

International Evaluation 2014

**NATIONAL RESEARCH CENTRE FOR THE
WORKING ENVIRONMENT**

Denmark

November 2014

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1. Background for the evaluation

1.1 Terms of reference for the evaluation:

Terms of Reference for the International Evaluation 2014 of the National Research Centre for the Working Environment

5 February 2014

1. Background and purpose

This evaluation will be carried out in accordance with the government order on evaluation of government research institutes.

The purpose of the evaluation is primarily to assess the quality, relevance and effect of the research, the dissemination of research results and the contribution to further education carried out at the National Research Centre for the Working Environment (NRCWE). Furthermore, it is important that the evaluation gives inspiration to improvements and potential new research objectives. The evaluation and the recommendations are expected to address the various clusters of research as well as the NRCWE as a whole.

The criterion of relevance used below refers to the NRCWE's organizational and political framework. Research and dissemination of research results, should be assessed in relation to the demands and needs of the Ministry of Employment, The Danish Working Environment Authority, the social partners, working environment advisers and workplaces as expressed in e.g. the national working environment strategy and the strategies of the NRCWE. The contribution to further education should be assessed in relation to the needs of the universities and the relevance to the NRCWE's overall activities.

The evaluation will cover the period 2009 – 2013. The latest international evaluation covered the period 2005 – 2008.

2. Form and participants

The evaluation will be carried out as an independent peer review performed by a panel of 6 highly acknowledged international researchers within the field of working environment research. It is desirable that at least one of the evaluators took part in the evaluation of the NRCWE in 2008.

The evaluators must in combination cover the entire range of research fields of the NRCWE and must be experienced in research management and in society- and user-oriented research.

Because of the broad research scope of the NRCWE, the research projects may be grouped in a number of related 'clusters'. Each cluster could be covered by an evaluator with focus on research and contribution to further education within the cluster. The 'clusters' could, for example, be 1) psychosocial working environment including occupational accidents and safety culture, 2) physical working environment, 3) nano safety including toxicology, and 4) working environment surveillance. The evaluators may consider if an evaluator should be dedicated to the evaluation of the dissemination of research results including counselling of the authorities and stakeholder relevance.

The panel must be independent of the Ministry of Employment, including the NRCWE.

The board of the NRCWE will appoint the panel on the basis of nominations from The Danish Council for Strategic Research.

3. Scope and main tasks

The main task of the NRCWE, namely research, and the related core tasks, dissemination of research results and education must all be evaluated with respect to relevance, effect and quality.

The evaluation must address the following questions:

Research

- Is the research quality of high standard and extent when compared to similar national and international groups of researchers?
- Are the researchers to a sufficient extent networking with strong research groups at other universities and research centres in Denmark and abroad?
- Is the networking sufficient for fundraising purposes? Is the degree of external financing sufficient?
- Are the resources applied in accordance with the NRCWE's strategic prioritization? Is it possible to increase synergy across the present/new research fields?
- Are the research topics relevant to the social partners, working environment advisers as well as employees and employers at the workplaces?
- Do the research and the strategies cover the needs of the authorities for counselling?

Dissemination of research results

- Is the dissemination of research results to a sufficient extent visible, relevant and user-oriented for the target groups among the social partners, working environment advisers and employees/employers at the workplaces?
- Is the NRCWE research-based counselling of the authorities to a sufficient extent relevant and user-oriented?
- Does the NRCWE attract the attention of the general public? How can the NRCWE strengthen its future impact?

Education

- Does the NRCWE to a sufficient extent contribute to working environment-related education at the universities?
- Does the NRCWE to a sufficient extent contribute to the education of undergraduates/postgraduates and PhDs within the working environment field?

Background material

- The NRCWE will provide the necessary background material such as:
- The by-laws of the NRCWE
- The international evaluation of 2008 and the follow-up statement from the board
- National working environment strategies for the evaluation period¹
- Performance contracts and strategies for the evaluation period²
- The NRCWE's annual reports for the evaluation period 2009 – 2013
- Bibliometrics

Procedure

An independent academic consultant will assist the evaluation panel during visits to the NRCWE and in drawing up the evaluation report. This secretarial assistance to the evaluators will be independent of the NRCWE and the Ministry of Employment.

The NRCWE will organize site visits to the NRCWE and will provide practical assistance to the evaluators. It is a prerequisite that the panel involves the stakeholders when evaluating the relevance and effect of the NRCWE.

Time schedule

The evaluation report must be submitted to the NRCWE no later than 10th November 2014.

The details of the time schedule will be discussed with the evaluators when the panel has been appointed.

Financing

The evaluation will be financed by the Ministry of Employment.

¹ 'Report of the future working environment 2010 – new prioritization of the working environment effort' and 'A new strategy for the working environment effort to 2020'

² The Ministry of Employment's management concept has changed during the evaluation period. In 2009 – 2010, the concept consisted of both annual performance contracts with specific goals and longer term strategies. From 2011, the specific annual goals have been integrated in strategies. The specific documents are: AMI/NRCWE Strategy 2006 – 2010; NRCWE Performance contract 2009 – 2012; NRCWE Performance contract 2010; NRCWE/Working Environment Information Centre - Background Paper of the business strategy 2010 – 2014; NRCWE/Working Environment Information Centre - Business strategy 2010 – 2014; NRCWE/Working Environment Information Centre - Business strategy 2011 – 2015; NRCWE/ Working Environment Information Centre Business strategy 2012 – 2015, and finally; NRCWE Strategy 2013 – 2017.

1.2 Evaluators:

Chief evaluator and partly evaluator of psychosocial working environment (including occupational accidents and safety culture):

Professor Stein Knardahl, MD from the University of Oslo and PhD from the Faculty of psychology, the University of Bergen. Head of the Department of Work Psychology and Physiology, National Institute of Occupational Health (STAMI), Norway. Has been adjunct professor at the Dept of Psychology of the University of Oslo for 15 years. Has coordinated and chaired research programs of work and health of the Norwegian Research Council. Member of the editorial board of the '*Scandinavian Journal of Work, Environment and Health*'. Member of the panel of the 2005-2008 evaluation of the NRCWE and chaired the evaluation of the Swedish Institutet för psykosocial medicin (IPM; 1994-1998; presently The Stress research institute). Member of the scientific advisory panel for The Danish Working environment research fund (DWERF). His main research areas are psychophysiological mechanisms of chronic pain and high blood pressure, contributions of psychosocial work factors to health, absence, and exit from working life.

Psychosocial working environment (including occupational accidents and safety culture):

Professor Michiel Kompier, Department of Work and Organizational Psychology, Radboud University, Nijmegen, the Netherlands. He is associate-editor of the '*Scandinavian Journal of Work, Environment and Health*', member of the international advisory board of the '*Journal of Occupational Health Psychology*' and member of the editorial board of '*Work and Stress*'. He is past chairman of the Scientific Committee 'Work Organization and Psychosocial Factors' of ICOH (International Commission on Occupational Health) and past director of the Behavioural Science Institute (Radboud University).

Psychosocial working environment (including occupational accidents and safety culture) and working environment surveillance:

Professor Jørn Olsen MD, PhD, Department of Public Health, University of Aarhus, Denmark. He is professor of Social Medicine at AU and professor of epidemiology at SDU and UCLA. He was head of the Danish Epidemiology Science Centre from 1994 to 2004. He is head of the National Birth Cohort in Denmark and was Chair of the Department of Epidemiology at UCLA from 2005 to 2011. Has been a member of the Danish Research Council and is currently Head of Scientific Committee for the Work Environment Fund. He has evaluated research projects and research institutions in Denmark, Europe and the US. He is editor of the IJE and Human Reproduction Update and is co-editor of a number of other scientific journals.

Physical working environment:

Professor Svend Erik Mathiassen, Department of Occupational and Public Health Sciences, University of Gävle, Sweden. SvEM is research director at the department and coordinator of the national Centre of Excellence The Body at Work – from Problem to Potential at the University funded by the Swedish Research Council for Health, Working Life and Welfare. He holds a master in exercise physiology from Copenhagen University, and a PhD in occupational physiology from Karolinska Institutet in Stockholm. His main research interest is physical activity variation: how to measure “variation”, effects of different types of variation on performance, fatigue and disorders, and interventions in working life promoting or obstructing variation. His interest in exposure variability has also led to frontline research on cost-efficient strategies for collecting and analyzing data on physical load.

Nano safety including toxicology:

Professor Gunnar Johanson, Institute of Environmental Medicine, Karolinska Institutet, Sweden. Head of the Unit of Work Environment Toxicology and professor of occupational toxicology and risk assessment since 2001. His research interests cover several areas in toxicology, from indoor air quality to work place exposures and chemical disasters. He is a member of several committees including the SCOEL (European Commission), the AEGL (US Nat Res Council), the Nordic Expert Group (chair) and the Swedish Criteria Group for OELs (vice chair).

Dissemination of research, counseling of authorities and stakeholders:

Director of Communication and International Relations Sture Bye, National Institute of Occupational Health (STAMI), Norway. Chairman of the Executive Committee NOROSH, publisher of The Scandinavian Journal Of Work Environment and Health, and Board member of Nordic Institute for Advanced Training in Occupational Safety and Health (NIVA). Has extensive experience of research dissemination as well as communication in both the public and private sector.

Panel secretary:

Research scientist Håkon A. Johannessen, PhD, Department of Occupational Health Surveillance, National Institute of Occupational Health (STAMI), Norway. His research interests cover several areas in occupational epidemiology, in particular health outcomes related to psychosocial exposures at work.

1.3 Evaluation procedures

The evaluation committee was formally appointed by the Board of governors of the NRCWE March 17th 2014.

The evaluation was based on (i) “A new strategy for the working environment effort to 2020” and the several strategic priority documents and performance contracts of the evaluation period 2009-2013, (ii) written material from the NRCWE (background material and information requested from the

evaluation committee, see Appendix), (iii) a two-day site visit for interviews with directors and researchers representing all research fields (June 19th – 20th, 2014), (iv) interviews of representatives of primary stakeholders, the Ministry, and other relevant organizations, and (v) a follow-up interview of the management of the NRCWE after interviews of stakeholders.

The NRCWE provided information of current strategic priorities, evaluation of current strengths, weaknesses, opportunities, and threats (“SWOT-analysis”), description of organization, list of employees, list of publications, and data on annual funding with sources.

After reviewing the several strategic priority documents and performance contracts of the evaluation period 2009-2013, a list of strategic priorities was extracted:

1. Psychological, social, and organizational work factors contributing to/associated with musculoskeletal disorders (including methods for prevention).
2. Psychological, social, and organizational work factors contributing to/associated with accidents and other outcomes than musculoskeletal disorders.
3. Mechanical (physical) work factors contributing to/associated with musculoskeletal disorders (including methods for prevention).
4. Absence and exclusion (= Development of research-based models and practical methods for job retention including focus on immigrants).
5. The formation of an inter-institutional centre for nano safety = New technologies.
6. Development of methods for assessment of risks posed by exposures associated with new, green technologies = New technologies.
7. Development and implementation of a program for surveillance of the development of the work environment until 2020.
8. Noise.
9. Other chemical exposures and studies of toxicology.

For each of these fields, the NRCWE reported strategic priorities, lists of publications, impact on the society, research of interventions, resources spent on the research field, collaborators, PhD and Master students, teaching, and self-evaluation of current situation and future plan and opportunities (the entire list of requested information is included in Appendix 1).

Some of the strategic priorities pertain to occupational exposures (psychological, organizational, nano-safety, green technologies, noise), some fields address outcomes (musculoskeletal pain, accidents, absence and exclusion), and some fields pertain to general methods of monitoring and improving the situation of Danish employees. Hence, there is overlap between the research fields: some projects by design cover two or more fields (e.g. psychological work factors contributing to musculoskeletal pain disorders).

The Terms of reference for this evaluation proposed the following grouping of research topics:

Because of the broad research scope of the NRCWE, the research projects may be grouped in a number of related 'clusters'. Each cluster could be covered by an evaluator with focus on research and contribution to further education within the cluster. The 'clusters' could, for example, be 1) psychosocial working environment including occupational accidents and safety culture, 2) physical working environment, 3) nano safety including toxicology, and 4) working environment surveillance.

In accordance with the Terms of reference, the present report organizes research fields and strategies *according to exposures* (1. Psychosocial working environment, 2. Physical working environment, 3. Chemical, biological work environment: nanosafety) with the addition of (4) Working environment surveillance.

The site-visit interviews served to clarify and supplement the written information.

Interviews with representatives of stakeholders: The NRCWE provided a list of primary stakeholders with a proposal for representatives. Primary stakeholders were defined as organizations funding the NRCWE (The Ministry of employment, The Work environment research council), social partners (employers' and unions' organizations), primary users of the output of the NRCWE (the National working environment authority - Arbejdstilsynet), and collaborating institutions (occupational health hospital departments, universities)

The NRCWE reviewed the report for factual errors prior to its completion.

2. The political, economic, and organizational framework of the NRCWE

2.1 Organization: the Ministry of Employment

The Ministry of Employment is responsible for the framework and rules for employment and working conditions, safety and health at work and industrial injuries, financial support and allowances to all persons with full or partial working capacity as well as placement activities, services in relation to enterprises and active employment measures.

In addition, the Ministry has the overall responsibility for measures for all groups of unemployed persons, i.e. both unemployed persons on social assistance as well as unemployed persons receiving unemployment benefits.

The Ministry of Employment consists of the Department and the following four government agencies:

- The National Research Centre for the Working Environment,
- The Danish Working Environment Authority,
- The Danish Agency for Labour Market and Recruitment,
- The National Board of Industrial Injuries.

The Ministry of Employment has exclusive competence for legislation and programmes for labour law, safety and health at work, and compensation in connection with industrial injuries. In addition, the Ministry is responsible for several work-related allowances such as unemployment and sickness benefits, and social activation measures.

2.2 Stakeholders

Authorized by the Law of Government Research Institutes (Danish: Lov om sektorforskningsinstitutioner) and the Danish working environment act (in Danish: Lov om arbejdsmiljø), The Ministry of Employment by a statutory rule (Danish: Vedtægt for det Nationale Forskningscenter for Arbejdsmiljø) defined the role of the National Research Centre for the Working Environment (NRCWE) to provide the Ministry of Employment and its agencies with national and international work-environmental research-based knowledge. In addition, the NRCWE shall operate as a national coordination centre of work environmental research knowledge, and disseminate such knowledge to various authorities, labor organizations, enterprises, and work environmental advisors. In practice the NRCWE, as established through its by-laws, transfer knowledge to society in three ways: i) counseling the Ministry of employment, ii) dissemination of research knowledge to OSH actors (i.e. the social partners, OSH consultants/practitioners and enterprises) and society at large, and iii) contribute to undergraduate and postgraduate education.

2.3 National strategy: “A new strategy for the working environment effort to 2020” (“En strategi for arbejdsmiljøindsatsen frem til 2020”)

This strategy is an agreement between the government (Denmark’s Liberal Party and the Conservative party), the Social Democratic Party, the Danish People’s Party, and the Social Liberal Party.

The following are excerpts of this strategic agreement:

Objectives and priorities of the 2020 working environment efforts

The parties agree to focus on the following working environment problems as part of the 2020 working environment efforts:

- Accidents at work
- Psychosocial working environment
- Musculoskeletal disorders

The following objectives regarding the working environment in 2020 have been agreed:

- The number of serious accidents at work is to be reduced by 25% in proportion to the number of employees
- The number of employees who are psychologically overloaded is to be reduced by 20%
- The number of employees who experience musculoskeletal disorders is to be reduced by 20%

These objectives are to be achieved in the period beginning 2012 until the end of 2020.

There is greater risk of working environment problems in some industries than in others. Therefore, enterprises are given points according to the index model based on the industries to which they belong. The Danish Working Environment Authority bases its knowledge on the Authority's experience gained from its decisions (e.g. improvement notices), guidance on psychosocial working environment, accidents at work and studies by the National Research Centre for the Working Environment (NRCWE). Working environment problems with the highest priority have higher values in the index than other working environment problems.

The basis of the new strategy of the Danish Working Environment Research Fund in 2011 is that the resources of the Fund should be targeted towards projects that primarily relate to the three focus areas for the working environment and measures. However, continued research in key areas such as indoor environment, chemicals and noise should be ensured.

The Danish Working Environment Authority, the National Research Centre for the Working Environment and the National Board of Industrial Injuries will adapt the existing measurement programme for progress with regard to the working environment. Information about the relevant working environment factors will be gathered to enable the regular monitoring of progress within the focus areas. Monitoring areas that are not focus areas will also be possible.

This National strategy constitutes a basis for strategic priorities of the NRCWE formulated in strategy documents. Furthermore, the National strategy provides strategic guidelines for The Danish Working Environment Authority which is a major primary stakeholder and for the Danish Working Environment Research Fund which is a major source of funding.

3. The NRCWE: overview

3.1 Description

The National Research Centre for the Working Environment (NRCWE) is an independent national research centre organized under the Ministry of Employment at the same level as sister agencies such as the Working Environment Authority (abb.: WEA; in Danish: Arbejdstilsynet), and the National Board of Industrial Injuries (abb.: NBII; in Danish: Arbejdsskadestyrelsen).

As part of the National efforts to ensure a healthy and empowering working environment, “The goal of the NRCWE is to provide a research-based knowledge base to ensure safe and developing working conditions in accordance with developments of the society and the needs of businesses and the work environment system” (Danish: “NFA har til formål at tilvejebringe et forskningsbaseret videngrunnlag for at sikre sunde og udviklende arbejdsforhold i overensstemmelse med samfunnsutviklingen og behovet hos virksomhederne og arbejdsmiljøsystemet”). This is provided by interdisciplinary surveillance, examination and research on the effects of work-related factors, and work environmental interventions on health, well-being, and productivity.

However, as a research centre the NRCWE has a special status and is, unlike the other agencies in the ministry, regulated by the Government Research Institutes act (in Danish: Lov om sektorforskningsinstitutioner) as well as by the Danish working environment act (in Danish: Lov om arbejdsmiljø). The Government Research Institutes act ensures that research (choice of methods and publication) is independent of the Ministry of employment. The law states that a board of governors must be established to ensure this independence.

3.2 Organization

The law on Government Research Institutes specifies that the NRCWE is managed by the board of governors. The board of governors (named by the Minister of employment) is responsible for the overall management of the NRCWE, including defining the strategy, whereas the day-to-day management is the responsibility of the director general. A chairman, six members with work environmental expertise nominated by the Working Environment Council (in Danish: Arbejdsmiljørådet), four members from universities (the three largest Danish universities and a Nordic university), and two NRCWE employees elected by the staff, have seats on the board of governors of the NRCWE. The Permanent Secretariat of the Ministry of Employment and the Working Environment Authority are observers at the meetings.

The director general reports to the Permanent Secretary of the Ministry of Employment and the chairman of the board. The director general is a member of the corporate management of the Ministry of Employment (in Danish: Koncernledelsen; KCL). In addition, the director general takes part as observer in the meetings of the Working Environment Council, which is a forum of social partner representatives counselling the Minister of Employment on matters relating to occupational safety and health.

The directors of the NRCWE have quarterly bilateral meetings with the directors of the Working Environment Authority and the National Board of Industrial Injuries. This is to ensure sharing of knowledge and coordination. Finally, the directors meet quarterly with the head of the political secretariat of the Permanent Secretariat (in Danish presently called ‘Center for Arbejdsliv’).

The top management of the NRCWE consists of three directors: the director general, Inger Schaumburg, the deputy director general, Ulla Skjøth, and the research director, Nils Fallentin. The middle management consists of three heads of research (in Danish: forskningschefer), the head of communications, the head of planning, and the head of secretariat, altogether a management group of nine people. Top management meet twice weekly for directors meetings and once weekly for management meeting (in Danish: chefmøde) of the nine managers.

3.2.1 Research management

The professors and key senior researchers take part in one of the management meetings per month, the so-called scientific management meeting (in Danish: forskningsfagligt chefmøde), which then focuses on strategy, coordination, and the content of research. Also, in order for the directors to coach the managers and to monitor progress of activities, bilateral meetings are held bi-weekly between the directors and the individual managers.

Research at the NRCWE is organised in projects varying considerably in size, duration and content. A typical research project is multidisciplinary in nature and makes use of the large number of competencies and methods available in-house and through national and international networks at universities, including the departments of occupational medicine at the university hospitals. Since research is organised in projects, project management and project coordination play important roles in the general management of the NRCWE. The three heads of research act as facilitators and financial controllers of the projects rather than as scientific managers. Their primary tasks are to develop and implement research programs along the lines of the NRCWE-strategy, to be personnel managers for staff of their research clusters, and to coordinate research within and between clusters so as to optimize the use of resources. The professors have a special role as scientific mentors (this is specified in their performance contracts with the director general).

The projects are organized in three clusters of research. The heads of research are Elsa Bach with working environment surveillance and epidemiology as the main clusters; Glen Winzor with psychosocial working environment and musculoskeletal disorders as the main clusters; and Lars Andrup with nanosafety, toxicology, microbiology, noise and occupational accidents and safety culture as the main clusters. Although the heads of research have the overall responsibility for managing the projects and overseeing that projects are carried out as agreed, it is the project leaders themselves who carry out the day-to-day management of the projects.

3.2.2 Management of services to the Ministry of Employment

The primary user of research based knowledge in the Ministry of Employment is the Working Environment Authority (Arbejdstilsynet) with whom the NRCWE meets every quarter at director level. An annual cooperation agreement between the two specifies themes for cooperation at expert level and terms and conditions for the on-going preparedness for emerging risks.

Operating in a ministerial setting often takes place in accordance with very formal procedures. In order to ensure clear internal coordination and a correct 'translation' of documents between the 'politico-administrative' and the 'scientific' sphere, handling of requests from the ministerial agencies is centralised to the Management Secretariat.

3.2.3 Management of educational activities

The statutory contribution of the NRCWE to undergraduate, postgraduate and research education is primarily managed through performance management contracts. Issues concerning education are addressed at the scientific management meetings, in bilateral annual performance talks between the professors and the director general, and when new projects are being developed. The NRCWE signed strategic cooperation contracts with the five major universities in 2007-2008.

3.2.4 Management of communication

Communications is managed by Head of Communications Hannah Weil, and the field comprises research communication of NRCWE research projects and broader communication via the Working Environment Information Centre (WEIC). Scientific publication of articles in international scientific journals with peer review is managed by the respective researchers themselves. General popular science communication from own projects are primarily mediated as news articles (with links to original articles) via the website <https://nfa.dk>, an electronic news letter and social media. This work is carried out by two communicators and a web-coordinator who in close contact with researchers monitor progress of projects.

The WEIC serves as an entrance for broad working environment knowledge and gathers and communicates working environment knowledge and examples of good practice from all relevant sources, including but not restricted to the NRCWE.

3.3 Research strategies 2009 – 2013

In the period 2009 – 2013 the Ministry of Employment altered its management concept. There are several steering documents pertaining to strategy and performance for the evaluation period. The strategy for the time period 2006-2010 listed the following prioritized research fields:

- Occupational accidents
- Absence and exclusion
- Work-related pain in muscles and joints
- Psychological working environment
- Organising and management
- Noise
- New technologies
- Intervention and implementation

The business strategy for the time period 2010-2014 listed the following prioritized research fields (translated from Danish):

- Development and implementation of models for prevention of psychological work environment problems and promotion of well-being related to altered structures, altered work arrangements, new types of organizations, including the development and implementation of safety-culture concept for the prevention of occupational accidents.
- Development of research-based models and practical methods for job retention work including focus on immigrants.
- Development and implementation of methods for primary and secondary prevention of musculoskeletal pain.
- The formation of an inter-institutional centre for nano safety and the development of methods for assessment of risks posed by exposures associated with new, green technologies.

The business strategy for the time period 2011-2015 listed the following prioritized research fields (translated from Danish):

- Development and implementation of models for prevention of psychological work environment problems and promotion of well-being related to altered structures, altered work arrangements, new types of organizations, including the development and implementation of safety-culture concept for the prevention of occupational accidents.
- Development and implementation of methods for primary and secondary prevention of musculoskeletal pain.
- The formation of an inter-institutional centre for nano safety.

- Development and implementation of a program for surveillance of the development of the work environment until 2020.

Hence, the following research fields were given priority in the time period 2009-2013:

1. Development and implementation of models for prevention of psychological work environment problems and promotion of well-being related to altered structures, altered work arrangements, new types of organizations (= Psychological working environment and Organising and management).
2. Occupational accidents, including the development and implementation of safety-culture concept for the prevention of occupational accidents.
3. Development and implementation of methods for primary and secondary prevention of musculoskeletal pain (= Work-related pain in muscles and joints).
4. Absence and exclusion (= Development of research-based models and practical methods for job retention including focus on immigrants).
5. Intervention and implementation.
6. The formation of an inter-institutional centre for nano safety (= New technologies).
7. Development of methods for assessment of risks posed by exposures associated with new, green technologies (= New technologies).
8. Development and implementation of a program for surveillance of the development of the work environment until 2020.
9. Noise.

3.4 Project initiation and management

Initiation of research projects is described by the management as a bottom-up process at the NRCWE. New ideas are typically presented at or emerge from informal internal scientific meetings organized by the scientists.

A number of formal initiatives for developing new projects result from visits of the director and key senior researchers to other OSH research groups in Denmark, primarily the departments of occupational medicine at the university hospitals and university departments. In addition, new user-oriented ideas for research initiatives arise at the regular meetings at expert level between inspectors of the WEA and researchers of the NRCWE.

Project proposals (at an early stage) and external financing possibilities are on the agenda at all meetings of the management group.

The monthly scientific management meetings assess potential quality, feasibility and potential for external financing. In addition to the top management and the three heads of research, the professors and senior researchers take part in these monthly meetings.

Approximately six months before the deadline of submitting grants for the Working Environment Research Fund, ideas for new projects are systematized and discussed in the coordination committee of the heads of research chaired by the research director. The members of this group serve as internal peer reviewers and challenge new ideas with constructive criticism in order to ensure viability relevance, interdisciplinarity, stakeholder involvement, external cooperation, internal scientific reference group, budget, and communication plan.

3.5 Dissemination of knowledge: organization

The two entities working with communication and dissemination; NRCWE research dissemination and the more broad knowledge from the Working Environment Information Centre (WEIC), were merged in 2013.

The two entities have been governed as one organizational unit although one has chosen to continue to uphold a division between the two entities communicative objectives and work-tasks. The NRCWE research dissemination unit consists of 3 communicators (web and communication). The WEIC communication unit consists of 24 communicators (web, consultants, coordinators, journalists etc).

The WEIC was established in 2005 as a part of the NRCWE, holding its own independent mission. In 2008, on the basis of triparty agreement, it was strengthened. The WEIC has been funded extraordinarily to perform particular efforts aimed at public workplaces, a funding which will end in 2015. The organizational setup of the WEIC will then change in relation to the funding situation.

3.6 Key numbers institute level

The NRCWE's research financing consists of:

- A. A basic government grant
- B. Politically prioritized grants
- C. Research fund grants

The funding through the last five years is presented in table 3.1.

Table 3.1 Overall annual account 2009 – 2013 (Million DKK.). Source: the NRCWE.

Year	2009	2010	2011	2012	2013
Income					
Basic government grant	70.1	61.1	69.5	68.1	64.6
External funding	44.7	40.0	43.9	38.7	45.0
a. political prioritized grants	13.0	9.0	9.0	13.0	14.0
b. research fund grants	31.7	31.0	34.9	25.7	31.0
Total	114.8	101.1	113.4	106.8	109.6
Costs	110.5	99.9	99.7	106.7	109.6
Results	4.3	1.2	13.7	0.1	0.0
<i>External funding in percent of costs</i>	40.5	40.0	44.0	36.3	41.1

Publications

We consider the number of scientific articles published in international peer-reviewed scientific journals as a good indicator of the general output of NRCWE research. It is a good indicator of productivity, scientific quality, and originality.

Table 3.2 depicts the articles published by year and their citations in addition to conference presentations and PhD-theses. Source: the NRCWE.

Publication year	2009	2010	2011	2012	2013
Articles in internationally recognized peer-reviewed journals	122	137	150*	132	153
Publications indexed by the ISI**	464	509	539	602	624
Citations**	2.608	2.855	3.043	3.794	4.004
Citation per publication**	5.6	5.6	5.6	6.3	6.4
Conference contributions***	110	67	48	41	68
PhD Theses	3	10	4	4	2

* One article more has been included in 2011 than stated in the annual report due to re-adjustment.

** Based on correction with authors from the NRCWE indexed by the Institute for Scientific Information (ISI), USA. The table lists publications and corresponding citations in comparable 5-year periods up to and including the indicated year.

*** Conference contributions have not been systematically registered in the period 2010-2012.

Many studies are carried out by collaborating institutes and the NRCWE are expected to facilitate collaborative efforts. In general, authorship of research publications is arranged in accordance of the respective contribution of the researchers: the first author has contributed more than the others in terms of amount of work and in terms of writing the article. The last author (often referred to as the senior author) generally has been responsible for the study, and sometimes the ideas or research questions.

Impact factor is a proxy for the general impact of a scientific journal. The impact factor of a journal is a measure of the average number of citations of recent articles published in the journal. This can only be taken as an approximate indicator, since certain publication factors may influence it. For instance, review articles are often cited rather than original articles in order to save space, hence journal may increase their impact factors by publishing review articles. Furthermore, the number of scientist in a given area reflects the impact factor. Scientists who do research in narrow, but potentially important area, have few peers to cite their work. Occupational health is not a large research topic worldwide.

In order to present the contribution of NRCWE scientists' publications and to present a proxy of scientific impact, table 3 shows authorship and impact factors pertaining to the NRCWE publications.

Table 3.3 Impact Factor of articles published in 2013. Source: the NRCWE.

Impact Factor	First or last authorship (%)	All publications (%)	Ratio
<2	36 (37.5)	43 (28.0)	0.84
2-4	49 (51.0)	87 (57.0)	0.56
>4	11 (11.5)	23 (15.0)	0.48
Total	96 (100)	153 (100)	0.63

4. Evaluation of NRCWE's research

Some of the strategic fields of the strategic priority documents for the Research centre pertain to occupational exposures (psychological, organizational, nano-safety, green technologies, noise), some fields address outcomes (e.g. musculoskeletal pain, accidents, absence and exclusion), and some fields pertain to general methods of monitoring and improving the situation of Danish employees. Hence, there is overlap between the research fields: some projects cover two or more fields (e.g. psychological work factors contributing to musculoskeletal pain disorders).

In general, most strategic research fields pertain to creating knowledge of work factors that contribute to health, well-being, work ability, absence, and exit from working life. Creating knowledge of work factors that contribute to work motivation and work performance have not been included in the strategic fields of this evaluation period. However, the NRCWE have performed several studies of individual-based interventions (e.g. exercise programs), studies of facilitating recovery from sickness absence, and of rehabilitation measures for patients with a given disorder or disability.

The present evaluation systematizes the research fields of the strategic plans according to clusters of occupational exposures: (1) Psychosocial exposures (including organizational factors and culture), (2) physical exposures (including mechanical exposures, noise), and (3) chemical, biological exposures: nanosafety (including nanoparticles, toxicology, microbiology). The surveillance of working life is evaluated as a separate cluster.

Intervention and implementation will be discussed for each cluster.

4.1 Psychosocial work environment

This exposure cluster includes knowledge of psychological (e.g. work content), social (e.g. social interactions, culture, justice), and organizational (e.g. working hours, shift schedules, organizational change) factors. These factors may contribute to a variety of outcomes, hence aspects of the following strategic fields are included in this cluster:

- Development and implementation of models for prevention of psychological work environment problems and promotion of well-being related to altered structures, altered work arrangements, new types of organizations (= Psychological working environment and Organising and management).
- Occupational accidents, including the development and implementation of safety-culture concept for the prevention of occupational accidents.
- Development and implementation of methods for primary and secondary prevention of musculoskeletal pain (= Work-related pain in muscles and joints).
- Absence and exclusion (= Development of research-based models and practical methods for job retention including focus on immigrants).
- Intervention and implementation.

This chapter focuses on the psychosocial work environment and its effects on health and well-being, safety and workability. The psychosocial work environment includes the job content (work characteristics), several aspects of employment (e.g., pay, working hours, shift schedules), and social relations at work (e.g., social interactions, culture, justice). Also, new types of work organization, such as 'new ways of working' and telework, are included. These factors (or combinations of these factors) may influence workers' health and well-being, work ability, and workers' performance.

In accordance with the strategic priorities for the evaluation period, we have divided the work of NRCWE in this domain in three sections. The first section (4.1.1) concentrates on studies that investigate positive and negative outcomes of the psychosocial work environment, and studies into prevention and interventions. The second section (4.1.2) focuses on occupational accidents and safety. The third section (4.1.3) deals with the institute's work on absence and worker exclusion.

As most classifications, this division is somewhat arbitrary. These sections and the research projects they incorporate are related and are somewhat overlapping. NRCWE researchers often work in more than one of these research lines. Nevertheless we are confident that this reporting provides an appropriate framework for the assessment of NRCWE's research in this area.

4.1.1 Development and implementation of models for prevention of psychological work environment problems and promotion of well-being related to altered structures, altered work arrangements, new types of organizations (= Psychological working environment and Organising and management).

This chapter includes all outcomes (mental disorders, musculoskeletal disorders, sickness absence, etc).

4.1.1.1 Introduction and background

Psychosocial work environment is a large and prioritized area within NRCWE. The main research themes are: (1) psychosocial work environment and health; (2) organization and social relations; (3) inclusion and retention at work and at the labor market (see section: 4.1.3). Furthermore the NRCWE emphasize the development of state-of-the-art research methods (e.g. COPSOQ) and the development of a methodology for intervention research.

Whereas in the 2008 evaluation 'Psychosocial work environment' and 'Organization and management' were two separate fields, these two areas are now integrated. Since 2011 all psychosocial work environment projects report to the same head of research (Glen Winzor). A joint strategy for this field was developed in 2011 and this strategy was updated in 2013.

This program has a multidisciplinary scope, and within the evaluation period collaboration between 'psychosocial' and 'musculoskeletal' researchers has been strengthened. According to the Self-evaluation report (general institute, p.4), the NRCWE 'seeks to further integrate research in the fields of psychosocial working environment and musculoskeletal disorders, which is why they were merged under the same head of research in 2013'. This development was stimulated because it is increasingly acknowledged that psychosocial work characteristics may contribute to musculoskeletal disorders, and that 'psychological' expertise with respect to implementation and process evaluation is needed for intervention and evaluation research.

We believe that this NRCWE decision has been a sound one, since it paves the way for an innovative and more integrated approach towards the interplay of mechanical and psychosocial exposures in the workplace.

4.1.1.2 Organization and management

The NRCWE has a horizontal organizational structure with a high degree of flexibility. Research is organized in projects. This is a multidisciplinary research group. All psychosocial work environment project leaders report to the same head of research. The head of research agrees upon bilateral performance contracts with the project leaders. There are two professors who act as scientific mentors.

During the site visit the staff representatives made a competent and engaged impression.

During the site visit, research with respect to psychosocial factors and health was discussed in two separate sessions: Psychological, social and organizational work factors contributing to/associated with musculoskeletal disorders (including methods for prevention) (*Field 1*); Psychological, social and organizational work factors contributing to/associated with other outcomes than musculoskeletal disorders (*Field 2*).

4.1.1.3 Key numbers

Staff

There have been considerable changes during recent years. Two professors moved to universities and various senior researchers left the NRCWE. Currently (*Field 2*) there are two professors, a chief consultant, four senior researchers, and a number of young researchers and PhD-students. In addition there is (technical) support staff.

New appointment(s) of senior staff would be welcome in order to maintain its high quality work and to remain productive and internationally competitive.

Finances

NRCWE pointed out that the 2013-percentage external funding (politically prioritized grants and research fund grants), as percentage of the total direct costs, was 73% (*Field 1*: 'psychosocial working environment and musculoskeletal disorders') and 79% (*Field 2*: 'psychosocial working environment and other outcomes'). The committee was informed that this 73% (*Field 1*, 2013) relates to DKK 8.6 million (total costs), and that this 79% (*Field 2*) relates to total costs of DKK 9.5 million. Comparatively the percentages of external funding are high.

Table 4.1.1 Psychosocial research field budget 2013: Promotion of well-being. Source: the NRCWE.

DKK*	Int. Financing	PPG** Financing	RG*** Financing	Total	RG (%)	RG/PPG (%)
Salaries	1,210,118	1,729,717	4,814,879	7,754,713	62.1	84.4
Running costs	750,809	571,704	435,973	1,758,486	24.8	57.3
Total costs	1,960,926	2,301,421	5,250,852	9,513,200	55.2	79.4

*DKK = Danish Krone without overheads

**PPG = Politically Prioritized Grants

***RG = Research Grants

Table 4.1.2 Psychosocial research field budget 2013: Musculoskeletal pain. Source: the NRCWE.

DKK*	Int. Financing	PPG** Financing	RG*** Financing	Total	RG (%)	RG/PPG (%)
Salaries	2,133,533	4,193,838	1,038,406	7,365,777	14.1	71.0
Running costs	163,412	696,981	366,877	1,227,270	29.9	86.7
Total costs	2,296,945	4,890,820	1,405,283	8,593,047	16.4	73.3

*DKK = Danish Krone without overheads

**PPG = Politically Prioritized Grants

***RG = Research Grants

The NRCWE leaders expressed concerns that they foresee a development where it may become more difficult to obtain external grants. Limited efforts are devoted to expanding the number of potential sources of external funds.

4.1.1.4 Collaboration

This is a research domain with a high level of national and international collaboration. This research is well integrated in the international research community.

4.1.1.5 Scientific output

Over the evaluation period the NRCWE have produced a very high scientific output in terms of publications. There is an impressive number of publications (e.g., 52 international peer reviewed journal publications in 2013, Field 2). Researchers do also publish in high-impact journals. It is evident that the NRCWE have successfully found innovative ways of using data from the several Danish registries that are available to scientific studies. Furthermore, the institute have run the National work environment cohort (Nationale Arbejdsmiljøkohorte, NAK, and its successor Arbejdsmiljø og helbred, see section 4.4) and have successfully promoted the use of rather comprehensive questionnaire instruments for measuring psychosocial work exposures, and successfully employed data from these surveys.

In total (Field 2) the NRCWE identified 255 journal articles, including 237 original articles, seven reviews/editorials/invited commentaries, and eight articles in Danish journals. Three articles were published in journals with an impact factor > 10. In these three publications NRCWE-researchers were co-authors in international teams of scientists.

As to Field 1, 32 original articles were published in international peer reviewed journals, and also one meta-analysis. There are a few double counts with the Field 2 publications.

4.1.1.6 Research quality and impact

We have studied the selected articles (Field 1, Field 2) and conclude without doubt that they do meet international standards of high research quality. An asset, also from an international perspective, is the special attention that the centre places upon process evaluation (intervention/implementation research).

With respect to Field 2, the institute provided interesting examples of conducted research of prevention and interventions to improve the psychosocial work environment, and of a 'process-outcome evaluation framework'.

The committee was also provided with examples of several intervention projects in the area of Field 1, which led to a vivid discussion with the institute's research staff during the site visit. The Evaluation committee discussed whether and to what extent - given the mission of the NRCWE and the content of the national strategy - interventions should target the individual (e.g. individual therapy) or the workplace.

The committee has the impression that, in line with much of the international literature, the NRCWE research into work factors and health is mostly based upon a limited number of theories, such as job strain theory, effort-reward imbalance theory, and demands-resources theory. In this field of research the term 'stress' often is confusing, since in the literature this term is used to denote both exposures, physiological responses, and distress. This is an impediment to conceptual clarity and theory advancement. In this light, it seems to the committee that there has been limited NRCWE publication effort to critically scrutinize concepts and theories, or to elucidate the specific mechanisms between the exposure to (combinations of) work stressors and short term and long term health consequences. The committee would have welcomed such editorials, commentaries or authoritative articles or book chapters. In a similar vein, although the work-environment assessment instrument COPSOQ was based on/influenced by the General Nordic questionnaire (QPSNordic)

which was explicitly based on concepts of organizational and perceptual psychology, the committee found few examples of critical discussions of constructs and their validation.

Taken together, the Committee considered future research plans to be clear and attractive (Field 2), although more so for theme 1 (Psychosocial work environment and health) than for theme 2 (Organization and social relations). Also the potential of a stronger combined focus on the combination of psychosocial and mechanical factors deserves further programmatic research attention.

4.1.1.7 Research relevance to the strategy and to the Danish work force

Research and dissemination of research results should be assessed in relation to the demands and needs of the Ministry of Employment, the Danish Working Environment Authority, the social partners, working environment advisers and workplaces as expressed in e.g. the national working environment strategy and the strategies of the NRCWE.

In the national OSH strategy ('Strategy for the working environment efforts up to 2020') 'the psychosocial work environment is one of the three focal areas of the strategy' (p.2). Parties have agreed that by 2020 'The number of employees who are psychologically overloaded is to be reduced by 20 percent'. It is the task of the NRCWE, in cooperation with the WEA and the NBII, to monitor this development and to measure if this quantitative goal will be achieved. Against this background, NRCWE's research is highly relevant to the national strategy and to the Danish workforce. NRCWE provided various strong and convincing examples ('impact on society'), such as the prevention packages (Field 1) and the development of "White papers" (Field 2).

The "New strategy for the working environment effort to 2020" states that "The number of employees who are psychologically overloaded is to be reduced by 20 percent". The definition of 'psychologically overloaded' is critical to defining the need for knowledge, designing measures, and for assessing whether the goal is met. One might expect NRCWE scientists to provide the theoretical and conceptual framework for this goal, even though it was decided by political parties.

4.1.2 Occupational accidents, including the development and implementation of safety-culture concept for the prevention of occupational accidents.

4.1.2.1 Introduction and background

Both in reports that the institute prepared for this evaluation (general institute level report (p.5), report of 'Occupational accidents and safety culture') and in discussions with our committee, the NRCWE management pointed out that there is a major change in the institute's research in this area: a transformation from a mainly epidemiological approach with a strong focus on the consequences of accidents, to include other approaches such as safety culture and climate, and the wider organizational aspects of causation and safety management. This change fits in an international movement from a reactive focus on accidents to a more proactive focus on safety, and to the development of the scientific basis for efficient safety culture and safety management.

4.1.2.2 Organization and management

This is a small research group organized by projects. Project leaders report to the head of research. At present, there is no professor in this group.

4.1.2.3 Key numbers

Staff

Because of general budget cuts and turnover, in the evaluation period the number of senior researchers was reduced from six to the current two seniors. In 2014 a visiting professor will be temporarily related to this field. Currently there is one PhD student. The group may be too small to develop large-scale research projects with international impact.

Finances

The 2013-percentage total external funding (politically prioritized grants: 0% and research fund grants: 48%) as percentage of the total direct costs is 48% ('Occupational accidents'). This is below the institute's external funding average of 60.8%. The total costs in this area are DKK 4 million in 2013. NRCWE is not particularly strong in earning grants in this area.

Table 4.1.3 Occupational accidents, budget 2013. Source: the NRCWE.

DKK*	Int. Financing	PPG** Financing	RG*** Financing	Total	RG (%)	RG/PPG (%)
Salaries	1,453,988		1,695,967	3,149,955	53.8	53.8
Running costs	624,516		219,739	844,256	26.0	26.0
Total costs	2,078,504		1,915,707	3,994,210	48.0	48.0

*DKK = Danish Krone without overheads

**PPG = Politically Prioritized Grants

***RG = Research Grants

4.1.2.4 Collaboration

The researchers participate in the Nordic Network of Accident Researchers. The NRCWE researchers are responsible for the coordination of the network for the Nordic Occupational Safety Climate Questionnaire (NOSACQ-50). It seems to the committee that national collaboration is better developed than international collaboration (outside the Nordic countries).

4.1.2.5 Scientific output

From this field 27 international journal articles have been published in this five year period (first authored or co-authored), eight of them in Safety Science and four in Safety Science Monitor. The number of publications in more general Occupational Medicine/Health and Safety journals, Ergonomic journals and (applied) psychology journals is limited. Two PhD theses have been defended. There are no literature reviews or meta analyses and also no examples of editorials or commentaries that may influence the international research agenda.

4.1.2.6 Research quality and impact

Although the impact of scientific articles can only partly be evaluated from the impact factor of the Journal that publishes the manuscript, it should be noted that in the evaluation period there is only one publication in Journals with an impact factor > 2. In more general terms it seems fair to state that as yet NRCWE's safety research is not published in high impact journals.

We have studied the 5 selected papers and have noted that the article by Kines et al. (*International Journal of Industrial Ergonomics*, 2011) is likely to be frequently cited in the international literature (already 25 citations, November 2014, Google Scholar).

4.1.2.7 Research relevance to the strategy and to the Danish work force

The national OSH strategy ('Strategy for the working environment efforts up to 2020') lists accidents at work as one of three high-priority issues. According to this plan the incidence of serious work accidents among employed must be reduced by 25 percent. It is the task of the surveillance unit of the NRCWE, in cooperation with the WEA and the National Board of Industrial Injuries (NBII), to

monitor this development, to provide advice how this goal may be achieved, and to measure if this quantitative goal will be achieved.

Although the program is in transition, the current stronger focus on safety management seems to fit well with the national strategy and targets. In this respect, one may ask why questions pertaining to safety culture, perceptions of threats, and safety-related behaviors have not already been included in the standard questionnaires of the working environment used in the large cohort studies by the institute.

There are interesting contributions from this field to inspections: a series of workshops with Labor Inspectors held in collaboration with the Danish Work Environment Authority, and a safety training course for general safety inspectors of the Danish Maritime Authority.

4.1.3 Absence and exclusion (= Development of research-based models and practical methods for job retention including focus on immigrants).

4.1.3.1 Introduction and background

This section builds upon the report 'Absence and exclusions' prepared by the NRCWE for the evaluation. This problem area includes research on themes such as sickness absence, exclusion, job retention, return to work, and also on the ageing workforce. Its aim is to contribute to work and labor market participation. According to the Self-evaluation report (General institute level, p.4), research into 'work retention and inclusion, including return to work' is one of the research lines under the heading of the Psychosocial Working Environment'. The research overlaps with other 'psychosocial research' and NRCWE staff in this area often also participates in other 'psychosocial' projects (section 4.1.1).

4.1.3.2 Organization and management

The report on 'Absence and exclusions' (p.3) is not very clear with regard to the organizational position of research/researchers in this area in the NRCWE. We understand that until 2008 there was a special research unit, whereas after a reorganization, research on absence and exclusion was distributed throughout the institute (particularly research in the psychosocial work environment, musculoskeletal disorders and noise). Furthermore there now appear to be two new organizational units: 1) a special analysis unit (2011), and 2) a research unit on intervention studies in the field of 'absence and exclusions' (2013). These two units work together and seem to be responsible for the strategic development of this field, in close cooperation with the researchers in field 1, 2 and 3. This all is a bit confusing and it seems to the committee that it is unclear who exactly is responsible for the content, cohesion, development and management of this research. Furthermore research is organized in projects. Project leaders report to the head of research.

4.1.3.3 Key numbers

Staff

There are four professors in the group (in total .85 FTE), about six senior researchers (also each part time in this area) and a few researchers and post docs. There are also several PhD students.

Finances

The 2013-percentage total external funding (politically prioritized grants: 9% and research fund grants: 37%) as percentage of the total direct costs is 46% ('Absence and exclusion'). This is below the institute's external funding average of 60.8%. The totals costs from this program amount to DKK 5.4 million. From these figures one may conclude that as yet NRCWE is not particularly strong in earning grants in this area.

Table 4.1.4 Psychosocial research field budget 2013: Absence and exclusion. Source: the NRCWE.

DKK*	Int. Financing	PPG** Financing	RG*** Financing	Total	RG (%)	RG/PPG (%)
Salaries	2,199,694	473,574	1,758,750	4,432,017	39.7	50.4
Running costs	708,967	21,486	240,456	970,909	24.8	27.0
Total costs	2,908,661	495,060	1,999,205	5,402,926	37.0	46.2

*DKK = Danish Krone without overheads

**PPG = Politically Prioritized Grants

***RG = Research Grants

4.1.3.4 Collaboration

Researchers in this domain have strong research contacts both nationally and internationally.

4.1.3.5 Scientific output

The NRCWE reported 91 international journal articles since 2008 in this problem area. They are divided over six research lines (which came a bit as a surprise to the committee, were not introduced in the written sources that were provided to the committee while preparing for the site visit). These lines are: 1) basic mechanisms and methods; 2) the impact of the working environment; 3) pain and sickness absence; 4) mental health and sickness absence; 5) return to work; 6) immigrants. Several of these publications have also been included in section 4.1.1 (double counts).

4.1.3.6 Research quality and impact

There are many publications on this list in scientific journals with impact factors > 2. In addition, one meta-analysis (Andersen et al., 2012) was published on return to work, also in a high impact journal. The quality of the listed publications is clearly at a high international level. Moreover, the institute-selected articles from this period represent high quality research, both in terms of content and development of (innovative) research methodology.

4.1.3.7 Research relevance to the strategy and to the Danish work force

According to the general NRCWE Self-evaluation report (p.4) 'labor market related issues such as retention, absenteeism, exclusion and workability are together with demographic changes such as more elderly and chronically ill people important common themes for NRCWE research for the coming years'. The national OSH strategy ('Strategy for the working environment efforts up to 2020') states that problems that arise from work accidents, a poor psychosocial work environment and musculoskeletal disorders 'lead to serious health issues, long-term absenteeism due to sickness and incapacity for work resulting in early retirement'. The research field 'absence and exclusion' thus has a high relevance for the national strategy.

4.1.4 Conclusions and recommendations

4.1.4.1 Conclusions

Our conclusions are organized according to the "Terms of Reference for the International Evaluation 2014 of the NRCWE" (see p.2).

Is the research quality of high standard?

Generally speaking the evaluation committee considers the research quality of NRCWE's 'psychosocial research' of high standard when compared to similar national and international groups of researchers.

This conclusion may be qualified, since the research lines 'Psychosocial factors and health' and 'Absence and exclusion' have performed better than 'Occupational accidents and safety culture'.

Quality and quantity of networking?

This previous conclusion is somewhat mirrored in the committee's conclusion with respect to networking. The committee concludes that NRCWE researchers are to a sufficient extent networking with strong research groups at other universities and research centres in Denmark and abroad. The research lines 'Psychosocial factors and health' and 'Absence and exclusion' exhibit stronger and more developed international networking.

Networking and external financing?

The committee has the impression that in the current evaluation period networking has been sufficient for fundraising purposes. However, attracting external funds for the research line 'Psychosocial factors and health' has been more successful than for the two other research lines. The latter two also score below the general average percentage of the NRCWE (year 2013).

Are resources applied in accordance with the NRCWE's strategic priorities?

Generally speaking, resources are applied in accordance with the NRCWE's strategic prioritization. It seems possible and desirable to increase synergy across the research lines (see 4.1.4.2).

Are research topics relevant to applied partners/stakeholders?

The research topics are relevant to the social partners, working environment advisers as well as employees and employers at the workplaces.

Does the research and strategies cover the needs of the authorities for counseling?

The authorities express satisfaction with the way the NRCWE provide counselling and knowledge-based advice, and confirm that they follow The National OSH Strategy.

4.1.4.2 Recommendations

Integrate accident and safety-research(ers) within the Psychosocial group

Any national working environment institute needs a strong orientation to safety. There is a mismatch between the strategic national emphasis on safety and accidents on the one hand, and the current NRCWE-infrastructure on the other. The group is small and notwithstanding promising work with respect to safety culture (e.g., Kines et al., 2011), a clear research focus is lacking.

One way to solve this undesirable situation is to further integrate current 'accidents and safety research' within a larger organizational unit, such as the 'Psychosocial group'. There are several arguments for such a step: 1) already existing internal cooperation; 2) such a step would well fit the stronger emphasis that the safety researchers nowadays place on 'psychological' topics such as safety climate, risk perceptions, safety-related behaviors, safety culture, safety management, and on broader prevention and intervention methodology.

Questions pertaining to safety culture, perceptions of threats, and safety-related behaviors may be included in the standard questionnaires used in the large cohort studies by the institute.

Staff appointments

Because of the general importance of safety and accident research for the mission of the institute, it is also recommended to attract a professor who is able to combine solid quantitative expertise in accidents, safety measures, and human error with the safety management topics mentioned above. This may also contribute to a more strategic research planning, which seems needed since we found the current future plans (Occupational accidents and safety culture) not particularly well specified.

Organization and management

The evaluation committee faced some difficulties in understanding the NRCWE's organization (organogram) of research fields and projects associated with psychosocial factors (Psychosocial factors and health; Occupational accidents and safety culture; Absence and exclusion). Basically, research are managed by a project organization, but the committee believes that the institute would benefit from a clearer and more transparent presentation of its organizational structure, research programs, and within these research programs, research lines. This would increase its visibility and may also contribute to a stronger strategic development of a future research agenda (for example for research on absence and exclusion) and a strategy for external grant applications.

4.2 Physical work environment

This exposure cluster includes knowledge of mechanical work exposures (e.g. lifting and moving objects, manual material handling), noise, vibration, electromagnetic fields, nuclear radiation. These factors may contribute to a variety of outcomes, hence aspects of the following strategic fields are included in this cluster:

- Development and implementation of methods for primary and secondary prevention of musculoskeletal pain (= Work-related pain in muscles and joints).
- Noise.

4.2.1 Development and implementation of methods for primary and secondary prevention of musculoskeletal pain (= Work-related pain in muscles and joints).

4.2.1.1 Introduction and background

The National OSH strategy for work environment efforts up to 2020 states “musculoskeletal disorders” as one of three prioritized areas (the two others being accidents at work, and the psychosocial work environment), noting that problems associated with any of these three areas lead to serious health issues, absenteeism, and incapacity for work. Motivated by this national agenda, NRCWE has defined “musculoskeletal disorders” as one of four research programs in its strategy 2014-2018, with a superior aim “...to generate knowledge for primary and secondary prevention...”. Within this framework, three focal issues are identified: 1) Reduction of risk factors in the physical working environment, 2) Causality, consequences, and options for action related to musculoskeletal disorders, and 3) Retention and inclusion, related to specific groups such as social and health care workers.

While musculoskeletal disorders and physical (biomechanical) exposures at work has been an important issue at NRCWE for at least 20 years, the development of the research area and the research group has been turbulent. About 10 years ago, the NRCWE housed a group of researchers with a strong and internationally renowned competence, particularly in biomechanics and work physiology. Research was extensive, comprising large field studies as well as controlled experiments in well-equipped laboratory facilities at NRCWE. Due to re-organizations at NRCWE and re-orientation of research priorities, this group was essentially dissolved, and for a period, the research area was manned with just a few junior staff. Realizing the need of increased activity within this field, NRCWE recruited two young scientists in 2008, who are now the driving researchers, now on temporary contracts as professors. For strategic and personal reasons, research priorities have changed, with a major downsizing of “basic” biomechanics and muscle physiology compared to the research portfolio 10-15 years ago, and a current emphasis on individual-targeted interventions (exercise programs), mainly for the purpose of reducing musculoskeletal pain, and on epidemiological studies of associations between biomechanical exposures and different outcomes, most notably musculoskeletal pain and cardiovascular morbidity. Some intervention studies have also addressed issues of adherence and compliance and the epidemiologic research has motivated a considerable investment of resources into developing direct technical measurement methods for collecting biomechanical exposure data and, lately, methods for retrieving repeated outcome information at regular intervals, both development addressing the need for obtaining information during long periods of time.

4.2.1.2 Organization and management

At present (2013) the group contains two professors on long-term contracts (until 2018), 2 permanently employed senior researchers (one of whom close to retirement), nine PhD students, five research assistants, some of which on contracts ending 2014 or 2015, and 2 permanently employed technicians. On top of this, some of the staff members listed in the group devoted to

psychosocial factors at work, perform research on musculoskeletal outcomes. The two groups report to the same head of research.

The daily work is initiated, led and organized by the two professors, mainly representing two different profiles, i.e. epidemiology and individual-based interventions, even if many good examples can be found of overlaps and collaborative projects. At the site visit, the group was represented by the two professors and a senior researcher. They all gave a very positive, professional, and engaged impression, confirming a genuine willingness to develop their area of research and to pursue a position in the international frontline.

We agree with the opinion expressed by the group in its self-evaluation, that resilience and stability is a matter of concern, given that only two senior researchers are, at present, permanently employed. The professors are employed on contracts until 2018, with the opportunity to be employed as senior scientists if those contracts are not prolonged. Furthermore, PhD students and research assistants are, to a considerable extent, funded by external grants (see below), which renders the group sensitive to even a temporary downturn in success of getting external funds.

4.2.1.3 Key numbers

In total, the group has an annual economic turnover (2013) of DKK 8.6 mill, of which DKK 2.9 mill (33.5 %) were covered by research fund grants. This is somewhat less than the NRCWE average for all research fields of 43.0 %. The proportion of total external funding (the sum of PPG and RG financing) of 79.6 % is, however, higher than the NRCWE average for all research fields (60.8%). Due to the rather small turnover, the proportion of external funding is quite sensitive to individual grant applications being successful or not, and can thus be expected to fluctuate substantially between individual years. The group has, in our opinion, shown a good and acceptable ability to attract external funding.

Table 4.2.1 Research field budget 2013: Physical work environment - musculoskeletal disorders. Source: the NRCWE.

DKK*	Int. Financing	PPG** Financing	RG*** Financing	Total	RG (%)	RG/PPG (%)
Salaries	1,059,977	3,025,292	2,348,800	6,434,069	36.5	83.5
Running costs	702,009	954,075	548,168	2,204,251	24.9	68.2
Total costs	1,761,986	3,979,366	2,896,968	8,638,321	33.5	79.6

*DKK = Danish Krone without overheads

**PPG = Politically Prioritized Grants

***RG = Research Grants

4.2.1.4 Collaboration

The group collaborates with several other research environments, mainly in Denmark (most notably the University of Southern Denmark), but even, to some extent, in Norway and Sweden. The collaborations include several joint PhD students and a considerable volume of research realized in close consortia of researchers from different groups, including NRCWE. The collaborations are clearly reflected in the publication list of the NRCWE group; a majority of papers have been authored by researchers representing different institutions. In the submitted materials to the evaluation committee, the group even lists a number of collaboration partners outside Scandinavia, but these collaborations have (so far?) resulted in few publications, and the contents and depth of the collaborations are therefore difficult to judge. Thus, the group is, so far, not very strong in collaborating with relevant *international* groups, even though we do not doubt that the competence, initiative and vitality of the group would render it very attractive as a partner in future international collaborations. Notably, as appears from the publication record, collaborations *within the NRCWE* have not resulted in any major publication activity yet. The present group is organizationally close to

the group of researchers devoted to psychosocial issues, and common research projects by these two groups are strongly encouraged as a strategic initiative at the central NRCWE level. We found some recent initiatives for such projects, and encourage further endeavors along this line.

4.2.1.5 Scientific output

Given the limited number of senior researchers in the group, its scientific output, in terms of peer-reviewed publications in international scientific journals, is impressive. According to the written materials provided by the group, the “list of publications” contains 151 scientific papers 2009-2013 from the field, while publications listed by year under the heading “productivity” contains 123 papers authored by the two professors during the same period. Thus, the output is very good, and the number of publications per year has increased consistently since 2009. While a considerable proportion of the publications represent – understandably – co-authorships on publications initiated by collaborating groups, the “core production” of papers emanating from research initiated by the NRCWE is also very good.

For several projects the group has shown a remarkable ability to cut up and document results in a multitude of papers. While this does improve publication statistics, it may not always be a commendable strategy from a scientific point of view. The International Committee of Medical Journal Editors has agreed on criteria for authorship and redundant publishing (“The Vancouver protocol”), and we would remind the NRCWE to include these guidelines in discussions of an internal “code of conduct” for scientific publishing.

Many papers have appeared in the most highly ranked journals in the area of occupational health, and some have been published in even higher ranked journals with a more general coverage of, for instance, public health issues or pain. However, the one paper listed to have appeared in a journal with impact>10 (Andersen LL et al.; Pain Physician 2012;15(5):385-93) is questionable: according to ISI Web of Knowledge (read Oct 10, 2014), this journal has an impact of 4.77.

While scientific publications may be a central indicator of scientific output, we would also like to complement the group for being active and visible in the international scientific community, for instance at conferences and in networking. The group has shown genuine openness to receiving inputs from colleagues, and a laudable willingness to discuss and develop its own research. Also, the two professors in the group are both highly involved in supervision of PhD students, both at the NRCWE and at collaborating universities, and all three senior researchers supervise master students, mainly at the universities of Copenhagen and Southern Denmark.

4.2.1.6 Research quality and impact

We consider the research, as appearing in scientific publications, to be of very good quality within the covered areas. Studies are, in general, planned well, realized to the extent possible using relevant methods and metrics, and effectively documented. Several results obtained by the group have gained considerable interest in the scientific community, as well as among practitioners in occupational health.

We would like to particularly emphasize the dedicated recent effort of the group to develop and use methods for direct technical recording of biomechanical exposures at the workplace. These methods will enable large epidemiologic studies based on objective exposure data, as opposed to the usual strategy of relying on self-reported exposures.

In intervention studies, which have a high priority in the research agenda of the group, the international collaboration for grading of the quality of evidence and the strength of treatment recommendations (GRADE; <http://www.gradeworkinggroup.org/>) require a double-blinded study design for accepting intervention studies as high-quality evidence. However, studies of effects of

physical training programs inherently have the problem that participating subjects cannot be blinded; neither to the intervention program itself nor to the expectations of its positive effects. Thus, blinding of both subjects and experimenters is generally impossible, and this may be perceived as discouraging when planning for training studies. We are, however, impressed by the determination of the group in realizing good intervention studies in field settings, following RCT ideals to the extent possible in spite of obvious and inevitable obstacles with respect to design, logistics, and compliance.

This said, we regard the conducted research to, to some extent, lack a clear overarching strategy for what to prioritize under a heading saying *Development and implementation of methods for primary and secondary prevention of musculoskeletal pain*. Quite some resources have been devoted to issues that may be considered difficult to defend under this heading, for instance research on cardiovascular health and diabetes. The conducted research in these areas is, indeed, both novel, of high quality, and of societal relevance, but we miss an explicit discussion of how it fits with the overall heading, as cited. This admonition also addresses the stated plans for future research 2014-2020, which fall under three themes: 1) Musculoskeletal disorders – causes, consequences and possibilities for action, 2) Reduction of risk factors in the physical work environment, 3) Maintaining workers with reduced resources at the labor market (e.g. senior workers and workers with chronic disorders). These themes are rather broad and we miss a discussion of how the stated, more explicit research initiatives (mainly a progression of the present intervention research focusing on individuals towards multicomponent interventions and better understanding of factors influencing successful implementation; an extension of the present epidemiologic research into designs based on long-term direct measurements of loads; and continued method development motivated by the needs in this research) fit with these themes, and how the planned research would, more specifically, lead to results as those implied by the headers of the three themes. While recognizing that resources set constraints on the feasible extent of research, we also miss an analysis of why the stated research initiatives were selected, among numerous other potential research issues and initiatives of relevance to the three stated themes.

4.2.1.7 Research relevance to the strategy and to the Danish work force

In being directly motivated by one of the three main priorities in the national 2020 strategy, the present research is of high relevance. The reason for identifying musculoskeletal disorders as a prioritized area in the 2020 strategy is that a considerable proportion of the Danish work force suffers from problems related to musculoskeletal health and well-being, which leads to negative consequences both for individuals and organizations. Thus, research into causes of musculoskeletal disorders; factors affecting their development over time; their consequences in the context of production; and effective initiatives at the individual, organizational and societal level that may prevent or alleviate them – just to mention examples – are all highly relevant issues of consideration in a national (and international) perspective.

4.2.2 Noise

4.2.2.1 Introduction and background

The research group 'Noise and Stress' was established in 2006. The group itself sees no reason to continue this research. Their main argument is that improved regulations and the use of protective equipment during the past decades have significantly reduced the incidence of hearing loss attributable to occupational noise exposure. Consequently, the aim of NRCWE has shifted from noise-induced hearing loss to subjectively reported effects of low-level noise exposures. Hence, the focus has been directed to exposures that may be annoying, but with little evidence of hard, objective health outcomes. Research will therefore not be part of legislative procedures and therefore not be directly used in prevention. One could study effects on performance, subjective health symptoms, and well-being, but these topics seem beyond the present priorities.

However, knowledge of effects of noise on hearing loss, annoyance/subjective complaints, and performance is still inadequate.

4.2.2.2 Organization and management

During the evaluation period a noise research group has been dissolved, the scientists reporting that they now spend efforts in other fields. Some material supplied by the NRCWE management for the present evaluation grouped noise under nanosafety, biological and chemical exposures.

Hence, it seems this field is currently being closed down due to lack of interest on the part of scientist and management, possibly due to lack of resources.

4.2.2.3 Key numbers

They list five persons in the research team. At the time of the present evaluation they were only three.

Table 4.2.2 Research field budget 2013: Noise. Source: the NRCWE.

DKK*	Int. Financing	PPG** Financing	RG*** Financing	Total	RG (%)	RG/PPG (%)
Salaries	39,739	0	601,432	641,171	93,8	93,8
Running costs	188,028	0	1,193,454	1,381,482	86,4	86,4
Total costs	277,766	0	1,794,886	2,022,652	88,7	88,7

*DKK = Danish Krone without overheads

**PPG = Politically Prioritized Grants

***RG = Research Grants

4.2.2.4 Collaboration

There has been collaboration with Danish research groups.

4.2.2.5 Scientific output

They have published 13 research articles since 2009.

4.2.2.6 Research quality and impact

Acceptable.

Table 4.2.3 Impact Factor of articles pertaining to noise exposure 2009-2013. Source: the NRCWE.

Impact Factor	First or last authorship (%)	All publications (%)	Ratio
<2	5 (56)	5 (39)	1.00
2-4	4 (44)	6 (46)	0.67
>4	0 (0)	2 (15)	0.00
Total	9 (100)	13 (100)	0.69

4.2.2.7 Research relevance to the strategy and to the Danish work force

There is limited knowledge of current prevalence of noise-induced hearing loss and of noise-induced subjective health and performance issues (e.g. tiredness, fatigue, disturbed communication and concentration, accidents).

Noise is no longer a priority according to the current strategy document of the NRCWE. However, noise is explicitly mentioned in the National strategy to 2010 ("continued research in key areas such

as indoor environment, chemicals and noise should be ensured"). Hence, maintaining competence of effects of noise is still highly relevant for the Danish working life.

4.2.3 Conclusions and recommendations: physical work exposures

4.2.3.1 Conclusions

Our conclusions are organized according to the "Terms of Reference for the International Evaluation 2014 of the NRCWE" (see p.2).

Is the research quality of high standard?

We conclude that the research in the group organized under the heading *Development and implementation of methods for primary and secondary prevention of musculoskeletal pain* produces research of very good international standards, and at an impressive rate. We would commend the group for its laudable initiative and vitality in developing and realizing research within its area.

The group devoted to noise is very small. The overall production of the group (13 peer-reviewed papers since 2009) does not reach the levels obtained in several other groups at the NRCWE, even with consideration paid to the limited size of the group

Quality and quantity of networking?

The group *Development and implementation...* is engaged in very relevant and productive collaborations with good groups, mainly in Denmark and, to some extent, in the other Scandinavian countries. We believe that the group has a good potential for developing fruitful collaborations with researchers outside Scandinavia to a larger extent than at present.

We do not have any impression of substantial networking for the small noise group.

Networking and external financing?

The group *Development and implementation...* is highly dependent on external funding, and has managed so-far to obtain grants to a reasonable extent, if somewhat less than the NRCWE average.

The noise group is externally funded to a very large extent; far beyond the NRCWE average.

Are resources applied in accordance with the NRCWE's strategic priorities?

In the group *Development and implementation...*, resources are effectively used to perform good research in relevant areas related to musculoskeletal exposures, health, performance and well-being; but the explicit relationship of that research with the strategic priorities of NRCWE is not thoroughly transparent.

Noise is not explicitly mentioned as a prioritized area in the NRCWE strategy, but the activity of the group falls under the issue of Reduction of risk factors in the physical working environment in a general sense.

Are research topics relevant to applied partners/stakeholders?

Since musculoskeletal exposures and their consequences are among the most prominent issues in occupational health, performance and well-being, the group *Development and implementation...* is engaged in research of a very high relevance to the social partners, working environment advisers as well as employees and employers at the workplaces. Also, these issues are of central interest to public health, organizational prosperity, and political economy.

Noise is explicitly defined as an area of concern in the national 2020 strategy, and effects of noise on health and performance is a very relevant issue in occupational life.

Does the research and strategies cover the needs of the authorities for counseling?

The authorities express satisfaction with the way the NRCWE provide counselling and knowledge-based advice, and confirm that they follow The National OSH Strategy.

4.2.3.2 Recommendations

Initiate discussions of NRCWE research in the context of the national 2020 priorities

We miss a thorough strategic discussion of explicit priorities in research based on an interpretation of the wide scopes expressed in the NRCWE 2014-2018 strategy (which is, in turn, an interpretation of the national 2020 strategy), and how individual projects could and should fit within the frame of the resulting credo. Thus, we encourage NRCWE to reconsider and more clearly formulate its interpretation of the area “musculoskeletal disorders” in the national 2020 priorities, than what is expressed in the current 2014-2018 NRCWE strategy. Does, for instance, NRCWE interpret this area to allow for *any* effects of physical (in)activity to be studied, including, e.g., cardiovascular health or diabetes? Does NRCWE pragmatically accept research within this area even if it does not very clearly relate to the 2020 strategy?

Develop an internal strategic plan for focus areas related to the physical work environment

If the three currently focused research areas related to the physical work environment (biomechanical exposures) are maintained, i.e., *1) Reduction of risk factors in the physical working environment, 2) Causality, consequences, and options for action related to musculoskeletal disorders, and 3) Retention and inclusion, related to specific groups such as social and health care workers*, we suggest to develop a more explicit strategic plan regarding which research initiatives to promote within those focus areas. This includes developing more explicit criteria than what has been formulated up to date for when a research idea/project will fit into each one of those areas (cf. the recommendation above of reconsidering the interpretation of the national 2020 strategy within the area “musculoskeletal disorders”). To this end, the strategic plan should be clear about whether a driving common denominator defining research would be a strive to understand and modify *outcomes* (and, in that case, which outcomes: pain? cardiovascular health? well-being? productivity?), or whether projects are unified by being devoted to similar *exposures* (and, in that case, which exposures: postures and forces? physical (metabolic) activity? sedentariness? factors outside work?). Also, the NRCWE should more clearly interpret which groups to prioritize under area 3), in addition to social and health care workers.

Give more emphasis to factors and interventions at the organizational level

We suggest the NRCWE increase their emphasis on investigating and understanding factors at the organizational level that can explain biomechanical exposures and related outcomes, in addition to the individual-focused approach which at present dominates both intervention studies and epidemiology in the group.

Decide priorities for future research into noise and its effects

We recommend the NRCWE to soon reach decisions on priority, direction, and resources allocated to research on effects of noise. There are still several unknowns in the role of noise in hearing loss, annoyance/subjective complaints, and performance. The NRCWE must decide how they could maintain the knowledge base required in the National strategy 2020 (performing in-depth research or only monitoring research from other groups).

Develop a strategy of whether to perform controlled experiments or not

We recommend a clear strategic choice of whether to invest resources in building functional laboratories for controlled experiments and method development, or whether to instead engage in

collaborations stimulating other groups to investigate issues of interest to the NRCWE using laboratory-based research designs. If a decision is taken to engage in laboratory-based studies of biomechanical exposures and work physiology at NRCWE, this should be followed by a substantial allocation of resources, without which this initiative would have a low likelihood of being effective.

Reinforce internal collaboration within the NRCWE

We suggest reinforcing incentives for increased collaboration between this group and other groups within the NRCWE, most notably the group devoted to the psychosocial work environment. An explicit bilateral exchange program may be a good model, and current initiatives should be strongly supported.

Develop further collaborations with groups outside Scandinavia

We suggest devoting efforts into extending collaborations to include groups outside Scandinavia that can complement in-house expertise and prioritized in-house areas of research. This could, for instance, include expertise in medical outcomes, production technology, and economics. This would comply with the stated ambition of the group to perform more multidisciplinary research. Collaborators should be selected on the basis of strategic discussions of which groups to approach with the highest priority, as guided by the strategic plans for prioritized NRCWE research (cf. above). To this end, we suggest supporting initiatives for increased external collaboration by investing resources in a running program for inviting guest researcher(s) or post doc(s) to perform research at the NRCWE.

Be observant on resilience

We suggest a dedicated investment of resources into stabilizing the group *Development and implementation...* and strengthening its resilience, e.g. by providing secure funding of one or two PhD students.

4.3 Chemical, biological work environment: nanosafety

This exposure cluster includes knowledge of chemical and biological exposures and adverse health effects at work. Exposure types include air-borne particles (dust) and droplets, gases, fluids, etc that are introduced by inhalation, ingestion, or by skin contact. The size of particles and droplets may be decisive in uptake/exposure modes and in determining chemico-physical properties. These factors may contribute to a variety of outcomes, hence aspects of the following strategic fields are included in this cluster:

- The formation of an inter-institutional centre for nanosafety (= “New technologies”).
- Development of methods for assessment of risks posed by exposures associated with new, green technologies (= “New technologies”).

4.3.1 The formation of an inter-institutional centre for nanosafety (= “New technologies”).

4.3.1.1 Introduction and background

Nanomaterials are usually defined as having at least one dimension of 1—100 nm. Due to the nanoscale, these materials often have unique and sometimes very attractive optical, electronic, or mechanical properties. The attractive properties have led to a rapidly increasing development, production and application of so-called engineered nanomaterials (ENMs). However, since these materials are in a sense “new”, very little is known about potential health hazards. For example, handling of nanomaterial powder may result in exposure to much finer dust particles than traditional work with pigments and other coarse particles. Thus, not only may the intrinsic properties differ, but also the site of disposition in the respiratory tract, as well as the systemic uptake, biodistribution elimination. Hence, there is a need for focused research to systematically unravel the hazards of different nanomaterials and the risk of workplace exposure.

For this reason, the political agreement of March 2011 supported the establishment of a Danish Centre for Nanosafety, with funding via the Danish Working Environment Research Fund. According to the agreement, 10 million DKK should be allocated annually for three years to a Danish Centre of Nanosafety and enter into force 2012 (source: A strategy for working environment efforts up to 2020). The funding has later on been extended to four years with a total funding of 30 million DKK for the period 2012-2016.

The idea at the nanosafety centre is to do research and to collect and disseminate knowledge on ENMs in the workplace essentially in three areas, namely (1) workers’ exposure, (2) adverse effects (nanotoxicology) and (3) risk assessment and management. The ultimate goal is to enable state-of-the-art risk assessment of ENMs based on the most recent knowledge. Apart from the 3-year financial support, focus on nanosafety is further enhanced by participation in several EU projects.

The by far largest resources within the chemical-biological domain at NRCWE have consequently been allocated to this nanosafety centre, where experts in physical- and chemical characterization, aerosol physics, in vitro and in vivo toxicology and risk assessment work together. Thus, 18 researchers, corresponding to approximately 15 man-years (as of Dec 31, 2013) and 10 technicians, corresponding to approximately 7 man-years, are working in the nanosafety domain.

4.3.1.2 Organization and management

The nanosafety centre is led by a professor (90%, as of Dec 31, 2013) with the assistance of two other professors (80% and 15%, respectively). The activities are overseen by an international scientific advisory group comprised of Anne Shvedova, US NIOSH, Michael Riediker, Institute for Work and Health (IST), Switzerland, and Kai Savolainen, FIOH. All three are highly reputable scientist in the field

of nanotoxicology. The advisory group meets yearly with the NRCWE researchers to discuss results and future plans.

4.3.1.3 Key numbers

Apart from the four professors mentioned above (corresponding to 1.9 man-years), nine senior researchers, five PhD students, two research assistants and ten technicians (including two animal caretakers) are to various extents involved in various aspects of nanosafety research, including exposure, physical and chemical characterization, nanotoxicology and risk assessment. Judging by the employee overview (table A in evaluation dossier 5), the major effort (nearly 8 of 15 researcher years) is on nanotoxicology. With respect to student tutoring a total of 13 individuals are listed as bachelor or master students during the period 2009-2014. Four of the project titles explicitly address nanomaterials.

Table 4.3 Research field budget 2013: Nanosafety, Green Technologies, and Other Chemical Exposures and Toxicology. Source: the NRCWE.

DKK*	Int. Financing	PPG** Financing	RG*** Financing	Total	RG (%)	RG/PPG (%)
Nanosafety						
Salaries	3,844,594		8,526,255	12,370,848	68.9	68.9
Running costs	2,391,177		1,025,283	3,416,460	30.0	30.0
Total costs	6,235,771		9,551,538	15,787,309	60.5	60.5
Green Technologies						
Salaries	307,711		742,187	1,049,898	70.7	70.7
Running costs	171,084		79,861	250,945	31.8	31.8
Total costs	478,795		822,048	1,300,843	63.2	63.2
Other chemical exposures/toxicology						
Salaries	1,920,172		1,713,457	3,633,629	47.2	47.2
Running costs	660,494		165,313	825,808	20.0	20.0
Total costs	2,580,666		1,878,770	4,459,436	42.1	42.1

*DKK = Danish Krone without overheads

**PPG = Politically Prioritized Grants

***RG = Research Grants

4.3.1.4 Collaboration

A research group for nanotoxicology was formed already in 2007 and consisted of researchers in several relevant fields; physiochemical characterization, occupational hygiene, chemistry and particle toxicology with genotoxicity, cardiovascular effects, asthma and effects on reproduction. The strong inter-disciplinary composition makes NRCWE an attractive partner in international projects. Thus NRCWE has participated in 17 EU projects on nanosafety since 2009, including for example, NANoREG where NRCWE scientists have leading roles. The nanosafety centre encompasses most Danish nanosafety researchers as well as a number of international collaborators.

The formation of the nanosafety centre, NANoREG and other projects has also led to interaction with various Danish stakeholders, including industry, unions, the Danish Working Authorities, the Danish EPA, the EU, OECD and occupational health professionals.

NRCWE has thus become increasingly internationally recognized in the field of nanotoxicology and nanosafety. Examples of international engagements include: Invited lectures at international scientific conferences, presentations at workshops and conferences, work package leadership in EU projects, chief editor of Nanotoxicology (Håkan Wallin, IF 7.84), editorial board members of Particle

& Fibre Toxicology (IF 9.18) and several other international scientific journals, and evaluators at funding organizations (Austria, Sweden, Norway).

National collaboration is carried out with several Danish universities (DTU, Copenhagen, Aarhus, Southern Denmark) and Copenhagen university hospitals (Bispebjerg, Gentofte). The list of international collaboration is even more extensive and includes universities and institutes in Finland, Norway, Sweden, Germany, United Kingdom, Poland, Turkey, Italy, the Netherlands, France, Belgium, Canada, Japan and USA. Collaboration and networking are carried out with additional universities and institutes via the various EU projects where NRCWE is involved. The extent of international and national collaboration is corroborated by the co-authorship of scientific articles. Thus, nearly all of the 69 original articles published in international journals for 2009-2013 have one or several co-authors from outside the NRCWE.

A further indication of external collaboration is that of educational interaction with universities in Denmark and elsewhere. The NRCWE scientist have frequently served as lecturers, opponents and Ph.D. committees etc, mainly in Denmark but also in several other European countries. However, it is not possible to identify from the evaluation dossier to what extent the educational activities are related to nanosafety. There is a relatively high number of bachelor-, master-, and PhD-students with main or co-mentors from the NRCWE listed for the period 2009-2015. Judging by the project title, about one third of the PhD-projects are related to nanosafety.

4.3.1.5 Scientific output

The nanosafety centre has listed 72 scientific papers published in peer-reviewed international journals during the period 2009-2013. Of these, one paper was published in a very high impact journal (IF>10) and three were reviews. NRCWE scientist were first and/or last author in 40 of the papers (56%). The sum of impact factors of the individual papers is 351, making an average of 4.9 per paper. For comparison, the entire NRCWE lists 694 scientific papers for 2009-2013, thus, by this measure, nanosafety has contributed with roughly 10% of the Institute's scientific output. No citation statistics were presented for this theme. In any case, it would be difficult to make bibliometric comparisons between nanosafety and nanotoxicology (very new but "hot" areas, with young journals) with other work environment areas or with toxicology in general.

4.3.1.6 Research quality and impact

The research findings have mainly been published in reputable peer-reviewed international journals, in most cases in the top journals in the field. Judging by the international publications, the research quality is very high. The close collaboration with Danish academia, authorities, and OSH professionals, with Nordic sister institutes and within the various EU projects further ensures high quality and impact. Additional impact has been achieved by dissemination of the results in a popular-science format via the increasingly used Working Environment Information Centre (with an impressive one million visits in 2013), aimed for the workplaces and the general public.

The nanosafety centre aims to address three areas, namely workers' exposure, adverse effects (nanotoxicology) and risk assessment and management. In contrast to the aim, an overwhelming part of the studies deals with adverse effects, mainly in rodents and to some extent in vitro. Although most of the toxicological studies include physical and chemical characterization of the nanomaterial of interest, only a few deal more in depth with nanomaterial characterization. Less than a handful studies address nanomaterial exposure, and then from a theoretical perspective. Risk assessment and management are only marginally addressed from a theoretical perspective. The lack of more substantial studies in these areas (workers' exposure, risk assessment and management) is intelligible, as there are (as yet) very few workplaces with shown exposure to engineered nanomaterials. Another central issue in nanotoxicology that has only been addressed to a limited

extent at NRCWE is which parameter should be used (mass, number, surface area) as the primary exposure metric.

4.3.1.7 Research relevance to the strategy and to the Danish work force

As described earlier, the increased focus on nanosafety and the formation of a nanosafety centre were a direct result of a political, strategic agreement. Thus, the research in this area is undoubtedly of very high relevance in relation to the NRCWE and nanosafety strategies. The high relevance is further corroborated by the successful participation in a vast number of EU projects on nanosafety. Time has come for them to take the lead in upcoming applications.

The relevance for the Danish work force is more difficult to judge. On one hand, the use of ENMs and, therefore, the number of exposed and potentially affected workers is difficult to estimate, but probably very low at present. Also, as a consequence of the limited use, the awareness among the public and workers about the potential health hazards is low. By these aspects, the relevance could be considered to be low at the present time. On the other hand, the proactive character of nanosafety research is commendable, this is a typical example of how things should be done, i.e. examine health hazards and safety before a new technology is introduced at a large scale.

4.3.2 Development of methods for assessment of risks posed by exposures associated with new, green technologies (= “New technologies”).

4.3.2.1 Introduction and background

The strategic research group now called Microbiology and Bioaerosol Exposure was developed as part of New Technologies as a subgroup working on Green Technologies with focus on bioaerosol exposure during work with biofuels, biopesticides and vegetable production. As seen in the group’s name, the main focus is on exposure to microorganisms and other bioaerosol components. The approach is highly oriented towards occupational hygiene and practical problems. The first step in most research projects is personal aerosol sampling at workplaces followed by aerosol characterization.

The group, although small, has a well-developed strategy for microbial exposures and health effects. The strategic areas include:

- The impact of global warming – e.g. workers exposures after flooding (enteric viruses, mold in buildings).
- New/green technologies – e.g. biofuel workers microbial exposure and health.
- Livestock-associated MRSA (methicillin-resistant *Staphylococcus aureus*) infections increase among, how can exposures and infections be reduced (no research at present)?
- New food stuffs, e.g. edible insects and seaweed, may result in exposure to bioaerosols.
- Airborne transmission of enteric viruses – e.g. the relation between exposure and gastroenteritis among wastewater workers.
- The lung microbiome and its relation to asthma and allergy.
- Identification of microbial species, including studies on culturability and identification by state-of-the-art methods (MALDI-tof, PCR, next-generation sequencing).
- Development of sampling methods for bioaerosols.

4.3.2.2 Organization and management

This research group is led by Dr. Anne Mette Madsen (senior researcher, 90%). She and a laboratory technician are the only permanently employed in this field.

4.3.2.3 Key numbers

As of December 31, 2013, the group consists of the group leader, two postdocs, two PhD students, two assistants and two lab technicians, corresponding to approximately 5 man-years. The overall budget for the evaluation period is unclear. During 2013, a total of 1.3 million DKK (excluding overhead costs) was spent by the group, whereof external funding was stated to account for 63% of the budget.

4.3.2.4 Collaboration

The external collaboration is mainly limited to Danish universities and research institutions, although a few international partners are also listed in the evaluation dossier. The authorship of the scientific papers suggests that the group is to a large extent working on its own. Three papers are to some extent a result of international collaboration (Cohn et al. 2010, Basinas et al. 2011, Job et al. 2013).

4.3.2.5 Scientific output

According to the publication list, 28 international scientific papers were published during the period 2009-2013. This corresponds to 4% of the publications emanating from the NRCWE. The group members were first or last author on 23 (82%) of the papers. According to the group, the papers were cited 501 times, making an average citation of 14 (but uncertain which papers are referred to). None of the papers was published in a high-impact journal and only one in a journal with IF>5. The sum of journal impact factors of the 28 papers is 75, making an average impact factor of 2.7 per paper. The publication list is impressive considering the composition and size of the group.

Three PhD theses were completed during the period. In addition the group has supervised two master/project students, both starting in 2013.

The group has had some teaching at the University of Copenhagen. It is difficult to assess the extent of teaching from the evaluation dossier, however, teaching appears to have been limited.

4.3.2.6 Research quality and impact

The research results have been published in relevant peer-reviewed international journals. The quality of the papers generally appears to be high. It is commendable that the group prioritizes to publish studies where the results are directly needed by the workplace and studies that have been asked for by the Danish Working Environment Authority (Arbejdstilsynet).

The results have been communicated as news and press releases and, as a result, have received attention by Danish media on numerous occasions.

4.3.2.7 Research relevance to the strategy and to the Danish work force

Most studies address microbial exposures at workplaces, including sampling and (sometimes) inflammatory and respiratory effects. Although not highly innovative, the research is very relevant in relation both to the strategy and to microbial and bioaerosol exposures at the workplace.

4.3.2.8 Stakeholders' contribution and use of results

Several stakeholders are more or less directly involved in the group's activities and vice versa. Thus,

- All projects run by the group have an advisory board with representatives from relevant workplaces. Some project advisory board have representatives from the trade union (3F – Fagligt Fælles Forbund), employers (GLSA – Gartneri-, Land- og Skovbrugets Arbejdsgivere), the Ministry of the Environment, the Energy Agency and/or from the Work Environment Authority (WEA; Arbejdstilsynet).
- The group is regularly contacted by health and safety representatives on issues related to exposures to fungi and organic dust.

- The group leader is a permanent member of the steering group of environmental research projects at the Danish Ministry of the Environment and a member of an advisory board advisory board of a MRSA project hosted by the Ministry of Food, Agriculture and Fisheries.

After a request from the WEA, the group reviewed the knowledge on work with high-pressure cleaners. Based on the review, the WEA are promoting a standard in the EU regarding a warning of aerosol formation when using high-pressure cleaners.

As a result of another review paper from the group, the fungus *Botrytis* has been included in the list of allergenic fungi at the information websites of the Danish society of pharmacies (www.apoteket.dk) and Astma-Allergi Danmark (www.astma-allergi.dk).

Several intervention studies have been performed. The group has thus shown that bioaerosol exposure in biofuel plants and greenhouses can be reduced. For example, the exposure to *Bacillus thuringiensis* during a special work task could be reduced 17-fold.

4.3.3 Other toxicology competence

4.3.3.1 Introduction and background

The NRCWE have maintained some research projects in addition to nanosafety and green technologies. A Toxicology group serves as a forum to gather NRCWE's experts within a broad field of toxicological science, whereas an Indoor Air and Chemistry group plays a central role in many of the experimental activities. During the evaluation period (2009-2013) these fields have been given low priorities. The research field has to a large degree continued thanks to external funding, mainly from private funds (CEFIC, Lundbeck Foundation, Dagmar Marschall Foundation, Eli Lilly Foundation, RealDania) and EU. Focus has been on indoor air, skin, and airway, cardiovascular and reproductive effects. In addition, external collaboration in the field of molecular epidemiology, especially in relation to cancer susceptibility, has continued (resulting in a high number of publications).

4.3.3.2 Organization and management

A former professor at the NRCWE is the leader of indoor air research and a senior scientist is coordinating the general toxicology activities including the documentation and consultancy for the Danish Working Environment Authority. Thirteen individual projects are run separately under the Director of Research Coordination Lars Andrup.

4.3.3.3 Key numbers

As of December 31, 2013, 4 professors, 6-9 senior researchers, two postdocs and one research assistant (10-16 persons in total, fluctuating numbers because conflicting information is given in the evaluation dossiers) are partially involved in the areas toxicology and indoor air, corresponding to approximately 4 man-years. The areas are supported by four technicians and two animal caretakers (2 man-years).

The overall budget for the evaluation period is unclear. The money spent during 2013 was 4.5 million DKK, where of 42% was external funding (research grants). Internal as well as external funding is said to have decreased during the period due to the prioritization of nanosafety research.

4.3.3.4 Collaboration

The group has extensive collaboration with Danish universities, research institutions and hospitals. Judging by the authorships, the international collaboration is more limited but, considering the size of the group, fully acceptable.

4.3.3.5 Scientific output

According to the publication list, 139 international scientific papers were published during the period 2009-2013. The sum of journal impact factors of the individual papers is 510, making an average impact factor of 3.7 per paper. The impressive publication list reflects the extent of external collaboration and high scientific competence of the NRCWE scientists.

Nearly one half of the papers, including two high-impact papers (Nature Genetics, IF 35.1, and Gastroenterology, IF 12.8), are not directly related to workplace exposures. Rather, they reflect extensive collaboration with groups outside the NRCWE in the field of molecular epidemiology. Disregarding these, the sum of impact factors of the remaining 76 papers drops to 249 with an average of 1.8 per paper.

With respect to student tutoring a total of 13 individuals are listed as bachelor or master students during the period 2009-2014 for the areas Toxicology and Occupational Hygiene, including Nanosafety.

4.3.3.6 Research quality and impact

The research results have been published in relevant peer-reviewed international journals. The quality of the papers generally appears to be high or very high. Considering the limited budget the output is impressive. More than half of the publications are of immediate high relevance for the work environment (including indoor air). The other papers mainly address molecular genetics and epidemiology in the general population, which is obviously also of relevance for workers.

Several results have been communicated to and used by different organizations such as the Danish Working Environment Authority, the Danish EPA, the Scientific Committee for Occupational Exposure Limits of the European Commission (SCOEL) and the European effort to harmonize guidance values for emissions from building products (EU-LCI). Previous research (prior to 2012) in the group has contributed to the setting of a WHO indoor air guideline for formaldehyde.

The expertise of the group is further applied by serving in expert committees including the SCOEL, the Nordic Expert Group, the Danish WEA OEL group and the EU-LCI group. The strong involvement in these committees is commendable and allows dissemination of results as well as input regarding new and emerging risks.

4.3.3.7 Research relevance to the strategy and to the Danish work force

No clear strategy is presented. However, the studies address a number of exposure factors and effects of high relevance for the working population, the main areas being:

- Susceptibility to cancer
- Air pollution - airway and cardiovascular effects
- Skin – uptake and disease
- Indoor air - health effects
- Chemicals - reproductive effects

4.3.3.8 Stakeholders' contribution and use of results

There appears to be limited formal involvement of the WEA and other Danish stakeholders. Input and dissemination of results is mainly performed on a project-by-project basis. However, input and dissemination is also channeled via extensive participation in the WEA OEL committee as well as several international committees and institutions (e.g. SCOEL, NEG, EU-LCI, EU-OSHA). Results are also communicated via the NRCWE website <https://nfa.dk>.

4.3.4 Conclusions and recommendations: chemical and biological exposures

4.3.4.1 Conclusions

Is the research quality of high standard?

Overall, evaluation committee considers the quality of research and the research output to be high or very high in all three areas of the cluster.

Quality and quantity of networking?

There is a high degree of networking at the national level in all three research areas. This conclusion is supported by the list of collaborating institutions in the evaluation dossiers, as well as the frequent coauthorship with scientist outside of the NRCWE. By the same measures, and also according to the personal experience of one of the reviewers, there is a high degree of international collaboration in two of the areas (Nanosafety and Other toxicology), a must considering the complexities and rapid development in toxicology as well as the rapid introduction of new products and technologies.

Networking and external financing?

The committee has the impression that in the current evaluation period networking has been sufficient for fundraising purposes.

Are resources applied in accordance with the NRCWE's strategic priorities?

Generally speaking, resources seem to be applied in accordance with the NRCWE's strategic prioritization.

Are research topics relevant to applied partners/stakeholders?

The activities are generally highly relevant in that they address important or potential (Nanosafety) occupational health issues. The anchorage with the rest of the society, including stakeholders, is generally good or very good.

Does the research and strategies cover the needs of the authorities for counseling?

The impression of the evaluation committee is that the needs for counseling are covered to a large extent. This is supported by the authorities who express satisfaction with the way the NRCWE provide counselling and knowledge-based advice, and confirm that they follow The National OSH Strategy.

4.3.4.2 Recommendations

Nanosafety

The focus on hazard identification/toxicity studies is understandable, as there are few workplaces with substantial exposure to engineered nanomaterials. To fulfill the expressed aims of the Nanocentre and as decision support for future directions, identification of relevant work tasks and workplaces, workers' exposure, toxicological risk assessment and risk management need to be addressed in more depth in the near future.

A very large part of the staff resources on toxicology have been allocated to Nanosafety research. Many of the nano research issues remain unsolved, especially with regards to workers' exposure. Meanwhile, the special funding from the Danish Working Environment Research Fund is coming to an end. NRCWE must therefore decide how much resources should be allocated to this area.

Microbiology and Bioaerosol Exposure

The group has a clear and relevant strategy, although some of the areas have not yet been followed-up upon (global warming, new food stuffs), a laudable stakeholder involvement, a good anchoring in

practical workplace problems, and good media coverage. This paves the way for a significant impact on workplace improvements.

A source of concern is the very small size of the group and the limited external collaboration. The limited collaboration is understandable for a small group, still, it makes e.g. coverage of scientific developments in the field difficult. The small group size also complicates maintenance and continuity (e.g. by recruitments) of competence and skills.

We therefore recommend that NRCWE considers an enlargement of the staff in the field of microbiology/bioaerosols.

Organization and management

The evaluation committee had difficulties to understand the organizational structure within the cluster of Chemical and Biological Exposures and the allocation of resources between the three areas herein. As with the cluster Psychosocial work environment, the committee believes that the institute would benefit from a clearer and more transparent presentation of its organizational structure, research programs, etcetera. This would increase the visibility and contribute to a stronger strategic development.

Overall strategy

Occupational toxicology deals with the potential exposure and potential (largely unknown) adverse health effects of tens of thousands of chemicals. A major problem, not unique to NRCWE, is how to cover such a vast area without becoming too superficial, i.e. how to find a balance between general coverage and more focused in-depth knowledge of some areas. The groups have, so far, managed to find an acceptable balance in spite of limited resources. Thus, a number of relevant research areas are currently addressed and the researchers are heavily engaged in committee work. However, NRCWE presents no clear strategy for these areas and the research depends to a high degree on the researchers' personal involvement and private funding. With limited resources, there is an obvious risk that the Institute's expertise on chemical workplace hazards gradually diminishes and that important and/or emerging hazards are left unattended already in the near future. Considering the age distribution of the researchers (especially two professors aged 67 and 70) the risk is even more imminent.

We strongly recommend that NRCWE develops a strategy for occupational toxicology, including all three areas (nanosafety, microbiology/bioaerosols, other toxicology). This should include competence needs, recruitment and resource allocation, the balance between general coverage and focus areas, as well as identifying new focus areas. Regardless of focus areas (nanosafety and/or something else), a strong competence base in general toxicology is essential.

4.4 Working environment surveillance

4.4.1. Introduction and background

Surveys are important and necessary to monitor work exposures and health not covered by existing mandatory administrative registers. They are important in monitoring outcomes related to specific political goals and they are important to better understand data analyses based on registry data. Unfortunately, these important features are not well appreciated by the public. An increasing number of invited participants decline taking part in surveys, probably because they are unaware of the importance of their contribution to provide data to improve the work environment. Many surveys reach a level of non participation that makes them un-representative of the target population which hampers analyses of trends over time. Although newer statistical methods (imputations) to some extent may adjust for selection bias and have improved analytical options, there are no perfect ways of collecting data that are not there.

The NRCWE institute conducts two major surveys as part of their services to the authorities– one focusing on employed individuals, the other addressing working environment efforts of Danish companies and other work place activities.

The National Work Environment Cohort (den Nationale Arbejdsmiljøkohorte, NAK) was conducted with five year intervals from 1990-2010. This survey was in 2012 replaced by a newly developed and extended survey, Work and Health (Arbejdsmiljø og Helbred, AH), that will be conducted every second year in the period 2012- 2020. The AH surveys are used directly to assess the impacts of the national action plan for an improved working environment and the group has been instrumental in developing two survey-based indices for overload, addressing psychological (see section 4.1.1.7) as well as musculoskeletal overload. In addition, the surveys have – and will be - used extensively in research projects (see also section 4.1.1.5) by internal and external researchers. In order to enhance the scientific potential of this essentially cross sectional sample, a cohorts study – comprising a subsample of the total population – has been nested in the survey. The most recent survey (AH2012) has also been published on the internet as an open access database, and is used primarily by the social partners and students. The survey focusing on companies and work places (Virksomhedernes Arbejdsmiljøindsats, VAI) is conducted in parallel with the AH surveys using the same two year interval. Results from this study has until now been used in one research project. Publications from this project has, however, not yet been published.

One could expect a larger research program to investigate selection bias related to non-response and a better understanding on why people refuse to participate. This has not been done as much as it should.

One could also expect more effort added to the understanding on how response rates could be improved. The unit seemed to have reacted quite slowly to the new condition. Only recently a proper, but insufficient response was activated. This may be related to time spent to meet demands for epidemiologic expertise from other departments of the NRCWE.

4.4.2 Organization and management

The surveillance unit is a large group of people with excellent qualifications. They also have a staff of data managers that could help developing new methods of data collections using the internet, mobile phones, several social medias etc. More work needs to be done in that direction.

4.4.3 Key numbers

The staff is rather small with only 8 scientists but the qualification level is high and includes 5 PhDs on the list.

Table 4.4 Research field budget 2013: Surveillance. Source: the NRCWE.

DKK*	Int. Financing	PPG** Financing	RG*** Financing	Total	RG (%)	RG/PPG (%)
Salaries	3,580,843		591,306	4,127,149	14.2	14.2
Running costs	1,509,954		2,327	1,512,281	0.2	0.2
Total costs	5,090,797		593,633	5,684,429	10.4	10.4

*DKK = Danish Krone without overheads

**PPG = Politically Prioritized Grants

***RG = Research Grants

The surveillance is primarily financed by a designated appropriation for monitoring working environment and health in Denmark, primarily with the survey “Arbejdsmiljø og Helbred” and “Virksomhedernes Arbejdsmiljøindsats”.

4.4.4 Collaboration

The group collaborate with relevant survey institutions in Denmark, especially Statistics Denmark (they do contract work for NRCWE) and the National Institute of Public Health and others. International collaboration is limited.

4.4.5 Scientific output

The group has published well with 28 publications since 2009 (as leading authors or co-authors).

At the interview the group did not add substantial new thoughts to how work in the future could be better organized. It is a group with an important role for many departments at NRCWE but with a too weak core in their own field - surveillance. Given their method training they spend much time on providing service for other groups, mainly in matters related to study design and data analyses.

4.4.6 Research quality and impact

One could expect a larger research program to investigate selection bias related to non-response and a better understanding on why people refuse to participate. This has not been done as much as it should.

4.4.7 Research relevance to the strategy and to the Danish work force

The surveillance data are given a high priority by the primary stakeholders and both authorities and social partners use these data.

4.4.8 Conclusions and recommendations

The group is facing a difficult time as all groups who work in surveillance. They need to restructure and spend more time to develop new models and to identify sources of bias in monitoring health and work conditions in a time period where participant rates in traditional surveys based entirely on self-reported questionnaires is being refused by more and more of the invited people. They probably need to get more people or less consultant tasks from other parts of NRCWE to have the time to reorganize their data collection and analytical tools.

One could also expect more effort added to the understanding of how response rates can be improved. The unit seemed to have reacted quite slowly to the new condition and perhaps this is related to the demand for epidemiologists from other departments of NRCWE.

5. Dissemination of research results

5.1 Introduction

Dissemination and communication are highly prioritized in the by-laws of the institute, both related to NRCWE scientific dissemination (Article 3) and the WEIC setup and responsibility (Article 10). Communication and dissemination are part of the overall strategy of the institute, directly relating to the scientific strategy and presented as a strategic point in every annual strategy/contract in the evaluation period.

In this period, dissemination and communication have been top objectives in all strategy documents. Over the evaluation-period dissemination has been lifted from an objective to become included into the vision and mission of the institute. The NRCWE-personnel enhance the importance of communication and dissemination having a more prominent and strategic role. This is related to both higher visibility and the importance of understanding the difference between WEIC and NRCWE.

5.1.1 Organization and management

Communication is organized under one Head of Communication who is responsible for both the NRCWE research dissemination and the more broad communication deriving from the WEIC. The staff is divided into two units; 3 communicators work with research dissemination and 24 communicators work with the broad communication and the extraordinary efforts aimed at public workplaces within the WEIC.

5.1.2 Key numbers

The key numbers relate to the two different areas of activities within the field of Communications; the NRCWE research dissemination and the WEIC.

Table 5.1 NRCWE Communication and Dissemination of research. Source: the NRCWE.

Research communication *	2009	2010	2011	2012	2013
Articles in internationally recognized peer-reviewed journals**	122	137	150	132	153
News on: https://nfa.dk *** Divided on	141	136	101	87	66
-scientific research	78	73	49	43	28
-Reports and PhD-thesis/surveillance	14	16	10	7	7
-other content (conferences etc.)	49	47	42	37	31
Reports***	13	6	6	7	6
Fact Sheets***	3	3	11	2	0
Published newsletters	29	32	16	24	24
Press quotes	1.189	1.568	1.977	1.337	1.686
External visits at nfa.dk****	1,074,238	1,083,697	1,003,357	931,893	772,137
Downloads of PDF-files from nfa.dk	56,299	55,717	52,987	50,742	44,442
Visits at nfa.dk****	277,204	265,527	219,856	236,637	202,436

* Research Communication was presented as Table 2 in the overview International Evaluation 2014, The general institute level.

** The figures on Articles in internationally recognized peer-reviewed journals were presented in Table 1 Research in overview International Evaluation 2014, The General institute level

***The extracted figures on newstype has been collected and translated from: Notat vedr. formidling af NFAs forskning til offentligheden i forbindelse med den internationale evaluering 2009-2014

****Calculated in WebTrends.

Table 5.2 WEIC Communication and dissemination to the general public. Source: the NRCWE.

Broad communication from the Danish Working Environment Information Centre	2009	2010	2011	2012	2013
Visits at the web portal at.dk**	278,402	441,932	534,593	661,168	1,020,730
Subscriptions to the magazine Arbejdsmiljø	6,389	5,965	5,510	5,020	4,922
Subscriptions to newsletter	9,587	12,187	13,326	14,468	17,574
Seminars, mini-conferences and workshops organized by the Team of Mobile Working Environment Communicators	107	260	257	308	305
Participants in meetings of the Team of Mobile Working Environment Communicators	10.733	15.717	11.583	18.032	17.014

* Broad Communication was presented as Table 3 in the overview International Evaluation 2014, The general institute level

**Total number of visits at at.dk, including campaign sites, calculated by Google Analytics.

5.2 Dissemination to target groups

The scientific production gives the basis for all research dissemination and communication. It provides, to a high degree, the foundation of the campaigns performed by the WEIC. This means that all external communication has its basis in quality assured knowledge and findings.

The target groups for research communication are:

- Scientists, experts, and students nationally and internationally
- Working environment advisors/consultants and experts in companies and organizations
- Press, TV/radio, magazines, web portals and other media
- The Ministry of Employment, the social partners, The Working Environment Council and the Sector Working Environment Councils

The researchers' prioritized setup on dissemination and communication is: 1) Scientific publications, 2) Contact meetings such as dialogue with authorities, collaborative partners and project councils (følgegrupper), 3) the NRCWE-webpages, 4) the WEIC-webpages and 5) Media. The execution of dissemination and communication among the researchers at the institute are in line with the intentions in the strategic plans, and thus points at rather good anchoring of the overall communication policy at the institute.

5.3 Dissemination to the general public

The Working Environment Information Centre (WEIC) was established in 2005 on the basis of a political agreement. It has its own independent mission; to serve as an entrance-point for working environment knowledge, and to gather and communicate working environment knowledge and examples of good practice from all relevant sources, including NRCWE, but not excluding others. The WEIC's target groups are employers and employees at Danish workplaces with particular focus on the working environment organization and managers.

The WEIC has been externally funded, outside of the NRCWE budgets. This funding will end in 2015, and the organizational setup of the WEIC will then change – depending on the possibilities of further

funding. The situation has not been fully clarified when it comes to the potential of further funding, but there are expectations on the continuation of the work after 2015. The Ministry of Employment state that it is crucial to have a platform to disseminate and communicate knowledge within the work environment field which is not dependent on any given researcher, but which can provide overarching and structured information.

The WEIC has, in the evaluation period, grown to become the one entrance point for working environment knowledge. As stated in the mission. This understanding is shared among target groups such as the working environment advisors/consultants and the general population. Some stakeholder representatives reported that they looked elsewhere when searching for original research and scientific collaboration. At the same time they expressed that the WEIC seem to be professional in their communication.

When looking upon the key figures, one can see that the number of visits to the WEIC-pages more or less have doubled every third year. At the same time one has stabilized the numbers of subscribers to the published magazine (Arbejdsmiljø); which is quite interesting knowing that the general on-print-subscription numbers are declining both within the scientific sector and in the overall market.

The WEIC has in the evaluation period produced several campaigns and disseminated research within all key research-areas for the NRCWE. The campaigns are built on more practical and useable knowledge in form of articles and references to other stakeholders. All of them are based on research, and most of the research originates from the NRCWE. The research based knowledge has been combined with good practice collected through the public sector and by collaboration with The Sector Working Environment for the Industry and other collaborating organizations.

The WEIC uses an external evaluator (Epinion) to perform measurements of activities, reach, and to a certain extent, impact. The measurements were performed once in 2012 and twice in 2013; both on regular activities and the campaigns themselves. The findings in these performance measurements are "average to good"; with approximately 30% of all employed in Denmark having knowledge of, or having used, the WEIC. Among these 30%, approximately 65% report having an excellent impression of their deliveries. The knowledge of the campaigns targeting the public sector differs from "little" to "quite well known" among public employees with range 3 – 49% depending on campaign. Among public employees who know of at least one of the campaigns, 43 - 57% say that the campaigns have led to some form of action in the workplace (Epinion, Årsrapport VFA, Februar 14).

5.4 Conclusions and recommendations

The research centre responds well to its priorities and the overall objectives related to communications and dissemination of research results and knowledge on the working environment. This is an overall impression from both the NRCWE's governing board and the different stakeholders such as the social partners, collaborating organizations, as well as representatives from the authorities.

Is the dissemination of research results to a sufficient extent visible, relevant and user-oriented for the target groups among the social partners, working environment advisers and employees/employers at the workplaces? Does the NRCWE attract the attention of the general public?

The NRCWE visibility is quite high, it is considered relevant by the stakeholders on behalf of their user groups, and it attracts the attention of the general public– as measured by media and press-coverage as well as visitors to the NRCWE and Working Environment Information Centre (WEIC) web pages. The institute – including both the research dissemination and WEIC - has a very good position as viewed by the stakeholders. The dissemination from the institute, in overall, has been declared as 'extremely good' and 'totally professional' from different stakeholders.

Is the NRCWE research-based counseling of the authorities to a sufficient extent relevant and user oriented?

The research centre itself has by the stakeholders been declared as the place to which one, in the future, can address questions on knowledge related to the sector; The Knowledge Centre within the sector. Not just by research, but by keeping control on, gathering and evaluating knowledge from other providers.

The researchers have a good perception of the importance of understanding the social partners' needs and the necessity of keeping a balanced and objective position between the social partners and the authorities when it comes to the dissemination of knowledge. This is expressed quite clearly by the Director General who states that the communication at NRCWE first and foremost should come from the researchers themselves, be clear from assumptions and politics, concretely related to the actual project and/or findings and nothing else. The stakeholders seemed to agree that the scientists themselves should be in charge of the dissemination of research results. All stakeholders seemed to agree that research results from the NRCWE are trusted, and they emphasized the objective and independent position of the NRCWE. Several stakeholder representatives voiced their need for more counseling.

How can the NRCWE strengthen its future impact?

Relating to the results in the period of evaluation and how communication as a field of interest has changed in the period, we suggest that the NRCWE continues on the chosen path. We trust NRCWE is able to identify research results that have reached a stage where communication to the public is in order and research results that would benefit from not being communicated before independent collaboration from other groups are in place.

At the same time there is room for tuning a few areas such as organization, strategy, the understanding and use of education as a communication channel, social media, the terminology used and an enhanced focus on production.

5.4.1 Organization

The restructuring of the communications department in 2012 should be reviewed. The NRCWE research dissemination and the WEIC have distending ways of working with communication and there is lack of balance between them (24 vs 3 persons). In 2015 the funding situation of the WEIC will impose an organizational change, and we see this as a possibility for the NRCWE to strategically restructure the organization and to make the two units work as the NRCWE communications department using the WEIC as a platform, balancing the resources and workload better.

The use of WEIC in research dissemination is already highly focused by both the researchers and the organization. The Ministry of Employment states that it is crucial to have a platform to disseminate and communicate knowledge within the work environment field which is not dependent on any given researcher, but which can provide overarching and structured information.

5.4.2 Communication strategy

The strategic position of communication and dissemination at the institute demands a clearer and more pointed communication strategy. When, co-organizing the WEIC with the NRCWE as one unit, one strives to achieve synergies, which there is quite a potential to have. This requires a formulated strategy on how the two distending units, having rather different objectives and ways of communicating, can interact and be used as the basic platform for integrated communication-efforts.

5.4.3 Using education as a communication channel

We suggest that the NRCWE communication and dissemination strategy include education and training. Using education and training as a communication channel, opens for direct dialogue with the professional work environment advisors and OSH-personnel. This will involve a higher use of researchers – making them more visible.

5.4.4 Social media

Social media (SoMe) is a set up of different channels which provide communication by closer interaction with the target groups. Dialogue as communication is demanding when communicating knowledge and scientific findings in a highly political sphere such as the work environment. The proper balance between 'quick and dirty' and the 'scientifically correct' therefore must be advocated. Using SoMe as billboards and not engaging in dialogue, as done today, is not the correct way of using these channels. Use of SoMe requires defined resources which research institutions often do not have. Treating SoMe as an extra task beside the other communication tasks, is a good way of being unsuccessful. We therefore recommend that the NRCWE: addresses SoMe in its communication strategy, defines what SoMe is for the institute, that the organization is being set up with defined resources on SoMe and that the researchers are involved in the interaction pertaining the scientific position.

5.4.5 Language and terminology

We recommend a more forward leaning profile on visibility, striving to make the content more understandable for the different target-groups. This includes working more with the language, fitting the information to different channels and users. The institute needs to untangle the more in-house scientific terminology for the Danish end-users. Achieving this would lead to more practical and user-friendly presentation of knowledge and thus respond well to the overall wishes from the different stakeholders.

5.4.6 Production and performance contracts

The production is focused on the scientific side of the NRCWE, relating to performance-contracts. We recommend heightening the focus on the communication and dissemination-side so that it follows the increased scientific production on a strategic level. This could, for example, be performed by including popular communication and dissemination into the performance contracts of the senior scientific personnel, and by introducing the head of communication to a performance contract, if not already included.

6. Education

6.1 Introduction

As a National institute, the NRCWE is obligated to take part in undergraduate, postgraduate and research education within its fields of research. A large proportion of the Danish occupational, safety, and health (OSH) scientists are employed at the NRCWE. As a sector institute it is therefore pivotal for the future research within the area that the institute produces an adequate number of PhDs.

Senior scientists and professors at the research centre have formal affiliations with universities as lecturers, mentors, and censors. Scientists of the NRCWE give lectures at universities for undergraduates and postgraduates, to some extent they take part in organizing educations, they mentor undergraduate, postgraduate and PhD-students based at the NRCWE or at universities.

The NRCWE define education as a core activity and are in the process of making strategic collaborative agreements with the universities in Denmark (several agreements are already in place) for professorships at the universities.

The NRCWE plan to develop international collaboration for exchange of PhD students and postdocs. Guest scientists will bring new or other perspectives that will be beneficial to the education at all levels.

6.1.1 Organization and management

Education is decentralized and managed through the performance management contracts with professors and senior researchers. Issues concerning education are addressed at the scientific management meetings and in performance talks with the director general as well as in the development of new projects.

6.1.2 Key numbers

The numbers provide an overview of the educational activities at the NRCWE in the evaluation period.

Table 6.1 Education in numbers*. Source: the NRCWE.

	2009	2010	2011	2012	2013
Ongoing PhD-projects**	22	27	26	23	21
Completed PhD-projects	4	7	4	4	3
Ongoing special projects	22	27	16	20	14
PhD Theses	3	10	4	4	2

*Table on education was published in the Annual Report 2013. It has been translated from Danish

**Including completed projects

6.2 Conclusions and recommendations

Does the NRCWE to a sufficient extent contribute to the education of undergraduates/postgraduates and PhDs within the working environment?

During the evaluation period the NRCWE have generated 4.6 PhDs per year (their own objective is 5 per year). There are a number of projects with students writing scientific papers. There is no absolute yardstick against which this may be measured. We find the contribution to education satisfactory.

Does the NRCWE to a sufficient extent contribute to working environment-related education at the universities?

Given their resources and other obligations, we find that the NRCWE “contribute to working environment-related education at the universities” “to a sufficient extent”.

However, the aims of working-environment related education are twofold: (I) giving persons (expert) competence in the field of OSH, and (II) producing interest and some basic understanding of OSH problem areas and topics.

It is difficult to assess the need for Danish experts in OSH-related areas (aim I). The NRCWE are in the process of developing collaborations which we expect will enhance teaching at the MSc and PhD levels. Hence, we recommend that the research centre continue their efforts to develop graduate level teaching and mentoring.

Competence and understanding of OSH-related topics are relevant to all leaders and managers (aim II): all employees are exposed to some work environment. Hence, promoting interest and understanding of OSH may be an important contribution of the NRCWE to future Danish working life. The NRCWE collaborate with the Technical University of Denmark. We recommend that the NRCWE also consider extending their collaborative efforts to schools and universities that educate leaders and managers (e.g. business schools). One option is to develop courses, lectures, open-online courses, or study material that raises awareness of OSH among future leaders, maybe primarily for human resource management (HRm) educations.

7. Stakeholders' evaluation

7.1 Interview procedures

'Primary stakeholders' were defined as "owners" of the NRCWE in line with previous evaluations. The NRCWE proposed four representatives from the Ministry of Employment, three representatives from social partners, three representative from users, and two representatives from cooperation partners. Eight representatives were contacted, none declined to meet the panel, seven were interviewed (one of whom by telephone meeting).

The following representatives were interviewed:

Ministry of Employment

Permanent Secretary **Peter Stensgaard Mørch**, The Permanent Secretariat of the Ministry of Employment

Director General **Peter Vesterheden**, The National Working Environment Authority

Social partners

Signe Kofoed, Consultant at The Danish Confederation of Trade Unions (LO), part of the Board of the Strategic Research Fund (SVU)

Head of Working Environment **Karoline Klaksvig** (member of the board of governors of the NRCWE), The Confederation of Danish Employers (DA)

Chairman **Lisbeth Lollike**, The Working Environment Council

Users

Head of Working Environment **Anders Just Pedersen**, Sectoral Working Environment Council for Industry (in Danish: Industriens Branchearbejdsmiljøråd)

Cooperation partners

Jens Peter Bonde, Head of Department, Professor at The Dept of Occupational and Environmental Medicine at Bispebjerg Hospital, Copenhagen.

In addition we interviewed the Chairman of the NRCWE board (appointed by the Ministry) **Kjeld Møller Pedersen**, Professor at The Dept of business and economics, Univ of Southern Denmark.

Representatives of primary stakeholders were interviewed by Stein Knardahl, Sture Bye, and Håkon Johannessen. The interviews were semi-structured with the following main questions:

- What is your opinion of the research conducted by the NRCWE?
- In your opinion, is the current strategy and prioritized research fields optimal?
- In your opinion, are there research fields that should be given higher priority by the NRCWE?
- In your opinion, are there research fields that should be terminated or given lower priority?
- The NRCWE scientists acquire competence of what goes on in the research front. To what degree should the NRCWE themselves (with their competence) define and prioritize research question and problems for their research?
- May special interests of individual partners (stakeholders) be an obstacle for research of the NRCWE?
- Have you applied research results from the NRCWE?
- Describe your communication with the management of the NRCWE?
- Describe your communication with individual scientists of the NRCWE?
- What should be the role of the NRCWE in Denmark's future working life?
- Follow-up question: Are there aspects that should be improved?

The average duration of interviews was one hour.

There is a possibility that representatives who are members of the board of governors of the NRCWE may be overly positive to decisions they have been part of. Hence, the interviews can only reflect the subjective perceptions and opinions of the stakeholder representatives, and cannot be taken as objective measurements of stakeholders' positions. Therefore, the interviews were not recorded on tape and individual interviews were not fed back to interviewees. The following is a summary of responses and statements. The text has been shown to interviewees for comments.

Statements pertaining to the dissemination of research results are presented in chapters 5 and 6.

7.2 Relevance and impact

Stakeholders' assessment of the quality, relevance and the effect of the research, the dissemination of research results and the contribution to further education carried out at the NRCWE.

7.2.1 General assessment of the research conducted at NRCWE

All of the stakeholder representatives explicitly emphasized that they considered the research conducted by the NRCWE to be of high scientific standard both by national and international standards. They used the following terms: "generally good scientific research"; "great confidence in the NRCWE ... can count on quality"; "thorough and solid"; "no questions of the professional level"; "in general, research at a high international level"; "credible"; "research with high integrity"; "high quality-research"; "qualified"; "very high level"; "ambitious"; "run professionally"; "applicable research"; "considerable value for Danish work-places"; "common national knowledge base"; neutral – can be trusted". The stakeholders voiced the importance of the Centre as productive in producing international-level peer reviewed research articles.

Some stakeholders underlined the importance of the role of the institute as a leading, inspiring, and unifying research unit for other research groups.

Several stakeholders pointed out that the knowledge base created and maintained by the NRCWE facilitates their work. As expressed by one of the stakeholders: "(The NRCWE) is our primary source when we have the need for high quality advice on the potential impact of emerging work-related risks on health." One representative of social partners pointed out that the NRCWE provides the knowledge base, relieving the social partners from discussing realities and facts.

In sum, the stakeholders expressed a high level of general confidence in the research management of the institute and in the quality, relevance and applicability of the research conducted at the NRCWE.

7.2.2 Assessment of the NRCWE's research strategy and the prioritized research areas

Most of the stakeholder representatives pointed out NRCWE's strategy is in accordance with the National strategy for 2020 signed by political agreement. Several stakeholder representatives voiced the opinion that the current strategy is reasonable and relevant for identifying important work environmental hazards, and consequently will contribute to improving workers' health. Some pointed out that the available resources limit the research fields that can be addressed since a minimal "critical mass" of research groups should be maintained.

The stakeholders maintained that the research conducted by the NRCWE generally meets the strategic priorities. Nevertheless, some stakeholders stated that the present strategy is too ambitious, and that there is an obvious mismatch between the aims in the strategy and what is reasonable to achieve with the available resources. Others mentioned problem areas that should be expanded if resources were made available.

In the overall picture, most of the stakeholders expressed consent and satisfaction with the research areas that have been prioritized by the NRCWE.

The stakeholder representatives mentioned the following areas and approaches that they would like to be given higher priority:

- Occupational accidents – safety culture
- Aging workers
- Research on primary prevention in general, and primary prevention applicable for the enterprises in particular
 - Research on effects of interventions: Which measures at the workplace work? What are the prerequisites/conditions for a measure to work? Research on effects of measures by the National working environment agency.
 - Research on how to prevent absenteeism and how to keep the aging population and vulnerable groups in paid labor
 - How change behaviors of enterprises and individuals?
- More systematic reviews and meta analyses (synthesis of results from primary research articles)
- Research on biopsychosocial factors rather than biomechanical factors
- Epidemiological research and more utilization (development/improvement) of registry data
- Research on work-related factors that promote health (salutogenic factors)
- Chemical exposures (not restricted to nanoparticles)
- Noise

When asked for research areas or approaches that should be terminated or given lower priority, almost all stakeholders' representatives explicitly said they would not reduce any of the ongoing research fields. One representative maintained that research on nanomaterials should be reduced and general toxicology be prioritized.

Some stakeholders underlined the challenge of anticipated reduced resources in future National budgets.

7.2.3 Assessment of the research centre's autonomy to determine and prioritize research areas

Questions: (I) The NRCWE scientists acquire competence of what goes on in the research front. To what degree should the NRCWE themselves (with their competence) define and prioritize research question and problems for their research? (II) May special interests of individual partners be an obstacle for research of the NRCWE?

All stakeholder representatives underlined that a sector research institute (the NRCWE) differs from the universities' free basic research regarding the autonomy to determine research areas and projects. In general, the stakeholders seemed to a large extent to agree that the research of the NRCWE should be bounded by the politically determined research strategy. On the other hand, representatives pointed out that the NRCWE should influence the premises of politically determined strategies.

However, representatives also underlined the importance of maintaining knowledge of the state-of-the-art of work environment research in general, i.e. for maintaining knowledge in fields outside of the research topics defined by strategic priorities. The NRCWE as a National centre should maintain

competence to provide advice on questions pertaining to the working environment in general. Furthermore, the NRCWE should maintain capability to direct attention to emerging risks.

The stakeholder representatives agreed to a great extent that within the general politically determined boundaries, the researchers should have unlimited autonomy to design research projects without interference from the social partners or political authorities. Moreover, some stakeholders voiced the opinion that researchers at the NRCWE also should be given the possibility, although to a limited extent, to carry out basic research and research themes not directly related to core elements of the strategy of the Centre.

On the other hand, several representatives mentioned that stakeholders recently got involved in NRCWE's development of a research questionnaire instrument. The criticism maintained that the study of factors related to topics subject of negotiations between social partners, is outside the tasks of the Institute. The interviewed stakeholder representatives seemed to agree that this recent issue has been resolved satisfactorily. However, these interviews did not allow any conclusions whether stakeholders may interfere with scientific research of factors that are seen as subject to their interests.

One of the stakeholder representatives stressed the opinion that the NRCWE "need to understand their role as sector institute more clearly, and to understand what kind of role they have in the political system and with the social partners".

7.2.4 Communication with the NRCWE

All stakeholder representatives maintained that they had excellent communication with the management of the NRCWE through their respective formal channels.

Some stakeholder representatives have had some direct contact with individual scientists. They all rated their communication as excellent.

7.2.5 Assessment of the dissemination of research results

The stakeholder representatives differed in opinions of the dissemination of research results. Some of the stakeholders claimed that the dissemination of research results has been too technical and circumstantial, while others claimed that the dissemination in some instances had been too "journalistic and popular". Nevertheless, there seemed to be agreement that the research dissemination reaches out, and is applicable to significant agents. Moreover, the stakeholders seemed to agree that the scientists themselves should be in charge of the dissemination of research results. All stakeholders seemed to agree that research results from the NRCWE are trusted.

The stakeholders see communication and dissemination of research as a prioritized field; both for increasing visibility and for making the science more useful, available, and practical.

The stakeholders expressed the need for NRCWE to stick to research-based knowledge and dissemination of scientifically based information – both by communicating findings from their own research projects and by strategic use of the WEIC.

7.2.6 Assessment of the counseling of stakeholders

The NRCWE hold quarterly meetings with the primary stakeholders in addition to the meetings of the board of directors (in which stakeholders are represented). The stakeholder representatives agreed that the NRCWE have an open and transparent relation with all stakeholders both on top level and with direct access to researchers when necessary.

As a counselor for the stakeholders the NRCWE need to maintain a strict division between scientific methods and counseling. All stakeholders confirm that they understand this division. At the same time they point out the role of the NRCWE as a sector institute and its obligation to respond to the “2020-Strategy”.

All stakeholders emphasized the objective and independent position of the NRCWE. Several stakeholder representatives voiced their need for more counseling.

7.3 Opinions on future priorities: The future role and challenges for the NRCWE as a national research institute of working conditions and health.

In general terms, the stakeholders expressed the need for an independent National research centre for work environment research and knowledge. They all expressed an anticipation that the NRCWE in the future by being an impartial and leading research-based advisor for the social partners and the labor authorities, continue to play an important role as a contributor to sustain a healthy and productive Danish work force.

In addition, the stakeholders anticipated that the Centre continues to play a leading role in unifying and guiding occupational health research groups in Denmark. Furthermore, the stakeholders expect the NRCWE to preserve its role as an internationally recognized research centre on work-related factors and health.

When encouraged to give advice for improving the Research Centre, stakeholder representatives produced the following:

- To a greater extent disseminate emerging work environmental challenges to the labor authorities, the social partners, and the enterprises
- To a greater extent transform research-based knowledge into applicable guidelines for the enterprises
- Produce popular-science reports from international conferences
- To advance and strengthen the collaboration with the Labor Inspection Authority
- Building up a knowledge base by conducting more systematic reviews
- More intervention research applicable for the enterprises.
- More focus on salutogenic factors and positive effects
- More focus on the inclusion of non-working individuals in the labor force
- More focus on young workers

This advice was given by individual representatives.

8. Discussion

8.1 Scientific output and quality

8.1.1 Scientific output

The NRCWE exhibit a very high scientific output in terms of number of published articles in International scientific journals, given the resources of the Centre. The fields psychosocial work factors, musculoskeletal disorders, and nanosafety/microbiology/toxicology have been very productive.

We find a tendency to maximize the number of publications emanating from large datasets, rather than publishing comprehensive articles. This is an understandable response to demands from funding institutions for a high publication rate, but it is not always optimal for the advancement of knowledge. We therefore support the initiative declared by the NRCWE management to look into and implement the recommendations for authorship of the International Committee of Medical Journal Editors; the Vancouver group.

8.1.2 Scientific quality

Generally, the scientific quality (originality of research, validity and reliability of methods, conclusions based on results) is very good, even if the different areas of research at the NRCWE show some dispersion in this respect, as commented previously in the specific comments. The NRCWE have conducted innovative studies and raised highly interesting and novel questions. Researchers have participated in large collaborative studies published in highly rated journals, but have yet to take a leading role in groundbreaking research with very high impact.

8.2 Relevance and impact of research

In general, the NRCWE research is highly relevant to the Danish working life. The research appears to have considerable impact on Danish authorities and the social partners.

A research centre for occupational health faces the challenge of dealing with two different dimensions of mechanisms of work and health: (I) The individual worker dimension, ranging from individual-based measures for prevention (e.g. exercise programs) to the basic assumption that the individual is responsible for his or her health and actions. (II) The work environment exposures dimension, ranging from organizational-based measures to modify exposures to the basic assumption that the work environment is basically responsible for all aspects of the workers' health. Scientific studies must consider both dimensions. The representatives of primary stakeholders voiced different views on these issues and it is clear that there are conflicting interests in the views on the balance between the two dimensions. In general, it seems clear that the NRCWE as a whole have managed to balance this conflict in performing research of relevance to both dimensions.

8.3 Dissemination of knowledge

The communication of the research conducted by the NRCWE is very good in terms of accurate presentation of results and conclusions of the studies conducted. They may spend more resources on ensuring that written descriptions of project questions, methods, and results are easily comprehensible to individuals outside the occupational-health community.

In some projects, informing participating subjects of hypotheses being tested or expected outcomes may introduce bias due to placebo or nocebo effects that may seriously influence the results. Balancing the (i) demand for information by participating subjects (and the requirement of dissemination of information by funding authorities) with the (ii) scientific requirement for methods

that avoid bias (which invalidate conclusions) is a challenge in work environment research. This raises the need to appraise whether communication during projects may challenge the quality of methods, and develop a communication strategy for each individual project.

The dissemination of research results and knowledge from the work environment arena in general is rated as very satisfactory by both the NRCWE's governing board and the stakeholders. Visibility is quite high, the institute is considered to be an important stakeholder with a high credibility, and it attracts the attention of the general public. The scientific production is high, and increasing, and thus provides a very good basis on which the institute can disseminate knowledge. The institute faces some challenges, especially related to the funding situation of the WEIC, the organization of the communication efforts, choice of strategy, and production orientation as well as the continuing development of communication channels.

The public discourse on work and health in Denmark seems rather occupied with 'stress' and 'psychological overload' (cf. National strategy: "A new strategy for the working environment effort to 2020"). These are concepts that are poorly defined or inherently circular, implying that work or some external factor is the cause of a health problem ("causal diagnosis"). 'Stress' is used to describe occupational exposures and mental distress, implying that mental distress is caused by the job. 'Psychological overload' can only be defined by outcomes that are highly related to characteristics and state of the individual. The NRCWE have not researched and adequately discussed consequences of the use of these concepts (e.g. nocebo effects, illness attributions). The NRCWE need to review their own popular-science material with respect to validity of concepts they use. Designing a general exposure – mechanism/mediation – outcome model for general popular science communication purposes may prove useful.

8.4 National and international networking and collaboration

The NRCWE do in some fields take the role as hub for project applications and they participate in a considerable number of Danish studies: Some of the scientists have extensive international networks, while others have not developed such networks to their full potential. In general, there should be room for more international project collaboration.

We propose supporting initiatives for increased external collaboration by investing resources in a running program for inviting guest researcher(s) or post doc(s) to perform research at the NRCWE.

NRCWE is located centrally in Copenhagen, but still geographically isolated from other research institutions. However, this does not inhibit collaboration with research units at the universities or other research institutes.

8.5 Interactions with authorities and stakeholders

Formal interactions with authorities and primary stakeholders seem to be very good. All parties interviewed reported satisfactory communications. The NRCWE seem to be able to cope with disagreements between social parties and to rectify misunderstandings by direct communication with stakeholders.

8.6 Financial situation: threats and opportunities

At present the NRCWE exhibit a very high output of research results of generally high quality. The ability of the NRCWE to maintain competence in the fields prioritized by strategic documents from the Ministry of employment depends on being able to obtain funding from the Work environment research fund. So far the NRCWE have produced good grant proposals and achieved adequate external funding. With an expected general reduction of Government spending, the NRCWE may expect reductions of its basic government grant. This may be met by three strategies: (I) shifting

research focus away from research topics that are expensive to study, i.e. terminating studies that require a large staff for data collection, or instruments that are expensive in use; (II) reducing activity in all fields; and/or (III) attempting to get funding from new sources that have not so far been explored, (IV) terminating studies that do not comply with the current research strategy. We suggest NRCWE to prioritize maintaining research which is internationally leading, research on factors that are specific to Denmark, and research that is not performed elsewhere. It is important that the NRCWE perform focused analyses of activities and capacities in other Danish and Nordic research groups when making strategic priorities if budgets are cut.

All stakeholder representatives underlined the importance of maintaining both, (A) high-quality scientific research at an international level in the prioritized fields and, (B) a high general level of competence in all aspects of occupational health.

The present competences and organization of the NRCWE offers promising opportunities for further development of research. Some of these new developments imply objective assessments of exposures previously recorded by subjective reports, i.e. novel methods that are resource intensive compared to subjective reports. It is important for maintaining quality and relevance to Danish working life that the NRCWE continues to collect data on work exposures even if registry-based epidemiology may be cheaper. Furthermore, the need for development and evaluation of interventions and preventive measures at the workplace may be seen as an opportunity for experimental verification of risk- and protective factors, and hence as a complement to findings in observational studies.

8.7 Future challenges to the health and productivity of the Danish workforce: strategic challenges

The aging workforce, unemployment among young people throughout most of Europe, and the continuously challenged European economy constitute a rather new framework for Danish working life. The aging population leads to a need for more employees in elderly care and nursing. New technologies seem to revolutionize production methods and robotics is developing rapidly. New organizational structures based on information and communication technology (ICT) are rapidly developing and the contents of many jobs will probably change to include more interruptions, more multitasking, and the possibility to work at any time and place. In addition, globalization of enterprises and information seems to proceed at a rapid pace. The NRCWE seem well aware of these challenges.

The primary NRCWE stakeholders request more knowledge of preventive measures and interventions; they particularly inquire for knowledge of measures that prevent/reduce health problems, absence, and exit from working life. The NRCWE meet this demand and a strategic challenge is to find ways of maintaining scientific quality (i.e. valid and reliable conclusion) while, at the same time, being expected to deliver quick results. The NRCWE must communicate preconditions for conducting applied research of adequate methodological quality to stakeholders.

9. Summary: general conclusions and recommendations

In general, the allocation of resources and efforts of the NRCWE meets the National strategy: “A new strategy for the working environment effort to 2020” (“En strategi for arbejdsmiljøindsatsen frem til 2020”) and the strategic documents for the research centre. There is however, a need for strengthening research on factors contributing to accidents and accident prevention.

The scientific production of the NRCWE is very good, both in terms of publication output (volume of production subjected to peer-review quality control) and in terms of scientific quality. Furthermore, the quality of communication of their research findings is generally very good.

The NRCWE have shown excellent ability to exploit several comprehensive Danish registries and their own work-environment surveys (Den Nationale Arbejdsmiljøkohorte, NAK and its successor Arbejdsmiljø og Helbred, AH) to perform innovative studies that are hardly possible to undertake elsewhere. Falling response rates to surveys throughout Europe is a challenge for both research and National surveillance programs, and the NRCWE need to develop strategies to meet this challenge.

NRCWE scientists have generated novel and original ideas and have implemented new methods that are in the absolute forefront (e.g. objective measurements of physical activity during work).

Accidents at work is one of the three main problem areas specified by the National strategy 2020. Current accident prevention strategies direct attention at safety culture, risk perception, procedures, human-machine interface, working hours and fatigue in addition to organizational and technological factors. There is a need for knowledge in this problem area. We recommend that the NRCWE strengthen their research efforts related to accidents at work. The NRCWE need to critically review their efforts and plans for research of accidents and develop an explicit strategy that takes existing competence in all research groups into account.

Stakeholders generally call for applied research and knowledge of effects of preventive measures. The NRCWE have directed considerable efforts to studies of effects of interventions. Evaluation of costs and economic benefits of interventions should be included in these studies. We recommend that the NRCWE consider broadening their mission to also include factors determining the development and maintenance of high workability and productive work behavior and performance: future workplaces should be attractive and healthy but also productive. The present main focus on occupational factors which contribute to health, safety, absence, inclusion, and exit from working life should be maintained. We also encourage a thorough discussion of priorities with respect to individual vs. organizational factors determining these outcomes, and, accordingly, which intervention strategies to focus in research.

The strategic priorities have been revised annually or biannually during the last five years. Moreover, some priorities pertain to occupational exposures while others are described in terms of outcomes. These may be reasons why the organizational structure of the research centre is somewhat intangible. We recommend that the NRCWE clarify and define their organizational structure. One alternative is to organize projects according to exposure factors (cfr the Terms of reference for this evaluation), possibly combined with type of outcomes in a matrix structure.

With changing contents of many jobs due to technological developments, changing ways of organizing work and businesses, and challenging demographic changes in all Western countries, there is a great need for assembling groups of scientists who know and understand Danish working life, and who can produce research at a good international scientific level, collaborating across disciplines, acknowledging that processes determining health, performance and behavior are almost

always multifactorial. Moreover, there is a need for a hub with competence to gather and maintain a general knowledge base in all fields of significance to work and health in order to provide advice and detect new potential exposure risks. We find that the NRCWE have fulfilled these needs in an excellent way and highly recommend continued funding by the Ministry with the present governing bodies. There is definitely a need for a National research centre for work and health.

The Danish Working environment research fund (DWERF; managed by Arbejdstilsynet) normally grants DKK 55-58 million per year and the NRCWE get a substantial proportion of their funding from DWERF. The strategic priorities of the DWERF are similar to those of the NRCWE, hence there is very little possibility to get funding from DWERF for projects that are outside current political priorities. Although beyond the terms of this evaluation, the DWERF is highly relevant to the NRCWE capacity for studying emerging risks. One might consider whether allocating a fixed percentage (e.g. 10 percent) of the DWERF to topics not explicitly mentioned in strategy documents would be a stimulus for further development of Danish work-environment competence.

The output, quality, and relevance of NRCWE research are very good in most areas. In order to maintain a high international level of competence and to serve as an independent, neutral supplier of knowledge to Danish working life and its stakeholders, it is essential that the activities of the NRCWE are guided by scientific principles and standards. Stakeholders barring research into particular factors may pose threats to the scientific quality of research by not allowing confounding or moderating determinants of outcomes to be included in studies. We recommend that the NRCWE put efforts into communicating concepts of work and health research to stakeholders in society, in order to promote understanding of exposure factors, moderators, mediating factors, confounding factors, and outcomes. Stakeholders' board representatives are encouraged to discuss and define the boundaries of NRCWE's research at the inception of new strategic plans and refrain from interference in specific projects.

APPENDIX 1

Information requested from the NRCWE:

International Evaluation 2014 of the National Research Centre for the Working Environment (NRCWE)

Request for information

I. Request for information pertaining to the general institute level

1. Current strategic priorities: motives and reasons for priorities and allocation of resources (e.g. political priorities, relevance/significance to social partners or authorities, prevalence of exposures, new exposures, methodological breakthroughs, resources, major external grants, etc; max 8 pages).
2. Evaluation of current strengths, weaknesses, opportunities, threats of the NRCWE (total max 4 pages).
3. Description of current organization and leadership of research.
4. Description of current organization and leadership of other activities (advisory activities, communication and dissemination of results, etc).
5. List of all employees, in alphabetical order with name, title and date of employment.
6. Full list of publications (per year).
7. Annual funding from the Ministry for 2009 – 2013.
8. Annual external funding of research 2009 – 2013.
9. Annual external funding of other activities (e.g. dissemination of knowledge, etc).

II. Request for information pertaining to prioritized research fields

The terms of reference for the evaluation outline 4 clusters of research groups:

1. Psychosocial working environment including occupational accidents and safety culture
2. Physical working environment
3. Nano safety including toxicology
4. Working environment surveillance

In the period 2009 – 2013 the Ministry of Employment altered its management concept. There are several steering documents pertaining to strategy and performance for the evaluation period. Several of the strategic research fields and priorities are not easily categorized according to these 4 clusters.

The strategy for the time period 2006-2010 listed the following prioritized research fields:

- Occupational accidents
- Absence and exclusion
- Work-related pain in muscles and joints
- Psychological working environment
- Organising and management
- Noise

- New technologies
- Intervention and implementation

The business strategy for the time period 2010-2014 listed the following prioritized research fields (translated from Danish):

- Development and implementation of models for prevention of psychological work environment problems and promotion of well-being related to altered structures, altered work arrangements, new types of organizations, including the development and implementation of safety-culture concept for the prevention of occupational accidents.
- Development of research-based models and practical methods for job retention work including focus on immigrants.
- Development and implementation of methods for primary and secondary prevention of musculoskeletal pain.
- The formation of an inter-institutional centre for nano safety and the development of methods for assessment of risks posed by exposures associated with new, green technologies.

The business strategy for the time period 2011-2015 listed the following prioritized research fields (translated from Danish):

- Development and implementation of models for prevention of psychological work environment problems and promotion of well-being related to altered structures, altered work arrangements, new types of organizations, including the development and implementation of safety-culture concept for the prevention of occupational accidents.
- Development and implementation of methods for primary and secondary prevention of musculoskeletal pain.
- The formation of an inter-institutional centre for nano safety.
- Development and implementation of a program for surveillance of the development of the work environment until 2020.

Hence, the following research fields were given priority in the time period 2009-2013:

- Development and implementation of models for prevention of psychological work environment problems and promotion of well-being related to altered structures, altered work arrangements, new types of organizations (= Psychological working environment and Organising and management).
- Occupational accidents, including the development and implementation of safety-culture concept for the prevention of occupational accidents.
- Development and implementation of methods for primary and secondary prevention of musculoskeletal pain (= Work-related pain in muscles and joints).
- Absence and exclusion (= Development of research-based models and practical methods for job retention including focus on immigrants).
- Intervention and implementation.
- The formation of an inter-institutional centre for nano safety (= New technologies).
- Development of methods for assessment of risks posed by exposures associated with new, green technologies (= New technologies).
- Development and implementation of a program for surveillance of the development of the work environment until 2020.
- Noise.

Some of these fields pertain to occupational exposures (psychological, organizational, nano-safety, green technologies, noise), some fields address outcomes (musculoskeletal pain, accidents, absence and exclusion), and some fields pertain to general methods of monitoring and improving the

situation of Danish employees. Hence, there is overlap between the research fields: some projects cover two or more fields (e.g. psychological work factors contributing to musculoskeletal pain disorders).

The terms of reference for the evaluation (Kommisiorium) calls for separate evaluations of research of psychosocial and physical work environments. Therefore, the research on musculoskeletal pain will be divided in two and reported according to the (predominant) exposure type investigated. The research of Intervention and implementation will be reported for each research field.

Hence, information is requested for each of the following research fields:

1. Psychological, social, and organizational work factors contributing to/associated with musculoskeletal disorders (including methods for prevention).
Corresponding strategic priorities:
 - a. Development and implementation of models for prevention of psychological work environment problems and promotion of well-being related to altered structures, altered work arrangements, new types of organizations = Psychological working environment and Organising and management.
 - b. Development and implementation of methods for primary and secondary prevention of musculoskeletal pain = Work-related pain in muscles and joints.
2. Psychological, social, and organizational work factors contributing to/associated with accidents and other outcomes than musculoskeletal disorders.
Corresponding strategic priorities:
 - a. Development and implementation of models for prevention of psychological work environment problems and promotion of well-being related to altered structures, altered work arrangements, new types of organizations = Psychological working environment and Organising and management.
 - b. Occupational accidents, including the development and implementation of safety-culture concept for the prevention of occupational accidents.
3. Mechanical (physical) work factors contributing to/associated with musculoskeletal disorders (including methods for prevention).
Corresponding strategic priorities:
Development and implementation of methods for primary and secondary prevention of musculoskeletal pain = Work-related pain in muscles and joints.
4. Absence and exclusion (= Development of research-based models and practical methods for job retention including focus on immigrants).
5. The formation of an inter-institutional centre for nano safety = New technologies.
6. Development of methods for assessment of risks posed by exposures associated with new, green technologies = New technologies.
7. Development and implementation of a program for surveillance of the development of the work environment until 2020.
8. Noise.
9. Other chemical exposures and studies of toxicology.

Projects and publications etc that belong in two (or more) research fields must be marked to make it easy to overview resources and results in each field and of the NRCWE as a whole.

The evaluation panel will decide how research fields will be grouped in the evaluation report.

For each of these 9 fields, the following information is requested:

- **Strategic priorities** pertaining to the research field: motives for increasing, maintaining, or decreasing efforts in this field during 2009 - 2013 (e.g. new exposures, political priorities, relevance to social partners or authorities, methodological breakthroughs, major external grants, resources, etc; max 1 page).
- **Relationship with international trends and developments in the research field** (max 1 page).
- **List of employees working in the strategic field**, with name, position, percentage affiliation with the NRCWE, percentage of time allocated to the research field (approx), academic degree, gender, age.
Scientists and technicians/staff separately.
Since strategic fields overlap, the data may be presented in a spreadsheet.
- **List of research projects** since 2009 (with sources of funding, funding period)
- **List of publications**
 - a. Articles with original data in international peer-reviewed journals (authors affiliated with the NRCWE highlighted in bold characters). Journal impact factor.
 - b. Review articles separately.
 - c. Scientific articles in national (Danish) journals, not peer reviewed.
 - d. Scientific articles in very-high-impact journals: impact factor > 10.
 - e. Conference abstracts (for studies not yet published in journals).
 - f. Books and book chapters.
 - g. Popular-science publications.
 - h. Communications to the public (if available).
- **Full copy of the 5 selected articles in the period** – aiming to illustrate scientific and practical value (impact), preferred research methods, strengths, or depth of the research.
- **Impact on the society** (max 2 pages)
 - a. Use of results for laws, regulations, directives, guidelines, etc
 - b. Practical applications of knowledge in large-scale campaigns or interventions
 - c. Participation in official national-level committees
 - d. Contact with and/or counseling of (specific examples)
 - Ministries
 - Authorities
 - Social partners
 - Occupational health clinics / hospital departments, occupational health services and advisers / consultants
 - Companies / businesses / organizations
- **Description on research on interventions (preventive measures) and implementation** (max 2 pages)
 - a. Research projects
 - b. Results and impact
- **List of collaborators and networks** (with projects)
 - a. National, including universities, hospitals and institutes
 - b. International
- **List of PhD students mentored by NRCWE researchers**
 - a. Present students – project title and mentor(s)
 - b. Completed PhD degree – thesis title and mentor(s)
- **List of master students mentored by (which) NRCWE researchers**

- **Teaching at Universities**
- **Money spent on the research field in 2013**
 - a. Salaries
 - b. Internal (institute) funding of research field 2013 (including running expenses)
 - c. External funding and sources (national and international) of research field 2013
- **Self evaluation of your current situation** in the strategic research field (max 4 pages)
 - a. Strengths and weaknesses
 - i. Scientific quality
 - ii. Competence
 - iii. Infrastructure in-house: (facilities/laboratories/instruments, methods repertoire, etc)
 - iv. Collaboration and networks
 - v. Funding: development last 5 years
 - vi. Productivity
 - b. Needs, problems, threats, factors that the committee should be aware of
- **Future plans and opportunities** (2014 – 2020) (max 2 pages)
 - a. Planned projects and strategic decisions
 - b. What is needed to meet strategic goals? (competence, resources, instruments)
 - c. What is needed for NRCWE to be excellent within this field? (competence, resources, instruments)
 - d. Expected availability of grant money for the field