

Final Progress Report, U13 Conference Grant

“Innovations in Research and Practice Improving Shiftworker Health and Safety” – the 24th International Shiftwork and Working Time Symposium

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List of Terms and Abbreviations

Co-PI	Co-Principal Investigator
NIOSH	National Institute for Occupational Safety and Health
PI	Principal Investigator
Shiftwork2019	24th International Symposium on Shiftwork and Working Time
WTS	Working Time Society

Abstract

Innovations in Research and Practice Improving Shiftworker Health and Safety” – the 24th International Shiftwork and Working Time Symposium

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This U13 Conference Grant enabled the organization of the 24th International Symposium on Shiftwork and Working Time (“Shiftwork2019”). The meeting was held at The Coeur d’Alene hotel and conference center in Coeur d’Alene, Idaho, September 9–13, 2019, and attended by 189 shiftwork researchers and practitioners (including 63 early career researchers). With as its theme “Innovations in Research and Practice Improving Shiftworker Health and Safety,” the primary goal of the conference was to convene experts from around the world to share cutting-edge research, innovative ideas, and best practices regarding working time arrangements and their impact on health and safety. The scientific program featured three keynote lectures, eight plenary symposia, eight oral presentation sessions, and two poster sessions, making for more than 170 presentations in total. Topics addressed during the conference covered a wide spectrum of health and safety issues in shiftwork populations, ranging from healthy work schedule design to fatigue countermeasures, occupational hazards, long-term health consequences, and social and industrial implications of nontraditional working time arrangements. A post-conference survey yielded high ratings on the conference with regard to exchange of knowledge, relevance of presentations and discussions, atmosphere for discussions, location, time and space for socializing, and balance of topics. Peer-reviewed abstracts of the conference have been published in a freely accessible special issue of the journal *Sleep Science*, which is enclosed. The proceedings of the meeting, which include 34 peer-reviewed articles, are being published in a special double issue of *Chronobiology International*. The contents of the proceedings range from discussions of working time arrangements and work-life balance to the relationships between sleep and health, from the challenges of shiftwork for nurses and other health care workers to the impact of shiftwork in transportation industries, from circadian misalignment associated with nightwork to the nature and timing of food intake during the night, and from sleep inertia after awakening to the consequences of sleep loss for safety. With a large amount of information exchange, excellent discussion and networking opportunities, and exceptionally high scientific output, the 24th International Symposium on Shiftwork and Working Time was an unequivocal success.

Section 1

Key findings

This U13 Conference Grant under NIOSH's Occupational Safety and Health Program made it possible to organize the *24th International Symposium on Shiftwork and Working Time* ("Shiftwork2019") in the US. The conference was held at *The Coeur d'Alene* hotel and conference center in Coeur d'Alene, Idaho, September 9–13, 2019. Under the theme "Innovations in Research and Practice Improving Shiftworker Health and Safety," the primary goal of the conference was to convene experts from around the world to share cutting-edge research, innovative ideas, and best practices regarding working time arrangements and their impact on health and safety. The primary objectives of the meeting were to (1) discuss the latest developments in the science and practice of shiftwork, working time arrangements, and health and safety countermeasure approaches; (2) foster international networking, cross-disciplinary collaboration, and early career researcher/practitioner development; and (3) disseminate best practices to workers, employers, and regulators nationally and world-wide. A total of 189 individuals (61% women, 39% men) from 19 different countries attended the meeting.

The Shiftwork2019 scientific program featured three 1-hour invited keynote lectures, eight plenary symposia of four 30-minute presentations each, two oral presentation sessions of six 15-minute short talks each, and six oral presentation sessions of four 15-minute short talks each. Two poster sessions featured up to 54 posters each. All in all, more than 150 attendees had an opportunity to present their work. A special symposium was included in the program to discuss the 2019 special issue of the journal *Industrial Health* containing consensus statements and reviews on non-standard working time arrangements and occupational health and safety. Furthermore, there was a 50th Anniversary symposium in celebration of half a century of International Symposium on Shiftwork and Working Time meetings. An early career researcher event was attended by 63 early career researchers and practitioners (73% women, 27% men) from 14 different countries. See the enclosed final program book for further details.

Topics addressed during the conference covered the spectrum of health and safety issues in shiftwork populations, ranging from healthy work schedule design and fatigue countermeasures to occupational hazards, long-term health consequences, and social and industrial implications of nontraditional working time arrangements. In a post-conference survey, attendees rated the conference highly with regard to exchange of knowledge, relevance of presentations and discussions, atmosphere for discussions, location, time and space for socializing, and balance of topics. Shiftwork2019 was a highly successful meeting with a large amount of information exchange, excellent discussion and networking opportunities, and exceptionally high scientific output.

Translation of findings

The first two primary objectives of the conference – (1) discussing the latest developments in the science and practice of shiftwork, working time arrangements, and health and safety countermeasure approaches; and (2) fostering international networking, cross-disciplinary collaboration, and early career researcher/practitioner development – were accomplished during the meeting (September 9–13, 2019). The other objective – (3) disseminate best practices to workers, employers, and regulators nationally and world-wide – was accomplished through publication output. Specifically, peer-reviewed abstracts of the conference have been published in a freely accessible special issue of the journal *Sleep Science*, which is enclosed. In addition, proceedings of the meeting are being published in a special double issue of *Chronobiology International* containing 34 peer-reviewed articles (see the Publications section later in this report).

Impact

While it is nearly impossible to summarize the breadth and depth of the many contributions to research and practice that attendees provided during the meeting (more than 70 oral presentations and more than 100 posters), the proceedings of the conference are broadly reflective of the wide range of topics covered. They range from work scheduling and work-life balance to the connections between sleep and health, from the challenges of shiftwork faced by nurses and other health care workers to the impact of shiftwork in transportation industries, from circadian misalignment caused by nightwork to the nature and timing of food consumption during the night, and from deficits due to sleep inertia after awakening to the implications of sleep loss for safety. These outputs contribute to a deeper understanding of the impact of shiftwork on safety and health; explain new developments in the science and practice of shiftwork; and provide a foundation for the development of novel health and safety countermeasure approaches.

It has been estimated that the cost of nonstandard work hours to US employers in terms of fatigue- and health-related lost productivity exceeds \$136 billion annually. The potential for new mitigations and solutions to address the adverse consequences of shiftwork and other nonstandard working time arrangements therefore has great value in our increasingly 24/7-oriented society, and Shiftwork2019 contributed substantively to the future realization thereof.

Section 2

Meeting goal and objectives

This U13 Conference Grant under NIOSH's Occupational Safety and Health Program enabled the Sleep and Performance Research Center at Washington State University to host the *24th International Symposium on Shiftwork and Working Time* ("Shiftwork2019"), held at *The Coeur d'Alene* hotel and conference center in Coeur d'Alene, Idaho, September 9–13, 2019.

The International Symposium on Shiftwork and Working Time series is a biennial meeting organized under the auspices of the Working Time Society (WTS) and the Scientific Committee on Shiftwork and Working Time of the International Commission on Occupational Health. Held since 1969, the meeting attracts an international group of scientists, industry members, labor representatives, government officials, health and safety professionals and policy makers with a common interest in working time arrangements, implications thereof for workers and for society, and strategies to mitigate the adverse health and safety consequences of shiftwork.

The primary goal of the conference was to convene experts from around the world to share cutting-edge research, innovative ideas, and best practices regarding working time arrangements and their impact on health and safety. Meeting this goal was facilitated by seven long-standing guidelines governing the meeting format known informally as the "Rutenfranz principles." These may be summarized as follows:

- hold the meeting in a secluded location so as to encourage all-day interactions among participants;
- include participants from a mixture of disciplines;
- include a good proportion of early career researchers and practitioners;
- have relatively concise presentations from as many participants as possible;
- have breaks and meals together to foster informal exchanges;
- include some group outings to encourage bonding;
- widely share the information that is presented with non-participants.

During the 50-year history of this meeting, several additional practices have evolved to help make the meeting unique and successful:

- the meeting is kept to a moderate size (typically 150–200 participants) and is therefore renowned for the close interaction and networking of all participants;
- participation from scientific and non-scientific stakeholders supports multi-disciplinary approaches to working time arrangements and health and fatigue risk management solutions;
- conference proceedings are published in a high-impact, peer-reviewed journal, to reach a wide audience.

Building on the 50-year history of the event to improve workplace health and safety among those who work nonstandard schedules, the 2019 meeting theme was set to be "Innovations in Research and Practice Improving Shiftworker Health and Safety." In the

context of this theme, the primary objectives of the meeting were to (1) discuss the latest developments in the science and practice of shiftwork, working time arrangements, and health and safety countermeasure approaches; (2) foster international networking, cross-disciplinary collaboration, and early career researcher/practitioner development; and (3) disseminate best practices to workers, employers, and regulators nationally and world-wide.

Major accomplishments for meeting plan

An international scientific committee was convened to determine the meeting theme and help create an innovative and worthwhile agenda for Shiftwork2019. The committee proposed three internationally renowned keynote speakers who encompassed broad geographic and demographic representation as well as diversity of ideas. The committee also selected symposia from proposals that had been submitted by the membership of the WTS, as well as oral presentations and poster presentations from submitted conference abstracts. These abstracts were also reviewed for awarding of travel grants and merit awards, which went to attendees from developing countries and/or early career researchers. The international scientific committee put together a rich, well-balanced, and high-caliber program, which is documented in the enclosed final program book.

The members of the international scientific committee were selected to meet the following criteria: documented evidence of significant contributions to shiftwork research and/or practice; representing a wide diversity of topics in the fields of shiftwork research and practice; well balanced in terms of gender, early career and senior researchers/practitioners, and geographic representation; and retention of organizational knowledge and efficiency through inclusion of individuals with ties to earlier renditions of the International Symposium on Shiftwork and Working Time.

In addition to the local organizers, Drs. Hans Van Dongen and Kimberly Honn of the Sleep and Performance Research Center at Washington State University, the international scientific committee was composed of the following 12 individuals from across the globe:

- Dr. Stephen Popkin (USA), president of the WTS, Director of Safety Management and Human Factors and Lead of the Safety Council Implementation Team at Volpe National Transportation Systems Center, and a renowned expert on transportation safety.
- Dr. Claudia Moreno (Brazil), secretary of the WTS and organizer of a previous iteration of the International Symposium on Shiftwork and Working Time, Associate Professor in the Department of Environmental Health at the University of São Paulo, and an internationally known researcher of circadian rhythms.
- Dr. Imelda Wong (USA), WTS board member and NIOSH liaison for Shiftwork2019, Co-Lead of the NIOSH Working Hours and Fatigue work group, and an early career occupational epidemiologist with expertise on the health effects of shiftwork and extended work hours.

- Dr. Gregory Roach (Australia), WTS board member and organizer of the most recent International Symposium on Shiftwork and Working Time, Professor in the Appleton Institute for Behavioural Science at Central Queensland University, and a widely known expert on the effects of sleep loss and circadian misalignment.
- Dr. Anastasi Kosmadopoulos (Canada), co-organizer of the most recent previous International Symposium on Shiftwork and Working Time, Postdoctoral Fellow in the Douglas Mental Health University Institute at McGill University, and an early career researcher of the effects of circadian rhythms on sleep and health.
- Dr. Sampsa Puttonen (Finland), WTS board member, Senior Researcher in the Unit of Research, Development, Training and Service of Occupational Health at the Finnish Institute of Occupational Health, and well-known expert on the health and epigenetic consequences of insufficient sleep and stress.
- Dr. Masaya Takahashi (Japan), WTS board member and selected organizer of the next (2022) International Symposium on Shiftwork and Working Time, Faculty Member at the National Institute of Occupational Safety and Health Japan, and a long-term expert on recuperation from stressful work.
- Dr. Samia Modawi (Sudan), Research Associate Professor in the Ministry of Health and Head of the Occupational Health Department in the National Health Laboratory in Sudan, and an expert on work environment risks and nighttime working hours.
- Dr. Heidi Lammers-van der Holst (Netherlands), Senior Lecturer of Medical Psychology at the Leiden University Medical Center and Visiting Researcher at Harvard Medical School in the US, and an early career researcher of the impact of shiftwork on sleep and health in police officers.
- Dr. Anna Korompele (Greece), Clinical Instructor in the Faculty of Nursing at the National and Kapodistrian University of Athens, and an early career researcher of the impact of shiftwork in healthcare.
- Dr. Kyriaki Papantoniou (Austria), Assistant Professor in the Center for Public Health at the Medical University Vienna, and an early career researcher in circadian and sleep epidemiology and circadian disruption as a potential environmental and occupational cause of cancer.
- Dr. Siri Waage (Norway), Postdoctoral Fellow in the Department of Global Public Health and Primary Care at the University of Bergen, and an early career researcher of shiftwork and sleep disorders.

To welcome early career researchers and practitioners to the conference and provide a comfortable and informal opportunity for networking and building community, a special event on the first evening of the conference was held that was organized for and by early career researchers and practitioners as part of the conference. An early career researchers committee was established for this, comprised of the following individuals:

- Dr. Hiroki Ikeda (Japan), Junior Researcher at the National Institute of Occupational Safety and Health, Japan, and selected co-organizer of the early career researchers event at the next (2022) International Symposium on Shiftwork and Working Time;
- Dr. Anastasi Kosmadopoulos (Canada), Postdoctoral Fellow at McGill University, serving as liaison with the international scientific committee (see above);
- Dr. Elaine Marquize (Brazil), Assistant Professor at the University of São Paulo;

- Dr. Raymond Matthews (Australia), Postdoctoral Fellow at the University of South Australia, and co-organizer of the early career researchers event at the most recent International Symposium on Shiftwork and Working Time;
- Dr. Grace Vincent (Australia), Postdoctoral Fellow at Central Queensland University;
- Ms. Amanda Hudson (USA), PhD Student in the Sleep and Performance Research Center at Washington State University, serving as liaison for the local organizers.

The Washington State University-based local organizers were Dr. Hans Van Dongen (PI of this U13 Conference Grant) and Dr. Kimberly Honn (Co-PI of this U13 Conference Grant), with assistance from Ms. Amanda Hudson (PhD Student at Washington State University) and conference support from Washington State University's *Conference Services* group (Ms. Brianne Wyatt, logistic and administrative support; Ms. Alexandra Dwyer, website and conference registration support; and Mr. Andrew Mack, graphic design). This U13 Conference Grant provided financial support for the *Conference Services* group. The grant also covered travel and conference expenses of 4 invited speakers, and paid for audio/visual supplies.

The 5-day meeting was held at *The Coeur d'Alene* hotel and conference center in Coeur d'Alene, Idaho, a picturesque lakeside town located in the Inland Northwest on the border of Idaho and Washington. The conference center had just been upgraded and was exceptionally well suited for a meeting of the size of Shiftwork2019. Two large plenary session rooms were available for single- and dual-track presentations and poster sessions. A small additional room was available for committee meetings and conference management functions. Integration of the conference center with the hotel in the same building made it easy to keep everyone together for networking and informal exchanges during meal breaks and at the end of each day, in keeping with the "Rutenfranz principles" (see previous section).

The Shiftwork2019 scientific program featured three 1-hour invited keynote lectures: one focused on applied and translational research, one on basic research, and one on practice and innovation. Dr. Anne Helene Garde, Professor in the National Research Centre for the Working Environment in Denmark, a widely recognized epidemiologist and psychologist with expertise work stress and well-being in the context of working hours, provided the applied/translational keynote lecture titled "Health and Safety Risks Related to Specific Characteristics of Shift Work Scheduling." Dr. John Axelsson, Professor in the Stress Research Institute at Stockholm University and Associate Professor in the Department of Clinical Neuroscience at the Karolinska Institute in Sweden, an internationally known researcher of the health and performance consequences of circadian misalignment, provided the basic research keynote lecture titled "When Can You Start to Trust an Awakening Brain?" Dr. Michael Belzer, Professor of Economics at Wayne State University, a renowned expert on labor economics, industrial organization, macroeconomics, and transportation economics with strong roots in operational practice, provided the practice/innovation keynote lecture titled "The Economics of Long Work Hours."

The Shiftwork2019 scientific program contained eight plenary symposia of four 30-minute presentations each, two oral presentation sessions of six 15-minute short talks each, six oral presentation sessions of four 15-minute short talks each, and two poster sessions of up to 54 posters each, so that more than 150 attendees had an opportunity to present their work. The aforementioned early career researcher event was also included in the program; as was a special symposium to discuss the 2019 special issue of the journal *Industrial Health* containing WTS consensus statements and reviews on non-standard working time arrangements and occupational health and safety. Furthermore, there was a 50th Anniversary symposium in celebration of half a century of International Symposium on Shiftwork and Working Time meetings, for which Dr. Kazutaka Kogi, Professor at the Ohara Memorial Institute for Science of Labour in Japan, provided an invited lecture on behalf of the International Commission of Occupational Health. See the enclosed final program book for further information.

A total of 189 individuals attended Shiftwork2019; see Figure 1. Attendees hailed from 19 different countries: Australia (18), Austria (2), Brazil (11), Canada (7), Denmark (12), Finland (6), France (1), Germany (4), Iceland (6), Japan (5), Netherlands (10), New Zealand (2), Norway (9), Peru (1), Philippines (1), South Korea (2), Sweden (10), United Kingdom (6), and USA (76). The attendees were 61% women, 39% men; and 20% were students. Of the 189 attendees, 63 (73% women, 27% men, from 14 different countries) attended the early career researcher event.



Figure 1. Photograph. Picture of the conference attendees gathering outside the conference venue on the edge of beautiful Lake Coeur d'Alene (Idaho, USA) for a well-deserved break at the end of the fourth day of the 5-day meeting.

Out of the 189 attendees, 64 (i.e., 34%) provided evaluations of the conference. Attendees were asked to evaluate the meeting based on 6 specific questions, which they could answer with “excellent” (4 points), “good” (3 points), “bad” (2 points) or “terrible” (1 point). The questions and scores were as follows:

1. “With regard to the exchange of knowledge, the format of the meeting was...”
Mean 3.6, standard deviation 0.5, median 4.
2. “The relevance of the presentations and discussions to my areas of interest was...”
Mean 3.5, standard deviation 0.5, median 4.
3. “The atmosphere for having informal discussions was...”
Mean 3.7, standard deviation 0.4, median 4.
4. “The location of the meeting was...”
Mean 3.6, standard deviation 0.5, median 4.
5. “The time and space for socializing was...”
Mean 3.6, standard deviation 0.6, median 4.
6. “The balance of topics in the program was...”
Mean 3.4, standard deviation of 0.5, median 3.

Shiftwork2019 was a highly successful meeting with a large amount of information exchange, excellent discussion and networking opportunities, high ratings from attendees, and considerable output. All aspects of the effort were completed, and the goals set for the conference were exceeded.

Target worker population

In the US, two in five workers are employed in shiftwork or other nonstandard work schedules outside the typical daytime (“nine-to-five”) hours, which encompass a variety of different working time arrangements including night and early morning shifts, rotating and irregular shifts, split shifts, on-call schedules, and extended hours. These types of schedules require workers to alter their sleep/wake cycles and cause misalignment between behavioral cycles and the biological clock in the brain. The adverse consequences thereof for performance, safety, health, and well-being have been extensively documented.

Shiftwork has been linked with most of the leading causes of death in the US, including cardiovascular disease, diabetes, and cancer, as well as a nearly two-fold increase in risk for work injuries and accidents due to fatigue. The cost of nonstandard work hours to US employers in terms of fatigue- and health-related lost productivity has been estimated to exceed \$136 billion annually. Aside from the health-related and economic costs, deleterious societal impacts such as reduced social and mental well-being have also been linked to shiftwork and extended work hours.

While the adverse consequences of nonstandard working time arrangements are relatively well understood, affecting hundreds of millions of individuals world-wide, much less is known about viable approaches to mitigating these effects. Solutions in terms of healthy work schedule design, education and training programs, pharmacological and

non-pharmacological countermeasure strategies, social and industrial interventions, etc., are the topic of active research. The conference advanced this research in all of its facets – from causes and consequences to solutions and implementation.

Collaborations and partnerships

The Shiftwork2019 meeting was organized by Washington State University, with support from the university's Sleep and Performance Research Center and the Elson S. Floyd College of Medicine, under the auspices of the Scientific Committee on Shiftwork and Working Time of the International Commission on Occupational Health and the WTS. The early career researchers event during the conference was supported by Integrated Safety Support (Australia). The publication of conference abstracts (see below) was supported by the Brazilian sleep society, Associação Brasileira de Sono, in conjunction with the WTS. Further, the WTS and Washington State University's Sleep and Performance Research Center provided a number of travel grants for early career researchers and practitioners. Through this U13 Conference Grant, NIOSH provided financial support for the meeting.

Immediately following the conference (September 13–14, 2019), NIOSH hosted the *Working Hours, Sleep & Fatigue Forum* in collaboration with the WTS. Held in the same location as Shiftwork2019 and making use of the assembled world-wide expertise, the *Working Hours, Sleep & Fatigue Forum* addressed research gaps and needs related to working hours, sleep and fatigue among US workers and employers. While beyond the scope of this report, this NIOSH meeting helped to further advance the mission of the NIOSH Working Hours and Fatigue work group to “reduce the health and safety risks associated with shiftwork and long work hours, in addition to promoting the wellness of workers in nonstandard schedules.”

Dissemination and translation of meeting accomplishments

Conference abstracts that were peer-reviewed and accepted for presentation at Shiftwork2019 have been published, in advance of the meeting, in a special issue of the journal *Sleep Science*, which is enclosed.

Furthermore, a call for papers for the proceedings went out following the conference, with the journal *Chronobiology International* agreeing to publish these papers in a special issue. Drs. Kimberly Honn (Washington State University), Erin Flynn-Evans (NASA Ames Research Center), Tomohide Kubo (National Institute of Occupational Safety and Health, Japan), and Ashleigh Filtness (Loughborough University, United Kingdom) served as guest editors. The response in terms of submitted contributions was so overwhelming that the journal graciously decided to devote a special *double* issue to the proceedings. The special double issue is currently being finalized and contains 34 peer-reviewed articles. Topics addressed in the proceedings cover a wide range of issues related to the meeting theme of “Innovations in Research and Practice

Improving Shiftworker Health and Safety” (see the Publications section later in this report).

Public health impact

In accordance with the Shiftwork2019 theme, “Innovations in Research and Practice Improving Shiftworker Health and Safety,” the meeting’s objectives were to discuss the latest developments in the science and practice of shiftwork, working time arrangements, and health and safety countermeasure approaches; foster international networking, cross-disciplinary collaboration, and early career researcher/practitioner development; and disseminate best practices to workers, employers, and regulators nationally and world-wide. In pursuing these objectives, Shiftwork2019 contributed substantially to a range of NIOSH priorities.

During the meeting and through published conference abstracts and proceedings (see below), the meeting addressed several NIOSH strategic goals (2019–2023):

- Promote safe and healthy work design and well-being;
- Improve workplace safety to reduce traumatic injuries; and
- Reduce occupational cancer, cardiovascular disease, adverse reproductive outcomes, and other chronic diseases.

Furthermore, the meeting pertained to all NIOSH mission goals and objectives (2016–2020), and specific sub-items thereof:

- Goal 1: Conduct research to reduce worker illness and injury, and to advance worker well-being. Develop innovative solutions for difficult-to-solve problems in high-risk industrial sectors.
- Goal 2: Promote safe and healthy workers through interventions, recommendations and capacity building. Enhance the relevance and utility of recommendations and guidance; Build capacity to address traditional and emerging hazards.
- Goal 3: Enhance worker safety and health through global collaborations. Take a leadership role to share knowledge and best practices; Provide workplace illness and injury reduction strategies; Build professional capacity to address workplace hazards through information sharing and research experience.

Shiftwork2019 also addressed multiple NIOSH intermediate goals across several sectors and cross sectors:

- Construction × Healthy Work Design: 7.1 Non-standard work arrangements (e.g., precarious workers, temporary workers). Better characterize risk factors for workers in nonstandard work arrangements, increase use of existing interventions among workers in nonstandard work arrangements, develop new cost-effective interventions for workers in nonstandard work arrangements.
- Health Care and Social Assistance × Cancer, Reproductive, Cardiovascular and Other Chronic Disease Prevention: 1.4 Work organization and cancer, cardiovascular disease. Work-related stress, anxiety, depression, fatigue as a result of suboptimal work organization; and Healthy Work Design: 7.2 Work organization.

Fatigue and stress due to suboptimal work organization, fatigue, stress, work organization as risk factors for motor vehicle crashes during commutes and shifts, nonstandard work arrangements.

- Mining × Healthy Work Design: 7.3 Work organization and fatigue-related injuries. Fatigue from long shifts over consecutive days, task-oriented fatigue, unique challenges in managing workload (seasonal, day/night), more systematic measurement and reporting of fatigue.
- Oil and Gas Extraction × Traumatic Injury Prevention: 6.10 Motor vehicle crashes. Refine understanding of motor vehicle risk factors (e.g., commuting, work organization including work hours), interventions (e.g., technologies like in-vehicle monitoring systems, fatigue risk management), fatigue prevention.
- Services × Cancer, Reproductive, Cardiovascular and Other Chronic Disease Prevention: 1.10 Risk factors for cardiovascular disease. Work organization factors (e.g., working time arrangements).
- Transportation, Warehousing and Utilities × Cancer, Reproductive, Cardiovascular and Other Chronic Disease Prevention: 1.13 Cardiovascular disease, obesity, work organization. Best types of interventions to address risk factors for obesity, work organization best practices (e.g., sleep); and Traumatic Injury Prevention: 6.14 Transportation incidents. Role of work organization (e.g., fatigue, sleep, stress, hours of service, commuting, nonstandard work arrangements), developing evidence-based interventions, vehicle design and technology (e.g., highly automated vehicles, connected vehicles, advanced driver assistance systems); and Healthy Work Design: 7.6 Work organization and obesity/chronic disease. Understanding links between obesity and fatigue, exploring existing data and ways to efficiently monitor contribution of fatigue, addressing socioeconomic risk factors (e.g., nonstandard work arrangements); 7.7 Work organization and fatigue-related injuries. Develop fatigue and stress interventions; 7.8 Stress/fatigue and human machine interaction. Displacement by autonomous vehicles, robotics and exoskeletons and interplay with fatigue (displacement, psychosocial).

Materials available for other investigators

The peer-reviewed conference abstracts of Shiftwork2019, published in a special issue of the journal *Sleep Science*, are available for download at no cost at the following web address: <https://cdn.publisher.gn1.link/sleepscience.org.br/pdf/v12s3.pdf>.

Publications

No publications resulted from the conference and the NIOSH U13 Conference Grant directly. For completeness, the publications submitted, peer-reviewed, and published afterwards as part of the proceedings – a special double issue of the journal *Chronobiology International* – include the following:

Aarrebo Jensen M, Hansen Å, Sallerup M, Nielsen N, Schlünssen V, Garde AH: [2020] Acute Effects of Night Work and Meals on Blood Glucose Levels. *Chronobiology International*, in press.

Aarrebo Jensen M, Kjærgaard J, Petersen J, Hansen Å, Kristiansen J, Garde AH: [2020] The Urinary 6-Sulfatoxymelatonin Level after Three Different Work Schedules with 2, 4 and 7 Consecutive Night Shifts among Danish Police Officers. *Chronobiology International*, in press.

Arsintescu L, Chachad R, Gregory K, Mulligan J, Flynn-Evans E: [2020] The Relationship between Workload, Performance and Fatigue in a Short-haul Airline. *Chronobiology International*, in press.

Bigand T, Cason M, Diede T, Wilson M: [2020] Pilot Testing an Electronic Food Diary among Registered Nurses Working Night Shifts. *Chronobiology International*, in press.

Brauner C, Wöhrmann A, Michel A: [2020] Congruence Is Not Everything: A Response Surface Analysis on the Role of Fit between Actual and Preferred Working Time Arrangements for Work-Life Balance. *Chronobiology International*, in press.

Centofanti S, Banks S, Coussens S, Gray D, Munro E, Nielsen J, Dorrian J: [2020] A Pilot Study Investigating the Impact of a Caffeine-Nap on Alertness during a Simulated Night Shift. *Chronobiology International*, in press.

Dall'Ora C, Ball J, Redfern O, Griffiths P: [2020] Night Work for Hospital Nurses and Sickness Absence: A Retrospective Study Using Electronic Rostering Systems. *Chronobiology International*, in press.

Erwin J, Skeiky L, Satterfield BC, Paech G, Layton ME, Van Dongen HPA, Hansen DA: [2020] Robustness of Inter-Individual Differences in Slow Wave Sleep for Daytime Sleep Periods After Total Sleep Deprivation With or Without Caffeine Administration: Potential Implications for Around-the-Clock Operations. *Chronobiology International*, in press.

Filtiness A, Beanland V, Miller K, Larue G, Hawkins A: [2020] Sleep Loss and Change Detection in Simulated Driving. *Chronobiology International*, in press.

Gregory K, Hobbs A, Parke B, Bathurst N, Pradhan S, Flynn-Evans Erin: [2020] An Evaluation of Fatigue Factors in Maritime Pilot Work Scheduling. *Chronobiology International*, in press.

Hilditch C, Arsintescu L, Gregory K, Flynn-Evans E: [2020] Mitigating Fatigue on the Flight Deck: How is Controlled Rest Used in Practice? *Chronobiology International*, in press.

Hudson AN, Hansen DA, Hinson JM, Whitney P, Layton ME, DePriest D, Van Dongen HPA, Honn KA: [2020] Speed/Accuracy Trade-Off in the Effects of Acute Total Sleep Deprivation on a Sustained Attention and Response Inhibition Task. *Chronobiology International*, in press.

Karhula K, Wöhrmann A, Brauner C, Härmä M, Kivimäki M, Michel A, Oksanen T: [2020] Working Time Dimensions and Well-being: A Cross-national Study of Finnish and German Health Care Employees. *Chronobiology International*, in press.

Kovac K, Vincent G, Paterson J, Aisbett B, Reynolds A, Ferguson S: [2020] Can an Increase in Noradrenaline Induced by Brief Exercise Counteract Sleep Inertia? *Chronobiology International*, in press.

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