaläggningsprogram och utbildning i stresshantering för chefer hade en positiv inverkan på balansen mellan arbetet och privatlivet och sjukfrånvaro. Det upptäcktes ett samband mellan snabbroterande 12-timmarsskift och förbättrad upplevd hälsa, då man jämförde med andra skiftscheman, t.ex. långsamt roterande 8-timmarsskift. Inom säkerhetskritiska skiftarbetesyrken visade det sig att systematiskt övervaka och riskbedöma trötthet i arbetet minskade trötthetriskerna och bidrog till bättre säkerhet. Viktiga inslag i arbetet med att förebygga trötthet var bland annat bättre arbetstidsscheman. På individnivå kan trötthetshantering handla om livsstilsfaktorer som motion och att ta korta tupplurar i nära anslutning till nattpassens start. Vidare fann vi evidens som tyder på att ljusterapins effektivitet för skiftarbetare beror på antalet nattskift i rad. Att använda ljusbehandling kan vara olämpligt för skiftarbetare som har snabbt (t.ex. få nattskift i följd) roterande skiftarbete. Inom företagshälsovården reducerade man allvarliga sömnproblem hos skiftarbetare med psykologisk behandling baserad på kognitiv beteendeterapi.

WOW-projektet har producerat och uppdaterat hälsorekommendationer relaterade till skiftarbete och flexibla arbetstider. Projektet har även sammanfattat rekommendationer om individuella motåtgärder som kan minska nackdelarna med skiftarbete.

PREFACE

This report summarizes the main findings and recommendations of a large-scale project called '*Working hours, Health, Well-being and Participation in Working life (WOW). Creating new working time models and solutions for Nordic countries*'. The project received funding from NordForsk for 1.6.2015–31.05.2021. It was carried out in co-operation by the Finnish Institute of Occupational Health (FIOH), Finland; the University of Tampere's School of Social Sciences and Humanities, Finland; the University of Stockholm's Stress Research Institute (SU), Sweden; the Karolinska Institute's Department of Neuroscience, Sweden; the National Institute of Occupational Health (STAMI), Norway; the University of Bergen's Department of Global Public Health and Primary Care, Norway; the National Research Centre for the Working Environment (NFA), Denmark; the University of Copenhagen's Department of Social Medicine, Denmark; Aarhus University's Department of Occupational Medicine, the Danish Ramazzini Centre, Aarhus University Hospital, Denmark, and the Danish Cancer Society Research Center, Denmark. The project was led by Professor Mikko Härmä (FIOH) together with a co-ordination group consisting of Professor Anne Helene Garde (NFA), Professor Göran Kecklund (SU), Dr Jenny-Anne Lie (STAMI) and Dr Kati Karhula (FIOH, project co-ordinator).

Over 50 researchers actively participated in the WOW project during 2015–2020 and the project has produced over 110 scientific publications (https://www.ttl.fi/en/research-and-development-projects/wow/scientific-publications/). It placed special emphasis on updating and implementing the produced recommendations and individual coping mechanisms. A novel aspect of the project was the utilization of detailed payroll-based registry data on working hours from several occupational cohorts, enabling the formation of more detailed recommendations for working hours and health. The WOW project supported Nordic co-operation in research on working hours and health through the Working Hours in the Nordic Countries (WINC) research network. The close collaboration between the partners, their annual scientific meetings and educational co-operation with, for example, Nordic Institute for Advanced Training in Occupational Health (NIVA) courses on working hours and health, have all strengthened the established research platform on working hours and health in the Nordic countries.

The authors of this report wish to thank NordForsk for enabling the work of this extensive consortium. We also thank all the national steering committees, organizations and study participants for their active participation.

The authors are solely responsible for the chapters they author and the related recommendations.

On behalf of all the authors

Professor Mikko Härmä, WOW Consortium Leader

5.11.2020, Helsinki, Finland

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LIST OF ABBREVIATIONS

ACPA	anti-citrullinated protein antibody
BMI	body mass index
CBT	cognitive behavioural therapy
CVD	cardiovascular disease
DWHD	Danish Working Hour Database
EU	European Union
EU28	European Union 28 Member States
EU LFS	European Union Labour Force Survey
EWCS	European Working Conditions Survey
FIOH	Finnish Institute of Occupational Health
FPS	Finnish Public Sector study
FWCS	Finnish Working Conditions Survey
FRMS	fatigue risk management system
HER2	human epidermal growth factor receptor 2
HHS	Helsinki Health Study
IARC	International Agency for Research on Cancer
ICD	International Classification of Diseases
ICSD	International Classification of Sleep Disorders
IHD	ischaemic heart disease
ILO	International Labour Organization
LKU	Survey of living conditions – Working environment (Norway)
NFA	National Research Centre for the Working Environment (Denmark)
OHS	occupational health services
RA	rheumatoid arthritis
RCT	randomized controlled trial
SLOSH	Swedish Longitudinal Occupational Survey of Health
STAMI	National Institute of Occupational Health (Norway)
STR	Swedish Twin Registry
SU	Stockholm University
SUSSH	The Survey of Shift Work, Sleep and Health
SWD	shift work disorder
TU	Tampere University
UiB	University of Bergen
ULF	Swedish Register for Living conditions
WHFPS	Working hours in the Finnish Public Sector study
WHO	World Health Organization
WINC	Working hours in the Nordic Countries (research network)
WP	work package

1 INTRODUCTION

1.1 Background

The characteristics and flexibility of working hours are changing rapidly in all the Nordic countries. Working hours are becoming more boundaryless among the higher socioeconomic groups, as work can be done at different times or in different places, unlike traditional office work. On the other hand, every fifth employee, mostly in the lower socioeconomic groups, still works shifts (24/7 society). While the traditional 24/7 industry has declined, the growing need for services in social and health care, information technology, commerce, hotels, and restaurants has kept the prevalence of shift work in Nordic countries high, at close to 20%. The irregular working hours of the service sector most often concern female employees.

Nordic countries share similar working life structures and bases for working hour regulations. The Nordic countries traditionally have strong, inclusive labour market regulations concerning collective bargaining, working conditions, worker autonomy, and combining work with family life (Eurofound 2016a, Gallie 2007, Mustosmäki 2017). In terms of working time arrangements, distinct 'Nordic regimes' have been identified, through macro-level bargaining, working time flexibility and gender equality at the workplace.

Nordic countries constitute an interesting and relevant setting in which to observe changes in working hours, and the effects of working hours on health, well-being, and participation in working life. They present good opportunities for register-based research on working hours and health as it is possible to follow individuals over time and to link working hours to survey and register-based data on health and mortality. The WOW project has focused on utilizing payroll-based objective working hour data in epidemiological research. Nordic countries also present unique opportunities for field studies with sophisticated design and methods, including objective measures of health and biological mechanisms related to the outcomes. Overall, the Nordic countries have a long tradition of working hour research and existing research networks, such as the Working Hours in the Nordic Countries (WINC) research network utilized in this project (Møller et al. 2014).

1.2 Aims of the project

The overall aim of the project was to develop evidence-based models and solutions related to working hours to support health, well-being and work participation in the Nordic countries. It has aimed to create working time-related solutions for women and ageing workers in particular, who often have challenging working hours. Work-life balance and health, which are the key determinants of well-being at work, were studied among these groups. The specific aims of the project have been to investigate the societal and socio-economical differences and trends of Nordic working hour patterns using representative national and European data to identify policy-relevant trends and vulnerable groups for targeted interventions. This was done in the Work Package 1 (WP) of the project. Secondly, we have studied the effects of shift work and working time autonomy on health, incident chronic diseases, work-life balance and work participation using five prospective cohorts in Denmark, Finland, Norway and Sweden (WP2). Finally, ten intervention and two diary-based studies have been carried out to create and test different organizational and individual level interventions related to working hours in shift work, boundaryless work, and safety-critical 24/7 industries, to generate criteria and tools to improve health, well-being and work participation (WP3). The project has placed special emphasis on updating and implementing recommendations regarding health-promoting working hour patterns and individual coping mechanisms in the Nordic societies (WP4).

1.3 Cohorts and field studies of the project

1.3.1 Working hours in the Nordic countries – societal and socioeconomic differences (WP1)

This work package consisted of comparative research on working hours in the Nordic countries to identify policy-relevant trends and vulnerable groups for further research. It utilized data from the European Union Labour Force Surveys (EU LFS), European Working Conditions surveys (EWCS) and the four representative national working condition surveys in Finland, Norway, Sweden and Denmark. The EU LFS is a large household sample survey conducted in all the EU Member States and in Norway and Iceland. Data selection covered all years from 1995 in the Nordic countries. In 2012, for example, the quarterly labour force survey sample size across the EU was about 1.5 million individuals (aged 15+). The EU LFS covers information on weekly working hours (usual, actual and preferred), working time arrangements (shift, evening, night, Saturday, and Sunday) and working at home. The EWCS (1995,

2000, 2005, and 2010, 2015, next: 2020) is collected in all EU Member States and many other European countries, including Norway. The sample consists of 15–64-year-old workers identified from a household-based sampling frame, with 1000 interviews conducted per country. The EWCS includes questions on the duration (number of agreed, actual and preferred weekly working hours, and paid and unpaid overtime), working time arrangements (evening/night/morning work, shift work, Saturday and Sunday work), working time intensity, autonomy of working time, and predictability of working time.

The four nationally representative Scandinavian questionnaires are: the *Finnish Working Conditions Survey* (FWCS, 1977–2013, n=3000–6000), which covers nationally representative samples of the working-age employed population in Finland (by Statistics Finland); The *Norwegian Work Environment Survey* (2006, 2009, 2013, n=about 12 500), covering a nationally representative sample in Norway; The *Swedish Longitudinal Occupational Survey of Health* (SLOSH, 2006–2020), a nationally representative longitudinal cohort survey conducted in Sweden covering up to 40 000 individuals; and the *Working Environment and Health in Denmark* (2012–2018, 30 000 respondents per round), a survey of a nationally representative sample in Denmark.

1.3.2 Working hours, health and welfare: prospective cohort studies (**WP2**)

This epidemiological work package utilized five different, large occupational cohorts in Denmark, Finland, Norway and Sweden, and covered information on working hours, health and well-being. The cohorts were *the Danish Working Hour Database* (DWHD, Denmark)*, the Finnish Public Sector study* (FPS, Finland), *the Survey of Shift Work, Sleep and Health* (SUSSH, Norway), *the Longitudinal Occupational Survey of Health* (SLOSH*, Sweden*), *the Swedish Twin Registry* (*STR*) *and the Swedish Register for Living Conditions* (ULF).

The DWHD contains payroll-based daily working hour data on all employees in the hospitals of the five Danish administrative regions from the period of 2007 to 2019, and covers over 250 000 employees (Garde et al. 2018). The DWHD is linked with information on health, well-being and disease from other national registers through a unique personal ID code.

The Finnish Public Sector study (FPS) includes register and survey data on 11 towns, 6 hospital districts/social welfare and health entities from 1997. The registry cohort

covers over 400 000 employees and the survey cohort over 100 000 employees. *The Working Hours in the Finnish Public Sector* (WHFPS) study includes payroll-based daily working hour data on all employees in the FPS study (Härmä et al., 2015), as well as similar data on eight additional university hospitals from 2007, covering over 200 000 employees. The WHFPS is based on the retrieval of daily data from Titania® (CGI Finland) shift scheduling software. The FPS is linked to national register data through a unique personal ID code.

The Survey of Shift Work, Sleep and Health (SUSSH) is a longitudinal cohort study in Norway, which began in 2008 and covers over 3000 nurses who have completed a comprehensive annual questionnaire. The survey is linked to health registers with information on sickness absence.

The SLOSH is a nationally representative longitudinal cohort survey on the associations between work organization, the work environment, and health. SLOSH started in 2006 and today covers about 40 000 employees. It is also linked to several national health registers. *The Swedish Twin Registry* (STR) is one of the largest twin registries in the world, with over 85 000 monozygotic and dizygotic twins. It started in the 1960s. *The Swedish Register for Living conditions* (ULF) contains 140 000 randomly selected Swedes surveyed by Statistics Sweden on their working hours (shift, night, day work), stress, fatigue, physical and psychosocial working conditions, and demographics.

1.3.3 Creating and testing solutions (WP3)

The four intervention studies of WP3, which examined *new working time models,* focused on both organizational and individual level interventions. The organizational interventions included one Danish and one Finnish intervention study of nursing personnel and the effects of self-rostering and/or the use of participative scheduling software on well-being, health (Karhula et al. 2020a) and sickness absence (Turunen et al. 2020). Both the Danish and Finnish studies utilized payroll-based databases (DWHD and WHFPS). The third study examined the effects of ergonomic shift scheduling rules on ageing shift workers' working hour characteristics and sleep (Karhula et al. 2020b). The data for this intervention were collected from two cohorts: the WHFPS and the Helsinki Health Study (HHS). The fourth intervention study evaluated rapidly forward rotating 12-hour shift systems in the paper and chemical industry (Karhula et al. 2016, Puttonen et al. manuscript). *The individual-based interventions* consisted of three randomized controlled trials (RCTs), which included one study on the effect of the non-pharmacological treatment of sleep disorders among nurses (Järnefelt et

al. 2020) and two studies on the effects of bright light treatment on shift working nurses (Bjorvatn et al. submitted) and traffic controllers (Lowden et al. in progress).

Four additional WP3 studies looked at *boundaryless work and work-life balance in knowledge-intensive occupations*. One of these studies investigated the association of daily working hours with sleep, recovery and detachment in expert work, collecting data from among the members of the Union of The Finnish Association of Business School Graduates (Ropponen et al. 2018) via a mobile app. A before-after intervention study analysed the effects of a mindfulness intervention on the stress management and recovery of foremen (Mellner et al. submitted). An evaluation study of an educational intervention investigated the effectiveness of a time management educational programme among office workers (Yli-Kaitala et al. 2020). The Finnish Time Use Survey is a time-budget study of a representative sample of Finnish households and 10+ year-old citizens conducted in 1979, 1987–1988, 1999–2000 and 2009–2010 (data collected by Statistics Finland), and investigates the association of working hours with work-life balance, sleep and lifestyle habits, according to socio-economic differences in work.

Fatigue management in safety-critical 24/7 industries was the subject of a series of studies that evaluated the factors related to on-the-job fatigue and safety among employees in different transportation and other safety-critical sectors, the usability of fatigue management strategies and tools, and the use of alertness-enhancing countermeasures to decrease risks.

2 WORKING HOURS IN THE NORDIC COUNTRIES

Timo Anttila, Jenny-Anne Lie, Satu Ojala and Jouko Nätti [1]

Work is moving beyond its traditional borders of time. The standard industrial model (eight-hour day, five-day week, daytime work, free evenings and weekends, annual holidays, and retirement with a pension) is increasingly changing toward a new 'post-industrial working time regime' (O'Carroll 2015). Under the pressures of technological change and globalization, this new regime is characterized by labour market deregulation, a de-standardization of both the duration and timing of working hours, increasing work intensity, and a blurring of the boundaries between family and working life. At best, the new regime may bring more flexibility and autonomy for the majority of employees and contribute to a more productive economy. At worst, it creates new risks for individuals and their families and reinforces societal inequalities (Warren 2015).

While the trend toward a post-industrial working time regime might exist in most industrialized countries, its intensity and outcomes are not necessarily the same everywhere. Countries have various regulatory working condition traditions, and institutional change is likely to be path dependent. The Nordic countries have a tradition of strong and inclusive labour market regulation concerning collective bargaining, working conditions, worker autonomy, and combining work with family life (Eurofound 2016a; Gallie 2007; Mustosmäki 2017). This makes these countries an interesting case for observing the changes in working hours in the last two decades.

In terms of working time arrangements, distinct 'Nordic regimes' have been identified in the literature as having at least three relevant dimensions: working time regulation through bargaining at a macro level, working time flexibility at the workplace, and high work participation of women. First, at the macro level, the Nordic countries are characterized by a 'negotiated' working time-setting regime (Berg, Bosch & Charest 2014, Eurofound 2016b). Collective bargaining agreements between employer and employee organizations, predominantly at the sectoral level, are the key instrument in establishing working time standards. This working time configuration is the

1 The other authors have revised this chapter from a draft written by late prof. Jouko Nätti (1954–2020).

result of a tradition of high trade union density and broad coverage of collective bargaining (Gallie 2007). According to Eurofound (2016b), countries belonging to the 'negotiated' working time-setting regime have the lowest regulated working hours and actual usual hours worked, due to the strong voice of employee organizations.

Second, working time regimes are not merely the result of formal agreements and legal norms at a macro level but also of voluntary and customary practices that influence working time practices at a micro level (Rubery et al. 1998). Chung and Tijdens (2013) found that the Nordic countries are characterized by high employee- and employer-centred flexibility. This means that working time flexibility can benefit both employees, through arrangements such as training, parental and care leave; and employers, through overtime, unusual hours and shift work. Hybrid arrangements can benefit both sides and include phased retirement, part-time work, and flexible or reduced working hours.

Third, the Nordic working time regime is characterized by high overall participation in employment by both men and women, the overall employment rate being 4–9% higher than the EU28 average 73.1% (Eurostat 2020a). Gender gap in employment is small in the Nordic countries, ranging from 2.7% in Finland to 7.2% in Denmark, whereas the EU28 mean was 11.4% in 2019 (Eurostat 2020b). According to Eurostat (2020c), part-time employment rates in Norway, Denmark and Sweden in 2019 were over 20%, which is higher than the EU28 mean. However, Finland is an exception to this, with a part-time rate of 14%.

2.1 WOW scientific results

2.1.1 Changes in usual working hours and part-time work in Denmark, Finland, Norway and Sweden in recent decades

WOW analysed whether convergence or divergence occurred between men and women in the countries in comparison to each other, and within the countries themselves (Riekhoff et al. 2019a). Moreover, it analysed whether structural differences and changes in the population have contributed to changes in working hours. We used annual data from the EU LFS to identify trends between 1996 and 2016 (N=730 133), while controlling for a set of structural factors. The duration of working hours was defined as the number of hours per week usually worked in one's main job. Part-time work was defined as 1–34 hours per week. The findings suggest a degree of divergence between the countries: usual working hours and the incidence

of part-time work were relatively stable in Finland and Sweden, whereas working hours decreased in Denmark and Norway. The latter was partly driven by a decline among the 15–29-year age group. A gender gap in working hours was evident in all the countries: on average, men worked more hours in paid work. However, the gender gap decreased somewhat over time, due to a rise in part-time work among men and a decline among women in Norway and Sweden.

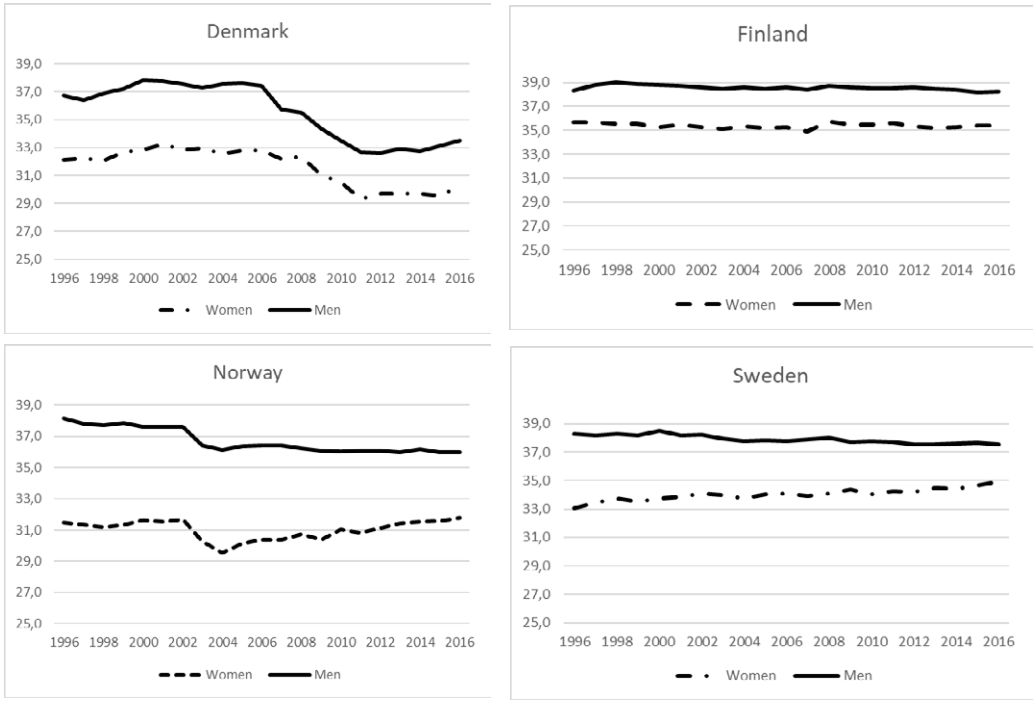

Figure 1. Trends of usual working hours (hrs/week) in Finland, Sweden, Denmark and Norway, 1996–2016.

2.1.2 Individual- and country-level factors that contribute to the risk of working unsocial hours in 30 European countries

Using the EU LFS data, we investigated the influence of labour market dualization, product- and labour market regulation, and collective bargaining on the individual risk of working unsocial hours (Riekhoff et al. 2019b). In the EU LFS data, the 'usually' response to work during evenings and nights means at least half of the days worked during a reference period of the preceding four weeks, whereas 'sometimes' means less than half of the days worked but at least one hour during the same period. For work during weekends, 'usually' means at least two of the Saturdays/Sundays during

a reference period of the preceding four weeks, whereas 'sometimes' is defined as work on only one Saturday/Sunday during the period, including at least one hour during the same reference period. The results show that there is no overall 24/7 economy or society in Europe if the incidence of working unsocial working hours (i.e. evenings, nights or weekends) is used as an indicator. The study showed large variations between countries. However, on average, more than one out of three of the employees in this study typically worked unsocial hours. The risks of working unsocial hours were strongly dualized between low and high skilled workers. In all the countries, lower skilled workers were most exposed to unsocial hours, but the size of the risk gap between low-skilled and high-skilled workers varied. In the countries in which collective bargaining plays a greater role in regulating working hours (e.g., the Nordic countries) the gap between low- and high-skilled workers was smaller.

2.1.3 Comparison of Nordic countries with other European countries in terms of working time and place dimensions and their associations with employees' work-life balance

A European comparison of the flexibility of working time and place found various types of flexibility regimes in Europe (Anttila et al. 2015). Nordic countries were characterized by shorter usual working hours, less unsocial (other than daytime) working hours, higher intensity, hastiness of work (work tempo), and more control over working hours. In addition, employees in northern Europe were the most satisfied with how their working hours fit in with their family or social commitments. Furthermore, working times were associated with perceived work-life balance. The more autonomy the employees had in terms of their working hours, the more often they felt that their working hours fit in well with their family or other social commitments. In contrast, the more working hours and the more frequent unsocial working hours or work in multiple locations that the employees had, and the higher working time intensity they felt, the less often they deemed their working hours a good fit with their family and social commitments.

2.1.4 Comparability of working hour variables in four national working condition surveys

We studied the comparability of the working hour variables of the different national working conditions surveys for a potential meta-analysis of the working hour trends in Scandinavia. The four national surveys were the *Working Environment and Health Study in Denmark (WEHD2012–WEHD2014)*, the *Finnish Working Conditions Survey*

Employees in telework may face challenges in work-life balance.

(FWCS, 1977, 1984, 1990, 1997, 2003, 2008, 2013), the *Survey of living conditions* - Working environment (LKU, Statistics Norway, 2006, 2009, 2013), and the *Swedish Longitudinal Occupational Survey of Health* (*SLOSH,* 2006–2014) (Lie & Nätti 2018). These four surveys showed large discrepancies in their definitions of both demographics and working hour variables. We recommend closer co-operation between the countries in the future, to facilitate new joint studies and improve between-country comparisons.

2.2 Other scientific evidence and conclusions

2.2.1 Usual working hours

Other studies looking at the European trends in working time have shown some convergence in recent years between old and new EU Member States and between working time-setting regimes (Eurofound 2016b). However, this convergence appears to be mainly due to countries with relatively long usual working hours experiencing a downward trend. Furthermore, earlier studies indicate that overall working hours

in the Nordic countries have been relatively stable (Eurofound 2016b). We analysed in more detail whether convergence or divergence occurred between the Nordic countries and genders when a set of structural factors were controlled for. Our results indicated a degree of divergence between the countries: usual working hours and the incidence of part-time work were relatively stable in Finland and Sweden, but working hours decreased in Denmark and Norway (Riekhoff et al. 2019a).

2.2.2 Unsocial working hours

Earlier studies indicate that working non-standard hours appears to be a widespread phenomenon in the US (Presser 2003) and Europe. In European countries, based on the 2005 labour force survey data, between 15% and 30% of wage earners usually work at night, in the evenings or in shifts, whereas between 20% and 35% of respondents usually work on Saturdays and Sundays (Presser et al. 2008). Using the 2010 EWCS data, Anttila and Oinas (2018) found that in most European countries, more than 50% of the workers worked during weekends at least once a month, between 40% and 60% worked in the evening, and less than 25% worked at night. However, there is only little evidence that these figures are part of an increasing trend of unsocial working hours across the working population and across countries (Hamermesh 1999). One Eurofound (2015) study indicated that Saturday work remained almost unchanged for over a decade, while Sunday work increased slightly from 13.5% to 14.6% between 2004 and 2014. The same report showed that overall in Europe, the incidence of shift work changed very little over time. In addition, little change was observed in evening and night work, in which the proportion of those who *usually* worked evening and night hours declined, and there was only a slight increase among those who *sometimes* worked these hours (Eurofound, 2015). Country studies in Belgium (Glorieux et al. 2008) and Finland (Anttila & Oinas 2018, Ojala & Pyöriä, 2015), which used detailed time-use survey data over longer periods of time, demonstrated substantial differences between the countries, but found no trend toward a 24/7 society in any of these countries.

2.2.3 Working time dimensions and work-life balance

Earlier studies on the linkages between working time dimensions and work-life balance have shown that a long working week (Grzywacz & Marks 2000, Crompton & Lyonette 2006), unsocial working hours (Gallie & Russell, 2009), and a high working time tempo (Grzywacz & Marks 2000, McGinnity & Calvert, 2009) usually have negative effects, and working time autonomy has positive effects on employees'

perception of the balance between work and other life spheres (Fagan et al. 2012). Based on meta-analytic research, Byron (2005) concludes that individual schedule flexibility is negatively related to work-family conflict. Another meta-analytical study by Michel and colleagues (2011) found that schedule flexibility benefited those who were married or parents. Hughes and Parkes (2007) found that high individual work-time control buffered the negative effect of longer hours on work-family relations. According to a comparative analysis of the European countries (Anttila et al. 2015), the Nordic countries appear to be a group of countries in which employees have a high level of autonomy regarding their working hours and the opportunity to work outside company premises, but also suffer from considerable time pressure at work. This northern group differed from all other country groups in its higher incidence of good work-life balance.

2.3 Recommendations

2.3.1 Usual and part-time working hours

Important factors that reinforce differences between countries and genders but that are not directly measurable using labour force survey data, are policy reforms and societal norms. The convergence in working hours between men and women in Norway and Sweden might be due to more gender-oriented work-life balance policies (Björnberg 2016, Haataja 2009). Differences in the norms regarding full-time work might explain why part-time work is still so much more uncommon in Finland than in its neighbouring countries. Nevertheless, norms are not static and can change, bringing along changes in practices. Mósesdóttir and Ellingsæter (2017), for example, have shown how in Norway, the norm of women working part-time is under pressure, and is slowly altering (see also Nätti & Nergaard 2019).

2.3.2 Unsocial hours

Given their wide occurrence and far-reaching negative effects, the regulation of non-standard work schedules has been a logical approach to limiting negative effects. At the EU level, the European Directive of Working Hours forces national legislation in the European Union, unlike in most other countries outside Europe. In addition, any effective strategy for addressing this issue must involve effective employee organizations, as well as the active engagement and commitment of employers. Collective agreements are made between employee and employer organizations. Thus, both have the right to modify the appliance of working time regulations by

law in the EU. This allows interaction between top-level (directive) and national and local level regulation, with a great deal of flexibility and interactions. Another issue is whether the regulations associated with well-being of the rather strict Directive are always sufficiently followed.

In addition, as unsocial working hours are unlikely to be completely eradicated, solutions should also be sought in occupational health and family policies. For example, the contribution of workplaces to occupational safety activities can help lower the risks of accidents and adverse health effects, and flexible access to childcare facilities might offer opportunities to reduce tensions between work and family life. Finally, a job with unsocial working hours may suit someone during a certain phase of life (e.g., a young person with no children) or might serve as a stepping stone to a job with more standard working hours. To avoid dead ends in one's working life, policies should aim to enable skill-upgrading, occupational mobility and sustainable working times over the life course.

2.3.3 Work-life Balance

Paid working hour arrangements are a central issue in European social policy. One of the main aims of the European Social Policy Agenda (see European Commission, 2019) has been to increase the employment rate, especially that of women. It is expected that a good balance between paid work and other life spheres will help achieve this goal. Analyses of the WOW project studies have shown that working hours are closely related to perceived work-life balance. Both the duration and timing of working hours predict perceived work-life balance.

3 LENGTH OF WEEKLY WORKING HOURS

Ann Dyreborg Larsen, Helena Schiller, Anne Helene Garde, and Göran Kecklund

Average weekly working hours are discussed in detail in Chapter 2 (Working hours in the Nordic countries). Overall, Finland has longer weekly working hours than the other Nordic countries. In 2016, the shortest weekly working hours were observed in Denmark. Part-time work, defined as less than 35 hours per week, is common in the Nordic countries: approximately 35% of women work part-time and the prevalence of part-time work among Nordic men is approximately 15%. Denmark has the highest prevalence of part-time work (35% in 2016), followed by Norway and Sweden (approximately 25%), whereas the lowest prevalence has been observed in Finland (15%) (Riekhoff et al. 2019a). Part-time work is also more common in certain sectors, such as health care, education and the service sector.

In this section, we report on WOW's scientific results related to the length of working hours. The section is split into studies on long weekly working hours and studies on short weekly working hours - with or without retained salary.

3.1 Association between long weekly working hours and health

Working time, especially long weekly working hours, has been subject to research for many years, and the research has had various health issues as outcomes. In the WOW project, it has been possible to study weekly working hours in relation to ischaemic heart disease (IHD), the use of hypertensive drugs, stroke, mortality, injuries (Larsen et al. 2017, Hannerz et al. 2018a, Hannerz et al. 2018b, Hannerz & Soll-Johanning 2018) and subjective health-related symptoms such as stress and sleep problems. Using the data from the Danish version of the EU LFS (Eurostat 2019), long working hours were studied in relation to health outcomes in a large, representative sample of the Danish labour force. With 120 000–160 000 study participants, the studies are, with respect to several of the outcomes, the largest single studies to date. Labour force surveys gather person-based information on weekly working hours. WOW's scientific results have shown that when the Danish study population was separated into 32–40 hours/week, 41–48 hours/week, and 48+ hours/week, the main part (84%) of the study population worked 32–40 hours/week, whereas 10% worked 41–48 hours/week, and only 6% worked more than 48 hours/week.

When studying IHD and the usage of antihypertensive drugs (Hannerz et al. 2018b), we combined information on weekly working hours from the labour force survey with clinical endpoints drawn as diagnoses from the National Patient Register (Lynge et al. 2011) or redemption of a prescription for antihypertensive drug usage from the Danish National Prescription Register (Kildemoes et al. 2011). We found no association between long weekly working hours and IHD or antihypertensive drug usage. Furthermore, when tested, we also saw no influence of sex, socio-economic status, or night work.

The primary aim of a study of strokes (Hannerz et al. 2018a) was to test whether findings from a large systematic review and meta-analysis could be reproduced in a large single study based on Danish data. To align with the previous study, we divided weekly working hours into <35, 35–40, 41–48, 49–54, ≥55 hours/week. Stroke diagnoses were drawn from the National Patient Register (Lynge et al. 2011). Our analysis did not support the hypothesis that long working hours were associated with increased rates of overall stroke in Denmark. It did, however, suggest that when strokes were divided into haemorrhagic and ischaemic stroke, long working hours were associated with increased rates of haemorrhagic stroke. In this context, it is interesting that haemorrhagic stroke constituted one fifth of overall stroke morbidity. It is also interesting that haemorrhagic stroke was associated with a lower life expectancy, as well as lower odds of returning to work, than ischaemic stroke (Hannerz & Nielsen 2001, Hannerz et al. 2011).

A study of long working hours and mortality (Hannerz & Soll-Johanning 2018) tested the EU Working Time Directive's threshold of 48 hours/week. Information on mortality was drawn from the Danish National Register of Cause of Death (Helweg-Larsen 2011). Of the study participants, 3374 died during 2002–2013. We found that when 32–40 hours/week was a reference, participants with moderately long weeks (41–48 hrs/week) were at a 25% lower risk of premature death and participants with 48+ hours/week were at an 8% lower risk of premature death.

Finally, we tested the association between weekly working hours and the risk of accidental injuries in both Denmark (Larsen et al. 2017) and Finland (Härmä et al. 2020). In the Danish study, we also tested whether the associations were affected by age, sex or socio-economic status. Neither the Danish nor the Finnish study found any association between long weekly working hours and accidental injuries, or any interaction with age, sex or socio-economic status. To the best of our knowledge, these two are by far the largest prospective cohort studies to be conducted on long working hours and the risk of accidental injuries.

3.2 Existing knowledge

During the WOW project period, the IPD-Work (Individual-Participant Data meta-analysis in working populations) consortium (Kivimäki et al. 2015) investigated the relationship between long weekly working hours and several health outcomes, including coronary heart disease, stroke, venous thromboembolism, atrial fibrillation, depressive symptoms and cancer, by use of systematic reviews and meta-analyses on both published and non-published data from several large cohort studies around the world.

Based on 25 studies from 24 cohorts in Europe, USA and Australia, and more than 600 000 individuals, the IPD-Work consortium found that employees who work long hours (≥55 hrs/week) are at a higher risk of *stroke* than those working standard hours, and that the association with *coronary heart disease* was weaker (Kivimäki et al. 2015). With regards to *atrial fibrillation*, the IPD-Work consortium found long weekly working hours of 55 hours or more to be associated with this endpoint. No associations were found with working under 55 hours/week (Kivimäki et al. 2017). As regards *venous thromboembolism,* similarly to previous studies, the results were only statistically significant for the association with weekly working hours when working more than 55 hours/week (Kivimäki et al. 2018).

In the study of weekly working hours and *depressive symptoms*, the IPD-Work consortium found an overall association between long working hours (≥55 hrs/week) and depressive symptoms. Further tests revealed that the association appeared to vary by geographic region: the studies from North America and Australia found no association between long working hours and depressive symptoms, the studies from Europe found a weak association, and the studies conducted in Asian countries found a stronger association (Virtanen et al. 2018).

The study of long weekly working hours and *cancer* found no clear evidence of an association when all types of cancers were included. Working 55 hours/week or more was associated with female breast cancer, but not incident colorectal, lung or prostate cancers (Heikkila et al. 2016).

The WOW results were included in a recent review and meta-analysis by the World Health Organization (WHO) and the International Labour Organization (ILO). They found ‘inadequate evidence for harmfulness’ when exposed to working hours of 41–48 and 49–54 hours/week for IHD (incidence, prevalence and mortality), but ‘sufficient evidence of harmfulness’ for IHD (incidence and mortality) when working

55 hours/week or more (Li et al. 2020). Further, they found 'inadequate evidence for harmfulness' for working hours of any length in regard to stroke prevalence and mortality and incidence when working 41–48 hours/week. Working 48–54 hours/week showed 'limited evidence for harmfulness' for stroke incidence and working 55 hours/week or more showed 'sufficient evidence for harmfulness' (Descatha et al. 2020). WHO and the ILO are currently preparing systematic reviews on exposure to long working hours and the risk of alcohol intake and depression (Godderis et al. 2018, Rugulies et al. 2019).

3.3 Part-time work

Part-time work has several operational advantages. For example, it promotes flexibility and better control of fluctuations in staffing demands. From the workers' point of view, part-time work is beneficial for work-life balance and provides more time for family responsibilities, leisure activities, social commitments, and recovery (Fagan et al. 2014). Part-time work may also make it easier for young adults to enter the labour market and extend working life for older workers. In addition, for employees with work disability, part-time work (combined with sick leave) seems to improve return to work and increases work participation compared to being on full-time sick leave (Viikari-Juntura et al. 2017).

However, several studies have found also part-time work to be associated with health risks. Sokejima and Kagamimori (1998), as well as Kivimäki et al. (2015), observed a U-shaped relation between mean daily (or weekly) working hours and the risk of coronary heart disease. A meta-analysis by Kivimäki et al. (2015) showed that workers working less than 35 hours/week showed a trend towards a higher risk of suffering a stroke. Furthermore, several cross-sectional studies have shown that part-time work is associated with depressive symptoms and poor self-rated health (Oenning et al. 2018, Oenning et al. 2019). The reason for these findings is probably related to healthy worker selection; workers who are sick are more likely to work part-time. Moreover, part-time work is often associated with job insecurity, poorer wages (leading to economic stress), lower job quality, multiple jobs, and poorer work scheduling (for example, a high degree of split shifts), which may have adverse consequences for long-term health (Fagan et al. 2014).

Whether or not reduced weekly working hours is voluntary is presumably a critical factor for the association between part-time work, health and well-being. Involuntary part-time work, due to not being able to find a full-time job (also called under-

employment), has been associated with poorer job quality and more mental health problems (Kauhanen & Nätti 2015, Mousteri et al. 2020).

3.4 Experiments with reduced weekly working hours with retained salary

In recent years, the debate on reduced weekly working hours with retained salary has escalated in the Nordic countries. Those who advocate shortening working hours with retained salary emphasize the beneficial effects on health and well-being. They argue that a shorter working week makes employees more efficient at work, and that shorter workdays mean that the balance between work and other life domains will lead to better recovery opportunities between workdays. There is some empirical support for these arguments (Nätti & Anttila 1999, Åkerstedt et al. 2001, Anttila et al. 2005, Lorentzon 2017). A reduction from 8 hours/day to 6 hours/day with retained salary has shown positive effects through reduced pain in the neck- and shoulder area for employees with physically demanding professions (Wergeland et al. 2003). A minor reduction (2.5 hrs) of weekly working time with retained salary showed small beneficial effects on health among female dentists (von Thiele Schwarz et al. 2008), which seemed to be related to increased physical exercise. Moreover, three Swedish reports have found reduced working time with retained salary to improve general well-being, yield increased energy, and lead to less overall stress, although results regarding sickness absence are mixed (Olsson 1999, Bildt et al. 2007, Lorentzon 2017).

However, as opposed to part-time work, reduced working hours with retained salary may also imply recruitments of new staff in order to cover the workload. Even though shortening working hours with retained salary might be a way of ameliorating recovery opportunities and promoting health, longitudinal research and intervention studies in this area are scarce. Moreover, these studies mainly date back 10 to 20 years.

Two WOW scientific papers evaluated a 25% reduced weekly working time with retained salary and its consequences for perceived stress, sleep and sleepiness over time. The papers were based on a large-scale, longitudinal intervention study that consisted of more than 500 full-time employees working mainly in the public sector. The results showed that time spent on recovery activities and sleep duration increased during workdays (Schiller et al. 2017, Schiller et al. 2018a). Moreover, sleep quality improved, and sleepiness and perceived stress decreased when working hours were reduced (Schiller et al. 2017). Thus, the results support previous findings of studies with smaller study groups (Nätti & Anttila 1999, Åkerstedt et al. 2001, Anttila et al. 2005).

Shortening working hours can reduce fatigue and sleepiness.

However, critics point out that reduced working hours with retained salary is very costly and that there is still no evidence of decreased rates of sick leave or increased productivity as a result. One negative aspect could also be that the actual workload does not diminish and that a shortening of working hours may only lead to more stress and time pressure at work (Erlandsson et al. 2012).

3.5 Conclusion on the basis of existing evidence

When studying working for >55 hours/week, several large international studies have found that very long weekly working hours are associated with an increased risk of ischaemic heart disease, stroke, atrial fibrillation, venous thromboembolism, depression, and breast cancer, but not cancer in general. In the same studies, the risk did not increase when people worked up to 48 hours/week. The latter results were also supported by large Danish studies, which generally found no increased risk when working more than 48 hours/week, which may partially be explained by the low number of employees with very long weekly working hours in Denmark, the healthy

worker effect, and the differences between societal contexts; for example, access to social security and access to free health care.

The health consequences of part-time work depend to a large extent on the context. Involuntary part-time work is often associated with job insecurity (temporary positions) and financial strain, which may have adverse health consequences.

A few Finnish and Swedish studies have evaluated reduced working hours, namely 6 hours/day or 30 hours/week, with retained salary. Their results indicate that reduced working hours with retained salary are beneficial for subjective health symptoms, perceived stress, sleep, recovery opportunities, pain experience, and well-being. However, evidence is insufficient to enable any conclusions regarding objective health indicators (e.g. sickness absence) and productivity.

3.6 Recommendations

Overall, the results regarding long working hours and health provide no reason to change the limits of the EU Working Time Directive: employers should ensure that their staff do not work more than 48 hours/week on average (including overtime), over a reference period of up to four months.

This does not mean that everybody can necessarily work 48 hours/week. Exceptions could be employees with diseases or in low socio-economic status jobs.

Part-time work may have both positive and negative consequences. Examples of positive effects are increased work participation, improved return to work for individuals on long-term sick leave and extended working lives for older adults. However, involuntary part-time work may also be associated with increased health risks.

Reduced working hours (for example, a 6-hr/day), with retained salary, is a special case of part-time work. So far, the results of such interventions have shown beneficial effects on subjective health and well-being in Finland and Sweden. However, it must be noted that a reduction of working time with retained salary is generally very expensive, and health economists should evaluate the costs and benefits before large-scale implementation can be recommended.

4 SHIFT WORK, HEALTH AND WELL-BEING

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4.1 Night work and work shifts: intensity and organization

Shift work is defined by the ILO and the European Directive 2003/88/EC as 'a method of organizing working time in which workers succeed one another so that the establishment can operate longer than the hours of work of individual workers'. The number of shifts (intensity), type of shifts (e.g. morning, evening and night), and the organization of consecutive shifts (e.g. rapidly or slowly rotating shift work) can vary between or within different shift systems. Night work - a primary concern of shift work in relation to health - has been defined as a work shift of at least three hours including the period from midnight to 5 am (European Directive 2003/88/EC).

Over 20% of employees are shift workers in Europe and 19% work at night-time at least once a month. Shift work is the most common in the following sectors: health care (40%), transport (33%), industry (28%), and commerce and hospitality (27%) (Eurofound 2017). In the WOW project, we compared the working hour characteristics of the largest sector using shift work, i.e. the health care sector, in Denmark, Finland and Norway (Garde et al. 2019). The frequency of nurses working in rotating night shift work was the highest in Norway (41%) and lower in Denmark (22%) and Finland (22%). Permanent night work, i.e. periods of working only during the night, was prevalent among 2–5% of the employees. For example, whereas 93% of the hospital workers with a shift work contract in one hospital district in Finland had at least one night shift per year, 23% were exposed to high-intensity night work (defined as the proportion of night shifts being ≥25% of all shifts) (Härmä et al. 2015). The intensity of night work, in terms of the annual number of night shifts, is normally lower in the service sector than in industrial 24/7 shift work.

Overall, research on the observed health effects of night and shift work has found shift work including nights to be associated with a higher risk of some chronic diseases than shift work without night work (Kecklund & Axelsson 2016). A number of possible pathways between night work and disease has been suggested, the most

important being general circadian disruption and disturbed sleep (Puttonen et al. 2010a, Stevens et al. 2011). The higher the number of consecutive night shifts, the greater the degree of circadian disruption in rotating shift work (Jensen et al. 2016), which has been suggested to be a possible link between night shift work and health impairments, including cancer and well-being.

In this section, we report the findings on the association between the intensity and organization of early morning, evening and night shifts as exposures, and health, well-being and participation in working life, using for example, sickness absence and early retirement as outcomes. The focus is on the studies published by the WOW consortium.

4.1.1 WOW scientific results

Cancer. Based on the Swedish Twin Registry (STR), long-term exposure to night shift work (>20 years) was related to an increased risk of incident *breast cancer* during a follow-up of 12 years (Åkerstedt et al. 2015). This study utilized self-reported exposure data and controlled for a large number of potential confounders. Shorter exposure to night work showed no notable effects on the risk of breast cancer. Similarly, using objective payroll data of exact working hours in the Danish DWHD cohort, including a maximum of five years of follow-up, the study found no support for short-term effects of night shift work on breast cancer risk. The results nevertheless weakly supported the possibility that the association of breast cancer with night shift work may be linked to HER2 (human epidermal growth factor receptor 2) receptor status (Vistisen et al. 2017). The Swedish Twin Registry cohort (Åkerstedt et al. 2017) showed no association between exposure to night shift work and prostate cancer, regardless of duration of exposure.

Cardiovascular diseases and risk factors. A cross-sectional design within the SUSSH cohort revealed that the number of night shifts worked in a year was positively associated with increasing body mass index (BMI), a well-known risk factor for cardiovascular disease (CVD) (Buchvold et al. 2015). Furthermore, the increase in the BMI of night workers was higher than that of day workers in a four-year follow-up study (Buchvold et al. 2018). An FPS cohort study, based on self-reported exposure information and a mean follow-up time of up to 11 years, which used registry data on prescribed medication, found mixed evidence from two cohorts regarding the association of shift work with hypertension, diabetes and dyslipidaemia (Tucker et al. 2019). Results from the larger 10-town study cohort, however, showed that among

middle-aged participants, shift work with night shifts was associated with increased use of medications for dyslipidaemia after adjustments for confounders, and that shift work without night shifts was associated with an increased use of medications for type-2 diabetes. Shift work both with and without night shifts was associated with an increased use of medications for hypertension in the 10-town cohort (Tucker et al. 2019). Working at night, based on the Danish Labour Force Survey linked to register data with diagnosis or drug use, was also associated with an increased risk of anti-hypertensive drug use, but not ischaemic heart diseases (Larsen et al. 2019).

Neurological diseases and mental health. Using two large population-based cohorts in Sweden with a long follow-up, Bokenberger et al. (2018) found that ever having shift work or night shift work was associated with higher dementia incidence. Increased duration of shift work and night work was associated with an increased risk of dementia. Two smaller Danish studies found no association between shift work and dementia (Nabe-Nielsen et al. 2017, Nabe-Nielsen et al. 2019). However, a higher risk of dementia was found in a subgroup of permanent night workers (Nabe-Nielsen et al. 2019). Using a Swedish population-based case-control study, Hedström et al. (2015) found that the risk of developing multiple sclerosis increased among those who started working shifts at a young age, i.e., before the age of 20, but observed a less pronounced association among those who started working shifts aged 20 or later.

Based on cross-sectional data from the SUSSH cohort (Bjorvatn et al. 2018), frequent headache, migraine and chronic headache were associated with shift work disorder (SWD) and insomnia but not with work schedule, number of night shifts or number of quick returns. Tension-type headache was associated with having worked 20 night shifts or more during the last year. According to the one-year follow-up of the SUSSH cohort, shift work was not associated with new cases of anxiety or depression (Berthelsen et al. 2015) and the effects of shift work on mental distress were not moderated by psychosocial work factors. The SLOSH survey, which linked prescription medication registers with a two-year follow-up, found no association between shift work and purchases of anti-depressant medication (Hall et al. 2019). However, another prospective cohort study based on SLOSH found that night workers in male-dominated occupations (occupations in which the workforce is predominantly male) were more likely to report symptoms of mild depression than their day-working counterparts; but no such trend was found for female-dominated occupations (Tucker et al. 2020).

Shift work is most common in social and health care sector.

Musculoskeletal and connective tissues. In a Swedish case-control study (Hedström et al. 2017), rotating and day-oriented shift work increased the risk of anti-citrullinated protein antibody (ACPA)-positive rheumatoid arthritis (RA). Permanent night shift workers appeared to be at a lower risk of both ACPA-positive RA and ACPA-negative RA. Kärkkäinen et al. (2017) found that night shift work was associated with an increased risk of disability pensions due to musculoskeletal disorders, independently from health and lifestyle factors.

Maternal health and miscarriage. Hammer et al. (2018) found that three or more consecutive night shifts during the first 20 weeks of pregnancy were associated with a 41% increased risk of hypertension and pre-eclampsia. Obesity among the pregnant women increased the risk 4–5-fold, when working long night shifts, longer spells of consecutive night shifts, and having many quick returns after night shifts. Night shifts, especially those lasting more than 12 hours, were associated with an increased risk of sick leave during all three pregnancy trimesters (Hammer et al. 2019a). The DWHD results did not find that night work during pregnancy increased the risk of postpartum depression among hospital employees (Hammer et al. 2019b).

However, women who stopped working night shifts after the first trimester were at an increased risk of postpartum depression, suggesting the healthy worker effect. Based on DWHD and the payroll data of working hours (Begtrup et al. 2019), women who had worked two or more night shifts the previous week were at an increased risk of miscarriage after the eighth week of pregnancy, compared to women who did not work night shifts. The accumulated number of night shifts during weeks 3–21 of pregnancy increased the risk of miscarriage in a dose-dependent pattern. However, among night-shift workers, the risk of pre-term birth was not related to the number of night shifts, the duration of night shifts, consecutive night shifts, or quick returns defined as short intervals between shifts (Specht et al. 2019).

Accidental injuries. The Danish version of the EU LFS, with over 150 000 participants, found that survey-based exposure to night-shift work was modestly associated with accidental injuries requiring hospital visits (Larsen et al. 2017) regardless of the workers' age, sex or socio-economic status. Using payroll data from the DWHD and register data on injuries from hospitals' emergency wards (Nielsen et al. 2018), the risk of injury was higher after a week of evening work and night work compared to weeks with only day work. Similar, although attenuated, estimates were found for evening work among evening workers, and for night work among night workers. Nielsen et al. (2019) found a higher risk of injury after quick returns (<11 hrs between the shifts) than after the standard interval between shifts, with a linearly increasing risk when shift intervals were shortened down to 3–5 hours.

The association between working hours and occupational injuries was further studied in the WHFPS, using a case-crossover design, and 18 700 hospital employees with their first incidence of occupational injury. The study found an elevated risk of occupational injury on workdays with evening shifts and on workdays following night shifts. Injury risk increased following a week of five or more morning shifts or three or more evening shifts. It did not increase according to the number of preceding night shifts. The length of the work shift, but not the length of the weekly working hours, was associated with an increased risk of occupational injuries (Härmä et al. 2020). A cross-sectional study using data on self-reported working hours and accidents by Vedaa et al. (2019) found that quick returns and night shifts were both associated with self-reported work-related accidents, near-accidents and dozing off at work. Similarly, a fairly consistent pattern emerged in which changes in the number of quick returns over a two-year follow-up period was associated with a corresponding change in the risk of occupational accidents (Vedaa et al. 2020).

Work-life conflict. Using the WHFPS data, Karhula et al. (2017, 2018) showed that shift workers more often had difficulties combining working and non-working life than day workers. Several working hour characteristics, especially evening work, but also night shifts, were associated with the work-life conflict.

Sickness absence. In a cross-over study using objective data from the WHFPS, exposure to ≥2, and especially ≥4 consecutive night shifts was associated with an increased likelihood of short (1–3 days) sickness absence among shift workers, whereas a high number (>25%) of evening shifts and having ≥2 consecutive evening shifts was associated with lower odds of sickness absence (Ropponen et al. 2019). A payroll-based study of over 37 000 nurses, using combined data from both Denmark (DWHD) and Finland (WHFPS) examined the association between working hour characteristics and long-term sickness absence (30+ days) (Larsen et al. 2020). The Danish data showed that evening workers and participants with five or more consecutive night shifts were at a higher risk of long-term sickness absence. When pregnant women were excluded, night workers were also at a higher risk of sickness absence. When stratified by age group, the risk of sickness absence was lower in the youngest age groups and higher in the oldest. The Finnish data showed mostly similar tendencies when stratified by age group.

Sleep and *fatigue*. The prevalence of SWD was studied using the WHFPS data and objective exposure data (Vanttola et al. 2020a, see also Section 6.3 Assessment and treatment of shift work disorder). SWD was defined as shift-related insomnia and/or excessive sleepiness (ICSD-2), also in combination with the reduction of total sleep time (ISCD-3). The prevalence of ICSD-3 based SWD was 3.4% in shift work without nights, 5.8% in shift work with nights, and 6.0% among permanent night workers. ICSD-2-based prevalence (without the requirement for sleep restriction) was higher: 8.8%, 18.2%, and 16.7%, respectively. Using a six-year follow-up, we studied the association between shift work with and without night shifts and sleep and fatigue (Härmä et al. 2019). Compared with day work, exposure to shift work with night shifts was associated with increased fatigue during days off and a change towards longer sleeping. Exposure to shift work without night shifts increased long sleeping but not fatigue during and after days with work shifts. A change from day work to shift work was associated with an increased risk of long sleep, and a change from shift work to day work with a decreased risk of long sleep and fatigue. In another study we examined whether changes in individual shift characteristics were associated with sleep (Härmä et al. 2018). Changes in night but not in morning or evening shifts were associated with parallel changes in the odds of longer sleep and fatigue during

days off. Similarly, several consecutive night shifts were associated with increased odds of fatigue during work and difficulties falling asleep. Among workers aged ≥50, the associations were strongest between night shifts and longer sleep. However, a prospective cohort study based on SLOSH (Tucker et al. 2020) found no associations between shift work (with or without night work) and self-reported sleep disturbance.

Mortality. Self-reported exposure to shift work, based on the Danish Labour Force Surveys linked to national all-cause mortality data, found no notable association between night work and all-cause mortality among employees in the general workforce (Hannerz et al. 2019). Another population-based study (Åkerstedt et al. 2020), based on the STR, reported a statistically significantly increased risk of mortality among shift workers after long-term exposure (over five years), specifically among male white-collar workers, compared to day workers. Associations with mortality due to cardiovascular diseases and cancer were both significant after long-term exposure. The Danish Nurse cohort study (Jørgensen et al. 2017) found that working night or evening shifts was associated with a significant increase in all-cause mortality compared to working day shifts. There were also positive associations between night shift work and mortality from cardiovascular diseases and diabetes, and between evening and rotating shift work and mortality from Alzheimer's disease and dementia.

4.1.2 Other scientific evidence and conclusions

In conclusion, the WOW findings provide new, extended support for associations between exposure to night shift work and several chronic diseases such as rheumatoid arthritis, type-2 diabetes, and hypertension. Exposure to night shift work was also associated with miscarriage, hypertension and preeclampsia during pregnancy, and an increased risk of occupational injuries, sickness absence and disability pensions. We found mixed results for the association between night shift work and breast cancer, mortality and dementia, and no support of an association between night shift work and prostate cancer.

The strengths of the WOW epidemiologic cohorts that produced these results are the large size of the cohorts, the long follow-up in several of the studies, and the use of precise exposure assessment in most studies. In particular, the use of payroll-based register data on daily working hours in the WHFPS (Härmä et al. 2015) and DWHD (Garde et al. 2018) enabled us to evaluate the risks in relation to the intensity and organization of the morning, evening and night shifts. In addition, the SUSSH cohort included specific questions on shift characteristics, increasing its validity in

the evaluation of exposure to night work and other key shift characteristics. Further, we found that while the survey questions used for permanent day work, shift work with night shifts and permanent night work were sufficiently valid compared to the use of objective data (payroll-based daily working hours), exposure misclassification in self-reported shift work may have contributed to exposure misclassification in the epidemiological studies on shift work without night shifts (Härmä et al. 2017). This emphasizes the need for more precise and confirmatory studies using life-long objective data on shift work, particularly in studies of shift work without night shifts.

The International Agency for Research on Cancer (IARC) re-evaluated night work and cancer risk in 2019, and some WOW researchers were appointed due to their expertise in exposure assessment methodology and epidemiology (IARC 2020). The combined IARC Working Group classified night shift work as 'probably carcinogenic to humans' (Group 2A), based on limited evidence of cancer in humans (breast, prostate, and colorectal cancer), sufficient evidence of cancer in experimental animals, and strong mechanistic evidence in experimental animals. The IARC Working Group also concluded that the association with breast cancer was strongest in high-intensity (i.e. high number of nights or more night hours per week) and long-duration night shift work. Further, these associations may be stronger among premenopausal women. The Working Group also concluded that the variation in the findings of most case-control and cohort studies may be attributed to differences in night work exposure assessment quality, poor study design, or the inclusion of mainly older post-employment women in some cohort studies that might not be able to determine an effect in younger women.

Our findings on the association of night shift work with outcomes other than cancer are mostly in line with earlier studies (Pan et al. 2011, Wagstaff & Sigstad Lie 2011, Vyas et al. 2012, Bonde et al. 2013), indicating that shift work increases the risk of some chronic diseases, especially cardiovascular diseases, type-2 diabetes, occupational injuries, as well as the risk of miscarriage and to maternal health. In many cases, WOW has been able to produce more precise estimates on the association between night shift work and the risk of chronic diseases. Valid exposure assessment is critically important in the interpretation of epidemiological studies as well as in the process of making recommendations for prevention. The findings on the associations between shift work and dementia, rheumatoid arthritis and multiple sclerosis can be regarded as novel due to the limited number of earlier studies with these outcomes (Puttonen et al. 2010b, Hedström et al. 2011, Jørgensen et al. 2017, Jørgensen et al. 2020). However, replication studies are needed.

Intensity and organization of work shifts

The WOW studies generally support the earlier literature (Sallinen & Kecklund 2010, Kecklund & Axelsson 2016) on the significance of night shift work and the number of consecutive night shifts for the short-term effects of shift work; sleep, fatigue, occupational injuries and miscarriage/maternal health. The prevalence of SWD was directly associated with the intensity of night shifts, being highest among permanent night workers and lowest among non-night shift workers in comparison to day workers (Vanttola et al. 2020a). A higher number of consecutive night shifts was associated with more detrimental effects on sleep (Harma et al. 2018, Harma et al. 2019), sickness absence (Larsen et al. 2020, Ropponen et al. 2019), miscarriage (Specht et al. 2019), and maternal health (Hammer et al. 2018).

The cohort studies on the long-term effects of shift work indicated that in addition to shift work with night shifts, shift work without night shifts also increased the risk of some of the studied diseases in a few cases. Shift work with or without night work predicted an increased risk of dementia more than non-shift work (Bokenberger et al. 2018). Similarly, although shift work with night work was associated with impaired cardiovascular risk factors, shift work without night shifts also increased the risk of the use of medication for both type-2 diabetes and hypertension in the FPS study (Tucker et al. 2019). Rotating shift work without night work also increased the risk of ACPA-positive rheumatoid arthritis, whereas permanent night shift workers appeared to be at a lower risk. The above results indicate that in addition to night work, other shift work characteristics (e.g. short time between shifts, irregularity, long work shifts) may also have significance for the observed health risks of shift work. Indeed, in the WOW studies, in addition to night work, other shift characteristics were also associated with, for example, increased risk of sickness absence (Larsen et al. 2020, Ropponen et al. 2019), maternal health complications (Hammer, Flachs et al. 2018), and occupational injuries (Nielsen et al. 2018, Härmä et al. 2020), although knowledge about the possible mechanism is limited and warrants further research. Other studies indicate that night work and the related circadian disruption plays a key role, at least in the case of breast cancer (IARC 2020).

According to the WOW studies, evening shifts were associated with an increased risk of occupational injuries (Nielsen et al. 2018) and long-term sickness absence (Larsen et al. 2020). Increases or decreases in evening work reflected the risk of work-life conflict (Karhula et al. 2018) even more clearly than changes in night work, as also indicated previously (Tuchsen et al. 2008).

We found mixed results with respect to shift work and mortality. One large Danish study observed no association between shift work and mortality in the general population (Hannerz et al., 2019) whereas a Swedish study found a modestly increased risk of all-cause mortality among men (Åkerstedt et al. 2020). A Danish nurse cohort (Jørgensen et al. 2017) showed that working night or evening shifts was associated with an increase in all-cause mortality in comparison to working day shifts. The literature also indicates associations between shift work and cardiovascular diseases and increased mortality after long-term exposure.

4.2 Length of recovery time between shifts

Sufficient recovery opportunity is essential for shift workers, and lack of such has been associated with sleep difficulties and fatigue (Kecklund & Axelsson 2016, Sallinen & Kecklund 2010). Incomplete recovery has been linked to negative outcomes, ranging from pronounced stress reactions (Geurts & Sonnentag 2006) to medical errors (McCormick et al. 2012) and chronic health effects (Kivimäki et al. 2006). Shift work is also generally associated with a higher need for recovery from work (Jansen et al. 2003).

Length of recovery time between shifts, from here on referred to as inter-shift recovery time, describes both the recovery time between two consecutive work shifts and the recovery time between two rows of consecutive work shifts. Short shift intervals, i.e. quick returns, are defined as inter-shift intervals of <11 hours (European Union, 2003). Actual inter-shift intervals may often be much shorter and, in Vedaa et al.'s study (2017a), for example, nearly 2/3 of short shift intervals were <9 hours; some were even less than seven hours. Most commonly, quick returns occur when an evening shift is followed by a changeover to a morning shift the next day. They also exist between night and evening shifts, and between day and night shifts starting on the same day (Kandolin & Huida, 1996, Vedaa et al. 2016). One study that used objective working hour data from three Nordic countries (Denmark, Finland, and Norway) found quick returns to be prevalent among Norwegian and Finnish nursing personnel with 64% and 47% of employees having more than 12 quick returns per year, respectively (Garde et al. 2019). In the WHFPS study, quick returns comprised 16–18% of all shift intervals (Karhula et al. 2019).

The WOW consortium has studied short recovery time between two rows of consecutive work shifts in relation to single days off, short shift intervals after night shift(s) (<28h), and weekend work. A WHFPS study showed that single days off

comprised 21% of all day off periods, and that 41% of all weekends included some weekend work (Karhula et al. 2019). Another WHFPS study reported that short shift intervals (<28 h) after night shifts were rare (Ropponen et al. 2017).

4.2.1 WOW scientific results

The WOW studies have reported several negative outcomes of quick returns. Nielsen et al. (2019) found a higher risk of injury after quick returns than after the standard interval between shifts, with a linearly increasing risk with shift intervals shortening down to 3–5 hours. A recent study showed that the number of quick returns during one year was associated with a higher risk of nurses reporting causing harm to themselves at work, to patients/others and to equipment at work (Vedaa et al. 2019). Further, experiencing an increase or a decrease in the number of quick returns over a two-year follow-up period was associated with a consistent pattern of a corresponding increase and decrease in occupational accidents (Vedaa et al. 2020). However, WHFPS study did not find a significant association between occupational injuries and the number of quick returns during the preceding week (Härmä et al. 2020).

Ropponen et al. (2019) studied the association between quick returns and short sickness absences (1–3 days) utilizing Finnish register data. The results showed that having few (≤3) quick returns over 28 days decreased the likelihood of short sickness absence, whereas having ≥5 quick returns increased short sickness absence. A register-based Norwegian study showed that nurses who had three quick returns per month had 21% more sick leave days the subsequent month than those who had no quick returns (Vedaa et al. 2017a). A Danish-Finnish register study of nursing personnel revealed an increased risk of long-term sickness absence among employees with at least 13 quick returns per year (Larsen et al. 2020).

Härmä et al. (2018) studied recovery using register data on working hours linked to survey responses of sleep and fatigue. A 25% change in the proportion of quick returns was associated with a parallel change in fatigue during work, fatigue during free time, and difficulties falling asleep. Karhula et al. (2017) found that quick returns were among the working hour characteristics that had the highest odds of work-life conflict. In addition, a follow up study found that an increase or decrease in the proportion of quick returns showed parallel changes in work-life conflict (Karhula et al. 2018).

As presented in Section 3 (3. Length of weekly working hours), a time-use study demonstrated a decrease in total workload (-65 min) and an increase in time spent in recovery activities on workdays (+53 min) when the length of work shifts was decreased to six hours, yielding two hours of extra recovery time (Schiller et al. 2018). After a change in the Finnish social and health care sector collective agreement, the proportion of short (<28 hrs) shift intervals after night shift(s) decreased from 5% to 3%. However, simultaneously, the average number of consecutive shifts and the proportion of single days off increased, which implies less time for recovery (Ropponen et al. 2017). Weekend work was associated with work-life conflict, whereas single days off were not (Karhula et al. 2017), and changes over time in these working hour characteristics produced the same results (Karhula et al. 2018).

4.2.2 Other scientific evidence

Previous research on quick returns has mostly focused on sleep and sleepiness, showing that quick returns from evening to morning shift are associated with shortened sleep duration (Axelsson et al. 2004, Dahlgren et al. 2016, Karhula et al. 2013, Vedaa et al. 2016) and increased sleepiness (Karhula et al. 2013, Vedaa et al. 2016) and fatigue (Flo et al. 2014). Recent studies suggest that, in terms of acute negative consequences, quick returns represent an equal, or even greater, problem than night shifts (Dahlgren et al. 2016, Eldevik et al. 2013, Flo et al. 2014). For example, among newly graduated nurses, a higher frequency of quick returns was a significant predictor of poor sleep quality, short sleep, difficulties unwinding, exhaustion, low satisfaction with working hours, and work-family conflict; whereas high frequency of night work did not predict these outcomes (Dahlgren et al. 2016). In a prospective study, the number of quick returns was a significant predictor of SWD (Flo et al. 2014). Other studies have also associated quick returns with higher levels of stress (Åkerstedt & Kecklund, 2017, Vedaa, et al. 2017b) and hypertension (Cho et al. 2020). Nurses with quick returns experienced a higher occurrence of needle stick injuries (Trinkoff et al. 2007). Previous intervention studies have shown that introducing longer recovery time between evening and morning shifts is associated with improved self-reported sleep, alertness (Hakola et al. 2010), and objective physiological recovery among nurses (Järvelin-Pasanen et al. 2013).

A diary study showed that nurses' fatigue decreased, and well-being improved during two recovery days after two night shifts (Haluza et al. 2019). Days off on weekends have been found to be more beneficial for recovery of vigour than days off on weekdays (Drach-Zahavy & Marzuq 2013). In a field study, nurses' sleep durations were at their

shortest and subjective ratings of recovery at their poorest in connection with night shifts and quick returns (Karhula et al. 2013). Organization-level intervention studies to reduce, for instance, long working hours or to redesign schedules to better fulfil ergonomic criteria, have shown positive results in employee well-being (Bambra et al. 2008, Neil-Sztramko et al. 2014, Karhula et al. 2020b). However, the link between changes in well-being and specific shift characteristics is not clearly established.

4.2.3 Conclusions

In conclusion, the WOW consortium has contributed significantly to the existing research on inter-shift recovery. As the consortium has used high-quality research methods and data, including objective data on working hours, the results strengthen previous results regarding the acute negative effects of quick returns on sleep and fatigue. In particular, the WOW consortium has contributed to expanding the research on occupational accidents and short- and long-term sickness absence, which all increase when the work schedules include frequent quick returns. The studied dose-response relationships between quick returns and occupational injuries were novel and show that the risk increases linearly with shift intervals shortening down to 3–5 hours. However, we still lack information on which proportion of the short shift intervals and single days off are scheduled according to employees' requests and which are not, although in both cases, recovery and work-life balance may be jeopardized.

4.3 Recommendations

In the European Union Member States, the Working Time Directive (2003/88/EC) dictates the maximum number of average working hours and the minimum level of daily rest periods. However, the Working Time Directive does not limit the maximum number of consecutive night shifts.

The accumulated knowledge on the association of night shift work, health and recovery, especially in relation to night work including several consecutive nights, which is associated with circadian disruption and several acute and chronic health effects and costs to society, must be taken into account. As discussed in an IARC consensus meeting attended by many WOW researchers, we recommend that the number of consecutive night shifts should be low, preferably a maximum of three, if possible (Garde et al. 2020). Pregnant women should have no more than one night shift a week. In special cases, such as on oilrigs and in other isolated workplaces with

better possibilities to adapt to daytime sleep, additional or other recommendations may apply.

According to the Working Time Directive, the minimum level for inter-shift recovery time is 11 consecutive hours of rest during each 24-hour period, and at least one day off during each week. However, the Working Time Directive also allows for exemptions in, for example, local collective agreements between the employer and the employee representatives. Therefore, this does not always occur in practice. Even though there is a need for more studies to evaluate the causal connection between short inter-shift recovery times and negative health effects (among others), the results from existing research are quite consistent in terms of the association with negative health outcomes. At the organizational level, a Finnish study has shown that it is also possible to reduce the number of short inter-shift recovery periods when planning shift schedules (Hakola et al. 2010).

The implementation of the Working Time Directive depends, however, on national and other contextual factors. Therefore, a stricter policy on exemptions and opportunities for an individual employee to opt out of schedules with inter-shift recovery periods under 11 hours could be relevant. Longer rest periods between shifts may be needed in cases of extended working hours and/or severe circadian disruption, as is also stated in the Working Time Society consensus statement (Wong et al. 2019).

Introducing self-rostering and the opportunity to adjust working hours to personal needs may also reduce possible negative effects in terms of work-life balance (Albertsen et al. 2014) and sickness absence (Turunen et al. 2020), and have positive impacts on job demands and the social environment at the workplace (Hansen et al. 2015, Tucker et al. 2015).

5 FLEXIBLE WORKING HOURS AND WORK-TIME CONTROL

Annina Ropponen, Sophie Albrecht, Timo Anttila, Constanze Leineweber, and Philip Tucker

Working hours are an aspect of working conditions that are regulated by multinational institutions such as the EU, national governments and social partners, and are applied but also often assessed at workplaces (i.e. working hours are registered by employers) (Ganster et al. 2018). At the societal level, the EU Working Time Directive guides both weekly working hours and rest-time periods between workdays. These regulations form the basis of national legislation, as in Finland, where new working time laws came into effect on 1.1.2020.

Definitions of flexible working hours and work-time control

Flexible working is defined here as having employment agreements that promote employees' control over: (1) when, (2) where, (3) for how long, and (4) how continuously the employee works (Blok et al. 2012, Kossek & Thompson 2015, Kossek & Lautsch 2017). This form of *employee-oriented flexibility* refers to the employees' entitlement to influence when and where they work, in accordance with their individual needs and wishes. This is in contrast with arrangements in which the employer determines the employees' working times and location, according to the company's needs (*company-based flexibility*). Here, we focus on employee-oriented flexibility related to working hours, i.e. the time-related autonomy that individuals have over their working hours with respect to the number of hours worked (duration), when the hours are worked (timing) and work tempo (hastiness, intensity) (Anttila & Oinas 2018) (Figure 2).

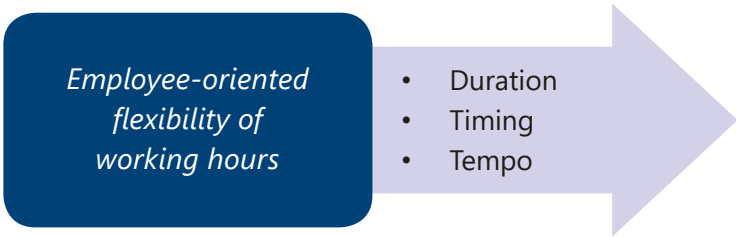

Figure 2. Concept of employee-oriented flexibility in this chapter.

In recent years, flexible working practices have increased dramatically with the surge in mobile technology, which makes it possible to work not only in offices, but also while travelling, at customers' premises, in public places, or other remote locations. This means that employees are available outside normal office hours (Eldridge & Wulff Pabilonia 2010, Ojala & Pyöriä 2013). The latest European estimates indicate that flexibility in terms of working hours is common; 70–75% of employees can take some time off due to personal matters, have a say in their schedules, or take advantage of flexible start and end times (Eurofound & ILO 2019). While flexible working hours are especially common in expert work that is knowledge-intensive, one aspect of flexible work that can be found to varying degrees across all occupations is work-time control.

Work-time control is closely related to flexible working hours but focuses on an individual's ability to influence their own working hours (not the location of work). This type of control allows workers to self-determine the length of their workday, the start and end times of a duty period, which days to work, taking breaks and running private errands during working time, and the scheduling of vacations and other types of leave from work (Ala-Mursula et al. 2002, Albrecht et al. 2016). A WOW study identified two sub-dimensions of work-time control: control over taking time off (i.e. taking breaks, running private errands and taking paid leave) and control over daily working hours (i.e. length of workday, start and end times) (Albrecht et al. 2016).

In this chapter, we report on both the recent knowledge based on the literature and on the results obtained regarding (1) flexible working hours and (2) work-time control in relation to well-being, with a focus on the new results produced by the WOW consortium.

5.1 Flexible working hours and well-being

5.1.1 Flexible working hours: Detachment from and engagement with work

Flexible working hours are generally linked to better health, well-being and work-life balance (Grönlund 2007, Morganson et al. 2010, Nijp et al. 2012, Chandola et al. 2019). However recent studies have also shown negative effects, highlighting the need for additional research in order to understand these contradictory findings (Charalampous et al. 2019, Kröll & Nüesch 2019). It is becoming clear that flexible working hours should have limits that reflect, for example, the importance of the

boundaries between work and leisure time. Placing boundaries on working hours enables detachment from work during leisure time, which is important for recovery, especially when an employee is strongly committed to work (Mellner et al. 2012, Mellner 2016). Although employees who are strongly committed to work feel more energetic and less overloaded after the working week than other workers (Sonnentag et al. 2008, Salanova et al. 2014), a high commitment to work may also lead to longer working hours and impaired recovery. These contrasting effects were highlighted by a meta-analysis which showed that although work engagement improved sleep length and quality, extended working hours negatively affected sleep length and quality (Litwiller et al. 2017). A recent WOW study (Ropponen et al. 2018), based on a sample of employees in knowledge-intensive expert work, found a two-way relationship between daily working hours and recovery during non-working hours. Not only did the length of a workday affect sleep and recovery over the subsequent night, but the degree of recovery experienced prior to a workday (i.e. during leisure time) also influenced the number of hours that were worked the following day (Ropponen et al. 2018).

Good work-time control is associated with better health and well-being.

Individual differences in the effects of flexible working hours. The relationship between working hour flexibility and health varies among individuals, and depends on factors such as age, gender, job complexity, job demands, non-work demands and norms (i.e. regulations) (Kompier 2006, Ganster et al. 2018, Chandola et al. 2019, Charalampous et al. 2019). The findings regarding the effects of flexible working hours in expert work on health and well-being have been mixed. In some studies flexibility has been associated with the promotion of health, but in others it has been associated with health impairment (Grönlund 2007, Kattenbach et al. 2010, Nijp et al. 2012, Ojala et al. 2014). These mixed findings are partly due to the fact that schedules for work tasks set by the employee him/herself may prove to be unrealistic, leading to increased workload and eventually negative consequences for health, such as depression (Weston et al. 2019), reduced well-being and poorer work-life balance (Grönlund 2007, Charalampous et al. 2019).

Potential negative effects of flexible working hours. Another explanation for the mixed effects of flexible working hours on health and well-being concerns remote work and telework (i.e. working elsewhere than the office). Working outside the office is often linked to flexible working hours, and flexibility may lead to feelings of increased time pressure and stress due to a lack of support and contact, or unclear expectations of results (Ojala & Pyöriä 2013, Charalampous et al. 2019). Flexibility may also lead to blurred boundaries between work and leisure time, and consequently to extended working hours (Mellner et al. 2012, Ojala & Pyöriä 2013). This may impact work performance (Binnewies et al. 2009), and recovery from job stress (Sonnentag & Fritz 2015, Chandola et al. 2019).

5.1.2 The extreme of flexible working hours: boundaryless work

Within flexible working hours in knowledge work, a specific case can be boundaryless work which can be defined as employees being less rule-/regulation-based in terms of when, where and on which tasks to work (Allvin 2008, Albertsen et al. 2010, Field & Chan 2018). Boundaryless work exists in today's contemporary working life due to blurred work-non-work boundaries and is especially common among organizational managers (Björk 2013, Mellner 2017).

One WOW intervention study investigated the potential long-term effects of a mindfulness programme on overall working life sustainability among managers (n=40) in boundaryless, knowledge-intensive work in a Swedish telecom company. A randomized intervention study comprised an eight-week mindfulness programme

(Google's Search Inside Yourself) with surveys conducted before, one week after and six months after the intervention. The programme included a standardized mindfulness-based stress reduction programme combined with elements of emotional intelligence. The reference group was on a waiting list for the programme. Mindfulness practice significantly decreased the level of experienced job demands, and improved psychological detachment, recovery, and health, as well as work-life balance, well-being, self-compassion and co-worker relations in terms of care and compassion for co-workers. It also increased the level of mindfulness per se. The significant intervention effects were still evident at six-month follow-up, except for job demands. Moreover, sustained home practice of mindfulness continued to have positive effects on recovery, self-compassion, and co-worker relations (Mellner & Aronsson 2018, Mellner et al. submitted, Mellner & Lychnell in progress). This study indicates that managers who have boundaryless working arrangements in high-stress organizational environments can benefit from mindfulness practice as it has long-term effects in terms of improved psychological detachment, recovery, health, work-life balance and socio-emotional well-being; and increased self-compassion and quality of co-worker relations in terms of care and compassion for co-workers.

5.2 Work-time control and well-being

Mechanisms linking work-time control and well-being. In general, our research and that of others shows that low work-time control tends to be associated with a deterioration in health over time, whereas high work-time control has the potential to protect employees against ill health (Ala-Mursula et al. 2002, Ala-Mursula et al. 2004, Nijp et al. 2012, Karhula et al. 2019). The underlying processes are not yet well understood, but two separate mechanisms have been proposed. One suggests that work-time control helps people align their work commitments with their private lives. The other suggests that it allows employees better opportunities to recover from the strain and effort associated with work, both while at work and outside work. In both mechanisms, the immediate impact of work-time control leads to a reduction in stress, thereby promoting better health (Nijp et al. 2012, Nätti et al. 2014). In WOW, we studied the effects of the use of participatory working time scheduling software to increase work-time control among shift-working hospital workers. In comparison to traditional scheduling with less work-time control, using participatory scheduling software had little effect on objectively measured working hour characteristics but increased perceived control over the scheduling of shifts (Karhula et al. 2020a).

Protective effects of work-time control. WOW consortium studies have added to the body of evidence demonstrating the positive impact of work-time control on work-life balance, health, participation in working life, and accident risk. Using data from the EWCS, one study demonstrated that positive perceptions of work-life balance were most prevalent in countries in which work-hour autonomy was the highest (Anttila et al. 2015). In the same vein, another WOW study based on a large sample of the Swedish working population (SLOSH), which was followed for over two years, found that reduced work-time control predicted an increase in work-life interference among both women and men (Leineweber et al. 2016). These findings are consistent with previous research in which some of the most consistently demonstrated effects of work-time control have been the improvement of work-life balance (Nijp et al. 2012). Supporting the notion that work-time control is beneficial to health through its impact on work-life balance, another WOW study based on SLOSH found that work-time control reduced work-life interference, which in turn lead to a small reduction in symptoms of depression and musculoskeletal disorders (Albrecht et al. 2020). Another longitudinal WOW study found that higher work-time control (particularly control over taking time off) led to a small but significant reduction in depressive symptoms over a six-year time span (Albrecht et al. 2017). Our findings are consistent with earlier evidence that work-time control protects against mental ill-health complaints, including depressive symptoms (Ala-Mursula et al. 2004, Takahashi 2012) and psychological distress (Ala-Mursula et al. 2002, Vahtera et al. 2010), and reduces sleep disturbance (Salo et al. 2014).

Work-time control and work participation. A WOW study based on FPS workers found that sickness absence due to musculoskeletal disorders was lower among those with higher work-time control (Albrecht et al. submitted). Another WOW study based on shift-working hospital workers found a reduction in sickness absence spells and sickness absence days in short absences from wards that used a participatory working time scheduling software (Turunen et al. 2020). These findings are consistent with other findings showing that work-time control predicts lower sickness absence (Ala-Mursula et al. 2002, Leineweber et al. 2013). There is also evidence that work-time control increases the likelihood that older workers will extend their working lives beyond the pensionable age (Virtanen et al. 2014). Another aspect of work-time control examined by WOW was its association with accident risk. Using data from SLOSH, one study showed that workers with low work-time control, in particular low control over taking time off, were more likely to report having an accident in the subsequent two years (Tucker et al. 2016). A few other comparable studies have been conducted, but their findings have been consistent with a later study, which

found that work-time control reduced accident risk, albeit by only a small degree (Nachreiner et al. 2019).

Differences in work-time control across working hour patterns. The extent to which individuals can self-determine their working hours differs between groups of workers. A WOW study found that women, public-sector employees, and shift workers in Sweden all tended to report lower levels of work-time control (Albrecht et al. 2016). These findings are consistent with studies conducted in other countries, including Finland (Ala-Mursula et al. 2004) and Japan (Takahashi 2012), and using one cross-national sample (Lyness et al. 2012).

Work-time control may be especially beneficial for some groups of workers, although the evidence of this is inconsistent. Some studies have found stronger positive effects of work-time control on health among women than among men (e.g. Ala-Mursula et al. 2004). However, one WOW study found that women (but not men) with flexible working hours (which made it likely that the majority had a high degree of work-time control) were more likely to be prescribed anti-depressant medication than those with standard working time arrangements (Hall et al. 2019). This apparently negative effect of work-time control may reflect the different ways in which this control is used by men (e.g. to optimize recovery and paid working hours) and women (to engage in additional unpaid non-work responsibilities). This finding is partly mirrored by results from another WOW study that examined work flexibility (i.e., an individual's flexibility relative to that of their partner). Gender, but not relative work flexibility, affected time use: mothers spent more time on household chores, while fathers reported longer working hours and taking more time for recovery (Leineweber et al. 2018).

Earlier research also suggests that shift workers benefit more from work-time control than non-shift workers in terms of well-being, health and work-life balance (Olsen & Dahl 2010, Nabe-Nielsen et al. 2012). However, the findings of one WOW study indicated that the additional benefits for shift workers do not extend to long-term sickness absence, with both shift and non-shift workers benefitting equally from higher levels of control (Nätti et al. 2014).

Finally, work-time control may be of particular benefit for those with reduced work ability (e.g. due to advancing age or ill-health), as they can adapt their workload and pace to their situation. A WOW study found that work-time control helped reduce sickness absence due to musculoskeletal disorders among older employees, less

well-educated employees, employees with existing musculoskeletal conditions, and employees with a high mental/physical workload (Albrecht et al. submitted).

Potential negative effects of work-time control. As noted above, work-time control may be associated with negative health consequences under some circumstances, or among certain groups of workers (cf. Hall et al. 2019). An earlier Finnish study found that the combination of high work-time control and long working hours was associated with increased sleep problems (Salo et al. 2014). It was suggested that high control may encourage self-imposed long working hours, allowing insufficient time for unwinding in the evenings after work, leading to disturbed sleep. This may be particularly true for men, who more often use higher levels of work-time control to increase working hours, which in turn can create work-life conflicts (Leineweber et al. 2018, Lott 2018). There have also been suggestions that shift workers with irregular schedules and high work-time control might prioritize their free time arrangements (e.g. by compressing the working week into fewer, longer shifts with limited rest breaks between shifts, so as to facilitate longer periods of time off), instead of planning work schedules in accordance with ergonomic principals. However, this suggestion was not confirmed by the findings of a WOW study that examined the associations between work-time control and working hour characteristics (Karhula et al. 2019).

5.3 Recommendations

Given that working hours impact on well-being (Ganster et al. 2018), both workplaces and occupational health service (OHS) agencies should prioritize the early identification of workers at risk of self-imposed excessive working hours. Employees in knowledge-intensive work and their supervisors should be made aware of the circular association between working hours, sleep and recovery, so as to encourage the setting of boundaries and the preservation of leisure time (Ropponen et al. 2018). Guidelines on how to introduce and use flexible working practices (in- and outside of work) should be tailored to the individual characteristics of employees (e.g. age, gender), the type of work, and the way in which work is organized (Kompier 2006, Ganster et al. 2018, Chandola et al. 2019, Weston et al. 2019). Placing limits on work demands is an important measure for the enhancement of employee well-being, especially in knowledge-intensive organizations. Flexible working hours might also be beneficial for older workers in terms of extending working careers (Virtanen et al. 2014, Vanajan et al. 2019).

Regarding work-time control, the weight of available evidence to date points towards beneficial effects on work-life balance, workplaces' social environment, mental/physical health, and protection against early exit from working life and accidents. Even though the effects may be small, work-time control is a potentially useful means of improving the work environment, given that in most occupations it is modifiable to some extent. Workers with low levels of control should be targeted in interventions to guarantee the availability of a minimum level of autonomy. Some research suggests that control over taking time off may be the most beneficial aspect of work-time control.

The recommendations below are intended to compliment national regulations and recommendations for knowledge-intensive expert work and flexible working hours in the Nordic countries:

- Denmark (in English)
- Finland New Working time Act (in Swedish)
- Norway (in Norwegian)
- Sweden (in Swedish)

6 INDIVIDUAL LEVEL MANAGEMENT OF SLEEP AND FATIGUE IN SHIFT WORK

6.1 Fatigue management in safety-critical industries

Mikael Sallinen and Torbjörn Åkerstedt

Human fatigue constitutes a safety hazard in 24/7 safety-critical industries (Sallinen & Hublin 2015). Two complementary approaches can mitigate this hazard. The prescriptive approach is based on the idea of regulating working hours, whereas the risk-based approach utilizes performance metrics (e.g., fatigue levels) to manage the risks of workplace fatigue (Honn al. 2019).

An influential model within the risk-based approach is the event trajectory (Dawson & McCulloch 2005). This identifies the following indicators for managing fatigue: prior sleep opportunity, prior obtained sleep, signs of on-duty fatigue, fatigue-related errors, and fatigue-related incidents. In addition, the time of day should also be considered, as it is an important determinant of sleep and fatigue. The main idea behind the event trajectory is the mitigation of both on-duty fatigue itself and the risks associated with it.

The WOW project has emphasized the first three indicators, complemented by time of day, aiming to mitigate fatigue through scheduling guidelines, biomathematical modelling, personal coping strategies, and self-assessed fatigue levels.

6.1.1 WOW scientific results

Our field studies showed that long-haul truck drivers and civil airline pilots report high fatigue levels during night shifts in particular (Pylkkönen et al. 2015, Sallinen et al. 2017, Sallinen et al. 2018). Among pilots, high fatigue levels were pronounced during overnight flights and among truck drivers during first night shifts. These results stress the role of night shifts as the main fatigue-inducer.

Interestingly, airline pilots reported higher fatigue levels than truck drivers, even though an algorithm-based fatigue modelling tool predicted very similar fatigue levels (Sallinen et al. 2020). One explanation might lie in safety culture and practices. For example, fatigue reporting and fatigue management training are practices that

Fatigue management is important in aviation.

are only regularly used in air transportation, and probably increase awareness of fatigue as a safety-critical factor.

A review identified fifteen types of measures to mitigate on-duty fatigue on an organizational level, such as staffing, scheduling shifts, and health screening (Phillips et al. 2018). Thus, 24/7 safety-critical organizations have possible multiple measures, which also leaves room for adjusting a set of measures according to contextual factors and the resources available.

In sum, our results support adopting more than one organizational fatigue mitigation measure as well as continuously assessing their benefits, even when shift schedules comply with prescriptive sets of rules. One promising organizational measure is biomathematical fatigue modelling based on shift schedules. Within the WOW project, a web-based tool called VIRE was developed for this purpose (Figure 3) (http://vire.arturcloud.com).

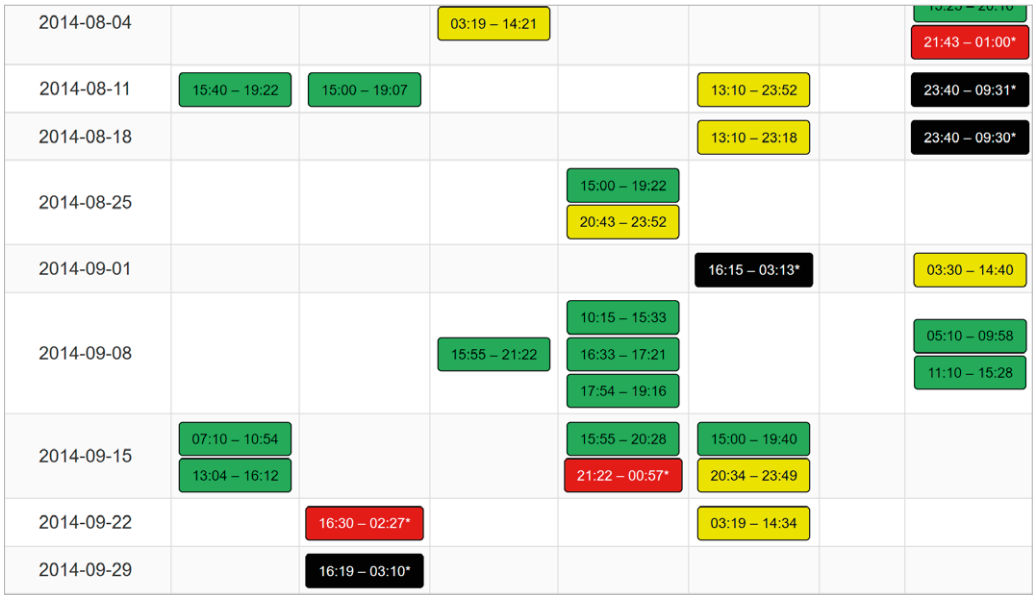

Figure 3. Example of one employee's shifts analysed by VIRE, based on shift start and end times. Green denotes a low, yellow a moderate, red a high, and black a very high risk of sleepiness during a shift. Start and end times are shown inside each bar representing a shift.

6.1.2 Other scientific evidence

Working at night is a well-recognized fatigue-inducer, mainly due to the downswing of circadian-regulated alertness and the low ratio between prior sleep and wake (extended time awake). Earlier evidence has shown that it is difficult to substantially reduce fatigue during night shifts. According to a systematic review, the evidence suggesting that a single person-directed measure, such as a nap break or bright light exposure, would markedly mitigate fatigue in night work is poor (Slanger et al. 2016). This suggests that only multiple, simultaneous measures might make a difference. To use different fatigue countermeasures in an effective and organized manner, many published papers recommend that organizations establish a fatigue management system (FRMS) (Gander et al. 2011, Honn et al. 2019). In addition to fatigue mitigation measures, fatigue proofing strategies, which support safe performance while fatigued, are often needed (Dawson et al. 2012). Examples of these strategies are standardized communication, double checking, and automatic controls for critical tasks and processes.

6.1.3 Conclusions

The current research of 24/7 safety-critical industries clearly shows that human fatigue cannot be completely overcome by working hour regulations or a single countermeasure (e.g., training or nap breaks). The most promising way to complement the prescriptive approach is to establish an FRMS that consists of multiple fatigue countermeasures. Further research is needed to determine the best ways to implement an FRMS, the most effective FRMS measures, or combinations of these measures. WOW has added knowledge on fatigue-inducing shift characteristics in transportation, differences between fatigue in different transportation modes, and feasible FRMS measures on an organizational level.

6.1.4 Recommendations

Macro-level

We recommend that the regulatory authorities of 24/7 safety-critical industries

- provide the pertinent interest groups and operators with guidelines on effective and feasible fatigue mitigation strategies and their implementation
- organize platforms to disseminate information, share good practices and create networks around the topic
- network among themselves to learn about successful practices for information dissemination and implementation.

Organizational level

We recommend that 24/7 safety-critical organizations

- make a documented plan on how to manage fatigue in an effective and feasible way with the resources available
- take the following four steps when making such a plan:
    a) evaluate the current situation
    b) determine their policy, practices and responsibilities
    c) select mitigation measures and set goals for them
    d) determine how to monitor developments

- use fatigue measures with generally established critical values and if possible, study the association of these measures with near-misses and incidents over a period of time when identifying fatigue as a safety hazard
- complement fatigue mitigation measures with fatigue proofing strategies to support safe performance when managing the risks associated with fatigue
- collaborate with one another to share their best practices and benchmark themselves against relevant fellow organizations.

Individual level

We recommend that the employees of 24/7 safety-critical organizations

- consider their own behaviours relevant to on-duty alertness, taking into account both short- and long-term consequences
- adopt the concept of shared responsibility and thus actively collaborate with management to identify fatigue hazards and develop fatigue management practices in their workplace
- report safety-critical fatigue events to their employer.

6.2 Use of light therapies to support alertness and recovery

Bjørn Bjorvatn and Arne Lowden

Night work is associated with increased sleepiness and reduced performance while at work, as well as with sleep problems following the shift (Kecklund & Axelsson 2016, Lowden et al. 2019). The reason for these difficulties is that the circadian rhythm does not adapt to night work. Several studies indicate that workers' circadian rhythms may not adapt even after more than a week of consecutive night work (Eastman et al. 1995, Pallesen et al. 2010). However, night workers in the offshore oil industry seem to adapt to night work within a few days, at least according to subjective measures (Bjorvatn et al. 1998). Lack of conflicting exposure to daylight in the morning has been suggested as an explanation for this faster adaptation. Several countermeasures for the difficulties experienced by night workers have been suggested: scheduled bright light (while at work), intake of melatonin (after the night shift), dark goggles when outside in the daylight (after the night shift), napping while at work, exercise (while at work), and intake of modafinil (while at work) (Pallesen et al. 2010). The use of scheduled bright light has been especially promising, as detailed in a recent literature review (Lowden et al. 2019). In this section, we report on the status of two WOW consortium studies of light treatment.

6.2.1 WOW scientific results

The WOW project had two randomized controlled intervention trials: One study in Sweden: 'Dynamic light regimen at the work-place: an RCT study' and one study in Norway: 'The effects of bright light on adaptation to night work among nurses'. The Swedish study consisted of railway traffic controllers subjected to self-regulated dynamic lighting at work to promote recovery, performance and health in connection to morning, afternoon and night shifts. Objective sleep was detected via actigraphy and light levels, using light sensors. Melatonin was measured in connection to night and morning work. Sleepiness and mood levels collected via a wake diary were related to light exposure. Data collection is still ongoing, but preliminary data (n=42) indicate large inter-individual differences in light level preferences but suggest that a strategy of strong light boosts at the beginning of night and morning shifts seems to promote alertness. The Norwegian study investigated the effects of scheduled bright light (10 000 lux) for 30 minutes each night on nurses working three consecutive night

shifts in hospital settings. The night workers were followed using both subjective (sleep diaries, validated questionnaires) and objective (actigraphy, reaction time tests) measures of sleep and sleepiness for three days *before* and *during* the three night shifts, and also for three days *after* the night work period. The workers (n=35) were exposed to scheduled bright light or dim red light in a randomized double-blind placebo-controlled crossover design. The data indicate no major benefit from the bright light condition (Bjorvatn et al. submitted).

6.2.2 Other scientific evidence

Several carefully executed studies show that scheduled exposure to bright light facilitates the adaptation of the circadian rhythm (Pallesen et al. 2010, Lowden et al. 2019). Most of the studies involve simulated night work, but a few field studies have also been encouraging (Bjorvatn et al. 1999, James et al. 2004). The effect of light depends on the timing of exposure relative to the nadir of the endogenous body temperature rhythm, which usually occurs one to two hours before the habitual time of awakening (Dijk et al. 1995). When bright light is received in the wrong circadian phase, adaptation to night work is impeded (Mitchell et al. 1997, Bjorvatn and Pallesen 2009). A recent review summarizes the literature on this issue (Lowden et al. 2019).

6.2.3 Conclusions

It seems that scheduled bright light may facilitate circadian adaptation to night work, and thereby support alertness and recovery (Lowden et al. 2019). However, several questions remain. Most studies are well-controlled laboratory-based experiments. In real-life settings, the timing of bright light treatment may conflict with work tasks. Furthermore, environmental light may counteract the effects of bright light treatment. However, for treatment with bright light to be of any practical benefit to night workers, the constraints of real-life settings must be accepted. Another question relates to the number of consecutive night shifts necessary for recommending bright light as a countermeasure. Bright light treatment may be appropriate for work schedules with many consecutive night shifts, whereas for schedules with one or a few consecutive night shifts, bright light might not be recommended. The two randomized controlled real-life field studies within the WOW project therefore add valuable and important data to the existing knowledge about the effects of light therapies on improving alertness and adaptation to night work.

6.2.4 Recommendations

Scheduled bright light treatment is recommended for night workers who struggle with poor adaptation to work schedules. Appropriately timed bright light facilitates circadian adaptation, and thereby improves alertness and performance. However, in rotating shift work, circadian adaptation to a night shift may make adaptation to the following day shifts more problematic. Thus, the appropriateness of bright light therapies will likely depend on the number of consecutive night shifts. Circadian adaptation is not recommended in fast-rotating shift work.

6.3 Assessment and treatment of shift work disorder

Heli Järnefelt, Päivi Vanttola, Siri Waage and Bjørn Bjorvatn

Shift work disorder (SWD) is a circadian rhythm sleep-wake disorder defined as insomnia and/or excessive sleepiness that lasts at least three months, and is associated with a shift work schedule that overlaps with habitual sleeping time (American Academy of Sleep Disorders, 2014). The prevalence rates of SWD vary among professions but may be up to 63% among shift workers (Di Milia et al. 2013, Taniyama et al. 2015, Waage et al. 2009), depending on the criteria used. This section presents new results on the prevalence, features, comorbid conditions, assessment, and treatment of SWD performed within the WOW consortium.

6.3.1 WOW scientific results

Our field study of Finnish airport ground staff members indicated that SWD was related to disturbed sleep and alertness when working both morning and night shifts, and to less compensatory sleep on days off (Vanttola et al. 2019). Shift workers with SWD had poorer sleep quality and were less relaxed at bedtime than those without SWD. Our epidemiological findings among Finnish hospital shift workers suggested that especially employees whose ICSD-2-based SWD was characterized by insomnia may need a longer time to overcome excessive sleepiness than allowed by their roster (Vanttola et al. 2020b). Using the criteria of the latest International Classification of Sleep Disorders (ICSD-3) (American Academy of Sleep Disorders, 2014), including a reduction of total sleep time, resulted in lower estimates of SWD prevalence among Finnish hospital employees than the earlier ISCD-2 criteria (American Academy of Sleep Disorders, 2005; Vanttola et al. 2020a). We also suggested a cut-off of ≥3/month for days with ICSD-3-based SWD symptoms. The use of this cut-off resulted in a prevalence of SWD of 3–6% (ICSD-3) and 9–18% (ICSD-2).

A Norwegian study found a significant difference in the prevalence of restless legs syndrome between nurses with SWD and nurses without SWD (Waage et al. 2018). This might indicate that nurses vulnerable to shift work are also sensitive to other complaints related to a misalignment of the biological clock. In addition, frequent headache, migraine and chronic headache were associated with SWD among nurses (Bjorvatn et al. 2018). A Finnish intervention study performed in OHS showed similar sleep improvements both after cognitive behavioural therapy for insomnia (CBT-I) and a short sleep hygiene control intervention among shift workers with insomnia

(Järnefelt et al. 2020). In this intervention study, half of the shift workers with insomnia showed features of SWD. The clinical condition of the insomniacs without SWD (insomnia also during days off) was more severe, and these participants benefitted more from the interventions than the insomniacs with SWD.

6.3.2 Other scientific evidence

A recent systematic review of 58 studies of health care shift workers showed that older age, morning-type, low circadian flexibility, being married or having children, increased caffeine intake, higher neuroticism scores, and lower hardiness scores were related to a higher risk of sleep-related impairment in response to shift work, whereas physical activity was a protective factor (Booker et al. 2018). Longitudinal studies of SWD among nurses suggest that night work and quick returns (less than 11 hours between two consecutive shifts) may be major causes of SWD (Eldevik et al. 2013, Flo et al. 2014, Waage et al, 2014).

Coding manuals, such as ICSD-2, ICSD-3 and ICD-11 (WHO 2019) give slightly different criteria for SWD, and they lack cut-off values for frequency of shifts and SWD symptoms. As a result, studies have used various instruments to define SWD (Barger et al. 2012, Rajaratnam et al. 2011, Waage et al. 2009, Vanttola et al. 2020a), which makes comparison between studies more difficult.

Previous studies have found poorer subjective sleep quality among swing-shift workers with SWD during a non-work period (Waage et al. 2009), and poorer subjective sleep efficiency during night work periods among permanent night workers with SWD (Gumenyuk et al. 2014) than among those without SWD. Studies using subjective sleep duration measures have shown either an association (Kalmbach et al. 2015) or no association (Di Milia et al. 2013) with decreased sleep duration among participants with SWD.

Based on the European guideline for the treatment of insomnia, CBT-I is recommended as the standard treatment for chronic insomnia (Riemann et al. 2017). Only a few CBT-I effectiveness studies have been conducted among shift workers, and the results of these studies vary (Järnefelt et al. 2012, Peter et al. 2019, Schiller et al. 2018). Moreover, these intervention studies have not taken SWD into consideration as a background factor. Many individual SWD treatment efforts target the core features of shift work, focusing on improving circadian adaptation and sleep, and reducing sleepiness (Wickwire et al. 2017). Standard individual SWD treatment options are

still lacking. Sleep-wake disturbances connected to shift work can also be decreased through ergonomic shift scheduling by, for example, minimizing the proportion of night shifts (Härmä et al. 2018, Sallinen & Kecklund 2010).

6.3.3 Conclusions

The studies of Finnish employees indicated that shift workers with SWD may lack the ability to recover between work shifts as optimally as those without SWD (Vanttola et al. 2019, Vanttola et al. 2020b). Diverse criteria and instruments have resulted in different prevalence rates of SWD which calls for standardized and validated tools. We also need longitudinal studies to investigate the causal relationships between shift work, sleep-wake disturbances, and other comorbid conditions.

This WOW intervention study has added knowledge on the assessment and treatment of insomnia among shift workers in the OHS context. It showed that both group- and self-help based cognitive behavioural therapy for insomnia and mere sleep hygiene intervention delivered by occupational health professionals may reduce insomnia symptoms among shift workers. However, shift workers with insomnia independent of working hours probably benefit more from non-pharmacological insomnia treatment than those with SWD-type insomnia. Earlier studies show that sleep-wake disturbances can also be reduced through ergonomic shift scheduling, which probably alleviates SWD-type insomnia in particular.

6.3.4 Recommendations

Future SWD studies should clearly define SWD and refer to the coding manual that the used definition most closely resembles. To exclude symptoms of insomnia and sleepiness unrelated to shift work, shift workers should have ≥3 days a month with SWD symptoms to be eligible as SWD candidates.

SWD and comorbid sleep disorders should be recognized and assessed in the OHS of shift workers. Treatment options using both ergonomic shift scheduling, sleep hygiene and circadian adaptation tools are recommended in the treatment of SWD. If a shift worker has insomnia independent of working hours, the standard treatment guidelines of chronic insomnia should be followed.

7 IMPLEMENTATION AND DISSEMINATION OF PROJECT RESULTS

The evidence-based solutions related to the WOW project have been implemented and disseminated as part of the project (WP4). Activities have included implementation in the scientific community and among work environment professionals such as social partners and policy makers, organizations and companies, and the general public. The implementation strategy is based on the inclusion in the process of strategic stakeholders (e.g. labour market organizations, public health organizations and authorities, private and software companies) or the intervention studies' steering groups.

The aims, structure, principal investigators, work package leaders, and scientific publications of the project are described on the project website (https://www.ttl.fi/en/research-and-development-projects/wow/). The individual publications of the project (over 110 scientific articles) have been featured in several interviews, and hundreds of public and news articles have been published in both the electronic and printed media which are not included here. Implementation in the scientific community has involved co-operation in organizing the Working Hours in the Nordic Countries (WINC) network scientific meeting in 2015 (Helsinki), 2016 (Stockholm), 2017 (Oslo), 2018 (Copenhagen) and 2019 (Copenhagen), and organizing scientific sessions in the annual WOW consortium meetings. Examples of the other main dissemination and implementation activities during the project are listed below (Tables 1 and 2).

Table 1. Main WOW dissemination and implementation activities among general public and policy makers and in legislation.

Year	Activity	Member of consortium
2018	Thematic electronic newsletter on long working hours and health, invited speech for the Union of public employees in Copenhagen	NFA
2020	A press info on how to schedule night shift work in order to minimize health and safety risks	NFA
2015, 2016, 2018, 2019, 2020	Press releases and info on new WOW scientific publications	FIOH
2017	Large FIOH seminar for invited stakeholders on health effects of shift work and press release to influence reform of Working Time Act in Finland	FIOH
2017-2019	Contribution to updating of new Working Time Act in Finland by joining hearings and providing expert reports and public statements to Ministry and Finnish Parliament.	FIOH
2017	WOW seminar with representatives of two ministries and all major labour unions and co-operating companies	FIOH
2017, 2019, 2020	Invited speeches in European Parliament: 'Working time and work-life balance in the EU' (TU), 'Long working hours' (TU), and 'Working hour policy and legislation' for directors of DG Employment (FIOH)	TU, FIOH
2015-2020	Updates of project website (2015, English), recommendations on use of 12-hour shifts in industry (2017), time use in expert work (2018), shift work and health (2019), recommendations on shift ergonomics (2019), shift work and ageing (2020) (Finnish)	FIOH
2019-2020	Finnish, Swedish, and English versions of reference database of payroll-based working hours in health and social care in Finland	FIOH
2018	Presentation of results of WOW project to Swedish Parliament	SU
2019	Book for general public on how to cope with night work and irregular working hours	UiB
2020	WOW Working Time Policy streamed meeting for policy makers and work environment professionals. Helsinki, November 2020	all

Table 2. Main WOW dissemination and implementation activities in organizations and work environment and among occupational health and safety professionals.

Year	Activity	Member of consortium
2015-2020	Advisory board meetings with Danish Regions, unions and employer's parties	NFA
2017	Meeting on use of registers in epidemiological research on work environment	NFA
2018	Invited speech to the Union of public employees in Copenhagen	NFA
2015-2020	WHFPS results discussed in steering groups of social and health care organizations	FIOH
2016	Meetings with collaborating organizations and end-users	FIOH
2019	FIOH 2019 traffic light shift scheduling recommendations based on WOW results, and related evaluation tool linked as part of CGI Finland Titania® shift scheduling software	FIOH
2015-2020	SUSSH results presented annually in journal of Norwegian Nurses Organization	UiB
2017	Meeting on WOW results with Sveriges Ingenjörer, Ingenjörshuset, in Stockholm and at Swedish Parliament (Sveriges Riksdag).	SU

8 CONCLUSIONS AND FUTURE IMPLICATIONS

8.1 Working hours in the Nordic countries

Based on comparative studies, the Nordic countries are doing relatively well in terms of the different dimensions of working times compared to other European countries: shorter and less unsocial usual working hours, and more control over working hours, although with higher tempo of working hours. Employees in northern Europe were the most satisfied with how working hours fit in with their family or social commitments. This is, at least partly, the result of a tradition of strong and inclusive labour market regulation concerning collective bargaining, working conditions, worker autonomy, and combining work with family life.

In relation to the trends of working hours in the Nordic countries, the observed convergence in working hours between men and women in Norway and Sweden might be due to more gender-oriented work-life balance policies. Differences in the norms of full-time employment might explain why part-time work is still more uncommon in Finland than in its neighbouring countries.

At the EU level, the European Working Time Directive forces national legislation in EU Member States. In addition, any effective strategy for addressing this issue must involve effective employee organizations, as well as the active engagement and commitment of employers. Collective agreements are made between employee and employer organizations; thus, both parties have legal rights to be involved in working time regulations in the EU. This allows interaction between the top-level regulation (directive), national level and the local level, with a great deal of flexibility and interaction. Another issue to consider is whether the rather strict Directive is always adequately followed in relation to the regulations associated with well-being.

Where possible, further studies should include various indicators of working time flexibility. It is important to recognize that the flexibility of working times and places has many dimensions, and that work-life balance is enabled by a certain combination of working time and place flexibility. Therefore, in the effort to understand the associations between the spatial and temporal flexibility of work and personal life, it is essential to grasp a holistic image of flexibility. In addition, further studies should provide a more detailed analysis of, for example, temporal and spatial flexibility among different socio-economic groups of workers in relevant countries. Time-use surveys

could explore the actual daily patterns of work as well as the actual spatial flexibility of work. Furthermore, an important focus for future research is the analysis of the similarities and differences between the countries in terms of statutory regulation, collective agreements, and policy orientations.

It is important to distinguish between the voluntary and involuntary nature of short and long working hours (i.e. underemployment or overemployment). This is a critical factor in the association between working hours, health and well-being. Further studies should also provide a more detailed analysis of working hours among different socio-economic groups of workers in different countries. All in all, in order to increase the comparability of working hour statistics between the Nordic countries, harmonization of the definitions of working hour variables is recommended.

8.2 Length of working hours

Several large international studies have found that very long weekly working hours (>55 hrs/week) are associated with an increased risk of cardiovascular disease manifestation (stroke, atrial fibrillation and venous thromboembolism), depression and breast cancer (but not cancer in general). These results were not replicated in a large Danish study. This may partially be explained by the low number of people with very long weekly working hours in Denmark, the healthy worker effect, and differences in societal contexts, for example, access to social security and health care.

The results of the WOW studies in Finland and Sweden showed that reducing the workday weekly to six hours, with retained salary had beneficial effects on subjective health and well-being. These positive results need to be confirmed using objective health indicators (for example, sickness absence) and productivity. Furthermore, a cost-benefit analysis is needed to evaluate whether the large societal cost of implementing reduced working hours can be justified.

8.3 Shift work, health and well-being

The WOW studies lend new support to associations between exposure to night shift work and several chronic diseases such as rheumatoid arthritis, type-2 diabetes, and hypertension. Moreover, they have associated night shift work with miscarriage, hypertension and pre-eclampsia during pregnancy, and with an increased risk of fatigue and insomnia, occupational injuries, sickness absence and disability pensions.

We found mixed results for the association between night shift work and breast cancer, mortality and dementia and no support for an association between night shift work and prostate cancer.

In many situations, WOW has been able to utilize more precise data on the association between night shift work and the risk of especially acute, and in some cases chronic diseases. Precise exposure and outcome information is critically important when making recommendation for prevention. Studies conducted in several countries have provided detailed recommendations based on the association between different working hour characteristics and accidental injuries, sickness absence, and maternal health.

The strengths of the WOW epidemiologic cohorts that produced these results are their large size, long follow-up times and the use of precise exposure assessments. In particular, the use of payroll-based register data on daily working hours provided us with new possibilities to evaluate the risks in relation to the intensity and organization of morning, evening and night shifts. However, more cohort studies on the association of payroll data with chronic diseases are needed. Due to the challenges associated with exposure assessment, selection bias, and confounding, we need to combine precise information on exposure to shift work with longer and more systematic follow-up. With objective information on shift characteristics, which are robust to differential recall, it may be possible to provide acceptable safety limits for the number of annual or consecutive night shifts for different exposure times and/or risk groups. Therefore, future etiological studies and research into the prevention of chronic health effects in shift work need to be based on the principle of obtaining precise and repeated information on exposure to shift work combined with long registry follow-up and repeated information on confounders and possible mediators.

The WOW consortium has contributed new knowledge about the possible negative aspects of short inter-shift recovery time. However, no randomized controlled trials have yet clarified the causal relationship between short inter-shift recovery time and negative health outcomes. Many shift workers prefer to have short inter-shift recovery times, for reasons that have not yet been fully determined. We know little about whether those who prefer short inter-shift recovery times suffer fewer negative effects than those who experience them as problematic. So far, most studies have focused on the short-term consequences of short inter-shift recovery times, and we lack research on how this schedule characteristic relates to long-term health.

8.4 Flexible working hours and work-time control

The current knowledge on flexible working hours points towards early identification of workers at risk of self-imposed excessive working hours. Employees in knowledge-intensive work and their supervisors should be made aware of the circular association between working hours, sleep and recovery for setting boundaries between work and leisure time. Further, the available research shows that the individual characteristics of employees (e.g. age, gender, family responsibilities), the type of work, and the way in which work is organized should be noted. Still, taken together, the weight of available evidence to date points towards work-time control having beneficial effects on work-life balance, workplace social environment, and mental/physical health while protecting against accidents. Some promising implications suggest that flexible working hours and increased work-time control might be beneficial for older workers in terms of reduced sickness absence and extended working careers.

Based on the results of the WOW studies, we conclude that interventions should target workers with low levels of control to guarantee the availability of a minimum level of autonomy, especially regarding their control over time off. Even though the effects may be small, work-time control is a potentially useful means of improving the work environment, given that in most occupations it is modifiable to some extent. At the same time, workers with very high work flexibility should be provided with tools to maintain the boundaries between work and leisure time.

8.5 Individual level management of sleep and fatigue in shift work

Fatigue management. The current research of 24/7 safety-critical industries clearly shows that human fatigue cannot be completely overcome by working hour regulations or single countermeasures (e.g., training or nap breaks). The most promising way to complement the prescriptive approach is to establish an FRMS that consists of multiple fatigue countermeasures. Further research is needed to examine the best ways to implement an FRMS and the most effective FRMS measures or combinations of these.

Bright light. Appropriately timed bright light facilitates circadian adaptation to night work and may improve alertness and performance among shift workers. However, in rotating shift work, circadian adaptation to night work makes adaptation to day work more problematic. For this reason, the appropriateness of bright light therapies

will likely depend on the number of consecutive night shifts. Circadian adaptation is not recommended in fast-rotating shift work. More studies are needed before firm conclusions can be made about the role of light interventions in different types of work schedules.

Shift Work Disorder (SWD). People with SWD have a poorer ability to recover on days off. The disorder is also associated with other sleep disorders and health complaints, highlighting the importance of recognizing and treating it properly. The prevalence rates of SWD depend on the measures and criteria used. In the future, both epidemiological and clinical studies should use standardized, validated tools in the assessment of SWD. Future SWD studies should clearly describe the criteria used for SWD and refer to the coding manual that the used definition most closely resembles.

Shift workers with insomnia may benefit from different non-pharmacological insomnia interventions performed in OHS. However, those with insomnia independent of working hours are likely to benefit more from individual interventions than those with SWD-type insomnia. In the future, we need more clinical trials of SWD to improve practical treatment guidelines.

9 SUMMARY OF KEY WOW RECOMMENDATIONS

Working hours in the Nordic countries

Given the wide occurrence and far-reaching negative effects of shift work and long working hours, regulation of non-standard work schedules is needed. The EU Working Time Directive forces national legislation in the European Union. The involvement of effective employee organizations, as well as the active engagement and commitment of employers, and agreements with high flexibility and interaction between the actors are necessary to modify central regulation.

- Comprehensive health and family policies are needed to support well-being when working hours are challenging. They should include access to OHS and flexible access to childcare facilities, which offer possibilities to reduce tensions between work and family life.
- Sustainable working times over the life course are needed to support appropriate working hours in different phases of life, as well as skill-upgrading and occupational mobility.

Length of weekly working hours

- Limiting weekly working hours to a maximum of 48 hours, as set by the EU Working Time Directive, remains well justified.
- Interventions on reduced working hours (e.g. 6-hr workday) on retained salary have shown beneficial effects on subjective health and well-being in Finland and Sweden. From the economical aspect a cost-benefit analysis is recommended.

Shift work, health and well-being

At the organizational level, reducing the number of consecutive night shifts and quick returns is recommended:

- The number of consecutive night shifts should be low, preferably a maximum of three.
- Quick returns (inter-shift interval of 11 hours or less) should be avoided, as ruled by the EU Working Time Directive.
- The use of quickly rotating shift systems (e.g. 2–3 consecutive night shifts) is recommended instead of the use of more slowly rotating schedules (4 or more consecutive night shifts). This recommendation does not, however, include some specific work settings such as oilrig platforms.

Flexible working hours and work-time control

- Working hour flexibility and work demands should have limits that reflect individual capacity and the need to maintain boundaries between work and leisure time.
- Workplaces and OHS should prioritize early identification of workers at risk of self-imposed excessive working hours.
- Guidelines on flexible working practices should be tailored according to age, gender, work ability, and type of work.
- Increase of work-time control is a potential and feasible way to improve health, well-being and work participation.
- Interventions should target workers with especially low levels of control to guarantee the availability of a minimum level of autonomy.

Fatigue management in safety-critical industries

Authorities should provide 24/7 safety-critical industries with guidelines on effective fatigue mitigation strategies and FRMS and their implementation.

Safety-critical organizations should use an FRMS that

- Includes a documented plan on how to manage fatigue in an effective and feasible way with the resources available. The plan should a) evaluate the current situation, b) determine the policy, practices and responsibilities, c) select mitigation measures and set goals for them, and d) determine how to monitor developments.
- Uses fatigue measures with generally established critical values and if possible, studies the association of these measures with near-misses and incidents.
- Complements fatigue mitigation measures with fatigue-proofing strategies to support safe performance when managing the risks associated with fatigue.

It is also important that these organizations share their best practices and benchmark themselves against relevant fellow organizations.

Light and cognitive behavioural therapies in the treatment of shift work disorder

- OHS should recognize and assess SWD and comorbid sleep disorders among shift workers.
- Treatment options using both ergonomic shift scheduling, sleep hygiene and/or cognitive behavioural therapies are recommended in the treatment of SWD.
- Scheduled bright light treatment is recommended for permanent night workers who struggle with poor adaptation to their work schedule.

- In rotating shift work, the appropriateness of bright light therapies will likely depend on the number of consecutive night shifts. Phase shifting is not recommended in fast-rotating shift work.
- If a shift worker has insomnia independent of working hours, the standard treatment guidelines for chronic insomnia should be followed, that is, CBT-I.

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This report summarizes the main findings and recommendations of a large Nordic project 'Working hours, Health, Well-being and Participation in Working life' (WOW, 2015–2021). The project has produced over 100 original publications on the societal and socio-economical differences and trends of Nordic working hours, and on the associations, countermeasures, recommendations, and tools related to the working hours to improve health, well-being and work participation. A novel aspect of the project was the utilization of detailed payroll-based registry data on working hours from several occupational cohorts, enabling the formation of more detailed recommendations for working hours and health.

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