

# Which subgroups of fire fighters are more prone to work-related diminished health requirements?

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Received: 5 April 2011 / Accepted: 20 October 2011 / Published online: 22 November 2011  
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## Abstract

**Purpose** To determine whether certain subgroups of fire fighters are prone to work-related diminished health requirements.

**Methods** The health requirements for fire-fighting were tested in a workers' health surveillance (WHS) setting. These health requirements included psychological, physical and sense-related components as well as cardiovascular risk factors. The odds ratio (OR) and 95% confidence interval (95% CI) for the presence of the diminished health requirements were calculated for the subgroups of gender, professionalism and age.

**Results** The prevalence of diminished psychological requirements was equivalent among the subgroups, and no significant high-risk group was identified. As compared to men fire fighters, women fire fighters were more likely to have diminished physical requirements (OR 28.5; 95% CI 12.1–66.9) and less likely to have cardiovascular risk factors (OR 0.3; 0.1–0.5). As compared to volunteer fire fighters, professionals were less likely to have diminished physical requirements (OR 0.5; 0.3–0.9), but professionals had a higher prevalence of cardiovascular risk factors with an odds ratio of 1.9 (1.1–3.2). As compared to the youngest fire fighters, the oldest fire fighters were more likely to have diminished sense-related requirements (OR 7.1; 3.4–15.2); a similar comparison could be made between oldest and middle-aged fire fighters (OR 5.1; 2.5–10.5). In addition, the oldest fire fighters were more likely to have cardiovascular risk factors when compared to the youngest (OR 4.4; 1.7–11.1) and to the middle-aged fire fighters (OR 3.1; 1.2–7.9).

**Conclusions** Subgroups (gender, professionalism and age) of fire fighters are prone to at least one specific work-related diminished health requirement. Therefore, parts of the WHS could be applied with more attention to these high-risk groups.

**Keywords** Fire fighter · Adverse health effect · High-risk · Subgroup

## Introduction

Certain subgroups of workers may be at higher risk of developing diminished health requirements in relation to the job they fulfil. A high-risk approach to monitoring can be used when these subgroups have been recognised. This approach was introduced by Rose (1985), who posed that the high-risk approach was a preventive strategy that seeks to identify high-risk susceptible individuals and to offer them individual protection. For susceptible workers, this approach can result in more attentive monitoring of their work-related health aspects, e.g. using a workers' health surveillance (WHS). In this article, our goal was to identify high-risk subgroups of fire fighters.

Work-related diminished health requirements have been studied in fire fighters, but very few studies can be found that identify high-risk groups. One of the few studies performed in ageing fire fighters found that musculoskeletal diseases increased with age (Sluiter and Frings-Dresen 2007). Other job-specific health aspects that were of interest to monitor in fire fighters were published in a recent review among several high-demand jobs (Plat et al. 2011). These include psychological aspects, physical aspects (energetic, biomechanical and balance), sense-related aspects and environmental exposure aspects as well as cardiovascular risk factors.

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Subgroups including gender, professionalism and age are examples of high-risk groups in a high-demanding job, like fire fighters. Literature examining gender difference in fire fighters is scarce, probably due to the small number of women fire fighters. Based on other literature, it can be concluded that women possess lower maximal strength when compared to men (Åstrand et al. 2003) and may therefore experience more difficulty when performing strenuous duties during fire-fighting tasks. In the subgroup of professionalism, fire fighters in the Netherlands can be grouped into one of the two types: volunteer and professional fire fighters. In the Netherlands, 22,000 volunteer fire fighters and 5,500 professional fire fighters are currently active. Volunteer fire fighters perform fire-fighting activities in addition to employment at a 'normal' job and are paged from their work or home during predefined time periods, but only when incidents occur. Volunteers operate primarily in more rural areas. Conversely, professional fire fighters perform 24-h shifts at the fire station, with 48-h rest in between shifts, and they are often located in urban areas. Professional fire fighters are assumed to have higher chances for developing diminished health requirements in this study due to more extensive and longer exposure than volunteer fire fighters. For example, fire-fighting contains several potential occupational cardiovascular hazards, such as long sedentary periods, smoke exposure, noise, shift work/partial sleep deprivation, fire house dietary patterns and occupational stress (post-traumatic stress disorders and high job demand and low decisional control) (Soteriades et al. 2011). So, we assume if professionals have more extensive and longer exposure compared to volunteers, they have a higher risk of these hazards and consequently for cardiovascular risk factors. In the limited amount of literature published about ageing fire fighters, older fire fighter groups were found to experience significantly higher emotional and mental demands than their younger colleagues, in addition to the musculoskeletal problems described above (Sluiter and Frings-Dresen 2007).

Until now, little insight has been available to assess which subgroups of fire fighters are at higher risk of experiencing work-related diminished health requirements. Thus, the research question addressed by this study is the following: Which subgroups of fire fighters are prone to work-related diminished health requirements? For the different subgroups, we hypothesized that:

- Women fire fighters are more prone to diminished health requirements when compared to men fire fighters.
- Professional fire fighters are more prone to diminished health requirements when compared to volunteer fire fighters.
- The oldest fire fighters are more prone to diminished health requirements when compared to the youngest and middle-aged fire fighters.

If subgroups have a higher chance for a specific diminished health requirement, that part of WHS can be given more attention in that subgroup in future. This so-called high-risk approach will lead to more efficient health screening.

## Methods

### Procedure and participants

Three regional fire departments throughout the Netherlands were selected with the help of a National Steering Group for the fire-fighting sector. Within these three fire departments, a total of 3,000 fire fighters were active. From these fire departments, a total sample of 1,100 fire fighters stratified for gender, professionalism (volunteer or professional) and age was invited to participate in the study. Of those invited fire fighters, 278 confirmed participation after receiving information about the study and signed informed consent. The ethics committee of the Academic Medical Center approved the study.

### Health requirements

The fire fighters participated in a WHS in which all of the health requirements necessary for appropriate job performance were measured according to newly proposed guidelines. All tested health requirements were work-related: on the one hand, they might have been caused by the occupation; on the other hand, if they are diminished, they might influence job performance. The health requirements were divided into the categories of 'psychological', 'physical', 'sense-related' and cardiovascular risk factors. Each health requirement was coupled to relevant health concepts and assessed using several measures. The criteria used to identify the diminished health requirements are listed in Table 1.

#### *Psychological health requirements*

Psychological health was assessed using information about sleepiness, work-related fatigue, depression, post-traumatic stress disorder and anxiety. The measurement scales and applied limits are shown in Table 1.

#### *Physical health requirements*

Two physical job-specific tests were used to measure physical health: the fire-fighting simulation test and the fire-fighting stair-climb test. These two physical, job-specific tests reflect the necessary physical capacity for satisfactory job performance, both in the cardio-respiratory system and in the musculoskeletal system, i.e. strength, balance, coordination and carrying capacity. The two tests are described

**Table 1** Health requirements of fire fighters, translated into necessary health concepts or involved organ systems and used instruments with applied criteria

Categories of health requirements	Health concept or involved organ system	Instrument (reference; applied limit)
Psychological health requirements	Sleepiness	Epworth sleepiness scale (Johns 1991; >15)
	Work-related fatigue	Need for recovery scale (van Veldhoven and Broersen 2003; $\geq 5$ )
	Depression	Brief symptom inventory for depression (de Beurs and Zitman 2005; >0.41)
	Post-traumatic stress disorder (PTSD)	Impact of event scale (van der Ploeg and Kleber 2003; $\geq 26$ )
	Anxiety	Brief symptom inventory for anxiety (de Beurs and Zitman 2005; >0.41)
Physical health requirements	Cardio-respiratory, musculoskeletal, relevant strength, balance, coordination, carrying capacity	Fire-fighting simulation test, test I (Plat et al. 2010a; not passing all parts, completion >24 min and 35 s or not passing the stair-climb test within one hour) Fire-fighting stair-climb test, test II (Plat et al. 2010b) (not finishing the test) OR ((not reaching >85% of theoretical max. heart rate at the end of the test or not within 2 min) OR (not within 1 min))
	Airways	Signalling question complaints airways/lungs after exposure (yes)
	Vision	Landolt C test (NOG 2004; best eye < 0.8 and least eye < 0.5) 5, 0.6 and 0.4 m
Sense-related requirements	Colour vision	Ishihara colour test (NOG 2004; >3 errors)
	Hearing	Whisper test (Eekhof et al. 2002; >4 errors at one ear)
	Skin	Signalling question complaints skin after exposure (yes)
Cardiovascular risk factors	Cardiovascular diseases (Graham et al. 2007)	Body mass index (>25.0) Waist circumference (men > 1.02 m; women > 0.88 m) Systolic blood pressure ( $\geq 140$ mmHg) Diastolic blood pressure ( $\geq 90$ mmHg) Smoking (yes) Diabetes mellitus (yes)

in detail by Plat et al. (2010a, b). In addition to these tests, fire fighters reported whether they experienced airway problems after incidental or recurrent exposure to a high concentration of inhaled gas in the previous 6 months (Table 1).

#### *Sense-related requirements*

Eye sight and proper hearing as well as skin problems of the hands/arms were tested. Proper eye sight was tested at several distances (5.0, 0.6, 0.4 m), and colour vision was also tested. Proper hearing was tested using the whisper test, which is a test used by Dutch general practitioners (Eekhof et al. 2002). Participants who normally wore glasses, contact lenses or hearing devices were instructed to wear them during the test. Skin complaints were tested by collecting a self-report about complaints after exposure of the hands/forearms to conditions in the workplace during

the previous 6 months. The physical examinations and self-report as well as the applied limits are summarised in Table 1.

#### *Cardiovascular risk factors*

Body mass index (weight/length<sup>2</sup>), waist circumference and systolic and diastolic blood pressure were assessed through physical examination by a physician's assistant. Smoking and diabetes mellitus were assessed based on answers to written questions. The applied limits for these risk factors are listed in Table 1.

#### *Subgroups*

To explore subgroups based on the high-risk approach, three variables were used: gender examined men versus women fire fighters; professionalism examined volunteer

**Table 2** Absolute and relative (%) prevalences of work-related diminished psychological requirements

	Total		Sleepiness		Work-related fatigue		Depression		Post-traumatic stress disorder		Anxiety	
	N	%	N	%	N	%	N	%	N	%	N	%
Men	35	15	0	0	4	2	16	7	8	3	19	8
Women	9	20	1	2	1	2	4	9	3	7	5	11
Volunteer	19	15	0	0	2	2	7	5	4	3	13	10
Professional	25	17	1	1	3	2	13	9	7	5	11	8
<36 years	18	16	1	1	1	1	9	8	5	4	11	10
36–45 years	17	16	0	0	2	2	9	8	2	2	10	9
>45 years	9	17	0	0	2	4	2	4	4	7	3	6

versus professional fire fighters; and age compared the youngest (<36 years), middle-aged (36–45) and oldest (>45 years) fire fighters.

### Analysis

Results were analysed with SPSS version 16.0 (SPSS Inc., Chicago, IL, USA). Mean, standard deviation and relative frequencies were used to describe the general characteristics of the subgroups of gender (women vs men), professionalism (professional vs volunteer) and age (three groups). The prevalence of diminished health was calculated by applying the limit per health concept as described in Table 1. Overall diminished psychological, physical, sense-related and cardiovascular requirements were the case when one or more of the underlying health concepts were diminished.

The prevalence of insufficiencies for each of the health requirements and health concepts was calculated based on subgroup. For subgroup comparisons of the diminished health requirements, the odds ratio and 95% confidence interval (95% CI) were calculated using logistic regression. For gender, the men subgroup was selected to be the reference group. Volunteers were selected to be the reference group for the professionalism variable. For age, the youngest group (<36 years) was selected to be the reference group; the oldest (>45 years) and middle-aged (36–45 years) fire fighters were compared with the youngest fire fighters. In addition, the middle-aged fire fighters were also used as a reference group, to be able to compare the oldest fire fighters with the middle-aged fire fighters.

### Results

The average age of fire fighters was 38 years (SD 9; range 19–60). The fire fighter subgroups consisted of 232 men, 46

**Table 3** Absolute and relative (%) prevalences of work-related diminished physical requirements

	Total		Test I		Test II		Airway	
	N	%	N	%	N	%	N	%
Men	31	14	30	14	22	10	1	1
Women	37	82	37	82	27	60	0	0
Volunteer	41	32	41	32	30	23	0	0
Professional	27	19	26	19	19	14	1	1
<36 years	34	30	34	30	25	22	0	0
36–45 years	23	23	23	23	15	15	0	0
>45 years	11	21	10	19	9	17	1	2

women: 131 volunteers and 147 professionals. The age subgroups consisted of 116 fire fighters in the youngest group, 108 fire fighters in the middle-aged group and 54 fire fighters in the oldest group.

The prevalences of work-related diminished health requirements are reported in Tables 2, 3, 4 and 5, which are organised to address each health concept. The largest differences in prevalence for insufficiencies for each health requirement among the subgroups included the psychological requirements between men (15%) and women (20%), for the physical requirement between men (14%) and women (82%), for the sense-related requirements between the youngest fire fighters (14%) and the oldest (54%) fire fighters and the cardiovascular risk factors between men (77%) and women (48%) fire fighters.

With respect to the diminished psychological requirements (Table 2), a prevalence for depression of 8% was found in the middle-aged and youngest category, whereas a lower prevalence (4%) was found in the oldest fire fighters. For anxiety, a prevalence of 10, 9 and 6% was found for the youngest, middle-aged and oldest fire fighters, respectively. In men fire fighters, post-traumatic stress disorder occurred

**Table 4** Absolute and relative (%) prevalences of work-related diminished sense-related requirements

	Total		Vision 5.0 m		Vision 0.6 m		Vision 0.4 m		Colour vision		Hearing		Skin	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Men	58	25	11	5	20	9	26	11	14	6	7	3	2	1
Women	7	15	2	4	3	7	6	13	0	0	0	0	1	2
Volunteer	35	27	9	7	14	11	18	14	8	6	2	2	1	1
Professional	30	21	4	3	9	6	14	10	6	4	5	3	2	1
<36 years	16	14	7	6	7	6	4	4	5	4	0	0	1	1
36–45 years	20	19	4	4	7	7	10	9	3	3	4	4	1	1
>45 years	29	54	2	4	9	17	18	34	6	11	3	6	1	2

**Table 5** Absolute and relative (%) prevalences of cardiovascular risk factors

	Total		BMI		Waist circumference		Systolic BP		Diastolic BP		Smoking		Diabetes	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Men	179	77	142	61	34	15	61	26	38	16	51	22	2	1
Women	22	48	10	22	8	17	3	7	2	4	11	24	2	4
Volunteer	86	66	64	49	25	19	30	23	13	10	22	17	2	2
Professional	115	78	88	60	17	12	34	23	27	18	40	27	2	1
<36 years	75	65	48	41	12	10	24	21	9	8	29	25	4	3
36–45 years	78	72	63	58	16	15	19	18	14	13	23	21	0	0
>45 years	48	89	41	76	14	26	21	39	17	32	10	19	0	0

with a frequency of 3%, whereas the prevalence in women was higher (7%); lower prevalences of PTSD were found in the middle-aged (2%) as compared to the oldest (7%) fire fighters.

In case of diminished physical health requirements, women fire fighters had a higher prevalence (test I 82%; test II 60%) than men fire fighters (test I 14%; test II 10%). The prevalence of diminished physical requirements was higher for volunteer fire fighters and for the youngest age groups of fire fighters, as shown in Table 3. Airway complaints after exposure were reported seldom (prevalence < 3%).

In the case of sense-related requirements, higher prevalences of insufficiencies were found in the oldest age group. More volunteers than professional fire fighters exhibited diminished vision results (Table 4).

Cardiovascular risk factors were found in more than 45% of each fire fighter subgroup. Higher prevalences were found in professional and the oldest fire fighters. Women fire fighters exhibited lower prevalences of most of the risk factors than their men colleagues (see Table 5).

The odds ratios for having diminished health requirements based on comparisons of the subgroups are reported in Table 6. No significant differences between subgroups

were found for the psychological requirements with odds ratios of up to 1.4. The highest odds ratio was found for women fire fighters compared to men fire fighters for having insufficiencies in physical requirements (OR: 28.5; 95% CI 12.1–66.9). An odds ratio of 0.3 (0.1–0.5) was found for women fire fighters compared to men fire fighters for insufficiencies in cardiovascular risk factors. A comparison of professional to volunteer fire fighters revealed that professionals were less likely to have diminished physical requirements with an odds ratio of 0.5 (0.3–0.9), and professionals had a higher prevalence of cardiovascular risk factors with an odds ratio of 1.9 (1.1–3.2). A high odds ratio of 7.2 (3.4–15.2) was found for having diminished sense-related requirements when comparing the oldest fire fighters to the youngest fire fighters; for the oldest fire fighters compared to middle-aged fire fighters in the same requirement, an odds ratio of 5.1 (2.5–10.5) was found. When compared to the youngest fire fighters, the oldest fire fighters were also more likely to have cardiovascular risk factors, with an odds ratio of 4.4 (1.7–11.1), and they were also more likely to have cardiovascular risk factors when compared to the middle-aged fire fighters, with an odds ratio of 3.1 (1.2–7.9).

**Table 6** Odds ratio and 95% confidence interval in subgroups of fire fighters for having diminished health requirements

	Diminished psychological requirements		Diminished physical requirements		Diminished sense-related requirements		Cardiovascular risk factors	
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
<b>Gender</b>								
Men (ref)	1.0	–	1.0	–	1.0	–	1.0	–
Women	1.4	(0.6–3.1)	28.5	(12.1–66.9)	0.5	(0.2–1.3)	0.3	(0.1–0.5)
<b>Professionalism</b>								
Volunteer (ref)	1.0	–	1.0	–	1.0	–	1.0	–
Professional	1.2	(0.6–2.3)	0.5	(0.3–0.9)	0.7	(0.4–1.2)	1.9	(1.1–3.2)
<b>Age</b>								
Youngest (ref)	1.0	–	1.0	–	1.0	–	1.0	–
Middle-aged	1.0	(0.5–2.1)	0.7	(0.4–1.2)	1.4	(0.7–2.9)	1.4	(0.8–2.5)
Oldest	1.1	(0.5–2.6)	0.6	(0.3–1.3)	7.2	(3.4–15.2)	4.4	(1.7–11.1)
Middle-aged (ref)	1.0	–	1.0	–	1.0	–	1.0	–
Oldest	1.1	(0.4–2.6)	0.9	(0.4–2.0)	5.1	(2.5–10.5)	3.1	(1.2–7.9)

## Discussion

In this study, we explored which fire fighter subgroups were prone to specific diminished health requirements. No significant high-risk groups were found when the psychological requirements were tested. Women fire fighters exhibited huge increased odds (OR: 28) for diminished physical requirements when compared to men fire fighters, but women fire fighters had reduced odds for the presence of cardiovascular risk factors. Professional fire fighters had reduced odds for diminished physical requirements when compared to volunteer fire fighters, but they had an increased double odds for having cardiovascular risk factors. The oldest fire fighters had a considerably increased odds for having diminished sense-related requirements when compared to the youngest (OR: 7) and to the middle-aged (OR: 5) fire fighters. The oldest fire fighters also had impressing odds for the presence of cardiovascular risk factors when compared to the youngest fire fighters (OR: 4) and to the middle-aged (OR: 3) fire fighters.

The results of this study indicate that a new approach should be considered when using a WHS in which certain WHS aspects should have more attention in high-risk groups. However, due to the high demands in the job of fire fighters, all work-related aspects measured in this WHS are relevant for all fire fighters. For example, a prevalence of up to 20% was found for the psychological requirements, but no significant odds ratio was determined among the subgroups. However, because diminished psychological requirements may influence safe job performance, psychological requirements need to be assessed in the total WHS. Thus, applying the total WHS remains important for every fire fighter albeit at a lower frequency, in addition to a high-

risk approach. The general approach is valuable because it can improve the numbers of diminished health requirements present in the fire-fighting population as a whole, whereas the high-risk strategy may have a greater impact on the fire fighters who are most at risk (Rose 1985). The use of a high-risk group and general approach has already been applied to the general population in the prevention of cardiovascular disease, and it was recommended to use high-risk and population strategies complementary to each other (Cooney et al. 2009). The frequency of application for the specific parts in the high-risk groups is dependent on the latency of a disease, the effectiveness of the intervention and the assumed consequence of the diminished health for the work ability of the fire fighters.

Women fire fighters were more likely to show diminished physical requirements. Because many parts of the tests require high strength, it was not surprising that women had more difficulty in passing the tests. The physical tests should be a realistic task simulation of fire-fighting activities, and therefore, all active duty fire fighters should be able to pass these physical performance tests. This requirement is necessary because the job demands on fire fighters can hardly be changed. Therefore, training opportunities and better guidance are recommended to enable women fire fighters to perform physical fire-fighting tasks.

We hypothesised that professional fire fighters were more prone to acquiring diminished health requirements, when compared to volunteer fire fighters due to their more extensive exposure to job risks. However, based on this study, the physical requirements are more troublesome for volunteer fire fighters. Professional fire fighters seemed to be more prepared for the physical challenges of the tests when compared to the volunteer fire fighters. Thus, volunteers



may also need more guidance towards the necessary level of physical performance, as was also recommended for women fire fighters.

Sluiter and Frings-Dresen (2007) described that there are no cut-off points at which fire fighters seem to decline in health at once huge interindividual differences in health problems are reported. For this study, we chose to divide the age category into three subgroups, because it was unknown whether insufficiencies might develop during the fire fighter's career or whether problems increased exponentially later in their career. The results of the present study show the latter situation because significant odds ratios were found for diminished health requirements between the oldest fire fighters and the middle-aged fire fighters, but significant odds ratios were not found for diminished health requirements between the middle-aged and the youngest fire fighters. However, the used age groups were chosen from a practical point of view.

Based on the age-related differences in this study, the oldest fire fighters are more likely to have diminished sense-related requirements and cardiovascular risk factors when compared to the youngest and middle-aged fire fighters. Thus, more attention for applying the parts of the WHS concerning sense-related requirements and cardiovascular risk factors is recommended for fire fighters aged >45 years. However, because there was a high prevalence of cardiovascular risk factors in the youngest age group (65%) as well, it is important to start monitoring of these risk factors and interventions, e.g. lifestyle interventions, early in the fire fighters' career. The results of this type of early intervention should be studied to determine whether it results in a lower prevalence of cardiovascular risk factors in employees as they age.

A strength of this study is the stratification of the invited fire fighters for the variables gender, professionalism and age. This stratification allowed us to have the analysis in this paper as primary analysis, whereas in other studies, when subgroups are presented, they are often secondary analyses. A limitation of this study is that the determined odds ratios may be difficult to interpret. Due to the high prevalences found, the odds ratio could be an overestimation when compared to relative risk (Zhang and Yu 1998). Relative risk was probably slightly overestimated for some variables; therefore, we reported odds ratios.

A limitation of this study is the low response rate. Those who were invited and agreed to participate returned their informed consent form or agreed by email or phone. This approach may have attracted the most ideal workers, although it may also have attracted the least healthy fire fighters. In the Netherlands, WHS in this sector was performed on a voluntary basis. Therefore, the study population reported herein is thought to be a reflection of the future participants in WHS. For the determination of the

odds ratios, it is more important to have no specific selection within one of the subgroups in the comparison, for example in professionals or volunteers, because that could cause a change in odds ratio. We found no reason to assume that specific selection within one of the subgroups occurred.

From these results, it can be concluded that certain subgroups (gender, professionalism and age) of fire fighters are more prone to at least one specific work-related diminished health requirement. Therefore, specific parts of the WHS can be given more attention in high-risk groups. To determine the additional value of using the high-risk group approach for fire fighters, the long-term benefits of using the high-risk and general approaches to keep fire fighters healthy and with good performance in their jobs should be studied in future.

**Acknowledgments** We thank the fire departments and fire fighters for their cooperation in this study. This work was supported by a grant from 'A + O fonds Gemeenten'.

**Conflict of interest** The authors declare that they have no conflict of interest.

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## References

- Åstrand P, Rodahl K, Dahl H, Strömme SB (2003) Textbook of work physiology. Physiological bases of exercise. Human Kinetics, Champaign
- Cooney M, Dudina A, Whincup P, Capewell S, Menotti A, Jousilahti P et al (2009) Re-evaluating the Rose approach: comparative benefits of the population and high-risk preventive strategies. *Eur J Cardiovasc Prev Rehabil* 16:541–549
- de Beurs E, Zitman F (2005) Brief symptom inventory (BSI): reliability and validity of a practical alternative for SCL-90 [In Dutch: de brief symptom inventory (BSI): De betrouwbaarheid en validiteit van een handzaam alternatief voor de SCL-90]. Leiden, LUMC: department Psychiatry; Report No. 8
- Eekhof JAH, van Weert HCPM, Spies TH, Huffman PW, Hoftijzer NP, Mul M, Meulenberg F, Burgers JS (2002) Dutch society of general practitioners- standard for hearing impairment (In Dutch: NHG-standard slechthorendheid)
- Graham I, Atar D, Borch-Johnsen K, Boysen G, Burell G, Cifkova R et al (2007) European guidelines on cardiovascular disease prevention in clinical practice: executive summary. *Eur Heart J* 28:2375–2414
- Johns MW (1991) A new method for measuring daytime sleepiness: the Epworth sleepiness scale. *Sleep* 14:540–545
- NOG (2004) Guidelines Dutch ophthalmic company. Test requirements sight [In Dutch: Richtlijnen Nederlands Oogheelkundig Gezelschap. Keuringseisen gezichtsvermogen]. Nijmegen, The Netherlands
- Plat MJ, Frings-Dresen MHW, Sluiter JK (2010a) Clinimetric quality of the fire fighting simulation test as part of the Dutch fire fighters workers' health surveillance. *BMC Health Serv Res* 10:32
- Plat MJ, Frings-Dresen MHW, Sluiter JK (2010b) Reproducibility and validity of the stair-climb test for fire fighters. *Int Arch Occup Environ Health* 83(7):725–731

- Plat MJ, Frings-Dresen MHW, Sluiter JK (2011) A systematic review of job-specific workers' health surveillance activities for fire-fighting, ambulance, police and military personnel. *Int Arch Occup Environ Health*, Published online 12 February
- Rose G (1985) Sick individuals and sick populations. *Int J Epidemiol* 14(1):32–38
- Sluiter JK, Frings-Dresen MHW (2007) What do we know about ageing at work? Evidence-based fitness for duty and health in fire fighters. *Ergonomics* 50(11):1897–1913
- Soteriades ES, Smith DL, Tsismenakis AJ, Baur DM, Kales SN (2011) Cardiovascular disease in US fire fighters. *Cardiol Rev* 19(4):202–215
- van der Ploeg E, Kleber RJ (2003) Acute and chronic job stressors among ambulance personnel: predictors of health symptoms. *Occup Environ Med* 60:i40–i46
- van Veldhoven M, Broersen S (2003) Measurement quality and validity of the “need for recovery scale”. *Occup Environ Med* 60(Suppl 1):i3–i9
- Zhang J, Yu KF (1998) What's the relative risk? A method of correcting the odds ratio in cohort studies of common outcomes. *JAMA* 280(19):1690–1691