Long-term physical health effects of the air disaster in Amsterdam in professional assistance workers

The study presented in this thesis was performed at the EMGO Institute of the VU University Medical Center, Amsterdam, the Netherlands, in collaboration with KLM Health Services. The EMGO Institute participates in the Netherlands School of Primary Care Research (CaRe), which was re-acknowledged in 2000 by the Royal Netherlands Academy of Arts and Sciences (KNAW).

The study was funded by the Dutch Ministry of Health, Welfare, and Sport, The Hague, the Netherlands; the City of Amsterdam; the Amsterdam-Amstelland Regional Police Force; and KLM Royal Dutch Airlines, Amsterdam. Financial support for the printing of the thesis has also been kindly provided by the EMGO Institute and the Vrije Universiteit.

ISBN-10: 90-5669-102-3
ISBN-13: 978-90-5669-102-8
NUR: 860

Photos by: Wilfred Bolten
Cover by: Pauline Slottje, Menno Sijtsma, and Jan-David Hartsuijker
Printed by: Febodruk b.v. Enschede, the Netherlands

VRIJE UNIVERSITEIT

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ACADEMISCH PROEFSCHRIFT

ter verkrijging van de graad Doctor aan
de Vrije Universiteit Amsterdam,
op gezag van de rector magnificus
prof.dr. T. Sminia,
in het openbaar te verdedigen
ten overstaan van de promotiecommissie
van de faculteit der Geneeskunde
op donderdag 11 mei 2006 om 13.45 uur
in de aula van de universiteit,
De Boelelaan 1105

door

Pauline Slottje

geboren te Hoogeveen

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	dr. J.W.R. Twisk

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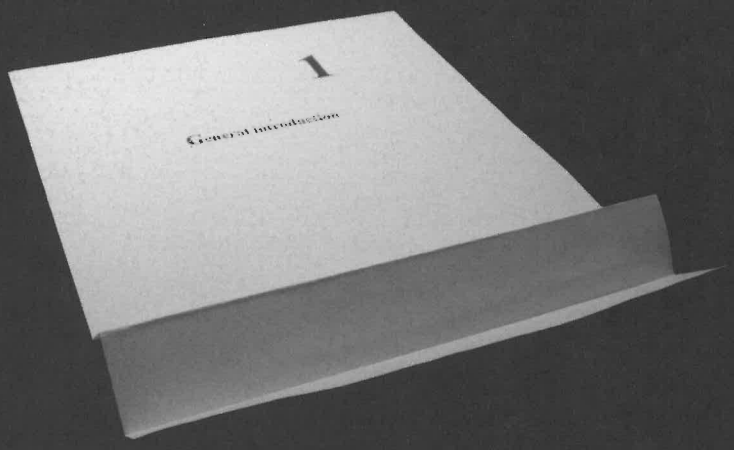
General introduction



1.1 Background

On October 4, 1992, an El Al Boeing 747-F cargo aircraft crashed into apartment buildings in the suburb Bijlmermeer of Amsterdam. The aircraft had lost two of its engines shortly after take-off from Schiphol Airport. The disaster killed 43 people, including 4 occupants of the aircraft, and destroyed 266 apartments. Besides this immediate impact, the disaster had an extended and troublesome aftermath. The public and political unrest eventually called for a parliamentary enquiry in 1998[1]. This once again evoked much media attention and public discussion and led to investigations into the cause of the accident, the contents of the cargo, and the potential health risks from exposure to hazardous materials. No excess in chronic morbidity due to noxious exposures was predicted in retrospective risk evaluations. A seemingly growing number of people nevertheless attributed health complaints to the disaster[2-4].

Among those with health concerns were groups of professional firefighters and police officers who had been working at the disaster site, as well as so-called hangar workers who had been working in the hangar where the aircraft wreckage was placed. In 1998 the employer of these professional assistance workers decided to start an independent scientific assessment of their health status and its relationship with occupational exposure to the disaster. The occupational health service of these three groups of workers (i.e. KLM Health Services, formerly KLM Arbo Services) was assigned to organize this assessment. The EMGO Institute of the VU University Medical Center agreed to independently perform the epidemiological analyses: the Epidemiological Study Air Disaster in Amsterdam (ESADA)[5,6]. In addition, all the professional workers were offered an individual medical examination. Of all the workers participating in the ESADA, 45% underwent such an examination.

Previous health investigations after this disaster include assessments of posttraumatic stress disorder in samples of people who experienced the disaster at close range, and an inventory of the health complaints that residents and workers on their own initiative reported to be related to the disaster at a toll-free call centre[7]. Although these previous investigations were based on selective samples, they did show that at least some of the people affected by the disaster suffered from long-term health problems, and they suggested what type of problems this might be. As such, their results guided the ESADA in selecting health outcomes that needed to be validated with respect to their relationship with the disaster, e.g. autoimmune outcomes[1,8].

Two aspects of the ESADA set it apart from these previous investigations. Firstly, the ESADA uses historically registered occupational cohorts, which include not only the workers exposed to the disaster but also reference groups of their nonexposed colleagues, irrespective of their health status. This epidemiological design enables to for the first time assess *group level* associations between exposure to this disaster and health measures. Secondly, the ESADA included an assessment of the long-term *physical* health of *professional assistance workers* who were exposed to *one disaster in particular*. There is little epidemiological literature as yet on the effects of disasters on

the physical health of professional assistance workers, let alone on their *long-term* physical health.

This thesis is based on data of the ESADA. It focuses on the long-term physical health effects of exposure to the air disaster in Amsterdam in professional firefighters, police officers and hangar workers. The adjective 'long-term' is used here, to refer to the fact that the health assessment took place on average 8.5 years after the disaster. Hence, it does not (necessarily) imply lasting or chronic adverse health outcomes. The health outcomes covered here include both clinical laboratory parameters and self-reported health measures. The following sections of this chapter address the characteristics of the disaster and its aftermath, and of the occupational exposure of the professional assistance workers to this disaster. The results of previous scientific studies on the physical health effects of other disastrous events are then described. This chapter concludes with the main hypothesis and the research questions to test this hypothesis. The general study design and health outcomes of the ESADA are described in detail in Chapter 2.

1.2 The air disaster in Amsterdam

1.2.1 Characteristics of the disaster and its aftermath

A disaster can be defined as a sudden, collective stressful experience leading to a massive disruption of society's well-being, welfare and functioning, and requiring an extraordinary level of emergency services. Disasters can be characterised according to three dimensions: (a) their natural versus man-made (technological) origin, e.g. volcanic eruptions versus industrial explosions; (b) their potential for exposure to hazardous materials, e.g. flood-borne infectious agents, toxic gases of volcanic or industrial origin; (c) their potential for a harmful intent, e.g. terrorist attacks on subways versus major traffic accidents[9,10]. Via these dimensions, disasters might induce a different physical and/or psychosocial impact on the population involved.

According to these dimensions, the air disaster in Amsterdam can be characterised as a man-made (technological) disaster with potential exposure to hazardous materials, which occurred by accident. The national disaster was officially declared from 4 through 27 October 1992. The disaster was followed by an extended aftermath, which has been referred to as a 'second disaster'[8], and a 'public health crisis'[11]. Extensive compilations and narrative reviews of the disaster and its aftermath have been published previously and from various viewpoints[1,8,11-14]. Through the years rumours and elaborate media reports emerged on various potential exposures, and on victims with alleged disaster-related health problems[3,4]. This was particularly the case shortly before and at the time of the parliamentary enquiry on the disaster in 1998-1999. These public issues will also have been discussed between exposed professional assistance workers. These events in the aftermath could also have influenced the health of the exposed workers.

In short, three aspects of this disaster and its aftermath are of particular relevance for the present study. Firstly, in retrospective risk evaluations no excess morbidity was predicted due to exposures related to material from the cargo, the destroyed apartments, and the aircraft, including its balance weights of depleted uranium[1,15-17]. Secondly, a seemingly growing number of affected residents and workers attributed various kinds of health complaints to the disaster[2-4]. Thirdly, the recognition that it is not possible to separate the independent health impact of the disaster itself and that of its aftermath after on average 8.5 years.

1.2.2 Characteristics of involvement in the disaster

In general, involvement in a disaster can be characterised according to three dimensions: (a) physical damage to oneself, close ones, and personal belongings; (b) exposure to hazardous materials (chemical toxins, radiation, and biological agents); and (c) exposure to psychotraumatic or otherwise stressful events[18]. With respect to exposure to hazardous materials, this refers to both real exposure and perceived exposure, because subjective health problems can also develop after perceived exposure[10,19-22].

A fourth dimension is the *type* of involvement (role) in a disaster, e.g. professional assistance workers, paramedic first-responders, volunteer assistance workers, and residents of a disaster-struck area. These groups are not readily comparable regarding both exposure to and health effects of disasters. For example, the health status of occupational populations is generally more favourable than that of the general population. This so-called 'healthy worker effect' relates to known and unknown selection mechanisms, such as mandatory medical examinations for certain occupations. Of the three occupational groups included in the ESADA, this might be particularly true for the professional firefighters and the police officers. Another aspect that sets professional firefighters and police officers apart from the general population and from a community struck by disaster is the fact that they are more frequently faced with potentially stressful experiences. On the one hand, these professionals could therefore be at higher risk for health problems. On the other hand, their professional education and experience, and selection mechanisms for these occupations, will probably favour their ability to cope with such situations compared to the general population. Finally, occupational exposure to hazardous materials in general may also differentiate occupational populations (such as the three included in the ESADA) from the general population and from populations struck by disaster.

The emergency response after the air disaster in Amsterdam and the salvage of the aircraft wreckage has been reconstructed in detail in the final report of the parliamentary enquiry on this disaster[1]. The three groups of professional assistance workers were involved in the disaster each in their own way. Firefighters and police officers were mostly involved in tasks related to the disaster site, such as firefighting, rescuing and supporting people, cleaning-up the crash site, and closing off, security and surveillance of the disaster area. From the day after the disaster onwards parts of the aircraft

wreckage were transported to hangar 8 at Schiphol Airport, where hangar workers were involved in the security, sorting, and the investigation of the wreckage. Initially, the search focused on parts of the wreckage in an attempt to establish the cause of the crash. A few days later, the wreckage was searched also for its balance weights, which consisted of depleted uranium. In 1994, a second search for missing depleted uranium parts was performed at this hangar.

The ESADA used a detailed questionnaire to determine the involvement in the disaster according to the above-mentioned dimensions for each of the workers. The terms 'exposure' and 'involvement' are used interchangeably in this thesis. Because the ESADA aimed to assess the health impact of *occupational* exposure to the disaster, exposure status was based on reported *disaster-related tasks*. Workers who reported to have performed at least one disaster-related task were defined as 'exposed'; all others as nonexposed. Workers who resided in the disaster area at the time of the disaster were excluded from the statistical analysis, because of this different type of involvement in the disaster. Appendix A presents a flow chart of the study population. Appendix B presents a detailed description of the involvement in the disaster as reported by the exposed workers, i.e. prevalence rates of disaster-related tasks and psychosocial events as well as histograms of the number of tasks. In addition to the exposure questionnaire addressing involvement in the disaster, an overall measure of the perceived severity of the disaster and its aftermath was assessed.

1.3 Physical health effects of other disastrous events

The scientific evidence linking a particular disaster to physical morbidity is largely based on (convenience samples of) communities struck by disaster. These studies predominantly focused on acute traumata, e.g. injuries, infectious diseases[23], and acute renal failure due to crush syndrome[24,25]; and on physical health effects of toxic exposures, such as those seen after the Bhopal disaster[26], the Chernobyl disaster[27], and the Seveso disaster[28]. An impaired health-related quality of life has also been demonstrated in communities after natural and technological disasters[29-33], and after the terrorist attack on September 11, 2001[34].

The effects on physical health of one disastrous event on professional assistance workers have rarely been assessed. Most of the studies on this subject focused also on acute injuries and on morbidity related to noxious exposures, e.g. the respiratory morbidity in firefighters, clean-up and recovery workers exposed to the dust at the World Trade Center site after the terrorist attack on September 11, 2001[35-38]; leukaemia and, possibly, thyroid cancer among clean-up workers after the Chernobyl disaster[27]; and a decline in psychomotor and memory function up to 7 years after the Tokyo Subway Sarin attack in exposed rescue staff, police officers, and subway workers[39]. In addition, an increase in musculoskeletal, psychological and respiratory health problems, as presented to their occupational physician, was found up to 24

months in a longitudinal analysis of rescue workers after an explosion of a fireworks depot in a residential area of the Dutch city of Enschede in 2000[40].
An occupational group that is to some extent comparable with professional disaster assistance workers is that of active military personnel involved in war and peacekeeping service. In contrast to the relative scarcity of studies on the physical health of professional assistance workers after disasters, there are numerous studies on physical health problems after war and peacekeeping service among military personnel. These studies show that they are at risk for long-term adverse health-related quality of life[41-44], and for multiple physical symptoms. These physical symptoms have been attributed to various deployment-related factors, such as to vaccinations and to depleted uranium from ammunition. Usually, however, these symptoms lack sufficient medical explanation[45-47]. These medically 'unexplained physical symptoms' also become increasingly recognised in civilian populations after disasters[18], and particularly in populations that are faced with potential exposure to hazardous materials[19,31,48-52]. Unexplained physical symptoms have also been suggested to co-occur or interact with psychological consequences of disasters, notably with posttraumatic stress disorder[53-58]. Posttraumatic stress disorder constitutes a psychiatric disorder that people may develop after a traumatic experience (American Psychiatric Association, 1994). These patients chronically suffer from three categories of symptoms (i.e. intrusion, avoidance, and hyperarousal) to such a degree that their daily functioning and quality of life is impaired.

The concept of 'unexplained physical symptoms' is not unique to military and civilian populations after disastrous events and perceived exposure. These symptoms probably also occur in the general population[59]. Similar symptoms have also been described as 'syndromes' in various clinical, psychological, occupational and environmental disciplines. These syndromes have been given different names, including Functional Somatic Syndrome, Chronic Fatigue Syndrome, Fibromyalgia, Irritable Bowel Disorder, Somatisation (Disorder), Somatoform Disorders, (Abridged) Somatisation, (Mass) Hysteria, Mass Sociogenic/Psychogenic Illness, Sick Building Syndrome, Multiple Chemical Sensitivity, and Gulf War Syndrome. These syndromes differ with respect to alleged causative agents, the situations and populations in which they have been described, and, to some extent, the prominent symptoms and symptom severity. However, they do share common features[60-63], including:

- the absence of a sufficient toxicological, medical or psychiatric explanation;
- a similar collection of diffuse physical symptoms;
- stress is somehow involved, i.e. it may play a predisposing, precipitating and/or perpetuating role in these symptoms;
- an impaired well-being and functioning;
- clear, difficult to refute, causal attributions.

1.4 Research questions and outline of thesis

The overall aim of this thesis is to assess the long-term physical health effects of occupational exposure to the air disaster in Amsterdam in professional firefighters, police officers and hangar workers. The main hypothesis is that this exposure resulted in a phenomenon of 'unexplained physical symptoms'. According to this hypothesis, it is expected to find:

(a) no consistent differences between exposed and nonexposed workers in clinical urine and blood parameters, including autoantibody serology, that would indicate disaster-related pathological processes;
(b) elevated prevalence rates of physical symptoms among exposed professional assistance workers, which is not solely accounted for by posttraumatic stress symptoms;
(c) a lower health-related quality of life among exposed workers; and
(d) that exposed workers with physical complaints attribute these complaints to the disaster and its aftermath.

To test the main hypothesis, the following research questions will be addressed:

1. Do professional firefighters and police officers who were occupationally exposed to the air disaster in Amsterdam differ from nonexposed colleagues with respect to long-term physical symptoms and clinical parameters in blood and urine? (Chapter 3)

2. Do professional assistance workers who were occupationally exposed to the air disaster in Amsterdam differ from nonexposed colleagues with respect to long-term autoimmune-like symptoms and autoantibody serology? (Chapter 4)

3. Is there an association between occupational exposure to the air disaster in Amsterdam and multiple long-term physical symptoms of professional firefighters and police officers, and do long-term posttraumatic stress symptoms play a role in this association? (Chapter 5)

4. Is there an association between occupational exposure to the air disaster in Amsterdam and the long-term health-related quality of life of professional firefighters and police officers? (Chapter 6)

5. To what extent do professional assistance workers who were occupationally exposed to the air disaster in Amsterdam attribute long-term physical complaints to this disaster and its aftermath, and is such an attribution associated with types of exposure and background characteristics? (Chapter 7)

Chapter 2 elaborates on the general study design of the ESADA. Further information is provided in the following appendices: Appendix A presents a flow chart of the study population, Appendix B presents descriptive statistics of the involvement in the disaster for exposed workers, and Appendix C presents the list of the 34 physical symptoms addressed in a questionnaire that was drawn up for the ESADA. The selection of these physical symptoms was partly based on the results of a previous health investigation after this disaster[8]. Chapters 3 through 7 deal with the above-mentioned research questions in sequence. Chapter 8 integrates and summarises the main findings, discusses the ESADA approach, draws overall conclusions, and puts forward recommendations for future research.

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2

Epidemiological study air disaster in Amsterdam (ESADA): study design

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BMC Public Health 2005;5:54

Abstract

Background

In 1992, a cargo aircraft crashed into apartment buildings in Amsterdam, killing 43 victims and destroying 266 apartments. In the aftermath there were speculations about the cause of the crash, potential exposures to hazardous materials due to the disaster and the health consequences. Starting in 2000, the Epidemiological Study Air Disaster in Amsterdam (ESADA) aimed to assess the long-term health effects of occupational exposure to this disaster on professional assistance workers.

Methods/Design

Epidemiological study among all the exposed professional fire-fighters and police officers who performed disaster-related task(s), and hangar workers who sorted the wreckage of the aircraft, as well as reference groups of their non-exposed colleagues who did not perform any disaster-related tasks. The study took place, on average, 8.5 years after the disaster. Questionnaires were used to assess details on occupational exposure to the disaster. Health measures comprised laboratory assessments in urine, blood and saliva, as well as self-reported current health measures, including health-related quality of life, and various physical and psychological symptoms.

Discussion

In this paper we describe and discuss the design of the ESADA. The ESADA will provide additional scientific knowledge on the long-term health effects of technological disasters on professional assistance workers.

Background

In the early evening of October 4th, 1992, an El Al Boeing 747-F cargo aircraft lost two of its engines just after take off from Schiphol Airport and crashed into two apartment buildings in the Bijlmermeer, a densely populated suburb of Amsterdam (the Netherlands)[1]. The air disaster killed 43 people, and destroyed 266 apartments[1,2]. Fire-fighters and police officers were called to the scene to extinguish fires, to search and rescue people, to assist in the identification of human remains and personal belongings, to secure the surroundings and to clean-up the devastated area. Many of them were faced with bewildered residents and extensive destruction, and some witnessed dead or injured victims. Within a few days the wreckage of the aircraft was transported to a hangar at Schiphol Airport, where employees (i.e. 'hangar workers') sorted and inspected the wreckage.

In the extensive aftermath of the disaster, rumors and questions arose about the cause of the accident, the contents of the cargo, potential exposure to hazardous materials, and health consequences [2,3]. Every now and then the media highlighted stories of individual victims, as well as uncertainties about potential exposures during the disaster[4]. One of the major topics concerned exposure to depleted uranium from the aircraft's balance weights, particularly because some of the depleted uranium has never been recovered from the rubble[1]. However, the authors of a retrospective risk analysis "considered it improbable that the missing uranium had indeed led to the reported health complaints"[5]. Nonetheless, it appeared that a growing number of exposed workers and affected residents reported health complaints, which some of them attributed to the disaster[6]. Public and political unrest thus waxed and waned in the aftermath of the disaster[2,3]. Eventually, a parliamentary inquiry, that was held in 1998, recommended an epidemiological study on the health effects of the disaster[1].

About the same time, in 1998, the employers of professional fire-fighters and police officers in Amsterdam decided to start an independent assessment of the health status of professional workers involved in the disaster. The mayor of Amsterdam assigned their occupational health service, the KLM Health Services, to organize this assessment. The employer of the hangar workers at Schiphol Airport joined this initiative, as did government representatives of the affected inhabitants and volunteer workers. It was decided to offer a medical examination to all people involved in the air disaster, residents as well as assistance workers, and that an epidemiological study would be performed simultaneously by the Institute for Research in Extramural Medicine (EMGO Institute). In this paper we report on the design of the epidemiological study among professional assistance workers: the Epidemiological Study Air Disaster in Amsterdam (ESADA). Unfortunately, the epidemiological study among residents had to be cancelled, due to low response rates.

The ESADA is the first epidemiological study that has ever been conducted after a major technological disaster in the Netherlands. The aim of this study is to assess the

long-term psychological and physical health effects of occupational exposure to the air disaster in Amsterdam on professional assistance workers, i.e. fire-fighters, police officers and hangar workers. Based on the scientific literature on the health effects of disasters, the main hypotheses of the ESADA concern unexplained physical symptoms[7-12], and post-traumatic stress symptoms and associated psychological symptoms[13-15]. Due to the fact that the ESADA originated partly from societal concerns, we considered it necessary to also include some additional outcomes that will answer questions for some of the affected people, which, in turn, might help to reassure them. These societal questions relate to depleted uranium, Mycoplasma species and carnitine levels in plasma. The first of these questions stems from the concerns about the depleted uranium from the aircraft's balance weights, described above. The other two questions are primarily based on an alleged resemblance between the symptoms of some of the people affected by the air disaster in Amsterdam and the symptoms of patients with chronic fatigue syndrome (CFS) and Gulf War (I) Syndrome (GWS). Although some authors may have suggested a link between these syndromes and Mycoplasma species[16-21] or carnitine deficiency[22-26], others have rejected the existence of such links[27-29].

In this paper we describe and discuss the design of the ESADA. More details on the (organization of the) ESADA can be found on its website[30].

Methods / Design

Design

The ESADA is designed as a historical cohort study, in which the health of the professional fire-fighters, police officers and hangar workers who were occupationally exposed to the 1992 air disaster in Amsterdam is compared with the health of reference groups of workers with the same jobs and employers at the time of the disaster, but who were not occupationally exposed to this disaster.

Study population

The ESADA study population consisted of professional fire-fighters, police officers and hangar workers. Eligible subjects had to (1) sign informed consent; (2) have sufficient mastery of the Dutch language to fill in the questionnaires; and (3) belong to one of the following three occupational groups:

1. All professional fire-fighters who were, according to company records, employed in the Amsterdam fire department at the time of the disaster. Additional professional fire-fighters who started working in this fire department after the disaster were also invited to participate in the study, as almost the entire fire department had been exposed to the disaster.
2. All police officers (*i.e.* constables, warrant officers, sergeants and their supervisors) who were, according to company records, employed in the

Amsterdam-Amstelland regional police force on the date of the disaster (October 4th, 1992), and were still employed there on the 1st of January 2000.

3. All the hangar workers registered as working for one of the departments involved in the transport, security and sorting of the wreckage on the date of the disaster (October 4th, 1992), and who reported to have been involved in these activities; as well as a random sample, matched with their colleagues for age, sex, department and job title, who were also registered as working for these departments on 30th November 1992, but who did not report to have been involved in any disaster-related activities.

Procedures and data-collection

The study design was approved by the two independent Medical Ethics Committees of the medical facilities involved in this project: the VU University Medical Center (VUmc) and the 'Onze Lieve Vrouwe Gasthuis' (OLVG) in Amsterdam. Potential participants were initially informed about the study via announcements in staff magazines, after which they were approached via personal letters, and eventually by telephone. All participants signed informed consent and participated voluntarily. Data were collected at the Prinsengracht out-patient clinic of the OLVG from January 2000 to March 2002, i.e. on average 8.5 years after the disaster. In addition, data on about half of the hangar workers were collected at Schiphol Airport for logistic reasons. Trained medical research assistants checked that the questionnaires had been completed, measured body height and weight, drew blood samples, and assisted with the collection of urine and saliva samples. A team of administrative employees carried out the data-entry of the questionnaires. Data of each participant were entered twice by two of these employees independently, after which inconsistencies were reviewed and any mistakes rectified. All remaining problems in the interpretation of data, such as dubious handwriting, were consistently resolved by one of the authors (AH, PS or AW).

Blood, saliva and urine samples were dealt with according to standard procedures for collection, transportation, storage and laboratory analysis. Laboratory technicians could have been aware that the samples were from the ESADA, but they were blinded for exposure and health status. The laboratories were all certified according to accredited Dutch standards.

Occupational exposure to the disaster

All participants were asked to fill in a questionnaire on occupational exposure to the air disaster. This questionnaire addressed several specific disaster-related tasks, and also the total time spent on these tasks and the location in which they were performed (e.g. on or near the disaster site, in the hangar where the wreckage was temporarily placed, or elsewhere). They were also asked to describe any other disaster-related task(s) that they had performed. Answers to the latter question were categorized (by PS and AW). The questionnaire also covered disaster-related psychosocial events in a number of items on personal experiences during the disaster (e.g. "were you in life-threatening danger?",

"did you see the disaster scene during the first hours after the crash?", and "were any of your family members injured?").

These personal records of occupational exposure to the disaster were used to define 'exposed' workers, i.e. those who reported at least one disaster-related task, and 'non-exposed' workers, i.e. those who did not report any disaster-related tasks.

In addition to comparing exposed and non-exposed workers, we examined exposure-response relationships among exposed workers, in which level of exposure is characterized by the type of tasks and psychosocial events and the duration of exposure. As an additional dimension of level of exposure, we took into account the differences in potential psychotraumatic impact of exposure items, based on criterion A1 of the diagnostic criteria for Post Traumatic Stress Disorder (PTSD; American Psychiatric Association [APA]; Diagnostic and Statistical Manual of Mental Disorders-IV-Text Revision [DSM-IV-TR, 2000])[31]. This criterion states that "the person has experienced, witnessed, or been confronted with an event or events that involve actual or threatened death or serious injury, or a threat to the physical integrity of oneself or others". Five experts on PTSD from different universities and psychiatric hospitals independently rated the likelihood of potentially psychotraumatic disaster-related tasks and events to meet this criterion on a 4-point Likert Scale ranging from 1='very unlikely' to 4='very likely'. Subsequently, we assumed that items with a mean item score of three or higher met the A1 criterion for PTSD (i.e. A1 tasks and events), as opposed to items with a lower mean score (i.e. non-A1 tasks and events). Table 1 lists the disaster-related tasks and the psychosocial events according to their potential psychotraumatic impact.

Table 1: Disaster-related tasks and psychosocial events according to their potential psychotraumatic impact

	A1* (traumatic)	Non-A1* (non-traumatic)
Tasks	1. Identification or recovery of victims from the rubble/ transport or search for human remains 2. Rescue people	1. Fire-extinguishing 2. Clean up of destructed area 3. Transport of injured victims 4. Provide first aid/support injured victims or workers 5. Security tasks (surveillance, prevent burglary, keep disaster area free of bystanders) 6. Other tasks (e.g. traffic management) 7. Sort wreckage in hangar (at Schiphol Airport) 8. Other tasks in hangar in the presence of the wreckage 9. Transport of wreckage 10. Burning of contaminated soil remnants (from disaster site)
Psycho-social events	1. Having been in life-threatening danger during disaster 2. Personal injuries due to disaster 3. Witnessed dead or injured victims 4. Having been in or near one of the destroyed buildings at the time of the disaster 5. Immediate family members (partner, children) died / in life-threatening danger / injured due to the disaster 6. Other family members died due to the disaster	1. Saw the aircraft crash / saw or heard the aircraft when it crashed 2. Felt or heard the impact of the crash 3. Saw the fire 4. Saw the disaster site during the first hours after the crash or when the wreckage was still there 5. Other family members in life-threatening danger or injured due to the disaster 6. Friends or acquaintances died, injured or in life-threatening danger due to the disaster 7. Apartment of other family members, friends, or acquaintances damaged due to the disaster 8. Lived in the affected suburb of Amsterdam (Bijlmermeer) at the time of the disaster 9. Visited the hangar where the wreckage was kept

*A1 and non-A1 = items with a mean score of ≥3 or <3, respectively, on a 4 point Likert Scale indicating the likelihood for an item to meet criterion A1 for post-traumatic stress disorder (from 'very unlikely' [=1] to 'very likely' [=4]) (see Methods).

Main health outcomes

***Self-reported health measures*:**

- *Post-traumatic stress symptoms*: (a) The Dutch 22-item Self-Rating Inventory for PTSD (SRIP)[32-34] and, among exposed subjects only, (b) The 15-item Dutch version of the Impact of Event Scale (IES), which addressed post-traumatic stress symptoms with explicit reference to the air disaster in Amsterdam[35-37] .
- *General mental health*: (a) The 90-item Symptom Checklist (SCL-90)[38,39]; (b) The 20-item General Health Questionnaire (GHQ-12)[40].
- *Fatigue and associated symptoms*: The 20-item Checklist Individual Strength (CIS)[41,42].
- *Health-related quality of Life*: The MOS 36-item Short-Form Health Survey (SF-36) [43,44].
- *Chronic conditions*: One questionnaire assessed the current presence and history of the following chronic conditions, which are considered to have a significant impact on well-being: diabetes; stroke, brain hemorrhage or infarction; heart attack; other heart problems (such as heart failure, or angina pectoris); cancer; chronic osteoarthritis (wear) of the hip or knee joints; hypertension; asthma, chronic bronchitis or lung emphysema (Chronic Obstructive Pulmonary Disease [COPD]); serious or persistent intestinal disorders (longer than 3 months); chronic stomach disorders, stomach or duodenal ulcers; serious or persistent back complaints (including hernias); chronic inflammation of the joints (chronic rheumatism, rheumatoid arthritis). Workers with these chronic conditions were subsequently asked in what year the onset was, to determine whether this was before the disaster took place.
- *Physical symptoms*: Multiple questionnaires were used to assess the current presence of various physical symptoms, such as a number of respiratory, musculoskeletal, and skin symptoms.
- *Attribution of current problems to the air disaster in Amsterdam and its aftermath*. Another questionnaire assessed the extent to which exposed workers related any of their current physical, psychological or practical/financial problems to the air disaster and its aftermath. Those who attributed physical symptoms to the disaster and its aftermath were asked to specify these symptoms.

Laboratory outcomes:

General laboratory tests[45]*:*

- *Hematological and blood chemical outcomes*: hemoglobin, leukocyte count, differential count, platelet count and mean corpuscular volume (Sysmex SE 9000, TOA medical electronics Co. ltd); potassium (Roche Modular ISE900, Roche Diagnostics); creatinine, alkaline phosphatase, gamma-glutamyl transferase, alanine aminotransferase, creatine kinase and C-reactive protein (Roche Modular P800, Roche Diagnostics); ferritin and thyroid stimulating hormone (Centauer, Bayer Diagnostics); β2-microglobuline (IMx Abbott).

- *Autoantibodies:* nuclear antigen antibodies, anti-double stranded DNA antibodies[46], Immunoglobulin (IgM) rheumatoid factor[47], antineutrophil cytoplasmic antibodies[48,49], and cardiolipin antibodies[50,51].
- *Urine outcomes*: creatinine (Hitachi 747, Roche Diagnostics GmbH, Mannheim, Germany); micro-albumin (Beckman Array 360 system); and β2-microglobuline (IMx Abbott); screening for protein, glucose, pH, blood and leukocytes (teststrip Boehringer Mannheim B.V.), followed by microscopic evaluation of the urinary sediment if indicated.
- *Saliva outcome*: cortisol concentration (Wizard 1470, Perkin Elmer).

Additional laboratory tests with respect to the societal questions:

- *Uranium 238*: concentration in urine (Inductively Coupled Plasma-Mass Spectrometry [ICP-MS] analyser, Finnigan Mat Element) and, at concentrations above 50 ng/l or above 50 ng/g creatinine, also the ratio of uranium 235/238 isotopes[52].
- *Total and free carnitine*: concentration in blood plasma (Mira Plus, Roche Diagnostics)[53,54].
- *DNA of any Mycoplasma species*: presence in peripheral blood mononuclear cells (DNA-isolation, Magna Pure, Roche Diagnostics; real time PCR, Taqman, Applied Biosystems); positive samples were subsequently evaluated for the presence of DNA of *Mycoplasma fermentans*[55,56].

Self-reported socio-demographic characteristics:

- *Age*: at time of assessment in years.
- *Sex:* male or female.
- *Ethnicity:* categorized into those who considered themselves as European (i.e. Dutch, British, Dutch/Irish, Dutch/Chinese, Dutch/Indonesian, Portuguese, Spanish, Dutch/ Spanish and European), and others (*e.g.* Moroccan, Turkish, Surinam).
- *Level of education*: highest level of education completed, categorized as: high (higher vocational education, university); medium (intermediate vocational education, higher general secondary education, or pre-university education); and low (no education, elementary school, lower vocational education, or lower general secondary education).
- *Current executive function*: yes (i.e. supervising one or more people) or no.
- *Level of physical activity*: the total number of hours spent each week on physical activities such as physical exercise, gardening and housekeeping, classified into high, medium and low according to the 33rd and 66th percentiles.
- *Alcohol consumption*: Usual and exceptional consumption of alcoholic beverages, classified into: none; light-moderate; and (extremely) excessive, i.e. consumption of (a) six or more glasses on 9-20 days a month and on 3-4 days in

the last week, (b) four or more glasses on at least 21 days a month and on at least 5 days in the last week, and/or (c) more than six glasses a day, on a weekly basis.
- *Cigarette-smoking:* categorized as: never, former smoker, and current smoker.
- *Negative life events:* the number of reported negative life events, based on a questionnaire which specified 13 such events and also included two open-ended questions in which other events could be described. Subjects were asked to indicate whether any of these events happened to them before or after the disaster.

Discussion

In recent years there has been increasing scientific and societal interest in the health consequences of man-made, technological disasters, i.e. a collective stressful experience with a sudden onset due to technological failure. Technological disasters have had psychiatric consequences[13-15,57], such as PTSD, as well as medical consequences, in particular those of toxic exposures[58-61]. In addition to direct toxic health effects, the mere suspicion and fear of exposure to hazardous materials can also take its toll on the quality of physical, psychological and social well-being in the community[62-64].

Technological disasters strike unexpectedly and suddenly, which puts time-pressure on researchers to develop study protocols, gather exposure data, call in multidisciplinary experts, and obtain financial resources for immediate epidemiological research. Disaster researchers may also have to deal with complicated socio-political and legal aspects. In addition, they have to face a number of methodological problems. These difficulties include: (a) defining the entire potentially 'affected' population and appropriate reference groups; (b) contacting potential participants, particularly in the case of evacuation and hospitalization; low response rates; usually without data on non-respondents[65]; (c) collecting exposure data immediately after the event, which is actually also needed for long-term epidemiological studies.

Probably due to these difficulties, evidence from large-scale epidemiological studies that have been carried out after technological disasters is rather scarce[66,67]. Furthermore, before-after comparisons are rare and only possible by chance in ongoing research projects, due to the unexpected nature of technological disasters[68-70]. Most of the studies that have been conducted so far have relied on 'convenience samples', which were mainly composed of those who were directly affected, such as victims and residents; were based on non-epidemiological study designs; and used group-level or retrospective, self-reported exposure data, which can be affected by recall and reporting bias[71-74].

ESADA approach

The purpose of the ESADA is to assess long-term health effects of occupational exposure to the air disaster in Amsterdam on professional assistance workers. In view of

the above-mentioned difficulties in epidemiological research on disasters, the ESADA has some strong methodological points. With respect to the study population, we have been able to identify the complete cohort of exposed and non-exposed workers accurately, based on company records of employment at the time of the disaster.

Another strong point of the ESADA is that we included reference groups of colleagues, who had the same jobs and employers, but who were not occupationally exposed to the disaster. Hence, we are able to draw group-level conclusions on associations between health status and occupational exposure to the disaster.

With respect to exposure assessment, we were able to collect individual data on occupational exposure to the air disaster. Moreover, this consisted of multiple aspects of self-reported occupational exposure, including the duration and location of various disaster-related tasks and the experience of potentially stressful events during these tasks. Finally, we also included various assessments of long-term health, such as laboratory tests and self-reported symptoms and health-related quality of life, to obtain an integral evaluation of health status.

Notwithstanding these strong methodological qualities, some limitations of the ESADA design should also be mentioned. Firstly, although company records of employment were available, we still had to resolve a few difficulties regarding the definition of the study population. For the fire-fighters, this was due to the fact that almost the entire fire department of Amsterdam had been exposed to the disaster. Therefore, in order to achieve an adequate reference group, we decided to also include fire-fighters who joined this fire department after the disaster took place. With respect to the police officers, we were unable to trace those who had left the Amsterdam-Amstelland regional police force in the years after the disaster, due to administrative difficulties. Hence, it was necessary to restrict this group to those who were still working for this police force in 2000.

A second methodological issue concerns the self-report nature of occupational exposure status, and the average time-lag of 8.5 years between the disaster and the assessment. Due to administrative deficiencies in the historic registration of the exposure status, we used our detailed questionnaire data to define exposure status for all workers. Strictly speaking, the ESADA is therefore not a historic cohort study, but a cross-sectional one. The time-lag between the disaster and the exposure assessment may have led to recall bias, especially concerning certain details of exposure to the disaster, such as the duration of activities. However, it seems reasonable to assume that the workers did recollect whether or not they performed any as opposed to no disaster-related tasks, which was used to define occupational exposure status. It is therefore very unlikely that recall bias has resulted in (non-) differential misclassification of exposed and non-exposed workers. Nevertheless, recall bias should be kept in mind with respect to exposure-response relationships. We included multiple aspects of level of exposure, such as the duration and the potential psycho-traumatic character of disaster-related tasks, as it is unknown which aspect of occupational exposure to disasters is relevant for

long-term health. However, we may still have missed other potentially relevant aspects, such as exposure to disaster-related media reports in the aftermath of the disaster[4,75].

Thirdly, we acknowledge the fact that, with the exception of the laboratory variables, we rely on self-reported health outcomes. However, most of the health questionnaires that we used have been validated and widely accepted, except for those used to assess the physical symptoms. Differential misclassification in self-report health measures could occur if exposed workers are more likely than non-exposed workers to interpret and report bodily sensations as symptoms. On the other hand, hypervigilance and hypochondria themselves could well be adverse health effects of (toxicological) disasters[76,77].

In conclusion, to increase our knowledge of potential health consequences of (technological) disasters, it is important to be prepared for epidemiological disaster research. Incorporating basic multidisciplinary, epidemiological research protocols into disaster management plans will stimulate scientifically sound research on the health effects of disasters. The ESADA will provide additional scientific knowledge on the long-term health effects of technological disasters on professional workers.

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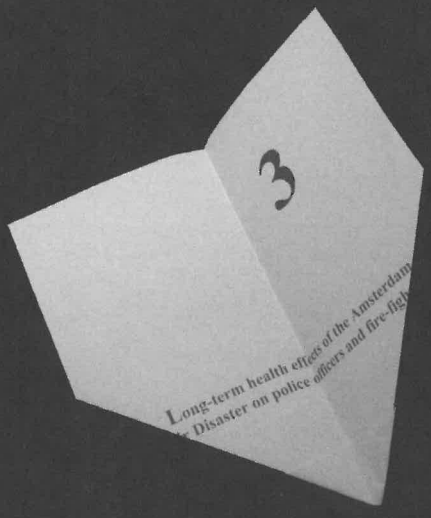
3

Long-term health effects of the Amsterdam air disaster on police officers and firefighters



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Submitted

Abstract

Objectives

On October 4th, 1992, a cargo aircraft crashed into apartment buildings in Amsterdam, the Netherlands. Firefighters and police officers assisted with the rescue work. The present study examined the long-term health effects on rescue workers exposed to a disaster.

Methods

A historical cohort study was performed among police officers (n=834) and firefighters (n=334) who performed at least one disaster-related task and reference groups of their non-exposed colleagues (n= 634 and n=194, respectively). The main outcome measures included digestive, cardiovascular, musculoskeletal, nervous system, airway, skin, post-traumatic stress, fatigue and general mental health complaints; hematological and biochemical laboratory outcomes, and urinalysis outcomes.

Results

Police officers and firefighters who were professionally exposed to a disaster reported more physical and mental health complaints, compared to the reference groups. No clinically relevant statistically significant differences in laboratory outcomes were found.

Conclusions

Our study is the first to examine long-term health effects of a large sample of rescue workers exposed to a disaster in comparison to reference groups of non-exposed colleagues. Our findings show that even in the long term, and in absence of laboratory abnormalities, rescue workers report more health complaints.

Introduction

On October 4th, 1992, a cargo aircraft crashed into two apartment buildings in a densely populated suburb of Amsterdam, the capital of the Netherlands. The Amsterdam Air Disaster resulted in 39 fatal injuries on the ground, killed all four occupants of the aircraft, and destroyed 266 apartments. Firefighters and police officers helped to rescue the victims of this disaster, to extinguish the fire and to clear away the debris.

Several years later, some of the police officers and firefighters who had been exposed to the disaster, and a number of inhabitants of the area were still worried about the content of the cargo of the aircraft. They reported a variety of health complaints, which they attributed to the disaster, and called for a study to investigate whether their health complaints were related to the disaster. In 1998, a parliamentary inquiry was held to investigate the cause of the crash and to gain insight into the content of the cargo of the aircraft. One of the recommendations was that an epidemiological study should be conducted to investigate the health status of the victims of the disaster and the rescue workers exposed to the disaster.

The Amsterdam Air Disaster is an example of a technological disaster with a sudden onset. Other studies have shown that such disasters may result in acute injuries (such as burns and fractures) and short-term symptoms (such as respiratory symptoms)[1]. However, the mere threat of exposure to hazardous material during such an event may also be a source of stress, associated with changes in mental health, physical health, and health-related behaviour[2]. Indeed, various symptoms, such as headache, fatigue, memory disorders, joint and muscle aches, bowel symptoms, dizziness, anxiety, depression, and Post-Traumatic Stress Disorder (PTSD) have sometimes been found to develop over time among affected populations after various disastrous events[3-6]. Moreover, the long aftermath of the Amsterdam Air Disaster and the confusing and ambiguous information in the media may have been an additional cause of distress to those involved.

Most of the previous studies have focused on the health status of inhabitants of the affected area of a disaster and reported short-term health effects only. Furthermore, very few studies included a reference group of people who were not exposed to the disaster, and information on disaster-related long-term health complaints of rescue workers is scarce. The present large-scale historical cohort study was designed to study the long-term health effects on police officers and firefighters exposed to a disaster.

Our aim was to investigate the physical and mental health status of police officers and firefighters 8.5 years after they had been exposed to the Amsterdam Air Disaster and to compare their health status with that of colleagues in reference groups.

Methods

Participants

All police officers and firefighters who were on active duty at the time of the disaster and in the weeks afterwards, were invited to participate in the study. They completed a questionnaire on professional exposure to the disaster, which included questions on disaster-related tasks such as "saving people's lives", "extinguishing the fires", and "transporting the wounded". Police officers and firefighters who performed at least one task, were defined as being 'exposed'. Professional colleagues who did not perform any disaster-related task were also invited to participate in the study, in 'non-exposed ' reference groups, and were matched according to job title. The exclusion criteria were: having insufficient knowledge of the Dutch language and therefore not being able to fill in questionnaires, residing in the disaster area, and missing questionnaire data on disaster-related tasks.

All of the participants gave written informed consent and participated voluntarily. Data were collected in an outpatient clinic of the Onze Lieve Vrouwe Gasthuis (OLVG) in Amsterdam, which took place from January 2000 to March 2002, on average 8.5 years after the Amsterdam Air Disaster. Details of the history and the set-up of the study have already been reported elsewhere[7].

Health outcomes

Perceived health complaints

The International Classification of Primary Care (ICPC), as designated by the World Organization for Family Doctors (WONCA), was used to classify the symptoms reported by the participants[8]. The following somatic symptoms categories were used in the analysis: (a) general and non-specific, (b) digestive system, (c) cardiovascular system, (d) musculoskeletal system, (e) nervous system, (f) respiratory tract, and (g) skin. A dichotomized score was composed for each category of symptoms ("0" = no symptom, "1" = at least one symptom in this category).

Post-traumatic stress symptoms were assessed using the Self-Rating Inventory for Post-traumatic Stress Disorder (SRIP), a 22-item questionnaire [9-11]. The items were based on symptoms of post-traumatic stress disorder as described in the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) for psychiatric diagnoses[12]. A cut-off score of 39 was predetermined to define individuals who have problems due to involvement in a traumatic event[13].

Fatigue symptoms were measured with the Checklist Individual Strength (CIS), a 20-item scale, resulting in four subscales and a total score. For the present study, use was made of dichotomized scores on the 'subjective fatigue' sub-scale (cut-off score: 35) and the total score (cut-off score: 76)[14-15].

General mental health was assessed by means of the Symptom Checklist (SCL-90)[16]. This is a 90-item questionnaire, which consists of 8 sub-scales (somatic symptoms, depression, anxiety, obsessive-compulsive behavior, agoraphobia,

interpersonal sensitivity, hostility, sleeping problems). Scores above the 65th percentile of the normal Dutch population were regarded as deviant[17].

Laboratory outcomes

All the laboratories involved in this study carried out their analyses according to the accredited (Dutch) standards. We used the clinical cut off values of these laboratories to define a deviant outcome[18]. The hematological laboratory outcomes included hemoglobin, leukocyt count, differential leukocyt count, and platelet count. Blood chemical outcomes included potassium, creatinine, alanine aminotransferase, alkaline phosphatase, gamma-glutamyl transferase, creatine kinase, thyroid stimulating hormone, C-reactive protein and ferritin. Urinalysis included the dipstick test followed by microscopic evaluation of the urinary sediment if indicated by presence of protein.

Statistical analysis

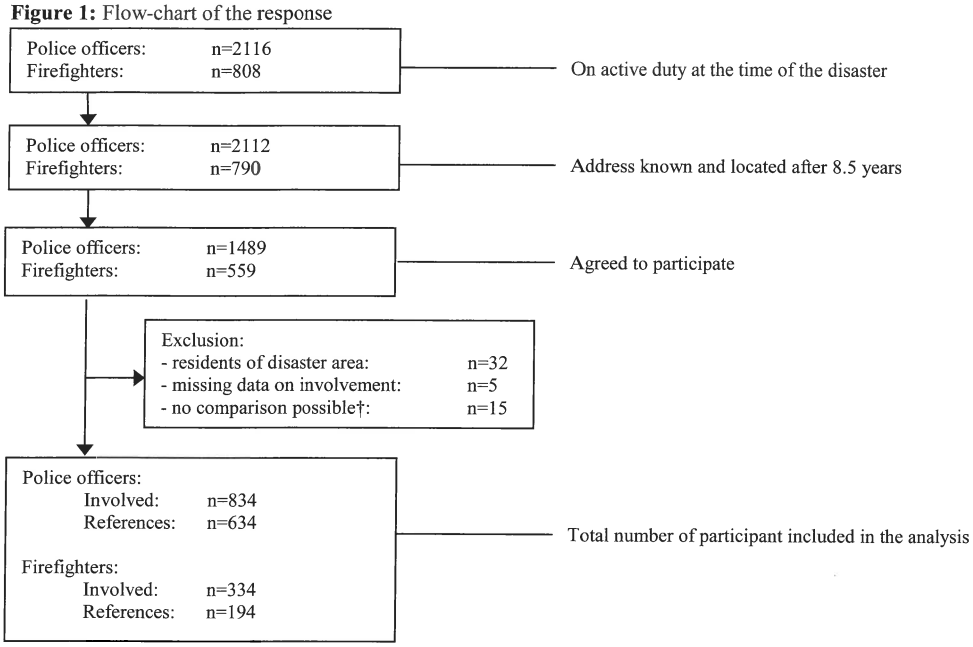
Differences between the exposed police officers and firefighters and their reference groups were analysed with logistic regression analyses. All analyses were adjusted for the following potential confounders: age, professional level, level of education, alcohol consumption, smoking habits and level of physical activity. For police officers only, gender and ethnicity were added as potential confounders. In addition, mental health outcomes were adjusted for the number of adverse pre-disaster life-events and the presence of chronic diseases. Odds ratios (ORs) and the 95% Confidence Intervals (95% CI) were estimated. The analyses were carried out in SPSS version 10.1, and $p < .05$ (two-sided) was used to determine statistical significance.

Results

Response

The response from both the police officers and the firefighters was 70%. Of the 2112 police officers who were invited to participate, 1489 agreed. After the exclusion criteria had been applied, data from 834 exposed police officers and 634 non-exposed police officers were analysed. Of the 790 firefighters who were invited to participate, 559 agreed, and after the exclusion criteria had been applied, data from 334 exposed and 194 non-exposed firefighters were analysed. Details are shown in Figure 1. Table 1 presents background characteristics of the participants.

Figure 1: Flow-chart of the response



†Only one female firefighter participated and was therefore excluded; 14 firefighters in the reference group were of non-Caucasian ethnicity, and could therefore not be compared to the involved group, which included only Caucasian firefighters.

Table 1: Background characteristics of the participants

	Police officers		Firefighters	
	Involved	Reference	Involved	Reference
N	834	634	334	194
Age in years (SD)	44.0 (6.2)	44.8 (7.0)	51.4 (5.9)	38.8 (9.1)
Level of educational (%)				
Low	22.0	20.9	63.4	52.7
Intermediate	55.8	54.3	29.8	36.6
High	22.2	24.8	6.8	10.8
Alcohol consumption† (%)				
None	11.4	8.2	4.2	12.4
Low to moderate	74.3	75.7	72.8	70.6
Heavy	14.3	16.1	23.1	17.0
Smoking habits (%)				
None	33.1	27.9	32.0	44.8
Former smoker	31.7	38.0	35.0	29.4
Current smoker	35.3	34.1	32.9	25.8
Male gender (%)	88.5	84.9	100	100

SD = standard deviation; †Alcohol consumption was assessed according to the Garretsen index [41].

Perceived health complaints

Table 2 presents the results of the logistic regression analyses with regard to the ICPC symptoms categories, adjusted for potential confounders. In general, the exposed police officers and the exposed firefighters reported health complaints significantly more often than the respective reference group.

Table 3 presents the results of the logistic regression analyses with regard to mental health outcomes, adjusted for potential confounders. In general, again the exposed police officers reported symptoms significantly more often than the reference group, including PTSD, fatigue, and indices of psychopathology. The exposed firefighters reported significantly more fatigue and somatic symptoms than the reference group.

Table 2: Comparison between exposed police officers and firefighters and their reference groups with regard to health complaints, sub-divided into ICPC symptoms categories

	Police officers			Firefighters		
ICPC symptom categories	Involved	Reference	OR (95% CI)	Involved	Reference	OR (95% CI)
General/non-specific	40.4%	27.4%	1.9 (1.5 – 2.4)*	32.1%	16.0%	2.0 (1.1 – 3.6)*
Digestive	21.3%	15.1%	1.6 (1.2 – 2.1)*	21.3%	13.4%	1.8 (1.0 – 3.6)
Cardiovascular	25.7%	16.7%	1.8 (1.4 – 2.3)*	28.7%	11.3%	3.3 (1.7 – 6.4)*
Musculoskeletal	42.1%	29.2%	1.9 (1.5 – 2.3)*	53.9%	25.8%	2.6 (1.6 – 4.2)*
Nervous system	51.1%	39.7%	1.7 (1.3 – 2.1)*	49.2%	28.4%	2.9 (1.7 – 4.8)*
Airway	29.7%	19.7%	1.8 (1.4 – 2.3)*	29.9%	12.9%	1.7 (0.9 – 3.0)
Skin	51.9%	28.4%	2.8 (2.2 – 3.5)*	54.8%	32.5%	3.4 (2.0 – 5.6)*

* P < 0.05; ICPC: International Classification of Primary Care; OR: Odds Ratio; CI: Confidence Interval;
The percentages reflect the relative number of participants who reported one or more symptom(s) in the relevant symptoms categories. Analyses are adjusted for age, gender, ethnicity, professional level, and level of education, alcohol consumption, smoking habits, and level of physical activity.

Table 3: Comparison between exposed police officers and firefighters and their reference groups with regard to mental health complaints

	Police officers			Firefighters		
	Involved	Reference	OR (95% CI)	Involved	Reference	OR (95% CI)
PTSD (SRIP)	6.5%	2.4%	2.8 (1.5 – 5.0)*	5.4%	2.6%	1.1 (0.4 – 3.7)
Fatigue (CIS)						
Subjective fatigue	19.4%	9.9%	2.0 (1.4 – 2.7)*	11.7%	5.2%	2.5 (1.0 – 6.6)*
Total score	16.7%	8.8%	1.8 (1.3 – 2.6)*	11.7%	2.6%	3.6 (1.2 – 11.0)*
SCL-90						
Agoraphobia	8.3%	6.3%	1.2 (0.8 – 1.9)	9.6%	4.1%	1.9 (0.5 – 3.0)
Anxiety	31.7%	18.9%	1.8 (1.4 – 2.3)*	27.2%	20.6%	1.2 (0.7 – 2.5)
Depression	21.9%	11.4%	2.1 (1.5 – 2.8)*	20.1%	8.2%	1.6 (0.8 – 3.1)
Somatic symptoms	32.4%	17.0%	2.1 (1.6 – 2.7)*	34.4%	13.9%	2.6 (1.4 – 4.8)*
Obsessive-compulsive	26.9%	16.7%	1.7 (1.3 – 2.2)*	28.1%	12.9%	1.8 (1.0 – 3.2)*
Interpersonal sensitivity	12.0%	7.7%	1.5 (1.1 – 2.2)*	13.5%	6.7%	1.5 (0.7 – 3.3)
Hostility	42.7%	32.2%	1.5 (1.2 – 1.8)*	34.7%	24.2%	1.4 (0.8 – 2.3)
Sleeping problems	48.3%	35.5%	1.6 (1.3 – 2.0)*	47.9%	32.0%	1.4 (0.9 – 2.3)

* P < 0.05; OR = Odds Ratio; CI = Confidence Interval; PTSD = Post-Traumatic Stress Disorder; SRIP = Self-Rating Inventory for Post-traumatic Stress Disorder; CIS = Checklist Individual Strength; SCL-90 = Symptoms Checklist-90. The reported prevalences reflect scores above the cut-off values for the questionnaires. Analyses are adjusted for age, gender, ethnicity, professional level, level of education, alcohol consumption, smoking habits, level of physical activity, number of adverse life-events, and chronic diseases.

Laboratory outcomes

The laboratory analyses showed no significant differences between exposed participants and their respective reference groups. There were two exceptions. Firstly, in exposed firefighters the number of leukocytes was less frequently increased than in non-exposed firefighters. Secondly, in exposed workers a significant larger group of participants with a (slightly) increased percentage of monocytes was found. However, the increased percentage of monocytes did not exceed 15% of the differential count (data not shown).

Table 4: Comparison between exposed police officers and firefighters and their reference groups with regard to laboratory outcomes

	Police officers			Firefighters		
	Involved (n=834)	Reference (n=634)	OR (95% CI)	Involved (n=334)	Reference (n=194)	OR (95% CI)
Hematological outcomes						
Hemoglobin, % decreased	14.5%	17.1%	0.9 (0.6 – 1.1)	14.4%	25.3%	0.6 (0.3 – 1.1)
Leukocytes						
% increased	5.5 %	4.9%	1.1 (0.7 – 1.9)	3.0%	3.6%	0.2 (0.05 – 0.7)*
% decreased	0.2%	0.2%	--	0.0%	0.5%	--
Neutrophils						
% increased	1.0%	1.0%	1.0 (0.3 – 3.0)	0.9%	1.0%	--
% decreased	2.8%	2.4%	1.2 (0.6 – 2.4)	2.4%	2.1%	--
Lymphocytes						
% increased	15.0%	14.5%	1.0 (0.8 – 1.4)	12.9%	16.0%	0.8 (0.4 – 1.5)
% decreased	10.0%	8.7%	1.2 (0.8 – 1.7)	12.9%	7.2%	1.2 (0.6 – 2.7)
Monocytes						
% increased	9.7%	6.3%	1.6 (1.1 – 2.4)*	11.7%	8.2%	2.3 (1.0 – 5.5)*
% decreased	0.2%	0.2%	--	0.3%	0.0%	--
Eosinophils, % increased	8.2%	7.0%	1.2 (0.8 – 1.8)	5.7%	8.8%	0.5 (0.2 – 1.3)
Basophils, % increased	0%	0%	--	0.0%	0.0%	--
Platelet count						
% increased	0.7%	0.9%	0.8 (0.3 – 2.6)	0.3%	1.0%	--
% decreased	1.7%	1.4%	1.3 (0.6 – 3.0)	1.8%	1.0%	--
Blood chemical outcomes						
Potassium, % decreased	15.2%	18.5%	0.8 (0.6 – 1.1)	15.1%	14.5%	1.4 (0.7 – 2.8)
Alanine aminotransferase, % increased	10.8%	8.2%	1.4 (0.9 – 2.0)	6.9%	3.6%	0.9 (0.3 – 2.7)
Alkaline phosphatase, % increased	0.5%	0.5%	--	0.3%	2.1%	--
Y- Glutamyl transferase, % increased	14.1%	13.6%	1.1 (0.8 – 1.5)	16.2%	7.7%	0.9 (0.4 – 1.8)
Creatine kinase, % increased	17.9%	17.9%	0.9 (0.7 – 1.2)	23.4%	38.3%	1.1 (0.7 – 2.0)
Thyroid-stimulating hormone	1.1%	1.0%	1.4 (0.5 – 3.9)	1.2%	1.0%	--
% increased	1.0%	0.6%	--	0.9%	0%	--
% decreased	3.7%	3.2%	1.1 (0.7 – 2.2)	3.9%	3.1%	0.5 (0.1 – 1.7)
C-Reactive protein, % increased	12.5%	12.3%	1.0 (0.8 – 1.5)	21.0%	7.2%	1.7 (0.8 – 3.4)
Ferritin, % increased						
Urinalysis outcomes						
Creatinine clearance, % decreased	0.1%	0.5%	--	1.2%	0.5%	--
Proteinuria with either sediment abnormality or increased serum creatinine	4.4%	4.0%	1.2 (0.7 – 2.0)	2.7%	2.6%	1.5 (0.3 – 7.2)

* P < 0.05; --: analyses were not performed due to the very low number of cases (n<5). The reported prevalences reflect scores above (increased) or below (decreased) the cut-off values for parameters. Cut-off values: hemoglobin men < 8.7 mmol/L, women <7.5 mmol/L; leukocyt count < $3x10^9$/L or > $10x10^9$/L; differential leukocyt count: neutrophils <45% or >80%; lymphocytes <20% or >35%; monocytes <2% or > 10%; eosinophils > 5% and basophils > 2%; platelet count <$150x10^9$/L or > $400x10^9$/L; potassium < 3.6 mmol/L; creatinine men > 115 µmol/L, women 95 µmol/L; alanine aminotransferase > 45 U/L; alkaline phosphatase > 120 U/L; gamma-glutamyl transferase men > 50 U/L, women > 35 U/L; creatine kinase men > 190 U/L, women 170 U/L; thyroid stimulating hormone < 0.4 IU/L or > 4 IU/L; C-reactive protein > 10 mg/L; ferritin > 250 ng/mL; Urinalysis: Creatinine clearance: Cockroft equation ((140-age)*body weight) / ((creatinine (serum))*0.86 (males) or *1.01 (females)) was used to estimate clearance of endogenous creatinine, cut-off: < 75 ml/min. Proteinuria with either sediment abnormality or increased serum creatinine, cut-off: protein not negative, erythrocytes > 5 per high power field, leukocytes > 10 per high power field, bacteria not negative. Analyses are adjusted for age, gender, ethnicity, professional level, level of education, alcohol consumption, smoking habits, and level of physical activity.

Discussion

Our study is the first to examine long-term health effects of rescue workers exposed to a disaster in comparison to reference groups of non-exposed colleagues. In this historical cohort study we had the unique opportunity to compare the health status of exposed police officers and firefighters with that of a reference group of non-exposed colleagues, 8.5 years after the Amsterdam Air Disaster. Self-reported health complaints were compared, as well as routine laboratory analyses of urine and blood. The results showed that, even after 8.5 years, the police officers and firefighters who were professionally exposed to the disaster reported health complaints significantly more often than their colleagues in the reference groups. This difference concerned cardiovascular, musculoskeletal, nervous system, skin, and fatigue complaints for the exposed police officers as well as the exposed firefighters, and airway, digestive and general physical and mental health complaints for the exposed police officers only. Laboratory analyses showed no statistically significant or clinically relevant differences between the exposed participants and their reference groups.

The results of this study are highly relevant for future research on health effects of disasters on rescue workers. For instance, recent studies have shown that rescue workers who were exposed to the World Trade Center disaster in New York reported symptoms of ill health in the short term[19-20]. In fact, most previous studies on the health effects of disasters have focused on shorter term effects on direct victims, e.g. the inhabitants of an area that was struck by a flood[21] or a bush fire[22-23]. In general, these studies reported an increase in various health problems in natural disaster victims, compared to controls. A higher frequency of relatively minor physical symptoms rather than clinically relevant pathology, was reported in most studies [24]. However, in these studies a broad range of methods was used to assess the physical consequences of the disaster, and they varied in the number of participants, and in the follow-up duration after the disaster. For instance, several studies were based on small samples, and covered only a short period of time after the disaster, which is likely to result in a high incidence of temporary morbidity. Two studies compared self-report data on health before and after a disaster, because the disaster took place between the assessment waves of ongoing panel studies [25-26], and found that exposure to a flood accounted for 2% to 12% of the change in physical health status across the measurement intervals, but was not related to the onset of clinically relevant disorders.

In addition to natural disasters, several chemical and radiation disasters have taken place since 1980, including the Chernobyl disaster, the Three Miles Island incident, and other, smaller incidents in which inhabitants and rescue workers were exposed to potential hazardous materials[27-29]. In some cases, exposure to the hazardous materials was reported to be a plausible cause for the negative health effects that were found, while in others it was suggested that the insecurity, loss of control, and risk perception may have accounted for the reported health effects[27,30]. This may have played a role in the Amsterdam Air Disaster as well, since the crash was followed by a long aftermath,

with increased risk perception, and confusing and ambiguous information about the cargo contents.

Only a few studies have specifically focused on the health status of rescue workers, such as police officers and firefighters. Although rescue workers are usually not direct victims of a disaster, their duties may include exposure to very stressful and traumatic events, such as the salvage and identification of bodies, rescue work under high risk conditions with fear for their physical integrity, and even for their own lives, and contacts with the bereaved families. Several studies have shown that rescue workers are at risk for post-traumatic stress disorders[31-35]. Other mental health effects have also been found, including sleeping problems[36], and anxiety or depression[37-38]. In contrast, however, several studies have shown that rescue workers may be regarded as a highly resilient group of professionals with regard to the potentially harmful effects of stress[33;39-40].

The results of the present study demonstrate that police officers and firefighters exposed to the Amsterdam Air Disaster reported a broad range of health complaints even more than 8 years after the disaster, similar to what is sometimes found for victims of natural or technological disasters[3-6]. However, the symptoms of our participants were all based on self-report, and could not be confirmed by routine laboratory tests. The outcomes of laboratory tests show no morbidity in relation to the disaster. In addition, no difference in absence at work due to illness was found between the exposed police officers and firefighters and the reference groups (data not shown). These findings suggest that there is no serious somatic pathological condition underlying the self-reported symptoms.

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4

Epidemiologic study of the autoimmune health effects of a cargo aircraft disaster

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Arch Intern Med 2005;165:2278-2285

Abstract

Background

In the aftermath of a cargo aircraft crash in Amsterdam in 1992, indications of autoimmune disorders appeared in some of the affected population.

Methods

This epidemiologic study sought to determine the possible long-term autoimmune health effects of the aircraft disaster on professional assistance workers. Exposed professional firefighters (n=334) and police officers (n=834) who performed at least one disaster-related task and hangar workers who sorted and investigated the wreckage (n=241) were compared with reference groups of nonexposed colleagues who did not perform any disaster-related tasks (n=194, n=634 and n=104, respectively). Data were collected a mean of 8.5 years after the disaster. Questionnaires were used to assess disaster-related tasks and 11 autoimmune-like symptoms. All serum samples were tested for the presence of antinuclear antibodies, rheumatoid factor, and antineutrophil cytoplasmic and anticardiolipin antibodies.

Results

Compared with nonexposed colleagues, exposed workers reported significantly more autoimmune-like symptoms. They reported the following symptoms significantly more often: tingling sensations, myalgia, loss of strength, easily fatigued, and a feeling of sand in the eyes (all groups); infection proneness (firefighters); skin abnormalities and nocturnal transpiration (police officers and hangar workers); and vasculitis-like symptoms and Raynaud discoloring (police officers). In contrast, we found no significant difference between exposed and nonexposed workers in autoantibody prevalence.

Conclusions

Occupational exposure to the aircraft disaster resulted in an excess of long-term self-reported autoimmune-like symptoms in exposed professional assistance workers, but there was no difference between exposed and nonexposed workers in the prevalence of autoantibodies.

Introduction

On October 4, 1992, a cargo aircraft crashed into 2 apartment buildings in a densely populated suburb of Amsterdam. The disaster killed 43 people and destroyed 266 apartments[1]. In addition to its sudden impact, an extensive and disturbing aftermath followed the disaster[1,2]. Through the years, media reports suggested various potential health effects and exposures, including exposure to depleted uranium from the balance weights of the aircraft[3,4]. However, in retrospective risk evaluations it was concluded that given the exposure to hazardous materials during the disaster, excess morbidity was unlikely in the people affected by it[4,5].

In 1998, some cases of autoimmune diseases, and combinations of symptoms that could indicate, autoimmunity came to light in a health inventory of the affected inhabitants and workers[6]. Scientific research has demonstrated the effects of various kinds of stressors, such as disasters, on the human immune system and its functioning[7,8]. Some of these effects may increase susceptibility to diseases such as autoimmune diseases. In addition, exposure to various xenobiotics, including heavy metals, has been associated with the occurrence of autoimmune reactions, for example, autoantibodies and autoimmune diseases[9,10].

We aim to assess the long-term autoimmune health effects of occupational exposure to the aircraft disaster as part of the Epidemiological Study Air Disaster in Amsterdam (ESADA)[11]. To this end, we investigated whether professional assistance workers exposed to this disaster differ from their nonexposed colleagues with respect to prevalence rates of self-reported autoimmune-like symptoms and autoantibodies.

Methods

The study protocol of the ESADA has been published previously[11], but the relevant parts are described herein. The ESADA can be characterized as a historical cohort study, with self-reported exposure status.

Participants

The study population comprised 3 occupational groups: (a) all (exposed and nonexposed) professional firefighters employed in the Amsterdam fire department on the date of the disaster (additional nonexposed firefighters who started working in this fire department after the disaster were also invited to participate because almost the entire fire department had been exposed to the disaster); (b) all (exposed and nonexposed) police officers employed in the Amsterdam-Amstelland Regional Police Force on the date of the disaster and still employed there on January 1, 2000; and (c) all so-called hangar workers who were registered as working for the departments involved in the transport, security, and sorting of the wreckage on the date of the disaster and who reported that they had been involved in these activities and a random sample of

their colleagues, matched for age, sex, department, and job title, who were registered as working for these departments on November 30, 1992, but who did not report that they had been involved in these disaster-related activities.

A questionnaire assessed occupational exposure to the aircraft disaster regarding various disaster-related tasks, including rescuing people, identifying victims and human remains, firefighting, cleaning up, and sorting the wreckage. We defined workers who reported performing at least 1 disaster-related task as being occupationally exposed and all others as not being occupationally exposed.

Procedures and data collection

The medical ethics committees of both medical centers involved in the ESADA approved the study protocol. All participants signed informed consent forms and participated voluntarily. Data were collected at an outpatient clinic in Amsterdam (the Onze Lieve Vrouwe Gasthuis) and, for approximately half the hangar workers, at Schiphol Airport between January 1, 2000, and March 1, 2002 (a mean of 8.5 years after the disaster). Workers were asked to complete questionnaires assessing, in sequence, disaster exposure, health outcomes, and socio-demographical characteristics. Data from the questionnaires were entered twice, after which inconsistencies were reviewed and mistakes rectified. Trained medical assistants collected blood, urine, and saliva samples from the workers. Blood samples were centrifuged and transported within 2 hours to the Medical Immunology Laboratory at the VU University Medical Center for autoantibody analysis (see 'Autoantibodies' section below). The laboratory technicians were unaware of the exposure and health status of the participants. Besides autoantibodies, other laboratory outcomes were assessed, including (differential) leukocyte count, C-reactive protein level, and salivary cortisol concentration[11].

Autoimmune-like symptoms

Based on a questionnaire assessing the presence (yes or no) of physical symptoms, we defined 11 symptoms that may occur in patients with autoimmune diseases ("autoimmune-like symptoms"):

1. Inflammatory joint or low back pain: current low back pain or pain in other joints for at least 3 consecutive months indicating an inflammatory origin. We defined inflammatory low back pain as low back pain that is most severe at night or when getting out of bed in the morning but not after moving around. For joint pain, we assumed an inflammatory origin if 2 additional conditions were met: the pain was accompanied by stiffness and there was swelling in 1 or more joints for at least 3 consecutive months.
2. Skin abnormalities: at least 1 of the following 3 symptoms: strong and sustained oversensitivity of the skin to sunlight, redness in the shape of a butterfly on the nose and cheeks, that becomes worse in sunlight, and tightness of the skin in the past 3 months.

3. Infection proneness: excessive occurrence of infections or unexplained fever in the past 3 months.
4. Vasculitis-like symptom(s): at least 1 of the following 3 symptoms: inflamed (painful) arteries in the past 3 months; (unexplained) small bluish spots (resembling bruises), with or without sores; and numerous oral ulcers for a long time.
5. Tingling sensations: tingling sensations in the past 3 months.
6. Nocturnal transpiration: regular and excessive sweating at night during the past 3 months.
7. Myalgia: an unusually high level of muscle pain in the past 3 months.
8. Loss of strength: an unusual loss of strength in the past 3 months.
9. Easily fatigued: being unusually easily fatigued in the past 3 months.
10. Feeling of sand in the eyes: feeling of sand in the eyes for a long time.
11. Raynaud discoloring: white-blue-red discoloration of the fingers or toes for a long time.

Autoantibodies

Serum samples were aliquoted and stored at -30°C until they were analyzed for the presence (defined as positive test results, unless stated otherwise) of autoantibodies by using the following assays:

Antinuclear antibodies of the IgG class: indirect immunofluorescence performed on commercially obtained slides covered with HEp-2 cells (Immuno Concepts, Sacramento, Calif) according to the manufacturer's instructions (serum dilution in a ratio of 1:40); positive test results were characterized by the fluorescence pattern.

Anti-double-stranded DNA antibodies (total immunoglobulin): routine diagnostic procedure using an indirect immunofluorescence technique with *Crithidia luciliae* as substrate[12] and serum samples diluted in a ratio of 1:10; considered only in serum samples with positive, homogenous antinuclear antibodies.

IgG antibodies against extractable nuclear antigen: enzyme-linked immunosorbent assays (ELISAs) (Hycor Biomedical Inc, Garden Grove, Calif) performed according to the manufacturer's instructions; screening was performed using a mixture of 6 antigens, and positive serum samples were subsequently tested using individual ELISAs for SS-A, SS-B, Sm, Sm/RNP, Scl-70 and Jo-1.

IgM rheumatoid factor: routine diagnostic procedure using an ELISA based on heat-aggregated rabbit IgG[13]; rheumatoid factor was considered to be present if the concentration exceeded 20 IU/mL.

Antineutrophil cytoplasmic IgG antibodies against proteinase 3 and against myeloperoxidase: ELISAs (Hycor Biomedical Inc) performed according to the manufacturer's instructions.

IgM and IgG anticardiolipin antibodies: routine diagnostic procedure using an ELISA based on purified cardiolipin; cofactors, such as β_2-glycoprotein I, were

provided by a second incubation of the cardiolipin-coated plates with newborn calf serum, and the results were standardized according to the Harris directives[14,15].

Sociodemographic characteristics

Questionnaires assessed the following sociodemographic characteristics of the workers, as described previously[1]: age, sex (male vs female), ethnicity (other/non-European vs European), cigarette smoking (current or former vs never), alcohol consumption (none or light-moderate vs [extremely] excessive), highest level of education completed (low or medium vs high), and executive function (ie supervising ≥1 workers: yes vs no).

Statistical analysis

Sociodemographic characteristics of exposed vs nonexposed workers were analyzed using *t* tests for independent groups (age) and Pearson χ^2 (all others). We used logistic (prevalence of autoimmune-like symptoms and autoantibodies) and Poisson (number of autoimmune-like symptoms) regression analyses to compare exposed and nonexposed workers. Besides crude analyses, we adjusted for the previously mentioned sociodemographic characteristics, if applicable. For infection proneness and nocturnal transpiration, we ruled out seasonal effects by adding a dichotomous variable indicating the month of assessment (September through April versus all other months). We regarded 2-sided $P < 0.05$ as statistically significant, and we performed Poisson regression analyses using Stata version 7 (Stata Corp, College Station, Tex) and all other analyses using SPSS version 10.1 (SPSS Inc, Chicago, Ill).

Missing values

Health outcome data were almost complete (overall, 96.6%; symptoms, 96.9%; and autoantibodies, 99.8%). Workers with missing values for a particular health outcome were excluded from that specific statistical analysis. To avoid excluding additional workers from adjusted regression analysis, we replaced missing values with median values of each subgroup for sociodemographic characteristics with less than 5% missing values (ie, alcohol consumption, cigarette smoking, ethnicity, and executive function). For level of education (>5% missing values), we added a "missing" category in adjusted regression analyses. Data on age, sex, and season of assessment were complete.

Results

Response

Almost the entire study population could be invited to participate (n=3643 [97%]), and 2564 workers agreed to participate: 71% of the firefighters, 71% of the police officers, and 70% of the hangar workers. As described previously, we included 2499 workers in the statistical analyses: 528 firefighters (63% exposed), 1468 police officers (57% exposed), and 503 hangar workers (48% exposed)[1]. The reference group of hangar workers was further subdivided into a nonexposed reference group (21%) and visitors (31%), who reported that they had visited the hangar with the wreckage but had not performed disaster-related tasks. Table 1 gives the sociodemographic characteristics of all the workers. In general, exposed and nonexposed workers were comparable, with some small, statistically significant, differences. However, exposed firefighters were, on average, more than 10 years older than nonexposed firefighters.

Table 1: Sociodemographic characteristics of 2499 exposed, nonexposed and visiting professional assistance workers

	Firefighters		Police officers		Hangar workers		
Characteristic	Exposed (n=334)	Nonexposed (n=194)	Exposed (n=834)	Nonexposed (n=634)	Exposed (n=241)	Nonexposed (n=104)	Visitors (n=158)
Age, mean (SD), y	51.4 (5.9)*	38.8 (9.1)	44.0 (6.2)†	44.8 (7.0)	43.9 (7.8)	43.4 (7.8)	43.5 (7.9)
Sex, %			†				
M	100	100	88.5	84.9	100	100	100
F	0	0	11.5	15.1	0	0	0
Level of education, %	†						
Low	58.7	50.5	20.7	19.7	42.7	44.2	45.6
Medium	27.5	35.1	52.5	51.1	44.4	41.3	40.5
High	6.3	10.3	20.9	23.3	7.5	5.8	7.0
Missing	7.5	4.1	5.9	5.8	5.4	8.7	7.0
Alcohol consumption, %‡	§						
No	4.2	12.4	11.4	8.2	10.8	9.6	6.3
Low/ moderate	72.8	70.6	74.3	75.7	71.8	67.3	72.8
Excessive	23.1	17.0	14.3	16.1	17.4	23.1	20.9
Cigarette smoking, %‡	†		†				
Never	32.0	44.8	33.1	27.9	34.4	29.8	36.7
Formerly	35.0	29.4	31.7	38.0	31.1	29.8	24.1
Currently	32.9	25.8	35.3	34.1	34.4	40.4	39.2
Ethnicity, %‡							
European	100	100	97.2	98.4	96.7	95.2	93.0
Other	0	0	2.8	1.6	3.3	4.8	7.0
Executive function, %‡	*				†		†
Yes	42.5	20.6	40.3	41.2	34.4	21.2	29.7
No	57.5	79.4	59.7	58.8	65.6	78.8	70.3

*P < 0.001 by *t* test for independent groups (age) and Pearson χ^2 analysis (all others), with nonexposed as the reference group.
†P < 0.05 by *t* test for independent groups (age) and Pearson χ^2 analysis (all others), with nonexposed as the reference group.
‡Missing values (<5%) were replaced by median values within each subgroup.
§P < 0.01 by using Pearson χ^2 analysis, with nonexposed as the reference group.

Autoimmune-like symptoms

Table 2 (firefighters and police officers) and Table 3 (hangar workers) provide the results regarding autoimmune-like symptoms. Exposed workers and visitors reported 1 or more autoimmune-like symptoms significantly more often than nonexposed colleagues. In addition, exposed workers and visitors reported significantly more

autoimmune-like symptoms than their nonexposed colleagues. Compared with their nonexposed colleagues, exposed workers reported the following autoimmune-like symptoms significantly more often: tingling sensations, myalgia, loss of strength, easily fatigued, and a feeling of sand in the eyes (all occupational groups); infection proneness (firefighters); skin abnormalities, and nocturnal transpiration (police officers and hangar workers); and vasculitis-like symptoms and Raynaud discoloring (police officers). Visitors reported being easily fatigued and skin abnormalities significantly more often than nonexposed hangar workers. In contrast, no difference between exposed or visiting workers and nonexposed workers was found for inflammatory joint or low back pain.

The main complaints of police officers with skin abnormalities, infection proneness, and vasculitis-like symptoms were oversensitivity of the skin to sunlight, excessive occurrence of infections, and (unexplained) bluish spots and numerous oral ulcers, respectively (data not shown). Oversensitivity to sunlight was also the main complaint reported by hangar workers with skin abnormalities.

Table 2: Autoimmune-like Symptoms Reported by Exposed and Nonexposed Firefighters and Police Officers*

	Firefighters				Police Officers			
	Exposed	Nonexposed	ORs or IRRs (95%CIs)		Exposed	Nonexposed	ORs or IRRs (95%CIs)	
Symptom	(n=334)	(n=194)	Crude	Adjusted	(n=834)	(n=634)	Crude	Adjusted
Inflammatory joint or low back pain	6.3	6.2	1.0 (0.49-2.1)	0.63 (0.26-1.6)†	8.4	6.9	1.2 (0.83-1.8)	1.2 (0.83-1.8)†
Skin abnormalities	10.5	3.6	3.1 (1.4-7.2)‡	2.3 (0.83-6.2)†	13.1	3.6	4.0 (2.5-6.3)§	4.4 (2.8-7.1)†§
Infection proneness	4.2	0.5	8.5 (1.1-64.9)‖	32.3 (2.9-365.0)‡¶	5.9	3.9	1.5 (0.93-2.5)	1.6 (0.95-2.6)#
Vasculitis-like symptoms	3.6	2.6	1.4 (0.49-4.1)	1.4 (0.34-5.9)†	5.9	1.6	3.9 (2.0-7.8)§	3.9 (2.0-7.9)†§
Tingling sensations	14.7	5.7	2.9 (1.5-5.7)‡	2.5 (1.1-5.7)†‖	16.2	8.1	2.2 (1.6-3.1)§	2.3 (1.6-3.2)†§
Nocturnal transpiration	18.9	9.8	2.1 (1.2-3.7)‡	1.3 (0.64-2.5)#	19.5	8.5	2.6 (1.9-3.6)§	2.8 (2.0-3.9)§#
Myalgia	15.6	1.5	11.7 (3.6-38.0)§	10.8 (2.9-40.7)†§	11.1	5.8	2.0 (1.3-3.0)‡	2.1 (1.4-3.1)†§
Loss of strength	10.6	1.5	7.5 (2.3-24.8)‡	10.4 (2.5-43.0)†‡	8.8	3.5	2.7 (1.6-4.4)§	2.8 (1.7-4.5)†§
Easily fatigued	19.6	6.2	3.7 (1.9-7.0)§	3.0 1.4-6.7)†‡	22.8	10.1	2.6 (1.9-3.6)§	2.7 (2.0-3.7)†§
Feeling of sand in the eyes	17.1	3.6	5.5 (2.5-12.4)§	5.2 (2.0-13.9)†	13.6	4.9	3.0 (2.0-4.6)§	3.1 (2.1-4.7)†§
Raynaud discoloring	2.7	0	NA		4.0	1.6	2.6 (1.3-5.3)#	2.7 (1.3-5.6)†‡
≥1 Symptom	54.5	23.7	3.9 (2.6-5.7)§	3.0 (1.8-5.0)†§	54.9	32.0	2.6 (2.1-3.2)§	2.7 (2.2-3.4)†§
Symptoms, No., median (IQR)	1.0 (2.0)	0.0 (0.0)	3.0 (2.4-3.8)§	2.6 (1.9-3.4)†§	1.0 (2.0)	0.0 (1.0)	2.2 (2.0-2.5)§	2.3 (2.0-2.5)†§

Abbreviations: CIs, confidence intervals; IQR, interquartile range; IRRs, incidence rate ratios; NA, not applicable owing to the absence of the symptom in nonexposed firefighters; ORs, odds ratios. *Data are given as percentage and crude and adjusted ORs for each symptom and for 1 or more symptoms and as median (IQR) and crude and adjusted IRRs for number of symptoms, with nonexposed workers as the reference group. †Adjusted for age, alcohol consumption, cigarette smoking, level of education, executive function, and, for police officers only, sex and ethnicity. ‡$P < 0.01$. § $P < 0.001$. # $P < 0.05$. ¶ Adjusted for season of assessment, age, alcohol consumption, cigarette smoking, and executive function. # Adjusted for season of assessment, age, alcohol consumption, cigarette smoking, level of education, executive function, and, for police officers only, sex and ethnicity.

Table 3: Autoimmune-like Symptoms Reported by Exposed, Nonexposed and Visiting Hangar Workers*

	Hangar workers						
			ORs or IRRs (95%CIs), Exposed vs Nonexposed			ORs or IRRs (95%CIs), Visitors vs Nonexposed	
Symptom	Exposed (n=241)	Nonexposed (n=104)	Crude	Adjusted	Visitors (n=158)	Crude	Adjusted
Inflammatory joint or low back pain	6.7	9.7	0.67 (0.29-1.5)	0.67 (0.29-1.6)†	8.9	0.91 (0.39-2.1)	0.97 (0.41-2.3)†
Skin abnormalities	10.4	1.9	5.9 (1.4-25.3)‡	6.7 (1.5-38.9)†‡	11.4	6.5 (1.5-28.8)‡	6.5 (1.5-29.1)†‡
Infection proneness	5.0	1.0	5.4 (0.70-42.2)	5.1 (0.63-40.7)§	4.4	4.8 (0.58-39.4)	4.7 (0.56-38.8)§
Vasculitis-like symptoms	5.0	0	NA	NA	5.7	NA	NA
Tingling sensations	18.7	8.7	2.4 (1.1-5.2)‡	2.6 (1.2-5.7)†‡	14.1	1.7 (0.76-3.9)	1.7 (0.74-3.9)†
Nocturnal transpiration	25.8	7.8	4.1 (1.9-9.0)‖	4.8 (2.2-10.8)‖¶	3.4	1.8 (0.78-4.3)	2.0 (0.85-4.9)¶
Myalgia	24.5	8.7	3.4 (1.6-7.2)#	3.6 (1.7-7.7)†#	13.9	1.7 (0.75-3.9)	1.7 (0.73-3.9)†
Loss of strength	19.5	5.8	4.0 (1.6-9.6)#	5.1 (2.0-12.7)†#	7.6	1.3 (0.49-3.7)	1.4 (0.50-4.0)†
Easily fatigued	36.5	11.5	4.4 (2.3-8.5)‖	5.0 (2.5-9.8)†‖	24.7	2.5 (1.2-5.1)‡	2.6 (1.3-5.4)†#
Feeling of sand in the eyes	16.6	6.7	2.8 (1.2-6.4)‡	2.7 (1.2-6.3)†‡	13.3	2.1 (0.87-5.2)	2.1 (0.85-5.2)†
Raynaud discoloring	3.3	2.9	1.2 (0.30-4.4)	1.1 (0.29-4.4)**	2.5	0.88 (0.19-4.0)	0.88 (0.19-4.0)**
≥1 Symptom	61.8	35.6	2.9 (1.8-4.7)‖	3.1 (1.9-5.1)†‖	54.4	2.2 (1.3-3.6)#	2.2 (1.3-3.7)#‡
Symptoms, No., median (IQR)	1.0 (3.0)	0.0 (1.0)	2.7 (2.1-3.5)‖	2.8 (2.1-3.6)†‖	1.0 (2.0)	1.9 (1.4-2.5)‖	1.9 (1.4-2.5)†‖

Abbreviations: CIs, confidence intervals; IQR, interquartile range; IRRs, incidence rate ratios; NA, not applicable owing to the absence of the symptom in nonexposed hangar workers; ORs, odds ratios.
*Data are given as percentage and crude and adjusted ORs for each symptom and for 1 or more symptoms and as median (IQR) and crude and adjusted IRRs for number of symptoms, with nonexposed workers as the reference group. †Adjusted for age, ethnicity, alcohol consumption, cigarette smoking, level of education, and executive function. ‡$P < 0.05$. §Adjusted for season of assessment, age, ethnicity, level of education, and executive function. ‖ $P < 0.001$. ¶Adjusted for season of assessment, age, ethnicity, alcohol consumption, cigarette smoking, level of education, and executive function. # $P < 0.01$. **Adjusted for age, cigarette smoking, and executive function.

Autoantibodies

Table 4 (firefighters and police officers) and Table 5 (hangar workers) give the results regarding the autoantibodies. We found no significant difference between exposed or visiting workers and their nonexposed colleagues in the prevalence of autoantibodies. Only 11 workers had IgG antibodies against extractable nuclear antigens, that is, less than 1% in each group. Further subtyping of these 11 workers revealed antibodies gainst SS-A (n=9), SS-B (n=4), Sm (n=1), Sm/RNP (n=1), Scl-70 (n=1), and Jo-1 (n=1) antigens. One of these workers had SS-A, SS-B and Sm; another had SS-A and Scl-70; and 3 had SS-A and SS-B antigens.

Table 4: Autoantibodies in Exposed and Nonexposed Firefighters and Police Officers*

	Firefighters				Police Officers			
	Exposed	Nonexposed	ORs or IRRs (95%CIs)		Exposed	Nonexposed	ORs or IRRs (95%CIs)	
Autoantibody	(n=334)	(n=194)	Crude	Adjusted	(n=834)	(n=633)	Crude	Adjusted
ANAs	10.8	6.7	1.7 (0.87-3.3)	1.0 (0.46-2.3)†	10.4	10.3	1.0 (0.73-1.4)	1.0 (0.74-1.5)†
Homogenous	5.4	0.5	10.9 (1.5-81.9)‡	3.6 (0.45-28.1)§	4.4	4.4	1.0 (0.60-1.6)	1.1 (0.66-1.8)†
Nonhomogenous	5.4	6.2	0.86 (0.41-1.8)	0.84 (0.31-2.2)†	6.0	5.4	1.1 (0.71-1.8)	1.1 (0.69-1.7)†
Anti-double-stranded DNA#	0.3	0	NA	NA	0.2	0.2	NA	NA
Anti-ENA	0.6	0.5	NA	NA	0.5	0.3	NA	NA
RF >20 IU/mL	1.2	1.0	1.2 (0.21-6.4)	0.55 (0.069-4.4)†	0.84	1.0	0.89 (0.30-2.7)	0.91 (0.30-2.7)¶
ANCAs								
PR3	0.3	0.5	NA	NA	0.8	0.6	NA	NA
MPO	0	0	NA	NA	0	0	NA	NA
Anticardiolipins								
IgG	10.2	7.2	1.5 (0.76-2.8)	1.5 (0.60-3.5)†	6.4	7.6	0.83 (0.55-1.2)	0.84 (0.56-1.3)†
IgM	3.9	2.6	1.5 (0.54-4.4)	2.3 (0.53-9.5)§	1.4	2.5	0.56 (0.26-1.2)	0.53 (0.25-1.1)†
≥1 Autoantibody	24.0	17.0	1.5 (0.98-2.4)	1.3 (0.72-2.3)†	18.8	21.3	0.86 (0.66-1.1)	0.87 (0.67-1.1)†

Abbreviations: ANAs, antinuclear antibodies; ANCAs, antineutrophil cytoplasmic IgG antibodies against myeloperoxidase (MPO) and against proteinase 3 (PR3); anti-ENA, IgG antibodies against extractable nuclear antigen; CIs, confidence intervals; NA, not applicable owing to low prevalence; ORs, odds ratios; RF, rheumatoid factor. *Data are given as percentage and crude and adjusted ORs for each individual and for 1 or more autoantibodies, with nonexposed workers as the reference group. †Adjusted for age, alcohol consumption, cigarette smoking, level of education, executive function, and, for police officers only, sex and ethnicity. ‡ $P < 0.05$. §Adjusted for age, alcohol consumption, cigarette smoking, and executive function. #Anti-double-stranded DNA antibodies were assessed only in cases of homogenous ANA test results; in all other cases, anti-double-stranded DNA were assumed to be negative. ¶Adjusted for age, sex, alcohol consumption, cigarette smoking, level of education, and executive function.

Table 5: Autoantibodies in Exposed, Nonexposed and Visiting Hangar Workers*

	Hangar workers						
			ORs or IRRs (95%CIs), Exposed vs Nonexposed			ORs or IRRs (95%CIs), Visitors vs Nonexposed	
Autoantibody	Exposed (n=241)	Nonexposed (n=104)	Crude	Adjusted	Visitors (n=158)	Crude	Adjusted
ANAs	7.9	10.6	0.72 (0.33-1.6)	0.82 (0.37-1.8)†	9.5	0.89 (0.39-2.0)	0.88 (0.38-2.0)†
Homogenous	2.9	5.8	0.49 (0.16-1.5)	0.48 (0.15-1.6)‡	3.8	0.65 (0.20-2.1)	0.55 (0.16-1.9)‡
Nonhomogenous	5.0	4.8	1.0 (0.36-3.0)	1.2 (0.40-3.5)†	5.7	1.2 (0.39-3.7)	1.2 (0.39-3.8)†
Anti-double-stranded DNA§	0	1.0	NA	NA	0	NA	NA
Anti-ENA	0.4	0	NA	NA	0.6	NA	NA
RF>20 IU/mL	0.41	0	NA	NA	0	NA	NA
ANCAs							
PR3	0.4	0	NA	NA	1.3	NA	NA
MPO	0	0	NA	NA	0	NA	NA
Anticardiolipins							
IgG	5.8	6.7	0.86 (0.34-2.2)	0.89 (0.34-2.3)†	5.7	0.84 (0.30-2.3)	0.91 (0.32-2.6)†
IgM	1.7	3.8	0.42 (0.10-1.7)	0.42 (0.099-1.8)#	0.6	0.16 (0.018-1.4)	0.15(0.016-1.4)#
≥1 Autoantibody	13.7	18.3	0.71 (0.38-1.3)	0.79 (0.42-1.5)†	17.1	0.92 (0.48-1.8)	0.99 (0.51-1.9)†

Abbreviations: ANAs, antinuclear antibodies; ANCAs, antineutrophil cytoplasmic IgG antibodies against myeloperoxidase (MPO) and against proteinase 3 (PR3); anti-ENA, IgG antibodies against extractable nuclear antigen; CIs, confidence intervals; NA, not applicable owing to low prevalence; ORs, odds ratios; RF, rheumatoid factor. *Data are given as percentage and crude and adjusted ORs for each individual and 1 or more autoantibodies, with nonexposed workers as the reference group. †Adjusted for age, ethnicity, alcohol consumption, cigarette smoking, level of education, and executive function. ‡Adjusted for age, ethnicity, cigarette smoking, level of education, and executive function. §Anti-double-stranded antibodies were assessed only in case of homogenous ANA test results, in all other cases anti-double-stranded antibodies were assumed to be negative. #Adjusted for age, alcohol consumption, cigarette smoking, and executive function.

Comment

The results of this study show that, a mean of 8.5 years after the aircraft disaster in Amsterdam, occupationally exposed firefighters, police officers, and hangar workers report more autoimmune-like symptoms than their nonexposed colleagues. However, no difference in autoantibody prevalence was found between exposed and nonexposed workers. The excess prevalence of several autoimmune-like symptoms in exposed workers, particularly of the more specific symptoms, that is, skin abnormalities, vasculitis-like symptoms, and Raynaud discoloring, could indicate a systemic autoimmune or other pathological process. (Auto)immune health effects of psychological stress and certain hazardous materials have also been suggested in other studies[7-10]. However, as mentioned previously herein, we found no significant difference between exposed and nonexposed workers in the prevalence of autoantibodies. Furthermore, the overall prevalence rates of antinuclear antibodies and anticardiolipin autoantibodies in the present study population also resembled those found in other samples of apparently healthy blood donors and the general population[16-21]. It is also unlikely that we found an "early-stage" systemic autoimmune effect, but not yet detected by means of autoantibodies, because of the considerable period between the disaster and the assessment. Moreover, we also found virtually no statistically significant differences between exposed and nonexposed workers regarding the various other hematologic and biochemical clinical outcomes in blood, urine, and saliva (data not shown)[11]. Thus, we did not find a physiologic basis for the excess in autoimmune-like symptoms among exposed workers. However, we cannot exclude a physiologic but unmeasured basis for these symptoms.

Posttraumatic stress disorder (PTSD) could also play a role in the assessment of autoimmune health effects of disaster exposure; there is a large body of literature on the co-occurrence of PTSD and adverse physical health outcomes after traumatic events[8]. However, adding PTSD symptoms to our multivariate model did not essentially change the effect of exposure. We also found no significant interaction between exposure and PTSD symptoms with respect to the number of autoimmune-like symptoms. Still, irrespective of exposure, the presence of PTSD symptoms was positively and statistically significantly associated with most of the autoimmune-like symptoms (as opposed to the autoantibodies). A (mediating) role of PTSD symptoms in the excess of reported autoimmune-like symptoms in exposed workers is thus probably limited.

Because we found no physiological basis for and no substantial role of PTSD symptoms in the excess of autoimmune-like symptoms in exposed workers, we may rather deal with a phenomenon commonly described as "unexplained physical symptoms" and "functional somatic syndrome"[22], that is, physical symptoms without sufficient objective, demonstrable pathological abnormalities. This may also reflect a tendency of exposed workers to "overreport" symptoms because they are (unconsciously) more likely to interpret and report bodily sensations as symptoms[23,24].

Media reports on individual victims with multiple symptoms that they attributed to the disaster may have amplified this phenomenon[3].

Unexplained physical symptoms have been described after various other stressful events[8], particularly when exposure to hazardous materials was feared, such as technological disasters and incidents[25,26] and war service[27]. After the aircraft disaster, the media reported on various alleged disaster-related exposures, including depleted uranium from the aircraft's balance weights[1]. Therefore, fear of exposure may have also affected symptom reporting by the exposed firefighters and police officers, who mostly performed assistance activities at the disaster site, and the hangar workers, who sorted the wreckage and its balance weights. The prevalence rates of symptoms reported by hangar workers who visited the hangar with the wreckage are mainly in between those of exposed and nonexposed hangar workers.

The methodological strengths of the ESADA are the inclusion of highly comparable reference groups, the fact that almost the entire study population could be invited to participate (97%), the high response rate of 70% of those invited to participate, the considerably large study population, and the completeness and extensiveness of the data. However, some limitations should also be mentioned. One limitation is that only self-reported data on autoimmune-like symptoms are available, with no clinical assessment of these symptoms and their assumed link with autoimmunity. Furthermore, the invitation to the study and assessment of disaster exposure may have affected symptom reporting among exposed workers, particularly if they attributed any symptoms to the disaster. A similar effect on autoantibody prevalence seems unlikely. Thus, we cannot exclude the possibility of overestimating the effect of exposure on symptoms due to such reporting bias. Also, we cannot rule out that exposed workers might have overreported symptoms for reasons of financial compensation. Another methodological weakness is the interval of, on average, 8.5 years between the disaster and the assessment of exposure. Although we cannot exclude recall bias, it seems reasonable to assume that the workers remembered whether they performed any (as opposed to no) disaster-related tasks, which we used to define exposure. Therefore, (non-)differential misclassification with respect to exposure is probably limited.

The results of our analysis among the professional firefighters are limited by the fact that the nonexposed workers were younger than the exposed firefighters. This was unavoidable because almost the entire fire department was involved in the disaster, so we had to include new nonexposed firefighters who joined this fire department after the disaster. The applied statistical adjustments for age and other potential confounding sociodemographic characteristics may not have fully accounted for this systematic difference between exposed and nonexposed firefighters.

We further acknowledge that we performed multiple statistical tests using $P < .05$ as a cut-off value for statistical significance. Consequently, it is possible that some of the statistically significant differences between exposed and nonexposed workers are due to chance. However, most of the statistically significant (adjusted) differences

between exposed and nonexposed workers have a $P < .001$, which would most likely also be statistically significant after adjustment for multiple testing. A final limitation concerns the fact that some autoimmune-like symptoms and autoantibodies occurred too rarely to be able to calculate interpretable odds ratios between exposed and nonexposed workers.

In conclusion, the results of this epidemiologic study show that occupational exposure to the 1992 aircraft disaster resulted in an excess of long-term self-reported autoimmune-like symptoms in exposed professional assistance workers but that there is no difference between exposed and nonexposed workers in the prevalence of autoantibodies. These results suggest that disaster workers are at risk for long-term physical symptoms even after 8.5 years and underline the importance of developing optimal aftercare programs for disaster workers after future technological disasters with real and alleged exposure to hazardous materials.

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5

Post-disaster physical symptoms of firefighters and police officers: role of types of exposure and posttraumatic stress symptoms

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Submitted

Abstract

Objective

To examine relationships between (types of) exposure to the air disaster in Amsterdam and multiple long-term physical symptoms of firefighters and police officers, and the role of posttraumatic stress symptoms herein.

Methods

Historic cohort study, with exposure status based on self-report, among professional firefighters and police officers who were occupationally exposed to the disaster (n=334 and n=834, respectively) and their nonexposed colleagues (n=194 and n=634, respectively). On average 8.5 years post-disaster, questionnaires assessed (types of) occupational disaster exposure, current physical and posttraumatic stress symptoms, and background characteristics.

Results

Multivariate logistic regression analysis showed that exposed workers reported multiple physical symptoms significantly more often than nonexposed colleagues. Multiple physical symptoms seemed to have particularly affected those exposed firefighters who rescued people, and those exposed police officers who supported injured victims and workers, who were involved in the identification or recovery of or search for victims and human remains, who witnessed the immediate disaster scene, or had a close one affected by the disaster. Adding posttraumatic stress symptoms to the multivariate models did not essentially change these effects of (types of) exposure. No significant interactions between exposure status and posttraumatic stress symptoms were found.

Conclusions

The study shows an excess in multiple long-term physical symptoms after the air disaster in Amsterdam among exposed professional firefighters and police officers which could not substantially be attributed to posttraumatic stress symptoms. The finding that professional assistance workers are at risk for multiple long-term physical symptoms, underlines the need for prospective research on risk factors and preventive measures.

Introduction

In 1992 a cargo aircraft crashed into apartment buildings in Amsterdam, killing 43 people and destroying 266 apartments[1]. An extensive aftermath followed, in which various potential disaster-related exposures and health effects were publicly discussed[1-3]. However, no public health risk was predicted in retrospective evaluations on exposures related to the destroyed apartment buildings, and the aircraft, including its cargo and balance weights of depleted uranium[4,5]. The air disaster in Amsterdam is an example of a man-made disaster, i.e. a sudden collective stressful experience due to technological failure. Previous major technological disasters around the world have caused mortality and morbidity [e.g. 6-8]. They also had psychiatric consequences, notably posttraumatic stress disorder[9-12]. It also becomes increasingly recognised that victims of disasters may develop physical symptoms without sufficient or apparent medical explanation[13]. These so-called, yet ill-defined, medically 'unexplained physical symptoms' have been described particularly in communities and military samples faced with stressful events involving (alleged) exposure to hazardous materials[14-20].

A recent literature review of unexplained physical symptoms in communities struck by disaster identified some consistent risk factors, such as a high degree of physical damage and female gender[13]. Furthermore, evidence was found suggesting that posttraumatic stress symptoms is a perpetuating factor, i.e. a post-disaster factor that maintains or exacerbates unexplained physical symptoms. A mediating role of posttraumatic stress symptoms between exposure to traumatic events and the development of unexplained physical symptoms has also been postulated[21]. In any case, co-occurrence of and associations between posttraumatic stress symptoms and physical health problems have frequently been demonstrated[22-27].

Most of the evidence linking disaster to physical health effects is based on communities struck by disaster and military samples. Less is known about the physical health effects of disasters on professional assistance workers. The few published studies that have addressed this, suggested that these workers are also at risk for physical morbidity and physical symptoms[28-32]. Starting in 2000, the Epidemiological Study Air Disaster in Amsterdam (ESADA) aimed to assess long-term health effects in professional assistance workers who were occupationally exposed to this disaster[33]. Previously, elevated prevalence rates of self-reported physical and psychological symptoms were reported among exposed workers compared with nonexposed colleagues, without accompanying consistent differences in clinical laboratory outcomes in blood and urine[34,35]. The present study is based on the ESADA and aims to assess the relationship between (types of) disaster exposure and the occurrence of multiple long-term physical symptoms among professional firefighters and police officers. In addition, the potential mediating or moderating role of posttraumatic stress symptoms in this relationship will be explored.

Methods

This paper is based on data of the ESADA, of which the study design is described in detail elsewhere[33]. Briefly, the ESADA can be characterized as a historical cohort study, with self-reported exposure status.

Study population and data collection

The study population used in this paper comprised two occupational groups: (1) the professional firefighters who were employed in the Amsterdam fire department on the date of the disaster; and (2) the police officers who were employed in the Amsterdam-Amstelland regional police force on the date of the disaster and still were on January 1, 2000. In addition, firefighters who started working in the Amsterdam fire department after the disaster were also invited to participate, as almost the entire fire department had been exposed to the disaster.

The Medical Ethics Committees of both medical centres involved in the ESADA approved the study protocol. All participants signed informed consent and participated voluntarily. Data collection took place from January 1, 2000, to March 1, 2002, i.e. on average 8.5 years after the disaster.

Occupational disaster exposure

All workers were asked to complete a detailed questionnaire on occupational exposure to the disaster. Workers reporting at least one disaster-related task (including 'other' tasks) were defined as (occupationally) 'exposed'; all others as 'nonexposed'. In addition, type of exposure was characterised by the following aspects:

(a) A series of disaster-related tasks: rescuing people, firefighting, identification and recovery of or search for victims and human remains, clean-up of the disaster site, security and surveillance of the disaster area, and supporting injured victims and workers;
(b) Having witnessed the immediate disaster scene: having seen the disaster scene within the first hours after the crash or when the wreckage was still there;
(c) Having a close one affected by the disaster: having a close or beloved one(s) (i.e. family members, relatives, friends or acquaintances) affected by the disaster in any way (i.e. in life-threatening danger, injured, destroyed apartment, died, or affected in another way);
(d) Perceived severity of the disaster: the disaster and its aftermath was 'not bad', 'quite bad', 'terrible', or 'the worst thing that ever happened to me'.

Multiple physical symptoms

Three questionnaire-based definitions were used for the concept of 'multiple physical symptoms', resulting in three outcome variables:

1. Multiple 'somatic symptoms': an above average score compared to the general Dutch norm population (i.e. ≥19)[36] on the somatic symptom subscale of the Dutch version of the 90-item Symptom Checklist (SCL90)[37]. This subscale encompasses the following symptoms in the past 7 days on a 5-point scale (from not at all to all the time): headaches, faintness or dizziness, pains in heart or chest, pains in lower back, nausea or upset stomach, soreness of muscles, trouble getting breath, hot or cold spells, numbness or tingling, a lump in throat, feeling weak, and heavy feelings in arms or legs.

2. Multiple 'fatigue-related symptoms': a total score on the Checklist Individual Strength (CIS) above 76 (i.e. a cutoff score proposed for working populations[38]), which encompasses 20 items on fatigue, lack of concentration, motivation, and physical activity in the past two weeks[39].

3. Multiple 'physical symptom categories': having symptoms in at least three different categories. For this measure a list of 34 physical symptoms (currently present versus absent) that was drawn up for the ESADA was divided into 8 symptom categories according to the International Classification of Primary Care (ICPC)[40]: General and non-specified (n=4, e.g. fatigue and nocturnal transpiration); Digestive (oral ulcers); Eye (sand feeling in eye); Cardiovascular (n=3, e.g. varicose veins or leg ulcers); Musculoskeletal (n=4, e.g. chronic joint and low back pain); Neurological (loss of strength); Respiratory (n=6, e.g. chronic cough and shortness of breath); and Skin (n=14, e.g. eczema, photosensitivity of skin, and 'other'). Subsequently, the number of positive (i.e. ≥1 symptom) categories was counted, and an arbitrary cut-off of at least three was used to define having multiple physical symptom categories.

Posttraumatic stress symptoms

The Dutch version of the Self-Rating Inventory for Posttraumatic stress disorder (SRIP) was used to assess posttraumatic stress symptoms, i.e. symptoms of intrusion (six items), avoidance (nine items), and hyperarousal (seven items) during the preceding four weeks[41]. A total score of 39 or higher has been shown to indicate that a person probably suffers from posttraumatic stress disorder and this cut-off was therefore used to define presence of (a high level of) 'posttraumatic stress symptoms'[42].

Background characteristics

The following background characteristics were also collected: age, sex, ethnicity, cigarette smoking, alcohol consumption, highest level of education completed, and executive function (i.e. supervising one or more workers)[33].

Statistical analysis

The background characteristics and posttraumatic stress symptoms of exposed and nonexposed workers were compared by means of t-tests for independent groups (age), Fisher's exact test (posttraumatic stress symptoms), and Pearson χ^2 tests (all others). Comparisons between exposed and nonexposed workers regarding multiple physical symptoms were analyzed with logistic regression models, both unadjusted and adjusted for background characteristics. To avoid excluding workers from the adjusted regression analyses due to missing values on background characteristics, a 'missing' category was added for those background characteristics with more than 5% missing values (level of education), and median values (stratified according to exposure status and occupation) were imputed for the background characteristics with less than 5% missing values (all others, except age and sex for which the data were complete). The potential mediating or modifying role of posttraumatic stress symptoms was explored by adding posttraumatic stress symptoms to the adjusted regression model and, in a next step, the interaction between exposure status and posttraumatic stress symptoms.

For exposed workers, logistic regression was also used to analyze the association between multiple physical symptoms and the following types of exposure: the individual disaster-related tasks, having witnessed the immediate disaster scene, having a close one affected by the disaster (all coded as yes versus no), and perceived severity of the disaster (categorical with "worst thing that ever happened to me" as the reference category). The types of exposure were first introduced in separate ('univariate') models, after which they were all introduced together and those types of exposure with $P > 0.10$ were removed in a step-wise backward manner. Thus, the resulting multivariate model included only those types of exposure with $P \leq 0.10$. Posttraumatic stress symptoms were subsequently added to this multivariate model, in order to establish their potential influence on these associations. These univariate and multivariate analyses were adjusted for age and sex. It was decided a priori that this analysis of types of exposure would be performed only if exposed workers had multiple physical symptoms significantly more often than nonexposed workers.

All analyses were performed with SPSS (version 10.1) and two-sided P-values of less than 0.05 were regarded as statistically significant.

Results

Response

Almost the complete historic cohort of firefighters and police officers (99% of n=2924) could be traced and invited to participate in the ESADA in the year 2000. Response rate was 71% for firefighters (n=559) and police officers (n=1489). Subsequently, 31 firefighters and 21 police officers were excluded from the statistical analyses because they lived in the disaster area at the time of the disaster, had missing data on exposure status, or because no comparison was possible between exposed and nonexposed workers, i.e. only one female firefighter participated, and all 14 firefighters who were of non-European ethnicity were nonexposed. Thus, 528 firefighters (63% exposed) and 1468 police officers (57% exposed) were included in the statistical analysis.

Background characteristics and posttraumatic stress symptoms

In general, exposed and nonexposed workers were comparable regarding background characteristics, although some statistically significant differences were found (Table 1). Moreover, exposed firefighters were, on average, more than 10 years older than nonexposed firefighters. The prevalence rate of posttraumatic stress symptoms was higher among exposed than nonexposed workers; but this difference was statistically significant for police officers only (Table 1).

Table 1: Background characteristics and posttraumatic stress symptoms of exposed and nonexposed workers

	Firefighters		Police officers	
	Exposed (n=334)	Nonexposed (n=194)	Exposed (n=834)	Nonexposed (n=634)
Age, mean (SD), years	51.4 (5.9)*	38.8 (9.1)	44.0 (6.2)†	44.8 (7.0)
Sex, %			†	
Male	100	100	88.5	84.9
Female	0	0	11.5	15.1
Level of education, %	†			
Low	58.7	50.5	20.7	19.7
Medium	27.5	35.1	52.5	51.1
High	6.3	10.3	20.9	23.3
Missing	7.5	4.1	5.9	5.8
Alcohol consumption, %‡	§			
No	4.2	12.4	11.4	8.2
Low to moderate	72.8	70.6	74.3	75.7
Excessive	23.1	17.0	14.3	16.1
Cigarette smoking, %‡	†		†	
Never	32.0	44.8	33.1	27.9
Formerly	35.0	29.4	31.7	38.0
Currently	32.9	25.8	35.3	34.1
Ethnicity, %‡				
European	100	100	97.2	98.4
Other	0	0	2.8	1.6
Executive function,%‡	*		§	
No	57.5	79.4	59.7	58.8
Yes	42.5	20.6	40.3	41.2
Posttraumatic stress symptoms (SRIP ≥39), %	5.4	2.6	6.5	2.4

Abbreviations: SD= standard deviation; SRIP= Self-Rating Inventory for Posttraumatic stress disorder.
* $P < 0.001$, using t-test for independent groups (age) and Pearson χ^2 (executive function), with nonexposed as the reference group.
† $P < 0.05$, by means of t-test for independent groups (age) and Pearson χ^2 (all others), with nonexposed as the reference group. ‡ Missing values (<5%) replaced by median values within each sub-group. § $P < 0.01$, by means of Pearson χ^2 (alcohol consumption) and Fisher's Exact test (posttraumatic stress symptoms), with nonexposed as the reference group.

Multiple physical symptoms of exposed versus nonexposed workers

Exposed workers reported multiple physical symptoms significantly more often than their nonexposed colleagues, using each of the three outcome variables (i.e. somatic symptoms, fatigue-related symptoms, and ≥3 physical symptom categories) (Table 2). Adding posttraumatic stress symptoms to the regression models did not essentially change the effect of exposure status (Table 2). The percentage of change in the regression coefficient of exposure status among firefighters ranged from –16% (somatic symptoms) to –3% (≥3 physical symptom categories) compared to the analysis without posttraumatic stress symptoms. For police officers this ranged from +18% (fatigue-related symptoms) to +4% (≥3 physical symptom categories). Furthermore, no statistically significant interactions between exposure and posttraumatic stress symptoms were found (the P-values of these interactions ranged from 0.21 to 0.98 among firefighters, and from 0.19 and 0.89 among police officers).

A closer look at the 34 categorised physical symptoms indicated that exposed workers reported many of them (rather than certain selected symptoms) more often than nonexposed workers. The difference in the prevalence rates of these symptoms between exposed and nonexposed was statistically significant for 12 and 27 of the 34 symptoms among firefighters and police officers, respectively, using adjusted logistic regression analysis (data not shown).

Table 2: Prevalence of multiple physical symptoms among exposed versus nonexposed workers

	Prevalence		Odds ratio (95% confidence interval)		
	Exposed	Nonexposed	Unadjusted	Adjusted*	Adjusted + PTSS†
Firefighters, n	334	194			
Somatic symptoms	18.0 %	3.1 %	6.9 (2.9-16.3)‡	4.7 (1.8-12.4)§	6.0 (2.0-18.2)§
Fatigue-related symptoms	11.7 %	2.6 %	5.0 (1.9-12.9)§	4.4 (1.4-13.7)§	4.8 (1.4-15.7)¶
Physical symptom categories	34.4 %	8.8 %	5.5 (3.2-9.4)‡	4.4 (2.3-8.5)‡	4.6 (2.3-9.1)‡
Police officers, n	834	634			
Somatic symptoms	16.6 %	6.3 %	2.9 (2.0-4.3)‡	3.1 (2.1-4.5)‡	2.8 (1.9-4.1)‡
Fatigue-related symptoms	16.7 %	8.8 %	2.1 (1.5-2.9)‡	2.1 (1.5-2.9)‡	1.8 (1.3-2.6)§
Physical symptom categories	32.7 %	13.9 %	3.0 (2.3-3.9)‡	3.2 (2.5-4.2)‡	3.1 (2.3-4.1)‡

Legend: Somatic symptoms: score ≥19 on the subscale 'Somatic symptoms' of the 90-item Symptom Checklist; Fatigue-related symptoms: score >76 on the Checklist Individual Strength; Physical symptoms: symptoms in ≥3 symptom categories; PTSS: posttraumatic stress symptoms, i.e. score ≥39 on the Self-Rating Inventory for Posttraumatic stress disorder.
*Adjusted for background characteristics, i.e. age, level of education, alcohol consumption, cigarette smoking, executive function, and for police officers only, sex and ethnicity. †Adjusted for the above-mentioned background characteristics and posttraumatic stress symptoms. ‡ $P < 0.001$. § $P < 0.01$. ¶ $P < 0.05$.

Multiple physical symptoms according to types of exposure of exposed workers

Tables 3 and 4 give the prevalence rates of the types of exposure for exposed firefighters and police officers, respectively. Most of the exposed firefighters reported two of these tasks. About a quarter (24.6%) of them reported the combination of firefighting, clean-up of the disaster site and rescuing people. Most of the police officers reported one of these tasks. For about 64% of those reporting one task, this concerned security and surveillance.

Positive significant associations were found between multiple physical symptoms and types of exposure of firefighters (Table 3) and of police officers (Table 4). The types of exposure found to be univariately associated with multiple physical symptoms ($P \leq 0.10$), were generally also retained in the multivariate model with comparable

effect sizes. Adding posttraumatic stress symptoms to the resulting multivariate models did not essentially change the associations between multiple physical symptoms and types of exposure.

Among exposed firefighters, the multivariate analysis revealed that multiple physical symptoms (i.e. ≥3 physical symptom categories) were associated with four types of exposure (with odds ratios ranging from 1.6 to 2.0): rescuing people, clean-up of the disaster site, supporting injured victims and workers, and witnessing the immediate disaster scene (Table 3). Of these associations, only the one with rescuing people was significant. A similar effect size was also found between fatigue-related symptoms and clean-up of the disaster site ($P \leq 0.10$). In contrast, those who performed security tasks (n=11) reported at least 3 categories of physical symptoms less often ($P \leq 0.10$).

Among exposed police officers, multivariate analysis showed that multiple physical symptoms were reported significantly more often (with odds ratio's ranging from 1.5 to 2.5) by those who supported injured victims and workers (somatic symptoms), who were identification or recovery of or search for victims and human remains (≥3 physical symptom categories) who had a close one affected by the disaster, who witnessed the immediate disaster scene (both regarding ≥3 physical symptom categories) (Table 4). In addition, multiple physical symptoms were also non-significantly associated with two other types of exposure (with odds ratios ranging from 1.5 to 1.8): identification or recovery of or search for victims and human remains (fatigue-related symptoms), security and surveillance tasks (all three multiple physical symptom outcomes).

Table 3: Associations between types of exposure and multiple physical symptoms among 334 exposed firefighters*

Symptoms:	Rescuing people (n=163 [49%])	Identification or recovery of or search for victims and human remains (n=50 [15%])	Firefighting (n=199 [61%])	Clean-up the disaster site (n=180 [55%])	Security and surveillance of disaster area (n=11 [3.4%])	Support injured victims and workers (n=33 [10%])	Witnessed immediate disaster scene (n=246 [74%])	Close one affected by disaster (n=13 [3.9%])	Perceived severity of disaster 'not bad' (n=27 [8.1%])	Perceived severity of disaster 'quite bad' (n=40 [12%])	Perceived severity of disaster 'terrible' (n=219 [66%])
Somatic											
Univariate†	1.2 (0.66-2.0)	1.1 (0.53-2.4)	1.4 (0.76-2.5)	1.6 (0.90-3.0)	0.92 (0.19-4.4)	1.8 (0.79-4.1)	1.3 (0.66-2.5)	2.0 (0.58-6.6)	0.86 (0.26-2.8)	0.57 (0.17-1.8)	0.73 (0.34-1.6)
Multivariate‡	-	-	-	-	-	-	-	-	-	-	-
Multivariate‡ +PTSS	-	-	-	-	-	-	-	-	-	-	-
Fatigue-related											
Univariate†	1.3 (0.66-2.6)	0.81 (0.30-2.2)	1.7 (0.83-3.7)	2.0 (0.97-4.2)	n.a.	1.8 (0.70-4.8)	1.5 (0.65-3.4)	1.4 (0.29-6.4)	0.48 (0.09-2.5)	0.67 (0.18-2.5)	0.79 (0.32-1.9)
Multivariate‡	-	-	-	2.0 (0.97-4.2)	-	-	-	-	-	-	-
Multivariate‡ +PTSS	-	-	-	1.8 (0.86-3.9)	-	-	-	-	-	-	-
Physical											
Univariate†	2.0 (1.3-3.3)§	0.61 (0.31-1.2)	1.7 (1.0-2.7)#	1.6 (1.0-2.6)#	0.38 (0.08-1.8)	1.9 (0.92-4.0)	2.3 (1.3-4.0)§	0.80 (0.24-2.7)	0.87 (0.33-2.3)	0.49 (0.20-1.2)	0.56 (0.30-1.1)
Multivariate‡	1.7 (1.1-2.8)#	-	-	1.6 (1.0-2.7)	0.24 (0.05-1.2)	2.0 (0.90-4.3)	1.8 (0.99-3.3)	-	-	-	-
Multivariate‡ +PTSS	1.7 (1.0-2.8)#	-	-	1.6 (0.94-2.6)	0.21 (0.04-1.1)	1.8 (0.80-4.1)	1.8 (0.97-3.3)	-	-	-	-

Legend: Somatic symptoms: score ≥19 on the subscale 'Somatic Symptoms' of the 90-item Symptom Checklist; Fatigue-related symptoms: score >76 on the Checklist Individual Strength; Physical Symptoms: symptoms in ≥3 physical symptom categories; PTSS: posttraumatic stress symptoms, i.e. score ≥39 on the Self-Rating Inventory for Posttraumatic stress disorder; n.a.= not applicable.
*Table gives age-adjusted odds ratios with (95% confidence intervals) for each dichotomous definition of multiple physical symptoms, using the following reference categories: exposed workers not performing the specified task; not having seen the immediate disaster scene; not having some one close affected by the disaster; and perceiving the disaster as the worst thing that ever happened to them, respectively.
†Univariate: univariate (age adjusted) analysis in which each exposure characteristic is entered in separate logistic regression models.
‡Multivariate: multivariate (age adjusted) analysis in which all exposure characteristics are entered at one, after which those with $P > 0.10$ are eliminated in a step-wise backward manner and only those with $P \leq 0.10$ are retained and presented here; posttraumatic stress symptoms are subsequently added to this multivariate ('Multivariate + PTSS').
§ $P < 0.01$; # $P < 0.05$.

Table 4: Associations between types of exposure and multiple physical symptoms among 834 exposed police officers*

Symptoms:	Rescuing people (n=129 [16%])	Identification or recovery of or search for victims and human remains (n=68 [8.2%])	Clean-up the disaster site (n=40 [4.9%])	Security and surveillance of disaster area (n=655 [79%])	Support injured victims and workers (n=200 [24%])	Witnessed immediate disaster scene (n=624 [75%])	Close one affected by disaster (n=53 [6.4%])	Perceived severity of disaster 'not bad' (n=57 [6.9%])	Perceived severity of disaster 'quite bad' (n=87 [11%])	Perceived severity of disaster 'terrible' (n=515 [62%])
Somatic										
Univariate†	1.2 (0.76-2.1)	1.1 (0.57-2.2)	0.96 (0.39-2.4)	1.5 (0.93-2.6)	1.7 (1.1-2.5)§	1.4 (0.91-2.3)	1.5 (0.76-2.9)	0.42 (0.17-1.1)	0.66 (0.33-1.3)	0.63 (0.41-0.98)§
Multivariate‡	-	-	-	1.6 (0.93-2.6)	1.7 (1.1-2.5)§	-	-	-	-	-
Multivariate‡ +PTSS	-	-	-	1.4 (0.83-2.4)	1.5 (0.95-2.3)	-	-	-	-	-
Fatigue-related										
Univariate†	1.3 (0.81-2.2)	1.5 (0.83-2.8)	0.58 (0.20-1.7)	1.5 (0.92-2.5)	1.4 (0.96-2.2)	1.0 (0.67-1.6)	1.2 (0.57-2.4)	1.1 (0.51-2.5)	0.71 (0.33-1.5)	1.1 (0.69-1.8)
Multivariate‡	-	1.8 (0.95-3.4)	-	1.6 (0.98-2.8)	-	-	-	-	-	-
Multivariate‡ +PTSS	-	1.9 (0.96-3.8)	-	1.5 (0.86-2.6)	-	-	-	-	-	-
Physical										
Univariate†	1.5 (1.0-2.2)§	1.8 (1.1-3.0)§	1.4 (0.70-2.6)	1.4 (0.95-2.1)	1.3 (0.96-1.9)	1.6 (1.1-2.2)§	2.2 (1.3-3.9)#	0.55 (0.27-1.1)	0.82 (0.47-1.5)	1.0 (0.72-1.5)
Multivariate‡	-	2.3 (1.3-3.8)#	-	1.5 (0.97-2.2)	-	1.5 (1.0-2.1)§	2.5 (1.4-4.4)#	-	-	-
Multivariate‡ +PTSS	-	2.3 (1.3-3.9)#	-	1.4 (0.91-2.1)	-	1.5 (1.0-2.2)§	2.3 (1.2-4.1)#	-	-	-

Legend: Somatic symptoms: score ≥19 on the subscale 'Somatic Symptoms' of the 90-item Symptom Checklist; Fatigue-related symptoms: score >76 on the Checklist Individual Strength; Physical Symptoms: symptoms in ≥3 physical symptom categories; PTSS: posttraumatic stress symptoms, i.e. score ≥39 on the Self-Rating Inventory for Posttraumatic stress disorder.

*Table gives age-adjusted odds ratios with (95% confidence intervals) for each dichotomous definition of multiple physical symptoms, using the following reference categories: exposed workers not performing the specified task; not having seen the immediate disaster scene; not having some one close affected by the disaster; and perceiving the disaster as the worst thing that ever happened to them, respectively.

†Univariate analysis (age and sex adjusted): each exposure characteristic is entered in separate logistic regression models.

‡Multivariate analysis (age and sex adjusted): all exposure characteristics are entered at one, after which those with $P > 0.10$ are eliminated in a step-wise backward manner and only those with $P \leq 0.10$ are retained and presented here; post-traumatic stress symptoms are subsequently added to this multivariate ('Multivariate + PTSS').

§ $P < 0.05$. # $P < 0.01$.

Discussion

This epidemiologic study sought to examine associations between (types of) exposure to the air disaster in Amsterdam and multiple long-term physical symptoms among professional assistance workers, and to explore the potential role of posttraumatic stress symptoms in these associations. Exposed firefighters and police officers reported multiple physical symptoms significantly more often than their nonexposed colleagues. Furthermore, multiple physical symptoms particularly affected exposed firefighters who rescued people, and exposed police officers who supported injured victims and workers, who were involved in the identification or recovery of or search for victims and human remains, who witnessed the immediate disaster scene, or had a close one affected by the disaster.

Posttraumatic stress disorder has previously been postulated to play a mediating[21] or a moderating[13] role in the relationship between mass trauma exposure and physical health problems. The results of the present study did not suggest a mediating role because addition of posttraumatic stress symptoms to the regression models did not essentially change the associations between (types of) disaster exposure and multiple physical symptoms. No indication was also found for an effect-modifying role, because no statistically significant interactions between exposure status and posttraumatic stress symptoms were found. Thus, our results provide further support for the hypothesis that posttraumatic stress symptoms are likely to explain only a small proportion of post-event physical health problems[27, 43-45]. The low prevalence of posttraumatic stress symptoms in our population (overall 4.6%), however, warrants cautious interpretation of these results. Furthermore, the cross-sectional design of this study precludes drawing inferences about causality and the direction of associations between disaster exposure, posttraumatic stress symptoms, and multiple physical symptoms. No data are available on the course of symptoms in the period between the disaster and the assessment after on average 8.5 years. It is possible, for example, that some exposed workers had already recovered from disaster-related posttraumatic stress symptoms. In that case, their previous posttraumatic stress symptoms might still have contributed to the development of multiple physical symptoms. Other psychological symptoms, such as anxiety and depression, may also have influenced the association between disaster exposure and multiple physical symptoms. However, the results were similar when anxiety or depression symptoms were entered in the analyses instead of posttraumatic stress symptoms, i.e. the association between (types of) exposure and multiple physical symptoms remained essentially the same after adjustment for anxiety and depression symptoms, and no significant interactions were found that would indicate that the effect of exposure status on multiple physical symptoms was stronger among those with anxiety or depression symptoms (data not shown).

An alternative explanation for the excess in multiple long-term physical symptoms among exposed workers could be direct effects of exposure to hazardous materials. This explanation, however, seems less plausible because previous ESADA

studies showed no consistent significant differences between these exposed and nonexposed workers in various clinical parameters in blood and urine[34,35]. Furthermore, no indications were found for a disaster-related cluster of certain types of physical symptoms. Rather, exposed workers reported the same type of physical symptoms, yet at a higher prevalence rate than their nonexposed workers. Taken together, these ESADA results, and the fact that no public health risk emerged from retrospective risk evaluations of disaster-related exposures[4,5], make specific noxious exposures a less plausible explanation for the elevated prevalence of multiple physical symptoms among exposed workers. Instead, our findings may indicate a phenomenon of 'unexplained physical symptoms' resulting from the aggregate stressors of the disaster and its aftermath, similar to those seen in communities struck by disaster[13] and military personnel after war or peacekeeping service[18].

Such unexplained physical symptoms have been suggested to be particularly likely after real or perceived exposure to hazardous materials[15, 46-50]. The extended aftermath of the air disaster in Amsterdam was characterized by various rumours, public discussions, and extensive media coverage on alleged exposures to hazardous materials and on health consequences[1-4]. Moreover, these publicly discussed issues probably have also been subject of debate among exposed assistance workers. This could have contributed to sustained uncertainty among these workers and other exposed colleagues, and could have affected their perception and reporting of physical symptoms.

One strength of the present study is that historic registers were available to identify the complete historic cohort of professional firefighters and police officers who were employed at the time of the disaster. Moreover, almost all of the exposed and nonexposed workers could be traced in the year 2000, and 71% of those invited participated. Therefore selection bias was limited. In addition, a concise non-response analysis among firefighters revealed no significant differences between nonrespondents and participants regarding having current physical health complaints and general health perception.

The impact of occupational disaster exposure on multiple physical symptoms was assessed in two ways, i.e. a comparison of exposed and nonexposed workers, and associations with types of exposure. The types of exposure could partly overlap, e.g. rescuers most probably also witnessed the immediate disaster scene. However, in general, the associations between types of exposure and multiple physical symptoms that were found univariately remained essentially the same in multivariate analysis, thus indicating independent effects of these types of exposure on multiple physical symptoms.

Multiple instruments were used to assess physical symptoms: two validated questionnaires, and a list of other physical symptoms drawn up for the ESADA. Published external criteria were used to define high levels of (i.e. multiple) somatic symptoms[36] and fatigue-related symptoms[38]. However, for the ESADA questionnaire an arbitrary cut-off score (≥3) was used to define multiple physical symptom categories. A sensitivity analysis using a less (≥2) and a more (≥4) stringent cut-off score showed

that the results across these cut-off values were similar regarding the comparison of exposed and nonexposed workers (data not shown). However, the results of the multivariate associations with types of exposure depended to some extent on the cut-off value used. These results should therefore be considered with caution. Among police officers, for example, the effect sizes tended to be somewhat higher when using ≥3 compared to the other two cut-off values.

One limitation of the present study is that retrospective, self-reported exposure status was used. However, (differential) misclassification with respect to the dichotomy of exposed versus nonexposed workers seems unlikely, because workers were presumably able to recollect whether or not they performed any as opposed to no disaster-related tasks. It should be born in mind though that recall and reporting bias might have influenced the associations between the self-reported types of disaster exposure and multiple physical symptoms.

A final drawback concerns the fact that the exposed firefighters were on average more than 10 years older than the nonexposed firefighters. This was unavoidable because almost the entire Amsterdam fire department was exposed to the disaster and firefighters who joined this department after the disaster had to be included in the reference group. The applied statistical adjustments for age may not have fully accounted for this systematic difference between exposed and nonexposed firefighters.

In conclusion, this epidemiological study shows an elevated prevalence of multiple long-term physical symptoms among professional firefighters and police officers who were exposed to air disaster in Amsterdam compared to their nonexposed colleagues. Multiple physical symptoms particularly affected those exposed firefighters who rescued people, and those exposed police officers who supported injured victims and workers, who were involved in the identification or recovery of or search for victims and human remains, who witnessed the immediate disaster scene, or had a close one affected by the disaster. The excess in multiple long-term physical symptoms among (these) exposed workers could not substantially be attributed to posttraumatic stress symptoms. The most probable alternative explanation for the excess in multiple long-term physical symptoms is the aggregate stressor of the disaster and its extended troublesome aftermath, with rumours on alleged noxious exposures and health consequences. This study demonstrates that professional assistance workers are at risk for multiple long-term physical symptoms after disasters, similar to community members struck by disaster and military personnel. Further longitudinal studies on professional assistance workers are needed to address risk factors, improve aftercare, and prevent long-term physical symptoms.

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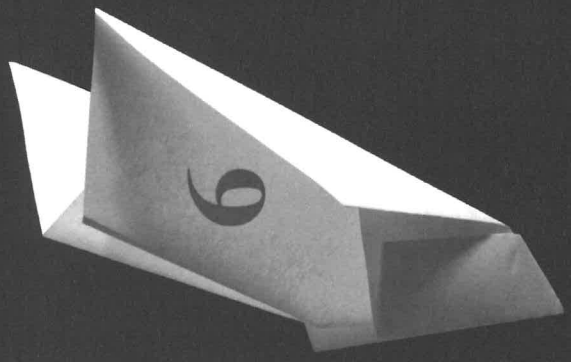
6

Health-related quality of life of firefighters and police officers 8.5 years after the air disaster in Amsterdam



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Submitted

Abstract

Background

In 1992 a cargo aircraft crashed into apartment buildings in Amsterdam. In the extended and troublesome aftermath of this disaster, rumours emerged on potential toxic exposures and health consequences. The aim of this study is to assess the long-term impact of exposure to this disaster on the health-related quality of life of professional firefighters and police officers.

Methods

Historic cohort study, using questionnaires to assess occupational disaster exposure, health-related quality of life (SF36), and background variables, at on average 8.5 years post-disaster. Participating were the exposed professional firefighters (n=334) and police officers (n=834) who reported disaster-related task(s), and their nonexposed colleagues who did not report such tasks (n=194, and n=634, respectively).

Results

Multivariate logistic regression analysis showed that exposed workers reported a significantly lower health-related quality of life than nonexposed workers. For firefighters this involved the physical aspects and vitality, whereas for the police officers this concerned all health-related quality of life aspects. Among exposed workers, a lower health-related quality of life was reported significantly more often by firefighters and police officers who had a close one affected by the disaster; by firefighters who rescued people, cleaned-up the disaster site, or witnessed the immediate disaster scene; and by police officers who supported injured victims and workers, or perceived the disaster as the worst thing that ever happened to them.

Conclusions

This study demonstrates that professional firefighters and police officers who are exposed to a disaster are at risk for a lower health-related quality of life, even after years.

Introduction

The air disaster in Amsterdam on October 4 1992, involved a cargo aircraft that crashed into a densely populated suburb of Amsterdam. It killed 43 people and destroyed 266 apartments and was followed by an extended and troublesome aftermath[1,2]. Over the years various rumours emerged concerning alleged toxic exposures and potential health consequences, although in risk evaluations no exposure-related excess morbidity was predicted[3,4]. Starting in 2000, the Epidemiologic Study Air Disaster in Amsterdam (ESADA) aimed to assess the long-term health effects of occupational exposure to this disaster on professional assistance workers, including health-related quality of life (HRQoL)[5].

The concept of HRQoL has become increasingly popular in clinical and community samples as a valuable measure of overall subjective health in terms of biopsychosocial well-being and limitations. Nevertheless, only a few studies have addressed HRQoL after disastrous events; these demonstrated impaired HRQoL after various types of disasters[6-10], and after the terrorist attack on September 11, 2001[11].

However, to our knowledge, the studies so far on HRQoL after disastrous events focused on (convenience) samples of disaster-struck communities, usually on the short to intermediate term. Therefore, less is known about the long-term impact of disastrous events on the HRQoL of professional assistance workers. Studies on active military personnel did reveal a profound impact on long-term HRQoL after service in the first Gulf War[12-15]. Notwithstanding the differences between the situations to which disaster assistance workers and military personnel are exposed (e.g. the likelihood of harmful intent and general environmental circumstances), these occupations share some important aspects, such as occupational exposure to both potentially psychotraumatic events and the threat of exposure to hazardous materials. Thus, similar to community members and military personnel, disaster assistance workers could also be at risk for adverse HRQoL.

The aim of the present study is to assess the impact of occupational exposure to the air disaster in Amsterdam on the long-term HRQoL of professional assistance workers.

Methods

Subjects and data collection

The study protocol of the ESADA has been published elsewhere[5]. Briefly, the ESADA can be characterized as a historical cohort study with self-reported exposure status. The study population used in the present study comprised the professional firefighters who were employed in the Amsterdam fire department on the date of the disaster, and the police officers who were employed in the Amsterdam-Amstelland regional police force on the date of the disaster, and still were on January 1, 2000. In addition, firefighters who started working in the Amsterdam fire department after the disaster were invited to participate, because almost the entire fire department had been exposed to the disaster.

The Medical Ethics Committees of both medical centres involved approved the study protocol. All participants signed informed consent and participated voluntarily. Data collection took place at an outpatient clinic in Amsterdam from January 2000 to March 2002, i.e. on average 8.5 years post-disaster. Questionnaire data were entered twice, after which inconsistencies were reviewed and mistakes rectified.

Occupational exposure to the air disaster in Amsterdam

All workers were asked to complete a detailed questionnaire on occupational disaster exposure[5]. Workers who reported at least one disaster-related task (including 'other' tasks) were defined as (occupationally) 'exposed'; all others as 'nonexposed'. The type of exposure of exposed workers was further characterised by the following aspects:

(a) Having performed the following disaster-related tasks: rescuing people; firefighting; identification and recovery of or search for victims and human remains; clean-up of the disaster site; security and surveillance of the disaster area; and supporting injured victims and workers.
(b) Having witnessed the immediate disaster scene: having seen the disaster scene within the first hours after the crash or when the wreckage was still there;
(c) Having a close one affected by the disaster: having a close or beloved one(s) (i.e. family members, relatives, friends or acquaintances) affected by the disaster in any way (i.e. in life-threatening danger; injured; destroyed apartment; died; or affected in another way).
(d) Perceived severity of the disaster: the disaster and its aftermath was 'not bad', 'quite bad', 'terrible', or 'the worst thing that ever happened to me'.

Health-related quality of life

The validated Dutch version of the 36-item Medical Outcome Study Short Form (SF36) was used to assess long-term HRQoL[16,17]. The scoring of the eight dimensions was performed according to its manual and includes transformation to 0-100 scales with higher scores indicating better HRQoL. Because the distributions were (even after log transformation) non-normal, all dimensions were dichotomised. For physical function, mental health, general health, and role limitations four standardised 'dichotomous

limitation indicator variables' are used[16]. Also, role limitations due to physical problems and those due to emotional problems were considered separately. For lack of standard dichotomisation, the remaining dimensions (bodily pain, vitality, and social function) were dichotomised according to the 25th percentile of each occupational group, with a score ≤ 25th percentile indicating a relatively lower HRQoL.

Background characteristics

Questionnaires assessed the following background characteristics: age, sex, ethnicity, cigarette smoking, alcohol consumption, highest level of education completed, and executive function (i.e. supervising one or more workers)[5].

Statistical analysis

The background characteristics of exposed and nonexposed workers were compared with t-tests for independent groups (continuous variables) and Pearson χ^2 tests (categorical variables). Logistic regression analysis was used to compare exposed with nonexposed workers regarding the HRQoL outcomes. Both unadjusted and adjusted comparisons were performed, adjusting for the above-mentioned background characteristics, if applicable. To avoid excluding workers from the adjusted regression analyses due to missing values on background characteristics, a 'missing' category was added for those background characteristics with more than 5% missing values (level of education), and median values (stratified according to exposure status and occupation) were imputed for the background characteristics with less than 5% missing values (all others except age and sex, of which the data were complete).

For exposed workers, logistic regression was also used to analyse associations between disaster-related HRQoL outcomes and the following types of exposure: each specified disaster-related task, having witnessed the immediate disaster scene, having a close one affected by the disaster (all coded as yes versus no), and perceived severity of the disaster (categorical with 'worst thing that ever happened to me' as reference category). The types of exposure were first introduced in separate ('univariate') models, after which they were all introduced together and those exposure variables with $P > 0.10$ were removed in a step-wise backward manner, resulting in a final 'multivariate' model with only those types of exposure that had $P < 0.10$. Both the univariate and the multivariate analyses were adjusted for age and sex. It was decided a priori to assess the associations with type of exposure only for disaster-related HRQoL aspects, i.e. those HRQoL aspects on which exposed workers scored statistically significantly worse than their nonexposed colleagues.

All analyses were performed with SPSS (version 10.1) and two-sided P-values of less than 0.05 are regarded as statistically significant.

Results

Response and characteristics of participants

Of the complete historic cohort of firefighters (n=808) and police officers (n=2116), 98% and 99.8%, respectively, could be traced and invited to participate in the year 2000. Response was 71% among both the invited firefighters and the police officers (n=559 and n=1489, respectively). Subsequently, 31 firefighters and 21 police officers were excluded from the statistical analysis for one or more of the following reasons: living in the disaster area at the time of the disaster, missing data on exposure status, and no comparison possible between exposed and nonexposed workers, i.e. only one female firefighter participated, and the 14 firefighters who were of non-European ethnicity were all nonexposed. Thus, 1996 workers were included in the statistical analyses: 528 firefighters (63% exposed), and 1468 police officers (57% exposed). HRQoL data were almost complete (96.5%) and occasional missing values on questionnaire items were dealt with according to its manual[16].

In general, exposed and nonexposed workers were comparable regarding background characteristics, although some statistically significant differences were found (Table 1). However, exposed firefighters were, on average, more than 10 years older than nonexposed firefighters.

Table 1: Background characteristics of the participants

	Firefighters		Police officers	
Characteristic	Exposed (n=334)	Nonexposed (n=194)	Exposed (n=834)	Nonexposed (n=634)
Age, mean (SD), years	51.4 (5.9)*	38.8 (9.1)	44.0 (6.2)†	44.8 (7.0)
Sex, %			†	
Male	100	100	88.5	84.9
Female	0	0	11.5	15.1
Level of education, %	†			
Low	58.7	50.5	20.7	19.7
Medium	27.5	35.1	52.5	51.1
High	6.3	10.3	20.9	23.3
Missing	7.5	4.1	5.9	5.8
Alcohol consumption, %‡	§			
No	4.2	12.4	11.4	8.2
Low to moderate	72.8	70.6	74.3	75.7
Excessive	23.1	17.0	14.3	16.1
Cigarette smoking, %‡	†		†	
Never	32.0	44.8	33.1	27.9
Formerly	35.0	29.4	31.7	38.0
Currently	32.9	25.8	35.3	34.1
Ethnicity, %‡				
European	100	100	97.2	98.4
Other	0	0	2.8	1.6
Executive function,%‡	*		§	
No	57.5	79.4	59.7	58.8
Yes	42.5	20.6	40.3	41.2

SD= standard deviation. * $P < 0.001$, by means of t-test for independent groups (age) and Pearson χ^2 (all others), with nonexposed as reference group. † $P < 0.05$, by means of t-test for independent groups (age) and Pearson χ^2 (all others), with nonexposed as reference group. ‡ Missing values (<5%) replaced by median values within each sub-group. § $P < 0.01$, by means of Pearson χ^2, with nonexposed as reference group.

Health-related quality of life of professional firefighters

Compared to the nonexposed firefighters, exposed firefighters reported a significantly lower HRQoL with respect to the physical aspects and vitality (Table 2). Table 3 presents the prevalence rates of the types of exposure among exposed firefighters. Most of the exposed firefighters reported two or three of the specified tasks. About 25% of the exposed firefighters reported the combination of firefighting, clean-up of the disaster site and rescuing people. Multivariate type of exposure analysis revealed that low HRQoL affected in particular those exposed firefighters who rescued people (physical functioning [p=0.04]); cleaned-up the disaster area (physical functioning [p=0.05], bodily pain [p<0.01]), supported injured victims and workers (vitality [p=0.07]), witnessed the immediate disaster scene (role-physical [p=0.04]), or had a close one affected by the disaster (bodily pain [p=0.01], role-physical [p=0.02]) (Table 3). The effect sizes of these multivariate associations were similar, but tended to be somewhat higher compared to those found in the univariate analyses. In contrast, the few exposed firefighters who reported security and surveillance of the disaster area (n=11) reported limitation in physical functioning less often (p=0.04).

Table 2: Health-related quality of life of exposed versus nonexposed firefighters

	Prevalence (%) of lower HRQoL		Odds ratio (95% confidence interval)	
	Exposed (n=334)	Nonexposed (n=194)	Unadjusted	Adjusted†
Physical limitation	53.9	22.2	4.1 (2.7-6.1)***	1.9 (1.2-3.2)*
Bodily pain (≤P25‡)	35.6	13.9	3.4 (2.2-5.4)***	4.0 (2.2-7.4)***
Unfavourable evaluation of health in general	12.3	1.0	13.4 (3.2-56.2)***	8.8 (1.9-40.8)**
Role-physical	23.4	8.8	3.2 (1.8-5.5)***	2.3 (1.2-4.5)*
Emotional limitation	6.3	3.1	2.1 (0.83-5.3)	1.5 (0.50-4.6)**
Social function (≤P25‡)	41.9	25.3	2.1 (1.4-3.2)***	1.5 (0.88-2.4)
Vitality (≤P25‡)	29.3	18.0	1.9 (1.2-2.9)**	2.2 (1.2-3.9)**
Role-emotional	13.2	6.2	2.3 (1.2-4.5)*	1.3 (0.58-2.9)
Role limitation	26.0	12.4	2.5 (1.5-4.1)***	1.6 (0.89-3.0)

Legend: Physical limitation= any limitation in physical function; emotional limitation= mental health ≤52; unfavourable evaluation of health in general= poor or fair versus [very] good, or excellent general health; role-physical= any role limitation due to physical problems; role-emotional= any role limitation due to emotional problems; and role limitation= any role limitation due to physical or emotional problems.

*Adjusted for age, alcohol consumption, cigarette smoking, educational level, executive function. †P< 0.001. ‡ P < 0.05. § P < 0.01. ¶Adjusted for age, cigarette-smoking, executive function. #25th percentiles: bodily pain=72.0, social functioning=87.5, and vitality=65.0.

Table 3: Associations between health-related quality of life and types of exposure of 334 exposed firefighters†

Aspect:	Rescuing people (n=163 [49%])	Identification or recovery of or search for victims and human remains (n=50 [15%])	Firefighting (n=199 [61%])	Clean-up the disaster site (n=180 [55%])	Security and surveillance of disaster area (n=11 [3.4%])	Supporting injured victims and workers (n=33 [10%])	Witnessed immediate disaster scene (n=246 [74%])	Close one affected by disaster (n=13 [3.9%])	Perceived severity of disaster 'not bad' (n=27 [8.1%])	Perceived severity of disaster 'quite bad' (n=40 [12%])	Perceived severity of disaster 'terrible' (n=219 [66%])
Physical limitation											
Univariate‡	1.5 (0.97-2.4)	1.5 (0.79-2.7)	1.2 (0.79-1.9)	1.5 (0.96-2.4)	0.28 (0.07-1.1)	1.4 (0.65-2.9)	1.6 (0.98-2.7)	1.8 (0.54-6.0)	0.88 (0.34-2.3)	0.81 (0.34-1.9)	1.1 (0.57-2.0)
Multivariate§	1.6 (1.0-2.5)*	-	-	1.6 (0.99-2.5)	0.24 (0.06-0.94)*	-	-	-	-	-	-
Bodily pain (≤P25#)											
Univariate‡	1.1 (0.71-1.7)	1.0 (0.54-1.9)	1.2 (0.72-1.8)	1.9 (1.2-3.0)*	1.1 (0.30-3.7)	1.0 (0.49-2.2)	1.3 (0.78-2.2)	3.2 (1.0-9.9)*	1.2 (0.45-3.1)	0.87 (0.36-2.1)	0.77 (0.40-1.5)
Multivariate§	-	-	-	2.0 (1.2-3.3)**	-	-	-	5.0 (1.4-17.6)*	-	-	-
Unfavourable evaluation of health in general											
Univariate‡	1.2 (0.65-2.4)	0.76 (0.28-2.0)	1.2 (0.62-2.4)	1.3 (0.66-2.6)	0.65 (0.08-5.2)	1.7 (0.64-4.3)	1.6 (0.73-3.7)	2.1 (0.55-8.0)	0.53 (0.10-2.8)	1.5 (0.47-4.9)	0.76 (0.31-1.9)
Multivariate§	-	-	-	-	-	-	-	-	-	-	-
Role-physical											
Univariate‡	1.4 (0.82-2.3)	0.68 (0.32-1.5)	1.4 (0.80-2.3)	1.4 (0.82-2.4)	1.2 (0.31-4.6)	1.7 (0.79-3.7)	1.7 (0.92-3.2)	2.9 (0.94-8.9)	1.5 (0.51-4.3)	0.63 (0.21-1.9)	1.1 (0.51-2.3)
Multivariate§	-	-	-	-	-	-	2.1 (1.1-4.0)*	4.0 (1.2-13.2)*	-	-	-
Vitality (≤P25#)											
Univariate‡	1.2 (0.73-1.9)	1.5 (0.78-2.8)	1.4 (0.84-2.3)	0.97 (0.59-1.6)	0.53 (0.11-2.5)	2.0 (0.94-4.1)	1.2 (0.72-2.2)	1.5 (0.49-4.8)	0.76 (0.27-2.1)	0.38 (0.14-1.0)	0.79 (0.41-1.5)
Multivariate§	-	-	-	-	-	2.0 (0.94-4.1)	-	-	-	-	-

Legend: Physical limitation= any limitation in physical function; Unfavourable evaluation of health in general= poor or fair versus good, very good and excellent general health; Role-physical= any role limitation due to physical problems.

†Table gives age-adjusted odds ratios with (95% confidence intervals) for each dichotomous health-related quality of life outcome, with the following reference categories: exposed workers not performing the specified task; not having witnessed the immediate disaster scene; not having some one close affected by the disaster; perceiving the disaster as the worst thing that ever happened to them, respectively.

‡Univariate analysis: separate logistic regression analyses for each combination of type of exposure and health outcome (numbers of included firefighters ranged from 326 to 334 due to missing values).

§Multivariate analysis: starting with all exposure variables, after which those variables with highest p-values are excluded from the logistic regression model in a step-wise backward manner until only those with $P \leq 0.10$ are retained (numbers of included firefighters ranged from 327 to 334 due to missing values).

¶25th percentiles: bodily pain=72.0, and vitality=65.0.

* $P < 0.05$; ** $P < 0.01$.

Health-related quality of life of police officers

Exposed police officers reported a significantly lower HRQoL than nonexposed colleagues (Table 4). This concerned all HRQoL aspects. Table 5 gives the prevalence rate of the types of exposure for exposed police officers. Most of the exposed police officers reported only one of the specified tasks. For about 64% of those reporting one task, this concerned security and surveillance. The multivariate type of exposure analysis suggested that lower HRQoL concerned in particular those exposed police officers who reported clean-up (mental health [p= 0.10]), security and surveillance (mental health [p=0.09]), supporting injured victims and workers (bodily pain [p=0.05], general health [p<0.01], mental health [p=0.04], social functioning [p=0.03]), having a close one affected by the disaster (role-physical [p=0.07], role-emotional [p=0.08], role limitation due to physical or emotional problems [p=0.03]), or perceiving the disaster as the worst thing ever happening to them (role-physical [p<0.01], vitality [p=0.03]) (Table 5). The effect sizes of these multivariate associations were very similar to those found in the univariate analyses.

Table 4: Health-related quality of life of exposed versus nonexposed police officers

	Prevalence (%) of lower HRQoL		Odds ratio (95% confidence interval)	
	Exposed (n=834)	Nonexposed (n=634)	Unadjusted	Adjusted†
Physical limitation	53.2	44.2	1.4 (1.2-1.8)**	1.5 (1.2-1.9)***
Bodily pain (≤P25‡)	32.3	20.0	1.9 (1.5-2.4)***	2.0 (1.5-2.5)***
Unfavourable evaluation of health in general	11.2	4.9	2.4 (1.6-3.7)***	2.6 (1.7-4.0)***
Role-physical	27.6	17.7	1.8 (1.4-2.3)***	1.8 (1.4-2.4)***
Emotional limitation	6.2	3.3	1.9 (1.2-3.3)*	2.0 (1.2-3.4)**
Social function (≤P25‡)	32.4	19.2	2.0 (1.6-2.6)***	2.1 (1.6-2.7)***
Vitality (≤P25‡)	37.4	24.6	1.8 (1.5-2.3)***	1.9 (1.5-2.4)***
Role-emotional	18.6	11.4	1.8 (1.3-2.4)***	1.8 (1.3-2.5)***
Role limitation	34.2	22.1	1.8 (1.4-2.3)***	1.9 (1.5-2.4)***

Legend: physical limitation= any limitation in physical function; emotional limitation= mental health ≤52; unfavourable evaluation of health in general= poor or fair versus good, very good and excellent general health; role-physical= any role limitation due to physical problems; role-emotional= any role limitation due to emotional problems; and role limitation= any role limitation due to physical or emotional problems.

*Adjusted for age, sex, alcohol consumption, cigarette smoking, educational level, executive function, and ethnicity.

†P< 0.001. ‡ P < 0.01. § P < 0.05. #25th percentiles: bodily pain=62.0, social functioning=75.0, and vitality=65.0.

Table 5: Associations between health-related quality of life and types of exposure of 834 exposed police officers†

Aspect:	Rescuing people (n=129 [16%])	Identification or recovery of or search for victims and human remains (n=68 [8.2%])	Clean-up the disaster site (n=40 [4.9%])	Security and surveillance of disaster area (n=655 [79%])	Supporting injured victims and workers (n=200 [24%])	Witnessed immediate disaster scene (n=624 [75%])	Close one affected by disaster (n=53 [6.4%])	Perceived severity of disaster 'not bad' (n=57 [6.9%])	Perceived severity of disaster 'quite bad' (n=87 [11%])	Perceived severity of disaster 'terrible' (n=515 [62%])
Physical limitation										
Univariate‡	0.92 (0.63-1.3)	1.1 (0.64-1.8)	0.70 (0.37-1.3)	1.0 (0.70-1.4)	1.3 (0.93-1.8)	0.99 (0.72-1.4)	1.2 (0.67-2.1)	0.67 (0.36-1.2)	0.77 (0.45-1.3)	0.90 (0.64-1.3)
Multivariate§	-	-	-	-	-	-	-	-	-	-
Bodily pain (≤P25¶)										
Univariate‡	1.1 (0.75-1.7)	1.2 (0.72-2.1)	1.4 (0.70-2.6)	1.2 (0.83-1.8)	1.4 (1.0-1.9)	1.1 (0.76-1.5)	1.1 (0.59-1.9)	0.58 (0.29-1.2)	0.84 (0.48-1.5)	0.93 (0.64-1.3)
Multivariate§	-	-	-	-	1.4 (1.0-1.9)	-	-	-	-	-
Unfavourable evaluation of health in general										
Univariate‡	1.0 (0.55-1.9)	1.2 (0.60-2.6)	0.22 (0.03-1.6)	1.3 (0.76-2.3)	2.0 (1.3-3.2)**	1.4 (0.83-2.4)	0.94 (0.39-2.3)	0.45 (0.13-1.6)	0.75 (0.31-1.8)	0.94 (0.55-1.6)
Multivariate§	-	-	-	-	2.0 (1.3-3.2)**	-	-	-	-	-
Role-physical										
Univariate‡	1.3 (0.87-2.0)	1.3 (0.78-2.3)	1.2 (0.60-2.4)	1.1 (0.75-1.6)	1.3 (0.95-1.9)	1.2 (0.81-1.6)	1.7 (0.98-3.1)	0.32 (0.14-0.75)**	0.60 (0.33-1.1)	0.88 (0.61-1.3)
Multivariate§	-	-	-	-	-	-	1.7 (0.97-3.1)	0.32 (0.14-0.76)**	0.61 (0.33-1.3)	0.88 (0.61-1.3)
Mental health										
Univariate‡	1.9 (0.94-3.8)	0.42 (0.098-1.8)	2.6 (0.96-7.0)	2.1 (0.90-4.9)	2.0 (1.1-3.5)*	1.5 (0.74-3.1)	2.0 (0.80-4.9)	n.a.	n.a.	n.a.
Multivariate§	-	-	2.3 (0.85-6.5)	2.1 (0.90-4.9)	1.9 (1.0-3.4)*	-	-	n.a.	n.a.	n.a.
Social function (≤P25¶)										
Univariate‡	1.3 (0.89-2.0)	1.2 (0.70-2.0)	0.97 (0.48-2.0)	1.4 (0.92-2.0)	1.4 (1.0-2.0)*	1.2 (0.86-1.7)	1.6 (0.93-2.9)	0.56 (0.27-1.1)	1.1 (0.65-2.0)	0.97 (0.67-1.4)
Multivariate§	-	-	-	-	1.4 (1.0-2.0)*	-	-	-	-	-
Vitality (≤P25¶)										
Univariate‡	1.1 (0.74-1.6)	0.84 (0.49-1.4)	1.1 (0.55-2.0)	1.2 (0.86-1.8)	1.2 (0.83-1.6)	1.0 (0.74-1.4)	1.1 (0.62-2.0)	0.45 (0.22-0.91)*	0.91 (0.53-1.6)	1.1 (0.76-1.6)
Multivariate§	-	-	-	-	-	-	-	0.45 (0.22-0.91)*	0.91 (0.53-1.6)	1.1 (0.76-1.6)
Role-emotional										
Univariate‡	1.1 (0.66-1.8)	1.1 (0.58-2.0)	1.2 (0.54-2.7)	1.3 (0.81-2.0)	1.0 (0.67-1.5)	0.98 (0.65-1.5)	1.8 (0.94-3.3)	0.57 (0.24-1.4)	0.86 (0.44-1.7)	0.89 (0.58-1.4)
Multivariate§	-	-	-	-	-	-	1.8 (0.94-3.3)	-	-	-
Role limitation										
Univariate‡	1.2 (0.81-1.8)	1.4 (0.81-2.3)	1.6 (0.82-3.0)	1.0 (0.70-1.4)	1.3 (0.91-1.8)	1.1 (0.77-1.5)	1.9 (1.1-3.3)*	0.44 (0.21-0.91) *	0.77 (0.44-1.4)	0.97 (0.68-1.4)
Multivariate§	-	-	-	-	-	-	1.9 (1.1-3.3)*	-	-	-

Legend: Physical limitation= any limitation in physical function; Emotional limitation= mental health ≤52; Unfavourable evaluation of health in general= poor or fair versus good, very good and excellent general health; Role-physical= any role limitation due to physical problems; Role-emotional= any role limitation due to emotional problems; Role limitation= any role limitation due to physical or emotional problems; and n.a.=not applicable.

†Table gives age and sex adjusted odds ratios with (95% confidence intervals) for each dichotomous health-related quality of life outcome, with the following reference categories: exposed workers not performing the specified task; not having witnessed the immediate disaster scene; not having some one close affected by the disaster; perceiving the disaster as the worst thing that ever happened to them, respectively.

‡Univariate analysis: separate logistic regression analyses for each type of exposure and health outcome (numbers of included police officers ranged from 821 to 834 due to missing values). §Multivariate analysis: starting with all exposure variables, after which those variables with highest p-values are excluded from the logistic regression model in a step-wise backward manner until only those with $P \leq 0.10$ are retained (numbers of included police officers ranged from 327 to 334 due to missing values).

¶25th percentiles: bodily pain=62.0, social functioning=75.0, and vitality=65.0.

*$P < 0.05$; **$P < 0.01$.

Discussion

This epidemiological study showed that occupational exposure to the air disaster in Amsterdam resulted in a significantly lower HRQoL in professional assistance workers, after on average 8.5 years. Exposed workers reported significantly lower HRQoL compared with their nonexposed colleagues. For professional firefighters this difference was confined to the physical aspects and vitality, for police officers it concerned all HRQoL aspects. In addition, a variety of multivariate associations between disaster-related HRQoL aspects and types of exposure was also found among exposed workers. The following types of exposure were significantly associated with lower levels of at least two HRQoL aspects: having a close one affected by the disaster (i.e. bodily pain and role-physical) among exposed firefighters; and supporting injured victims and workers (i.e. general health, mental health, and social functioning), and a worse perceived severity of the disaster (i.e. role-physical and vitality) among exposed police officers.

These findings of lower post-disaster HRQoL levels among these exposed assistance workers are in line with those of other studies in disaster-struck communities[6-11], and military personnel after service in the first Gulf War[12-15]. There are several potential explanations for the negative impact of occupational exposure to the air disaster in Amsterdam on the long-term HRQoL of these professional assistance workers. Firstly, direct unknown biological effects of disaster-related exposure to hazardous materials could have contributed to the lower HRQoL of exposed workers. However, this seems less plausible because no consistent significant differences were found previously between these exposed and nonexposed workers regarding various clinical parameters tested in urine and blood samples[18,19]. Furthermore, no excess morbidity was predicted due to disaster-related exposures in retrospective risk evaluations[3,4].

Secondly, disaster-related physical injuries could have had an impact on long-term HRQoL. However none of the exposed firefighters and only a few (0.4%) of the exposed police officers reported any personal injuries due to the disaster.

Thirdly, the negative impact on HRQoL might be due to exposure to disaster-related stressful events. Significant multivariate associations were found between multiple HRQoL aspects and potentially stressful exposure variables such as having a close one affected by the disaster, and supporting injured victims and workers. Still, both tasks that were rated as potentially psychotraumatic by posttraumatic stress experts (i.e. rescuing people, and identification or recovery of or search for victims and human remains[5]) were not consistently associated with lower HRQoL.

Fourthly, uncertainty about exposure to hazardous materials and potential health effects could also have played a role in the lower HRQoL of these exposed workers. This uncertainty may have been amplified by extensive media coverage and public discussions on various alleged disaster-related noxious exposures and health consequences in the extended aftermath of disaster[20]. Discussions on these public issues among troubled colleagues probably also contributed to this uncertainty, and

could have affected risk and health perception of these and other exposed colleagues. Uncertainty about, perceived exposure, and risk perception have previously been postulated to affect subjective health[21-24]. For example, McCarron et al. found a lower HRQoL particularly among the residents of a potentially contaminated area who perceived the environmental pollutant as harmful to health[25].

Finally, some of the found associations between (types of) exposure and HRQoL may also be due to chance, because multiple statistical tests were performed.

Another interesting finding is that among exposed firefighters the exposure impact seemed to be confined to the physical aspect of HRQoL and vitality, whereas it also affected mental aspects among exposed police officers. It would be worthwhile to know if this finding is replicated in future studies, and which factors contribute to this apparent differential disaster impact. In the present study, this finding might be related partly to the larger sample size and the more favourable comparability of exposed and nonexposed police officers. Among the firefighters, the comparison of exposed and nonexposed workers is limited by the fact that nonexposed workers were younger than the exposed workers. This age difference was unavoidable, because almost the entire Amsterdam fire department had been exposed to the disaster and firefighters who joined this fire department after the disaster had to be included in the reference group. The applied statistical adjustment for age may not have fully accounted for this systematic age difference.

One of the strengths of the present study is that it concerns a historic cohort of exposed and nonexposed firefighters and police officers. Almost all of these workers could be traced (99%), and of those invited 71% agreed to participate. Furthermore, a concise non-response analysis among firefighters revealed no significant difference on the general health dimension between nonrespondents (n=47) and participants (n=528) (8.5% versus 8.1%). Thus, selection bias was limited and it is therefore unlikely that such bias has seriously influenced the overall results.

Another strength is the availability of detailed exposure data of each worker, enabling to compare exposed and nonexposed workers, and associations between HRQoL and various types of exposure. The types of exposure could be partly inter-related, e.g. rescuers probably also witnessed the immediate disaster scene. Therefore, the exposure variables were entered in a multivariate model from which those with $P > 0.10$ were eliminated in a step-wise, backward manner. The associations that were found univariately, remained essentially the same in the multivariate analysis, thus indicating independent effects of these types of exposure on HRQoL. The use of self-reported exposure data could have introduced information bias, particularly regarding details of disaster exposure, such as types of exposure. However, (differential) misclassification with respect to the dichotomy of exposed versus nonexposed workers seems unlikely, because workers were presumably able to recollect whether they performed any, as opposed to no, disaster-related tasks.

HRQoL was measured with the validated, generic SF36 questionnaire[16,17]. Because the distributions of the eight dimensions were not normal, the standardised dichotomous limitations variables defined in its manual were used[16]. However, for

bodily pain, social function, and vitality, no such standardised definitions were available; for these variables the 25th percentile of each occupational group was used as an arbitrary cut-off. A sensitivity analysis using both a less (30th percentile) and a more (20th percentile) stringent cut-off revealed that the results were virtually independent of the chosen cut-off value (data not shown).

In conclusion, this epidemiological study shows that occupational exposure to the air disaster in Amsterdam resulted in a lower long-term health-related quality of life in professional assistance workers. Lower HRQoL affected particularly those exposed firefighters who had a close one affected by the disaster, and those exposed police officers who supported injured victims and workers, and perceived the disaster as the worst they ever experienced. The most likely explanation for the lower HRQoL of exposed workers is that it is related to the aggregated stressful events during the disaster and its aftermath, including sustained uncertainty about toxic exposures. These results underline the importance of developing optimal aftercare programs for disaster assistance workers and others involved in future disasters with real and alleged exposure to hazardous materials.

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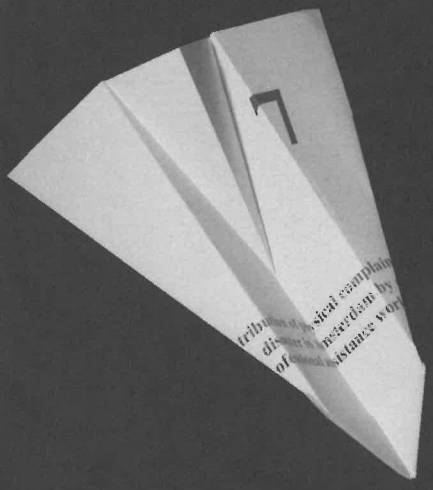
7

Attribution of physical complaints to the air disaster in Amsterdam by exposed professional assistance workers



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Submitted

Abstract

Objective

To assess to what extent occupationally exposed assistance workers attribute long-term physical complaints to the air disaster in Amsterdam and its aftermath, and to examine which exposure and background variables are associated with such attribution. The disaster involved a cargo aircraft crash into apartment buildings, which was followed by an extended, troublesome aftermath.

Methods

Historic cohort study, using self-reported disaster exposure data. The present study concerns the professional firefighters (n=334), police officers (n=834) and hangar workers (n=241) who performed at least one disaster-related task. Questionnaire data were collected on average 8.5 years post-disaster.

Results

Across the three occupational groups, a consistent percentage (ranging from 43% to 49%) of exposed workers with long-term physical complaints attributed these to the disaster and its aftermath to some extent. Those with more physical complaints attributed these to a stronger degree. Multivariate logistic regression analyses showed that among firefighters attribution was significantly associated with rescuing people, and among police officers with almost all the types of exposure, i.e. perceived severity of disaster, three of five tasks, having witnessed the immediate disaster scene, and having a close one affected by the disaster. Age, sex and educational level were not significantly associated with attribution in any of the groups.

Conclusions

This study shows that 45% of the exposed professional assistance workers with long-term physical complaints attributed these to the disaster and its aftermath, and that this attribution was associated with rescuing people among firefighters, and almost all types of exposure among police officers, but not with background characteristics.

Introduction

In 1992 a cargo aircraft crashed into apartment buildings in a densely populated area of Amsterdam, killing 43 persons and destroying 266 apartments. Through the years after the disaster, various alleged disaster-related exposures to hazardous materials and potential health consequences were reported in the media and publicly discussed[1-3]. No excess morbidity due to exposure to hazardous materials was predicted in retrospective risk evaluations[4,5], but health concerns remained among some of the residents and involved assistance workers[5,6].

It has been shown that both real and perceived exposure to hazardous materials can induce subjective health problems[7-10]. In times of stress and uncertainty about exposure, people could be more likely to 'scan' their bodies (hypervigilent), and more likely to interpret bodily sensations as pathological (hypochondric)[11,12]. People affected by a disaster who perceive bodily sensations as abnormal and seek an explanation for them, are likely to attribute them to the disaster experience and related exposures, whether this is realistic or not[12-14]. Causal attribution, i.e. the individual process of linking bodily sensations or symptoms to a certain cause[15,16], may thus play a role in the process through which (perceived) disaster-related toxic exposure leads to subjective health problems.

Causal attribution may also affect the course of physical symptoms. For example, strong attributions to somatic causes and environmental exposures have been shown to be associated with a worse prognosis in patients with chronic fatigue syndrome and in other patients with medically unexplained physical symptoms[17-22]. The medical expenses of these patients with sustained physical symptoms could be higher, because of their frequent visits to various medical specialists, who usually cannot confirm the patient's conviction[23,24].

Thus, causal attributions could affect physical health perception and health care utilization, both in general and after disasters. However, little is known about the extent to which people affected by disasters actually attribute post-disaster physical complaints to the disaster and which factors are associated with such attribution. Therefore, the aim of the present study is to assess the extent to which the professional assistance workers, who were occupationally exposed to the air disaster in Amsterdam, attribute their long-term physical complaints to this disaster and its aftermath. In addition, it is also examined which types of exposure and background variables are associated with such attribution.

Methods

Participants and data collection

The present study is part of the Epidemiological Study Air Disaster in Amsterdam (ESADA), of which the study design has been published elsewhere[25]. Briefly, the

ESADA is a historic cohort study, using self-reported exposure status. Its aim is to assess the long-term health effects of occupational exposure to the air disaster in Amsterdam in professional assistance workers. The cohort of professional assistance workers include both exposed and nonexposed workers. The overall participation rate was 70% of those traced and invited to join in the study (n=3742). For the purpose of the present study only the participating 1409 exposed workers were selected, i.e. the workers who reported to have performed at least one disaster-related task. This concerns three occupational groups: (1) professional firefighters (n=334) working at the Amsterdam fire department at the time of the disaster, (2) police officers (n=834) working at the Amsterdam-Amstelland regional police force at the time of the disaster and at the time of recruitment, and (3) so-called hangar workers (n=241), who worked for one of the departments involved in the transport, security and sorting of the wreckage at the time of the disaster.

The medical ethics committees of both medical centers involved in the ESADA (i.e. 'VU University Medical Center' and 'Onze Lieve Vrouwe Gasthuis') approved the study protocol. All participants signed informed consent and participated voluntarily. Data were collected from January 2000 to March 2002, i.e. on average 8.5 years post-disaster. All the data used in the present study were assessed by means of questionnaires and were entered twice, after which inconsistencies were reviewed and any mistakes rectified.

Long-term physical complaints and attribution thereof

Workers were asked to indicate whether they currently had physical complaints on a four-point scale (very many, many, few, or none). Those who reported having physical complaints were subsequently asked to indicate to what extent they thought these were related to the air disaster and its aftermath, on a four-point scale (a very strong, strong, weak, or no relationship). Workers who attributed physical complaints, were asked to specify these complaints, i.e. skin, back, joints, shortness of breath, lung problems, fatigue, headaches, or other.

Type of exposure to the disaster

Type of exposure is characterized according to the following variables:

(a) Perceived severity of the disaster: The air disaster and its aftermath was: not bad; quite bad; terrible, but not the worst thing that ever happened to me ('terrible'); or, the worst thing that ever happened to me ('worst thing ever').

(b) Disaster-related tasks: rescuing people; identification and recovery of or search for victims and human remains; firefighting; clean-up of the disaster site; security and surveillance of the disaster area; supporting injured victims and workers; and sorting of the wreckage in a hangar at Schiphol Airport.

(c) Witnessed the immediate disaster scene: having seen the disaster scene within the first hours after the crash, or when the wreckage was still there.

(d) Having a close one affected by the disaster: any close and beloved one(s) (i.e. family members, relatives, friends or acquaintances) affected by the disaster in any way (i.e. in life-threatening danger; injured; destroyed apartment; died; or affected in any other way).

Background characteristics

Background characteristics were categorized as follows: age at time of assessment (young [<median age of exposed workers with physical complaints per occupational group] versus old); sex (male versus female); and highest level of completed education (low [no education, elementary school, lower vocational education, or lower general secondary education], intermediate [intermediate vocational education, higher general secondary education, pre-university education], versus high [higher vocational education, university]). Data on age and sex were complete. For level of education a 'missing' category was also used in the statistical analysis, to prevent excluding these workers (6%).

Statistical analyses

The following statistical analyses were performed among the workers with physical health complaints, using SPSS (version 10.1) and considering two-sided P-values less than 0.05 as statistically significant. Associations between physical complaints and attribution thereof were analyzed by means of Pearson χ^2 tests. Logistic regression was used to analyze associations between attribution (dichotomized into yes [very strong, strong or weak relationship] and no [no relationship]) and the following independent variables: perceived severity of disaster experience, disaster-related tasks (each coded as yes versus no), having witnessed the immediate disaster scene (yes versus no), having a close one affected by the disaster (yes versus no), and the background characteristics. In this logistic regression analysis, the independent variables were first introduced separately in 'univariate' models, after which they were all introduced together and those with $P > 0.10$ were subsequently removed in a step-wise backward manner, until only those with $P \leq 0.10$ were retained in the final 'multivariate' model.

Results

Background characteristics of exposed workers

The firefighters, all male, had a mean age of 51.4 years (SD 5.9), and 59%, 28%, and 6% of them reported a low, intermediate, and high level of education, respectively (8% no data on education). The mean age of the police officers was 44.0 years (SD 6.2); 89% of them were male, and 21%, 53%, and 21% of them reported a low, intermediate, and high level of education, respectively (6% no data on education). The hangar workers, all male, had a mean age of 43.9 years (SD 7.8), and 43%, 44%, and 8% of

them reported a low, intermediate, and high level of education, respectively (5% no data on education).

Prevalence of long-term physical complaints and attribution thereof

The prevalence of long-term physical complaints and attribution thereof was very similar across the three occupational groups (Table 1). 72% of all exposed workers reported long-term physical complaints, of whom the majority reported to have few physical complaints. 45% of the workers with long-term physical complaints attributed these to the disaster and its aftermath to some extent. A minority of them (23%) reported a (very) strong relationship. Workers with more physical complaints ([very] many versus few) were more likely to attribute these complains to a stronger degree to the disaster and its aftermath (a [very] strong, or weak versus no relationship) ($P<0.0001$ within each occupational group).

The top three of types of physical complaints most frequently attributed to the disaster and its aftermath by firefighters, police officers and hangar workers were: skin complaints (58, 50% and 50%, respectively), fatigue (42%, 47% and 70%, respectively), and joint complaints (47%, 35% and 54%, respectively).

Table 1: Prevalence (%) of physical complaints and attribution thereof by 1409 exposed professional assistance workers

	Firefighters (n=334)	Police officers (n=834)	Hangar workers (n=241)
Physical complaints†:			
Yes (few through very many)	73 %	70 %	79 %
Few physical complaints	61 %	58 %	62 %
Many physical complaints	12 %	11 %	14 %
Very many physical complaints	0.6 %	1 %	2 %
Attribution to disaster and aftermath‡:			
Yes (weak through very strong)	46 %	43 %	49 %
Weak relationship	38 %	32 %	38 %
Strong relationship	7 %	9 %	8 %
Very strong relationship	0.9 %	2 %	2 %

†Percentage of all the exposed workers per occupational group; missing data on physical complaints for 4 exposed police officers and 4 exposed hangar workers.

‡Percentage of workers with physical complaints per occupational group; missing data on attribution for 11, 35, and 8 of the exposed firefighters, police officers and hangar workers with physical complaints, respectively.

Factors associated with attribution of physical complaints

Tables 2, 3 and 4 give the results for the firefighters, police officers and hangar workers with physical complaints, respectively, regarding the univariate and multivariate associations between attribution and types of exposure and background characteristics.

In the univariate analysis of firefighters with physical complaints, attribution was significantly associated with rescuing people, firefighting, supporting injured victims and workers, and having witnessed the immediate disaster site (Table 2). However, only rescuing people remained significant in the multivariate analysis, and supporting injured victims and workers, and having witnessed the immediate disaster scene had $P \leq 0.10$. The effect sizes of these types of exposure were similar, but tended to be somewhat

lower in multivariate compared to univariate analyses. Background characteristics were not associated with attribution.

With respect to the police officers, attribution was significantly associated with all the types of exposure both in univariate and in multivariate analyses, except for identification and recovery of or search for victims and human remains in univariate analysis, and rescuing people in multivariate analysis (Table 3). Some multivariate odds ratio's were somewhat higher, while others were somewhat lower compared to the univariate ones. Background characteristics were not significantly associated with attribution among police officers.

Regarding the hangar workers, none of the types of exposure or background characteristics were significantly associated with attribution, although the analysis of education level indicated that hangar workers with intermediate and low levels of education were less likely to attribute physical complaints to the disaster than those with a high level of education (P = 0.05) (Table 4).

Table 2: Associations between attribution and types of exposure and background characteristics in exposed firefighters with long-term physical complaints

	Prevalence (column %)		Odds ratio (95% confidence interval)	
	Attribution† (n=107)	No attribution† (n=125)	Univariate analysis‡	Multivariate analysis§
Type of exposure:				
Perceived severity disaster:				
- not bad	7	12	0.38 (0.12-1.2)	-
- quite bad	11	10	0.75 (0.26-2.2)	-
- terrible	67	67	0.70 (0.31-1.5)	-
- worst thing ever	15	10	Reference	-
Rescuing people	62	40	2.5 (1.5-4.2)**	2.0 (1.2-3.5)*
Identification and recovery of or search for victims and human remains	13	18	0.69 (0.33-1.4)	-
Firefighting	71	54	2.1 (1.2-3.6)*	-
Clean-up of disaster site	55	59	0.83 (0.49-1.4)	-
Security and surveillance of disaster area	5	2	3.0 (0.57-15.8)	-
Supporting injured victims and workers	16	7	2.7 (1.1-6.6)*	2.4 (0.95-5.9)
Witnessed immediate disaster scene	82	67	2.3 (1.2-4.2)*	1.9 (0.97-3.6)
Close one affected by disaster	3	6	0.49 (0.12-1.9)	-
Background characteristics:				
Age (young)	47	53	0.78 (0.47-1.3)	-
Education				
- high	10	5	Reference	-
- intermediate	26	26	0.46 (0.15-1.4)	-
- low	58	60	0.45 (0.16-1.3)	-

†Attribution (a weak through very strong relationship) versus no attribution (no relationship between physical complaints and the air disaster in Amsterdam and its aftermath). ‡Number of firefighters included in the univariate analyses ranged from 226 to 232 due to occasional missing values. §The final multivariate model included 228 firefighters and only those independent variables with P ≤ 0.10 after step-wise backward elimination of those with P > 0.10. *P < 0.05; ** P < 0.01.

Table 3: Associations between attribution and types of exposure and background characteristics in exposed police officers with long-term physical complaints

	Prevalence (column %)		Odds ratio (95% confidence interval)	
	Attribution† (n=235)	No attribution† (n=310)	Univariate analysis‡	Multivariate analysis§
Type of exposure:				
Perceived severity disaster				
- not bad	3	10	0.20 (0.08-0.48)***	0.23 (0.09-0.57)**
- quite bad	9	10	0.57 (0.29-1.1)	0.64 (0.32-1.3)
- terrible	62	61	0.70 (0.46-1.1)	0.73 (0.47-1.1)
- worst thing ever	26	18	Reference	Reference
Rescuing people	21	10	2.4 (1.5-3.9)***	1.6 (0.96-2.7)
Identification and recovery of or search for victims and human remains	12	8	1.7 (0.95-3.0)	2.2 (1.1-4.3) **
Clean-up of disaster site	7	3	2.8 (1.2-6.6)*	2.8 (1.1-7.0)*
Security and surveillance of disaster area	83	75	1.7 (1.1-2.5)*	1.8 (1.1-3.0)*
Supporting injured victims and workers	31	22	1.6 (1.1-2.4)*	-
Witnessed immediate disaster scene	83	70	2.1 (1.4-3.2)***	1.8 (1.1-3.0)*
Close one affected by disaster	11	4	2.8 (1.4-5.7)**	3.1 (1.5-6.5)**
Background characteristics:				
Age (young)	50	52	0.93 (0.66-1.3)	-
Education				
- high	21	21	Reference	-
- intermediate	49	56	0.87 (0.56-1.3)	-
- low	22	18	1.2 (0.70-2.0)	-
Sex (male)	91	85	1.9 (1.0-3.2)*	-

†Attribution (little through a very strong relationship) versus no attribution (no relationship between physical complaints and the air disaster in Amsterdam and its aftermath). ‡Number of police officers included in the univariate analyses ranged from 536 to 545 due to occasional missing values. §The final multivariate model included 529 police officers and only those independent variables with $P \leq 0.10$ after step-wise backward elimination of those with $P > 0.10$. *$P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

Table 4: Associations between attribution and types of exposure and background characteristics in exposed hangar workers with long-term physical complaints

	Prevalence (column %)		Odds ratio (95% confidence interval)	
	Attribution† (n=87)	No attribution† (n=91)	Univariate analysis‡	Multivariate analysis§
Type of exposure:				
Perceived severity disaster				
- not bad	9	16	0.35 (0.12-1.1)	-
- quite bad	15	18	0.50 (0.18-1.4)	-
- terrible	51	52	0.58 (0.26-1.3)	-
- worst thing ever	25	15	Reference	-
Sort the wreckage in hangar	62	70	0.69 (0.37-1.3)	-
Witnessed immediate disaster scene	8	11	0.71 (0.26-2.0)	-
Close one affected by the disaster	5	7	0.68 (0.19-2.5)	-
Background characteristics:				
Age (young)	44	58	0.56 (0.31-1.0)	-
Education				
- high	9	6	Reference	Reference
- intermediate	32	53	0.37 (0.11-1.2)	0.37 (0.11-1.2)
- low	53	37	0.85 (0.25-2.8)	0.85 (0.25-2.8)

†Attribution (little through a very strong relationship) versus no attribution (no relationship between physical complaints and the air disaster in Amsterdam and its aftermath). ‡Number of hangar workers included in the univariate analyses ranged from 174 to 178 due to occasional missing values. §The final multivariate model included 169 hangar workers and only those independent variables with $P \leq 0.10$ after step-wise backward elimination of those with $P > 0.10$.

Discussion

This aim of this study was to assess to what extent professional assistance workers who were occupationally exposed to the air disaster in Amsterdam attributed long-term physical complaints to this disaster and its aftermath, and to examine which exposure and background variables are associated with such attribution. The main finding is that after on average 8.5 years, almost half of the exposed firefighters (46%), police officers (43%), and hangar workers (49%) with long-term physical complaints attributed these to the disaster and its aftermath. Almost a quarter of them reported a (very) strong relationship. Those who reported having more physical complaints attributed these to a stronger degree to the disaster and its aftermath.

Multivariate logistic regression analyses further showed that attribution was significantly associated with rescuing people among firefighters, and with almost all types of exposure among police officers, i.e. perceived severity of the disaster, three of five tasks, having witnessed the immediate disaster scene, and having a close one affected by the disaster. Because most of the firefighters reported multiple tasks, whereas most of the police officers reported one of the specified tasks, it may have been easier to detect independent effects of particular tasks among police officers. The difference in sample size between the groups may also have contributed to this. No significant associations between attribution and types of exposure were found among hangar workers, but this analysis was limited to three variables: sorting the wreckage, witnessing the immediate disaster scene, and having a close one affected by the disaster. Only a few hangar workers reported the latter two items.

Attribution was not significantly associated with the background characteristics age, level of education, and sex. Sex could only be taken in consideration for police officers because all the included firefighters and hangar workers were male. These results regarding age and sex are not in line with those of Stuart et al. (2003) who found that among veterans of the first Gulf War, females and those who were older (age 32 to 61 years) were more likely to report belief in exposure to terrorist agents (nerve or mustard gas) [26]. In that study, as in the present study, belief in exposure to terrorist agents was also associated with, for example, degree of exposure, i.e. reporting more exposures (non-nerve or mustard gas) to potentially toxic agents and traumatic events.

In the present study, an univariate trend was found indicating that the more severe the disaster and its aftermath were perceived, the more likely the workers were to attribute their physical complaints to the disaster and its aftermath. This finding was significant only for the police officers, which was the largest of the three occupational groups. It remains unknown, though, to what aspect of the disaster and its aftermath (e.g. toxic exposures, physical or emotional trauma) these workers attributed their long-term physical complaints, and to what extent these attributions are realistic. The finding that the majority of workers who attributed physical complaints to the disaster and its aftermath reported this to be a weak relationship, might indicate that these workers could simply not exclude the possibility of such a relationship, rather than that they had

explicit causal ideas about it. Direct toxic physical health consequences of the disaster are unlikely, since no excess morbidity was predicted in retrospective risk evaluations[1,4,5]. Moreover, no consistent significant differences in various clinical parameters in blood and urine were previously found between these exposed workers and their colleagues who did not perform any disaster-related tasks[27,28].

The extended aftermath of the air disaster in Amsterdam was characterized by numerous media reports and public discussions on alleged toxic exposures and potential health consequences, which will also have been discussed among the assistance workers[1-3]. These rumours and discussions on alleged exposures and health effects could have affected health perception and attribution of health complaints among exposed workers in two ways. Firstly, they might have contributed to perceiving the disaster as a health threat. Previous studies have argued that considering an environmental factor as harmful to health is important for subjective health. For example, in a study after the Chernobyl disaster, risk perception was suggested to play a mediating role between (perceived) exposure and subjective health problems[29]. Also, in comparisons of residents of potentially contaminated and control areas, it is just those residents who consider the contamination as harmful to health, that report lower levels of subjective health[30,31]. Secondly, these rumours might have contributed to sustained uncertainty, in which case workers may have been more inclined to refer to the actions of 'similar others', i.e. symptomatic colleagues who attributed health problems to the disaster, to decide how to act themselves[10].

In the present study the top three of physical complaints attributed to the disaster were skin complaints, fatigue and joint pain in each occupational group. These results were thus comparable across the three occupational groups, even though (due to administrative difficulties) these data were limited to 18%, 99.6% and 53% of the firefighters, police officers and hangar workers, respectively, who attributed any physical complaints to the disaster and its aftermath. Previous ESADA showed that exposed workers reported various types (including these three) of physical symptoms significantly more often than their 'nonexposed' colleagues who did not perform any disaster-related tasks[27,28]. Exposed workers reported the same type of physical complaints, yet at a higher rate than their nonexposed colleagues[32]. Therefore, the aggregate stressors of the disaster and its aftermath are likely to have influenced long-term health perception in general and attribution of physical complaints, but no indications were found that this resulted in a disaster-related cluster of certain physical symptoms specific to the exposed workers.

Donker et al. (2002) previously reported on a self-selected group (n=553) of residents, first responders and others affected by the air disaster in Amsterdam. On their own initiative, these individuals called a toll free call centre (in June-July 1998) to report the health complaints they attributed to this disaster[6]. Of the above-mentioned three physical complaints that were most frequently attributed to the disaster in the present study, fatigue (45%) and dry skin (13%) were also in the top ten of spontaneously reported health complaints at the call centre. For 3% and 15% of these

two symptoms, respectively, a relationship between the disaster and these particular symptoms was considered to be realistic according to the general practitioners of the callers with these complaints.

The strength of the present study is that it is based on a historically-defined study population consisting of all professional assistance workers who were occupationally exposed to the disaster, irrespective of their health status. Therefore it tentatively provides a representative estimate of the prevalence of long-term physical complaints and attribution thereof among all the exposed professional firefighters, police officers and hangar workers.

One limitation of the present study is the fact that recall or reporting bias may have biased the associations between the self-reported types of exposure and attribution. Furthermore, the cross-sectional study design precludes drawing inferences on the direction or causality of the associations, e.g. between the number of health complaints and the degree of attribution, and between the perceived severity of the disaster and its aftermath and attribution.

In conclusion, this study demonstrates that, after on average 8.5 years, almost half of the professional assistance workers with long-term physical health problems attributed these to some extent to the air disaster in Amsterdam and its aftermath. This attribution was significantly associated with rescuing people among firefighters, and with almost all types of exposure among police officers, i.e. perceived severity of disaster, three of five tasks, having witnessed the immediate disaster scene, and having a close one affected by the disaster. Age, sex and level of education were not significantly associated with such attribution. It is plausible that the aggregate stressors of the disaster and its aftermath with rumours on noxious exposures and health consequences have affected perceived health and enhanced the attribution of physical complaints to the disaster and its aftermath. Future longitudinal studies are needed to determine whether attribution of post-disaster health complaints leads to persistence of health complaints and health care utilisation.

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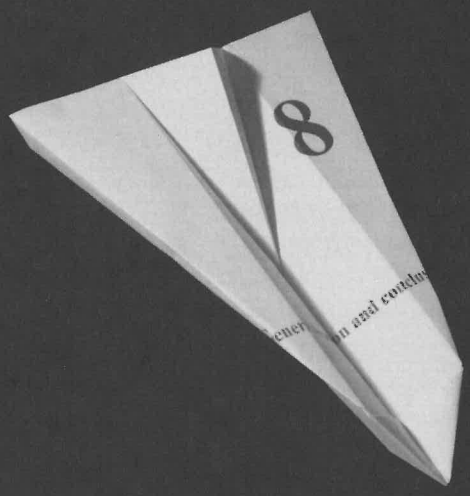
8

General discussion and conclusion



The aim of this thesis was to assess the long-term physical health effects of occupational exposure to the air disaster in Amsterdam on professional assistance workers. The overall hypothesis was that this exposure resulted in a phenomenon of 'unexplained physical symptoms'. To test this hypothesis five research questions have been addressed in sequence in Chapters 3 through 7. This final chapter integrates and summarises the main findings, discusses the ESADA approach, draws an overall conclusion, and puts forward recommendations for future research.

8.1 Main findings

The results of this thesis support the hypothesis that occupational exposure to the air disaster in Amsterdam has resulted in a phenomenon of long-term 'unexplained physical symptoms' in professional assistance workers. No evidence was found for disaster-related pathological processes based on clinical parameters in urine and blood including autoantibody serology. In contrast, a widespread excess in physical symptoms and a lower health-related quality of life was found among exposed workers compared to nonexposed workers. Although exposed workers reported several physical symptoms more often and a higher number of physical symptoms than nonexposed workers, no indications were found for a specific disaster-related cluster of certain physical symptoms. Long-term posttraumatic stress symptoms did not substantially account for the excess in multiple long-term physical symptoms among exposed firefighters and police officers.

Almost half of the exposed workers with long-term physical complaints attributed these complaints to some extent to the disaster and its aftermath. About a quarter of them reported a (very) strong relationship between their physical complaints and the disaster and its aftermath. Among exposed workers, multiple physical symptoms, low health-related quality of life as well as attribution of physical complaints to the disaster and its aftermath were significantly more often reported by exposed firefighters who rescued people and exposed police officers who had a close one affected by the disaster.

8.2 Study design

The study design of the ESADA has characteristics of historic (retrospective) cohort studies and of cross-sectional studies. Historic registers of employment were used to define the study population (historic cohort), which included both the exposed and nonexposed workers. Exposure status was based on self-report. Therefore, the ESADA is not a true historic cohort study, which also requires historically-defined exposure data. The cross-sectional characteristics of the ESADA limit the ability to draw conclusions on causality of the associations between disaster exposure and physical health outcomes, and the ability to assess mechanisms involved in such associations.

Because the ESADA was initiated in the late aftermath of disaster it focused on the long-term health effects only. Data were collected on average 8.5 years after the disaster. No data are available on workers' health in the pre-disaster period, or in the period between the disaster and the ESADA. Hence, the course and onset of health problems will remain unknown. For example, some exposed workers may in the meantime have recovered from disaster-related physical health problems. It can also not be excluded that differences between exposed and nonexposed workers in laboratory outcomes existed at an earlier point in time after the disaster.

8.3 Selection bias

Selection bias can be introduced when defining the study population. It can also result from inadequate response rates leading to a study sample that is not representative for the study population (non-response bias). One of the difficulties in disaster research is to define and include the 'exposed' population as well as appropriate reference groups. The exposed study population is also necessarily restricted to the survivors. For these reasons, epidemiological research after disasters is particularly prone to both these forms of selection bias.

In the ESADA selection bias was minimised in two ways. In the first place, historic registers of employment were available, which enabled the identification of the full cohort of exposed and nonexposed professional assistance workers. The original historic ESADA cohort was thus defined as all exposed and nonexposed workers registered as employees at the time of the disaster in one of the following occupational groups: (a) professional firefighters of the Fire Department of Amsterdam, (b) police constables, sergeants and their direct seniors of the Amsterdam-Amstelland Regional Police Force, and (c) hangar workers working at the departments of Schiphol Airport involved in the transport, security, sorting, and investigation of the aircraft wreckage. Although company records of employment were available, a few difficulties regarding the definition of the study population still had to be resolved.

With respect to the professional firefighters, the original cohort was extended to include nonexposed firefighters who joined this fire department after the disaster. This was unavoidable, because almost the entire fire department was involved in the disaster. As a consequence the nonexposed reference group of firefighters was, on average, more than 10 years younger at the time of the assessment than the exposed group. Due to the limited 'overlap' in age between exposed and nonexposed firefighters (Appendix D), it is likely that the necessary statistical adjustments for age resulted in broader 95% confidence intervals in the comparisons of exposed and nonexposed firefighters.

The cohort of police officers had to be limited to those who still worked at the Amsterdam-Amstelland police force at the time of recruitment for the ESADA in the year 2000. This restriction was necessary, because it was not possible to trace those who had left this police force in the years between the disaster and the ESADA. This might

have introduced selection bias, if leaving this police force was associated with disaster exposure or health status. However, there were no indications for such associations between leaving the police force and either disaster exposure or health status.

The second way in which selection bias was minimised in the ESADA was that it achieved the strict response requirements as determined in the ESADA protocol, i.e. at least 90% of the identified workers had to be traced at the start of the ESADA (in the year 2000), and at least 70% of those traced had to actually participate in the ESADA[1]. As shown in Appendix A, 97% of the identified workers could be traced and invited to participate in the year 2000. A total of 18 firefighters, 4 police officers and 77 hangar workers could not be traced or be invited to participate. Of these workers, 9, 2, and 13, respectively, had died between the disaster and the start of the ESADA. No data are available on the cause of death and the exposure status of these workers. In theory, this could have resulted in selection bias if the cause of death was associated with disaster exposure, but the numbers are small compared to the cohort size, also considering the period of eight years.

The response rate was 70% among those invited to participate. Of these responding workers, 97% could eventually be included as participants in the statistical analysis. Furthermore, a non-response analysis among firefighters and hangar workers revealed that non-respondents and participating workers were comparable regarding long-term perceived health and background characteristics (Appendix E). However, a few statistically significant differences were found. Compared to the participating firefighters, non-respondent firefighters were slightly older, had a higher level of education, and more often reported long-term psychological complaints and chronic arthritis since the year of the disaster. Among hangar workers, the few differences between non-respondents and participants were significantly associated with exposure status. Exposed non-respondents reported long-term physical complaints less often, and the nonexposed non-respondents were older than their participating counterparts. The employer of the police officers did not allow the collection of these data on non-respondent police officers. The few above-mentioned differences between non-respondents and participants indicate that response was selective to some extent with respect to long-term perceived health and background characteristics. The results may therefore not be entirely representative for the complete cohort of professional assistance workers, but it is unlikely that this has meaningfully affected the overall consistent results of the ESADA.

8.4 Exposure assessment

Ideally, exposure data are collected individually and immediately at the time of the disaster. However, this is seldom feasible. An accurate registration of presence in the disaster area and of (degree of) exposure to the disaster of the study population is therefore seldom available. Alternative measures of exposure include distance of

residence to disaster scene[2], aggregated environmental exposure levels[3], the recorded number of hours worked in the contaminated area[4], and self-reported exposure items, such as being a helper in a threatening or non-threatening situation[5], and presence in the exposed area as well as having suffered from acute exposure symptoms[6].

The ESADA used a detailed questionnaire to determine exposure to the disaster for all included professional assistance workers. The employers of the professional assistance workers also provided an estimation of their exposure status. This estimation was based partly on historic work schedules and partly on self-report. Because of the unknown, but questionable, quality of the employer's estimation of exposure status, it was decided to use only the data of the exposure questionnaire. A sensitivity analysis was nevertheless performed, comparing the questionnaire-based and the employer-based exposure status with regard to main outcomes selected from the chapters of this thesis. This analysis revealed that the overall results of the comparison of exposed and nonexposed workers did not depend on the choice of either of these two definitions of exposure status (Appendix F).

Self-reported retrospective exposure data are prone to information bias due to recall and reporting bias. This bias can be non-differential (i.e. unrelated to health status) as well as differential. However, (non)differential misclassification with respect to the dichotomy of exposed and nonexposed workers is unlikely, because it seems reasonable to assume that workers were able to recollect whether they had performed any, as opposed to no, disaster-related tasks. This probably also holds true for the dichotomous types of exposure considered in this thesis, i.e. whether workers performed a series of specified tasks, witnessed the immediate disaster scene, or had a close one affected by the disaster. In contrast, details such as duration of exposure are more prone to such information bias. For that reason duration of exposure was not included in the analysis.

The disaster was followed by an extended troublesome aftermath, which included elaborate media attention and rumours on various alleged noxious exposures and health consequences[7-9]. These public issues will also have been discussed among some of the exposed workers. The events in the aftermath may also have affected the health of exposed workers. Although no specific variables were addressed concerning this aftermath, an overall measure of the perceived severity of the disaster and its aftermath was also included in the analysis.

8.5 Assessment of physical health

8.5.1 Laboratory outcomes

The laboratory outcomes covered a broad range of clinical parameters in urine and blood including autoantibody serology. These laboratory outcomes enabled the assessment of group-level associations between disaster exposure and long-term systemic and organ-specific pathological processes. However, these parameters cannot

prove the absence or presence of somatic explanations for a given physical symptom, nor can they be considered as a substitute for a clinical judgment of the health status of an individual worker.

The quality of the laboratory outcomes was ascertained by the fact that the blood and urine samples of all workers were dealt with according to standardised procedures for the collection, transportation, storage and laboratory assessments. All the clinical laboratories involved in the ESADA carried out their analyses according to accredited (Dutch) standards. Laboratory technicians were blinded for exposure status and personal details. The data on all laboratory outcomes were complete for at least 95% of the participants. The clinical cut-off values of these laboratories were used to define a deviant outcome.

8.5.2 Self-reported health outcomes

Various measures were undertaken to assure the quality of the questionnaire data. Questionnaire completeness was checked, and the questionnaire data of each participant were entered twice, after which inconsistencies were reviewed and any mistakes rectified. All remaining problems in the interpretation of data, such as dubious handwriting, were consistently resolved by one of the ESADA team members of the EMGO Institute. The data of almost all subjective health outcomes were complete for at least 95% of the workers.

Validated questionnaires were used to measure health-related quality of life[10,11], and physical symptoms[12,13]. In addition, 34 other physical symptoms were assessed with a questionnaire that was drawn up for the ESADA (Appendix C). The validity of these questions is therefore unknown. As a consequence, the exact prevalence rates of these symptoms are difficult to interpret from a clinical point of view. However, this is not a major problem for the assessment of the health effects of exposure to the disaster, because this assessment was based on comparisons between exposed and nonexposed workers, and between exposed workers with and without a particular type of exposure.

Standardised, published cut-off values were used to define subjective health problems. If no such criteria were available, sensitivity analyses were performed to assess whether the results were influenced by the chosen cut-off value. In general, these sensitivity analyses showed that the results were essentially independent of the used cut-off value.

Differential misclassification in self-report health measures could occur if exposed workers are more likely than nonexposed workers to interpret and report bodily sensations as symptoms. On the other hand, hypervigilance and hypochondria themselves could be one of the major adverse health effects of disasters with potential exposure to hazardous materials[14,15]. The invitation to the ESADA and the assessment of disaster exposure may also have affected symptom reporting among exposed workers. Thus, the possibility of overestimating the effect of exposure on symptoms due to such reporting bias cannot be excluded.

8.5.3 Unexplained physical symptoms

In this section the statistical approach to assess unexplained physical symptoms is discussed. This thesis addressed the various physical health outcomes *independently*, or in some aggregated form, e.g. symptoms classified according to the international classification for primary care (ICPC), and the number of autoimmune-like symptoms. An alternative analytical approach would have been to use a *case definition* for unexplained physical symptoms. Although there is not one generally excepted case definition, some case definitions (e.g. Chronic Fatigue Syndrome[16]) have been reported and could be used as a reference. Unfortunately, the ESADA data set was not compatible with these case definitions, e.g. the symptoms were dichotomous without information on the duration and severity; some 'key' symptoms or features of these definitions were not addressed; and no clinical diagnostic information was available. Another option was to build our own case definition by combining data on, for example, the type and number of physical symptoms, laboratory abnormalities, and adverse health-related quality of life. Such an approach would have integrated as much data of each individual worker as possible in just one outcome measure. However, drawbacks include the inevitably arbitrary nature of such a definition, and the fact that such a complex definition impedes its interpretation and would not be reproducible in other research settings. Therefore, it was decided to use three relatively simple definitions of 'multiple physical symptoms'. Two were based on validated and commonly used questionnaires using published and validated cut-off values to enhance the comparability with other studies, i.e. a total score >76 on the Checklist Individual Strength[17], and a score ≥19 on the somatic symptoms subscale of 90-item Symptom Checklist[18]. The third definition was based on the ESADA physical symptom questionnaire (≥3 physical symptom categories, Appendix C).

Another interesting approach would have been to assess whether exposed and nonexposed workers differ in their *pattern* of physical symptoms. Such a 'sophisticated' analysis of interrelated symptoms (and to establish whether this pattern is association with disaster exposure), requires multivariate methods such as factor analysis, cluster analysis, and correspondence analysis. Such approaches, particularly factor analysis, have been applied in many studies on unexplained physical symptom phenomena[19-22]. Attempts were made to apply these methods to the ESADA data set, but the data proved to be unsuitable for them. This was primarily due to the dichotomous structure of the ESADA data (absence/presence of physical symptoms), and due to the finding that many symptoms were rarely reported, while a few symptoms were frequently reported.

The following results make one specific disaster-related symptom cluster ('syndrome') less plausible. Firstly, as mentioned above, many of the 34 physical symptoms were rarely reported (<10%), while only few symptoms were relatively often reported (>20%) (Figures 1 and 2). Secondly, the elevated symptom prevalence among exposed workers concerned many of the 34 physical symptoms rather than certain selected symptoms (Figure 1 and 2). Thus, exposed workers reported the same physical symptoms, yet at a higher prevalence rate. The top 5 of the most frequently reported

symptoms, for example, was very similar across exposed and nonexposed groups and also across the occupational groups (Table 1). Thirdly, most exposed and nonexposed workers reported no or a few of the 34 symptoms, while few workers reported many of these symptoms (Figure 3 and 4).

The results of the ESADA therefore demonstrate that exposed workers reported a higher prevalence of a variety of individual physical symptoms, as well as a higher number of physical symptoms than nonexposed workers, but that there is no evidence for a disaster-related cluster of certain physical symptoms.

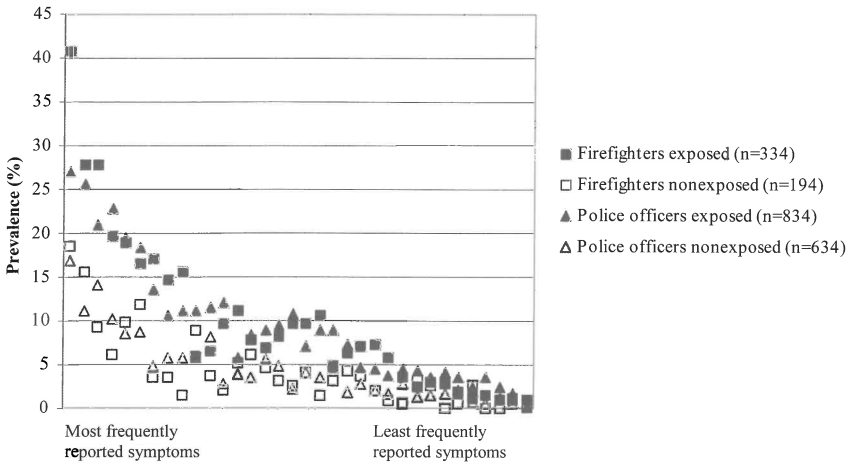


Figure 1: Prevalence of 34 physical symptoms among exposed and nonexposed firefighters and police officers in descending order of the average prevalence of these two groups of exposed workers.

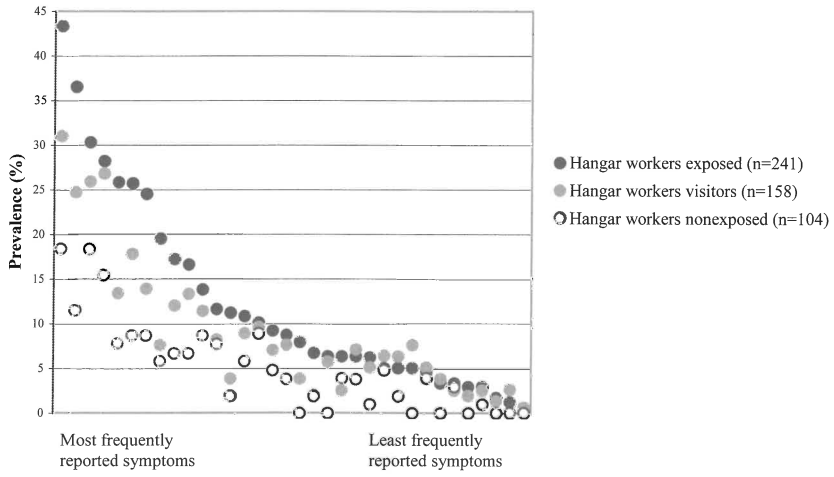


Figure 2: Prevalence of 34 physical symptoms among exposed, visiting and nonexposed hangar workers in descending order of symptom prevalence in exposed workers.

Table 1: The five most frequently reported physical symptoms (from a total of 34 symptoms)

	Firefighters		Police officers		Hangar workers		
	Exposed, n=334	Nonexposed, n=194	Exposed, n=334	Nonexposed, n=634	Exposed, n=241	Nonexposed, n=104	Visitors, n=158
1.	Joint pain (40.7%)	Joint pain (18.5%)	Joint pain (27.0%)	Joint pain (16.8%)	Joint pain (43.3%)	Joint pain (18.4%)	Joint pain (31.0%)
2.	Low back pain (27.8%)	Eczema or dermatitis (15.5%)	Eczema or dermatitis (25.6%)	Low back pain (14.1%)	Easily fatigued (36.5%)	Low back pain (18.5%)	Eczema or dermatitis (26.8%)
3.	Eczema or dermatitis (27.8%)	Redness or scaling of face, chest or head (11.9%)	Easily fatigued (22.8%)	Eczema or dermatitis (11.2%)	Low back pain (30.3%)	Eczema or dermatitis (15.4%)	Low back pain (25.9%)
4.	Easily fatigued (19.6%)	Nocturnal transpiration (9.8%)	Low back pain (21.0%)	Easily fatigued (10.1%)	Eczema or dermatitis (28.2%)	Easily fatigued (11.5%)	Easily fatigued (24.7%)
5.	Nocturnal transpiration (18.9%)	Low back pain (9.3%)	Nocturnal transpiration (19.5%)	Redness or scaling of face, chest or head (8.7%)	Nocturnal sweating (25.8%)	Chest tightness (8.9%)	Redness or scaling of face, chest, or head (17.8%)

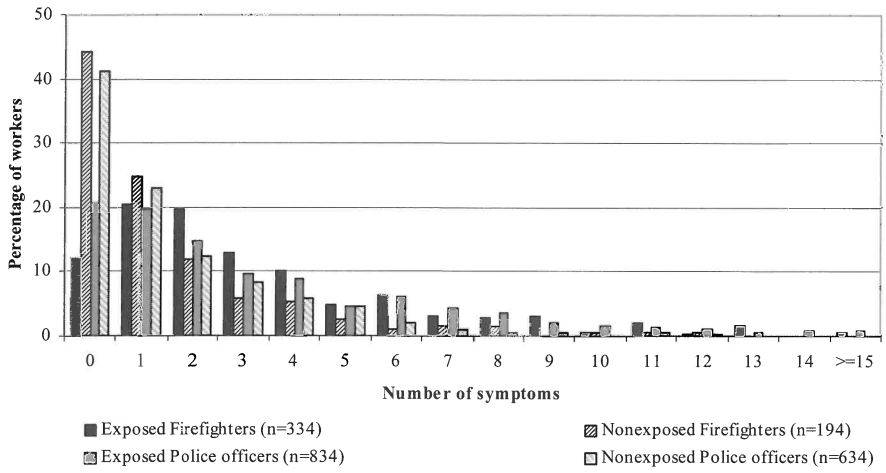


Figure 3: Distribution of the number of physical symptoms (from a list of 34 symptoms) among exposed and nonexposed firefighters and police officers.

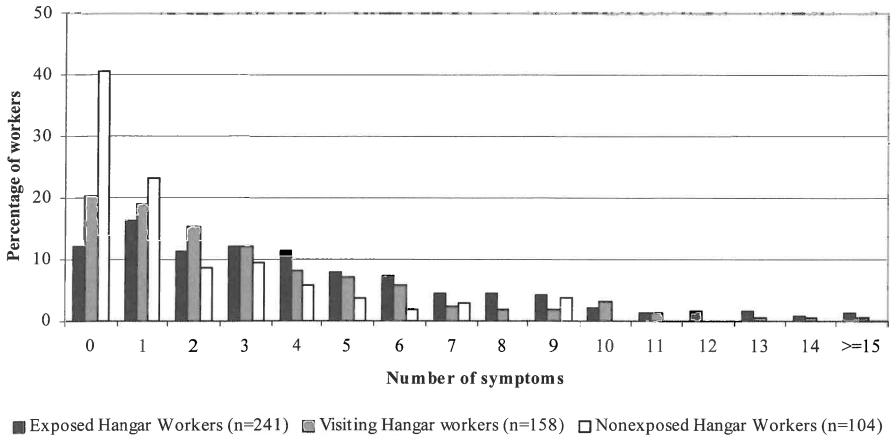


Figure 4: Distribution of the number of physical symptoms (from a list of 34 symptoms) among exposed, visiting, and nonexposed hangar workers.

8.6 Confounding and effect modification

Some factors might be associated with disaster exposure and with the physical health outcomes, and could therefore confound the association of interest. In the ESADA such potential confounding was minimised in two ways. Firstly, the exposed groups were compared to highly comparable reference groups of colleagues who were not occupationally exposed to the disaster. These nonexposed workers worked for the same employer, at the same departments, and had a similar job description at the time of the disaster as the exposed workers. Secondly, several general potential confounding background variables were accounted for in the adjusted regression models (e.g. age, sex, level of education, ethnicity, cigarette smoking and alcohol consumption). In general, these adjustments did not essentially change the associations between disaster exposure and health outcomes, with the exception of age among firefighters.

Certain factors may modify rather than confound the association between the disaster exposure and physical health outcomes, in which case significant interactions between that factor and exposure status would be found. Posttraumatic stress disorder was suggested to be one such factor in previous studies on subjective physical health after disastrous events. However, no significant interactions were found between disaster exposure and high levels of long-term posttraumatic stress symptoms with respect to multiple physical symptoms (Chapter 5). It should be borne in mind though, that the low prevalence of high levels of posttraumatic stress symptoms in the ESADA population limited the assessment of such interaction.

8.7 Conclusion and recommendations for future research

This epidemiological study demonstrates that professional assistance workers involved in a disaster are at risk for long-term subjective physical health problems, which cannot substantially be attributed to disaster-related pathological processes or posttraumatic stress symptoms. These results are in line with previous studies among civilian and military populations that were exposed to disastrous events with real or perceived exposure to hazardous materials.

Occupational health services of professional assistance workers need to be aware of and be prepared to respond to the potential health effects (including unexplained physical symptoms) of disasters and perceived exposure. Few other epidemiological studies have specifically addressed the long-term physical health of professional assistance workers after a disaster. Therefore, further epidemiological studies on such workers are needed to establish whether similar findings emerge after other disasters.

Epidemiological studies are a powerful tool to study physical health effects of disasters, but they will always be a challenge, because of the sudden, unexpected and complex nature of each disaster. Therefore, in order to increase our knowledge on the health consequences of disasters it is important to be prepared to perform epidemiological studies. Incorporating basic multidisciplinary, epidemiological research protocols into disaster management plans will stimulate scientifically sound research on the health effects of disasters. Some general recommendations can be made for future epidemiological studies after disasters irrespective of the study population, regarding (a) the assessment of exposure, (b) the assessment of physical health outcomes, including 'unexplained physical symptoms', and (c) the mechanisms involved and risk factors for unexplained physical symptoms.

Firstly, with respect to exposure assessment in epidemiological disaster research, assessments should preferably be performed at an individual level to prevent (differential) misclassification. Such exposure assessments should be collected at the time of the disaster and consistently thereafter, to enable to prospectively assess associations between the degree of exposure and health outcomes. Furthermore, the exposure assessment should include three aspects. The first aspect is the degree of damage to oneself, beloved ones, and properties. The second aspect is the degree of exposure to hazardous materials. This information is also needed for an immediate evaluation of toxic risks as to decide on preventive measures, to enable risk communication and reduce uncertainty about exposure[23], and to hopefully prevent unfounded rumours from spreading. To this end, the timely involvement of experts on risk communication is recommended in the aftermath of disasters. The third aspect is the degree of exposure to psychotraumatic and otherwise stressful events related to the disaster and its aftermath.

Secondly, it is recommended to include the following three types of outcomes in future studies on physical health effects of disasters: (a) the physical outcomes that are logical and relevant from a medical and toxicological perspective, (b) a general measure

of subjective physical symptoms, and (c) psychological symptoms (notably posttraumatic stress disorder) to ascertain their role in post-event physical health problems. Further research is needed to standardise the general measure of subjective physical symptoms and the assessment of their 'unexplained' nature. This will facilitate the interpretation and comparison of results of various studies on these symptoms after disasters.

Thirdly, a longitudinal study design in future disaster research is recommended to enable to further study the course of, mechanisms involved in, and risk factors for unexplained physical symptoms after disasters. Risk factors could include those found to be cross-sectionally associated with subjective health problems in the ESADA (e.g. rescuing people, supporting injured victims and workers, and having a close one affected by the disaster), and in other studies, such as pre-disaster health problems, female gender, the degree of damage, and posttraumatic stress disorder. Other factors of interest regarding potential mechanisms involved in post-disaster unexplained physical symptoms include personality factors (such as coping style, information processing style, and risk perception, e.g. whether subjects consider the disaster as a health threat), socio-environmental processes (such as litigation affairs; private and public discussions, rumours and media coverage on alleged exposure and health consequences), and other pre- and post-disaster negative life events. Care should be taken to focus not only on disastrous events that resulted in unexplained physical symptoms, but to also learn from similar situations in which such symptoms did not develop.

Finally, the usefulness of existing (electronic) registries for epidemiological disaster research could be explored further, which has also been proposed for general cases of local environmental health concerns[23]. Examples of such registries in the Netherlands include those of general practitioners[24] and of the occupational physicians of professional assistance workers. Potential advantages of such existing registries include the availability of pre-disaster and post-disaster longitudinal data on health, and of diagnostic information (e.g. whether symptoms relate to a diagnosis or not). However, the data of these registries may also have several limitations, e.g. the lack of detailed data on disaster exposure, selection bias, and information bias because physicians might more vigorously screen for and might be more inclined to diagnose (certain) health problems when they know a client was involved in the disaster. Therefore, a useful strategy to gain scientifically sound knowledge on the health effects of disasters might, at least in the Netherlands, be the combination of studies using data of such existing registries, and (longitudinal) population-based epidemiological studies.

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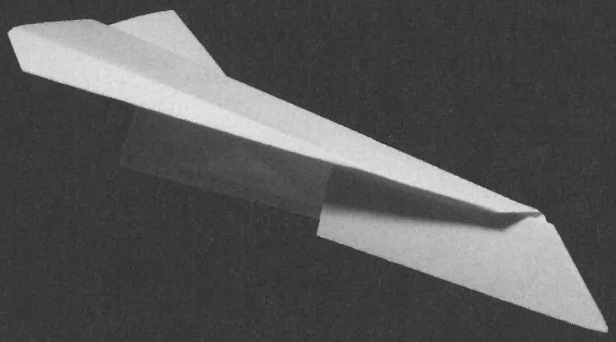
Appendices



Appendix A: Flow chart of the ESADA study population

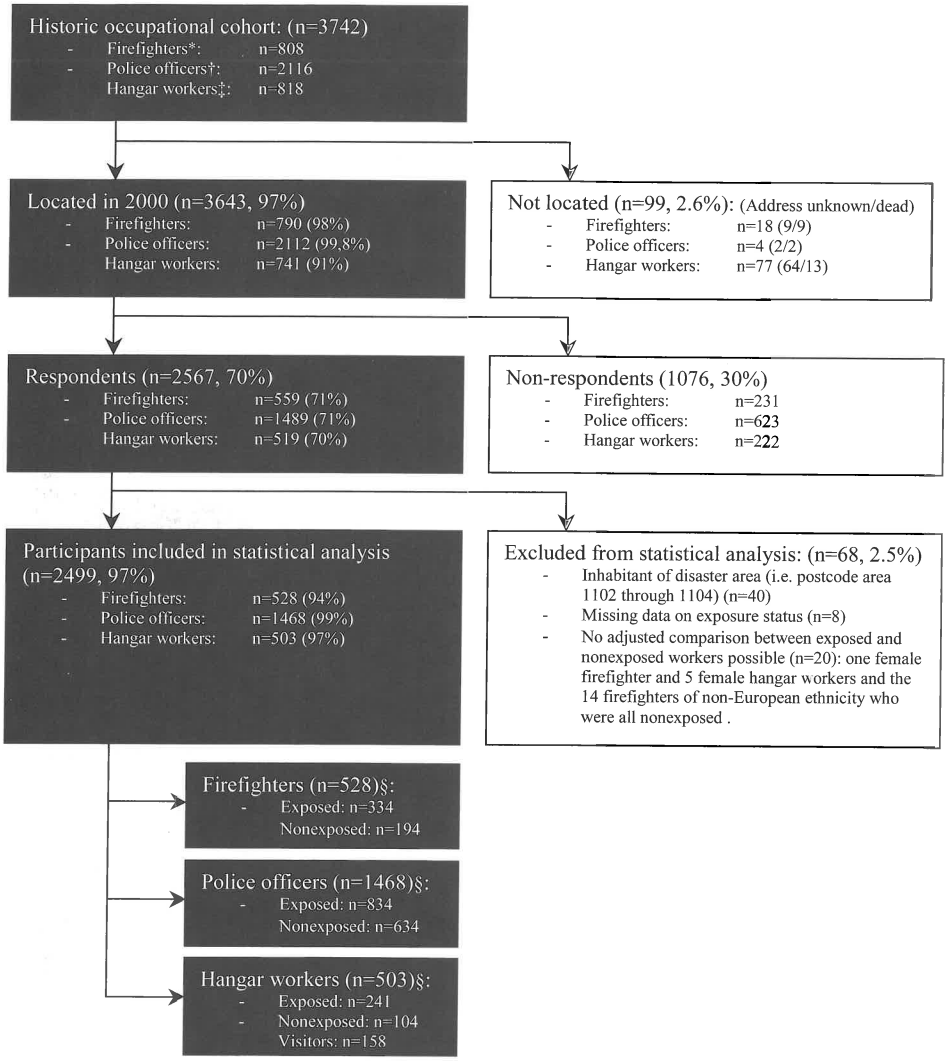


Figure A.1: Flow chart of the ESADA study population

*All professional fire-fighters who were, according to company records, employed in the Amsterdam fire department at the time of the disaster. Additional professional fire-fighters who started working in this fire department after the disaster were also invited to participate in the study, as almost the entire fire department had been exposed to the disaster.
†All police officers (i.e. constables, warrant officers, sergeants and their supervisors) who were, according to company records, employed in the Amsterdam-Amstelland regional police force on the date of the disaster (October 4th, 1992), and were still employed there on the 1st of January 2000.
‡All the hangar workers registered as working for one of the departments involved in the transport, security and sorting of the wreckage on the date of the disaster (October 4th, 1992), and who reported to have been involved in these activities; as well as a random sample, matched with their colleagues for age, sex, department and job title, who were also registered as working for these departments on 30th November 1992, but who did not report to have been involved in any disaster-related activities.
§Exposure status based on questionnaire: exposed workers reported at least one disaster-related task; nonexposed workers reported no disaster-related tasks; visitors reported being present in the hangar when the wreckage was there, but no disaster-related tasks.

Appendix B: Description of exposure to the air disaster in Amsterdam

Table B.1: Prevalence (%) of types of exposure to the air disaster in Amsterdam among exposed professional assistance workers

	Exposed* Firefighters (n=334)	Exposed* Police officers (n=834)	Exposed* Hangar workers (n=241)
A1† tasks:			
1. Rescuing people	49 ‡	16 ‡	0
2. Identification or recovery of victims from the rubble/ transport or search for human remains	15 ‡	8 ‡	1
Non-A1† tasks:			
3. Firefighting	61 ‡	0.1	0
4. Clean-up of disaster site	55 ‡	5 ‡	0.4
5. Security tasks (surveillance, prevent burglary, keep disaster area free of bystanders)	3 ‡	79 ‡	15
6. Supporting injured victims/workers	10 ‡	24 ‡	0.4
7. Transport of injured victims	4	4	0
8. Other tasks (e.g. traffic and communication management)	25	38	4
9. Sort wreckage in hangar (at Schiphol Airport)	0.3	2	67 ‡
10. Other tasks in hangar in the presence of the wreckage	0	3	67
11. Transport of wreckage	9	7	10
12. Burning of contaminated soil remnants (from disaster site)	2	1	1
A1† events:			
1. Immediate family members (partner, children) died / in life-threatening danger / injured due to the disaster §	0	0.5	0
2. Having been in life-threatening danger during disaster	1	1	0
3. Personal injuries due to disaster	0	0.4	0
4. Having witnessed dead or injured victims	17	45	1
5. Having been in or near one of the destroyed buildings at the time of the disaster	4	8	3
6. Other family members died due to the disaster §	0	0	0.4
Non-A1† events:			
7. Saw the disaster site during the first hours after the crash or when the wreckage was still there	74 ‡	75 ‡	9 ‡
8. Saw aircraft crash / saw or heard the aircraft when it crashed	7	5	7
9. Saw the fire	52	68	5
10. Felt or heard the impact of the crash	6	5	5
11. Other family members in life-threatening danger or injured due to the disaster §	0	1	1
12. Friends or acquaintances died, injured or in life-threatening danger due to the disaster §	3	5	3
13. Apartment of other family members, friends, or acquaintances damaged due to the disaster §	1	2	1
14. Lived in the affected suburb of Amsterdam (Bijlmermeer) at the time of the disaster #	1	2	2
15. Visited the hangar where the wreckage was kept	1	7	62

*Exposed workers reported at least one disaster-related task.
†See Chapter 2: A1= items with a mean score of three or higher on a 4-point Likert Scale from 'very unlikely' (=1) to 'very likely' (=4) to meet criterion A1 for post-traumatic stress disorder; non-A1= items with a mean score of less than three.
‡Item selected for the analysis of associations between types of exposure and disaster-related health outcomes.
#Those who lived in the area nearest to the disaster site (i.e. postcode 1102 through 1104) at the time of the disaster were excluded, those who lived outside this inner circle at that time were included in the statistical analysis.
§These items were combined to form the type of exposure variable 'having a close one affected by the disaster'.

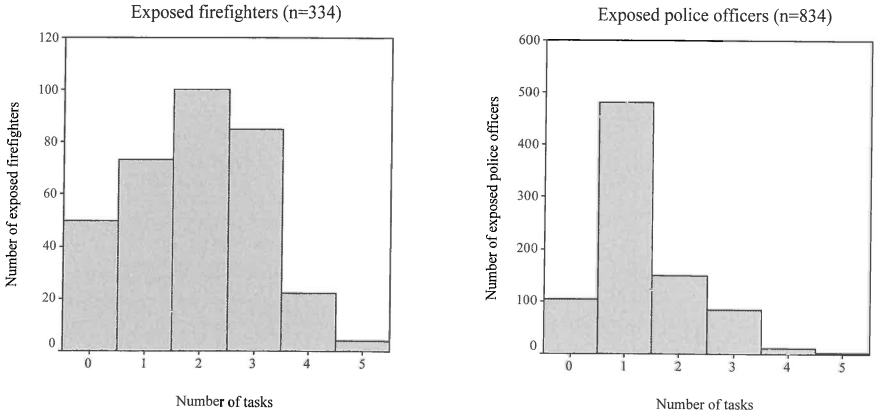


Figure B.1a and B.1b: Histograms showing the distribution of the number of the following 6 selected tasks among exposed firefighters and police officers: rescue people; firefighting; identification and recovery of or search for victims or human remains; cleanup of disaster site; security of disaster area; and support injured victims or workers.

Appendix C: 34 physical symptoms in the ESADA questionnaire

Table C.1: List and classification of 34 long-term physical symptoms according to the International Classification for Primary Care[1]

Class	Number of classified symptoms	Symptoms
1. General and non-specified	4*	Being easily fatigued (in the past three months); Regular, excessive nocturnal transpiration (in the past three months); Unexplained fever (in the past three months); Multiple infections (in the past three months).
2. Digestive system	1†	Oral ulcers (for a long time)
3. Eye	1‡	Sand feeling in eyes (for a long time)
4. Cardiovascular system	3*	Raynaud's discoloring (white-blue-red discoloration of the fingers or toes for a long time); Inflamed arteries (in the past 3 months); Varicose veins or leg ulcer (in the past 3 months)
5. Musculoskeletal system	4	Chronic low back pain (>3 consecutive months); Chronic joint pain (>3 consecutive months); Chronic swollen joints (>3 consecutive months); Excessive muscle pain (in the past 3 months)
6. Neurological	1*	Loss of strength (in past 3 months)
7. Respiratory tract	6	Chronic (>3 consecutive months in past 2 years) cough; Chronic (>3 consecutive months in past 2 years) productive cough; Shortness of breath (when walking in normal pace with peers on flat terrain); Wheezing chest (>1 week in past 2 years); Chest tightness (asthma attack); Bronchial hyperreactivity (i.e. having trouble breathing in at least 4 of the following 9 situations: (a) when the weather is changing from warm to cold; (b) when the weather is changing from cold to warm; (c) when it is misty; (d) when it is raining; (e) when it is freezing cold; (f) as a result of irritating chemical substances (such as exhaust fumes, chlorine, petrol, etc.); (g) as a result of baking or roasting fumes; (h) as a result of smoke; and (i) as a result of tobacco smoke)
8. Skin	14	Strong and sustained oversensitivity of the skin to sunlight; Redness or scaling on face, chest, or head; Eczema or dermatitis; Redness in butterfly-like pattern on nose and cheeks; Psoriasis (redness and scaling on the external surface of elbows or knees, coccyx, or crown); Itching rash; Pimples; Skin infections, such as furunculi; Discolored spots; Warts; Excessive hair loss; Bluish spots resembling bruises, with or without sores; Tight skin (in the past 3 months); Other skin complaints.

* In chapter 3 the following 7 items from the 90 item Symptom Checklist[2] [item number] were additionally classified (presence of symptom defined as 'a little through all the time' in the last 7 days): weakness [56] in 'general and non-specified'; nausea, upset stomach [40] in 'digestive system'; heart pounding/racing [39] and pains in heart/chest [12] in 'cardiovascular system'; headaches [1], numbness/tingling sensations [52], and faintness/dizziness [4] in 'neurological'.
† In chapter 3 the current presence of or a history of the following 2 chronic conditions were additionally classified: chronic or recurrent intestinal disorder and chronic gastric or duodenal ulcer or disorder in 'digestive system'.
‡ In chapter 3 this symptom (and class of symptoms) was not considered in the statistical analysis.

References:
1. Lamberts H, Wood M: *ICPC: International Classification of Primary Care.* Oxford: Oxford University Press; 1987.
2. Arrindell WA, Ettema JHM: *Handleiding bij een multidimensionele psycho-pathologie indicator. [Manual for a multidimensional psycho-pathology indicator]* . Lisse: Swets & Zeitlinger; 1986.

Appendix D: Age distribution of exposed and nonexposed firefighters

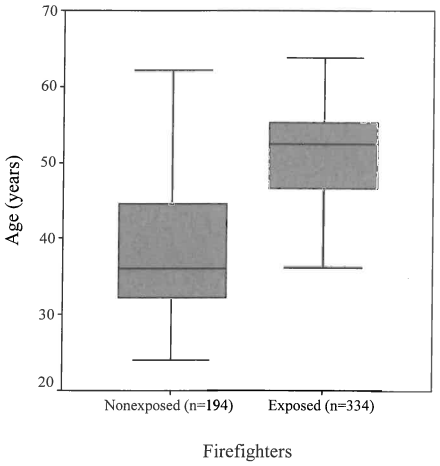


Figure D.1: Box plot of age distribution of exposed and nonexposed firefighters

Legend: Horizontal lines within the boxes represent the median age; upper and lower borders of the boxes indicate the 25th and 75th percentiles, respectively; the upper and lower horizontal lines indicate minimum and maximum age, respectively.

Appendix E: Non-response analysis

Table E.1 Background characteristics and perceived health of nonrespondent versus participating firefighters and hangar workers

	Firefighters		Hangar workers	
	Non-respondents (n=47)*	Participants (n=528)	Non-respondents (n=57)*	Participants (n=503)
Background characteristics:				
Exposure status^, %				
Exposed	40	63	32	48
Nonexposed	60	37	40	21
Visitors	-	-	28	31
Age (years), mean (standard deviation)				
All	47.6 (10.8)†	46.8 (9.5)	46.9 (9.4)‡	43.6 (7.8)
Exposed	53.6 (6.9)	51.4 (5.9)	44.1 (8.2)	43.9 (7.8)
Nonexposed	43.6 (11.1)‡	38.8 (9.1)	49.4 (9.0)‡	43.4 (7.8)
Visitors	-	-	43.5 (7.9)	46.5 (10.6)
Sex, %				
Male	100	100	100	100
Female	0	0§	0	0§
Level of education, %#				
Low	45†	56	49	44
Medium – high	55	38	48	49
Missing	-	6.3	3.5	6.6
Ethnicity, %				
European	100	100	90	95
Non-European	0	0¶	11	4.8
Perceived long-term health:				
General health, %				
Poor or fair vs. (very) good or excellent	8.5	8.1	7.0	16
Physical complaints, %				
Few-very many vs. none				
All	47	60	40†	68
Exposed	63	73	33†	79
Nonexposed	36	37	44	52
Visitors	-	-	44	64
Psychological complaints. %				
Few-very many vs. none	21†	10	5.4	13
Chronic condition (onset in 1992 or later), %				
Asthma/chronic obstructive pulmonary disease	2.1	2.1	8.8	2.4
Chronic arthritis	10†	4.2	5.3	2.6
Skin disorder	14	13	7.1	12

*Random samples of non-respondent firefighters (n=66 [29% of n=231]) and hangar workers (n=77 [35% of n=222]) were called up to 6 times on different occasions within a period of two weeks, after which n=46 (71%) and n=57 (74%) had completed the interview; five refused to participate, and 34 could not be contacted; All interviews were held before any of the ESADA results were published.

^Exposed workers reported at least one disaster-related task; nonexposed workers reported no disaster-related tasks; visitors reported being present in the hangar when the wreckage was there, but no disaster-related tasks.

†$p<0.05$ using logistic regression analysis with participants as the reference group, and adjusting for age, level of education, ethnicity and exposure status, if applicable.

‡$p<0.05$ using logistic regression analysis with participants as the reference group, and adjusting for age, level of education and ethnicity, if applicable; performed stratified by exposure status because of statistically significant interaction between exposure and nonrespondent status among hangar workers.

§One female firefighter and five female hangar workers did agree to participate in the ESADA, but were excluded from all the statistical analyses performed in the ESADA, because these low numbers of females did not allow a sex-adjusted comparison between exposed and non-exposed workers.

#Highest level of education completed was classified as low (no education, elementary school, lower vocational education, or lower general secondary education) versus higher levels; and participants for whom data on level of education was missing were excluded from the nonresponse analysis.

¶Ethnicity was classified as those who considered themselves as European (i.e. Dutch, British, Dutch/Irish, Dutch/Chinese, Dutch/Indonesian, Portuguese, Spanish, Dutch/Spanish, and 'European') versus others; 14 non-European firefighters did agree to participate in the ESADA, but were excluded from all statistical analyses in the ESADA because all of them happened to be nonexposed and hence no ethnicity-adjusted comparison between exposed and nonexposed firefighters could be performed.

Appendix F: Sensitivity analysis regarding self-reported and employer-based exposure status

Table F.1: Agreement between questionnaire* and employer-based† exposure status for 2499 workers included in the statistical analyses

Exposure status:	Firefighters (n=334)	Police officers (n=834)	Hangar workers (n=241)
Agreement (questionnaire* = employer†-based):	N=470 (89%)	N=1317 (92%)	N=302 (60%)
Exposed	n=331	n=751	n=206
Nonexposed	n=139	n=596	n=96
No agreement (questionnaire* vs. employer†-based):	N=58 (11%)	N=121 (8%)	N=201 (40%)
Exposed vs. nonexposed	n=3	n=83	n=35
Nonexposed vs. exposed	n=55	n=38	n=8
Visitor vs. nonexposed	-	-	n=74
Visitor vs. exposed	-	-	n=84

*All the workers included in the analysis completed a detailed exposure questionnaire on disaster-related tasks. Those workers who reported at least one disaster-related task were defined as being (occupationally) exposed; all others as nonexposed. With respect to the hangar workers a third group of visitors was defined, consisting of those workers who reported to have been in the hangar when the wreckage was there, but who did not report disaster-related tasks.
†For firefighters and police officers the occupational exposure status provided by their employers was based on historic work schedules; the accuracy thereof was unknown and actual practice could to some extent have deviated from scheduled work. For hangar workers there was no historic registration of exposure available. The exposure data provided by their employer was also based on self-report, albeit collected differently. All hangar workers were asked by their employer to report if they had been in the hangar with the aircraft wreckage and if they knew of others that had been present there (and perhaps no longer worked there anymore). These subjects were assumed to have been 'exposed', and all others who were on the list of employees on November 1, 1992 were assumed to be nonexposed. Subsequently, a random sample, matched for age, sex, department and job title, of these assumed nonexposed workers was drawn as the reference group and invited to participate in the ESADA.

Table F.2: Results of the adjusted comparisons between exposed and nonexposed firefighters and police officers regarding main physical health outcomes, using questionnaire-based and employer-based exposure status

	Odds ratio (95% confidence interval)			
	Firefighters (n=528)		Police officers (n=1468)	
Health outcome [number refers to relevant chapter]	Questionnaire-based: exposed (n=334) vs. nonexposed (n=194)	Employer-based: exposed (n=386) vs. nonexposed (n=142)	Questionnaire-based: exposed (n=834) vs. nonexposed (n=634)	Employer-based: exposed (n=789) vs. nonexposed (n=679)
Laboratory outcomes:				
Elevated albumin-creatinine ratio (≥2)†‡[3]	0.85 (0.31–2.4)	0.23 (0.073–0.73)*	1.0 (0.62–1.7)	1.0 (0.61–1.7)
Elevated leukocyte count (>3 x10^9/l)†[3]	0.19 (0.049–0.73)*	0.70 (0.11–4.5)	1.2 (0.72–1.9)	0.91 (0.56–1.5)
Low % neutrophils (<45%)†[3]	1.1 (0.23–5.2)	2.3 (0.27–19.9)	1.2 (0.61–2.4)	1.7 (0.86–3.4)
Low % lymphocytes (<20%)†[3]	1.2 (0.56–2.7)	1.9 (0.65–5.6)	1.2 (0.81–1.7)	1.2 (0.82–1.7)
Elevated % monocytes (>10%)†[3]	2.3 (0.96–5.5)	2.0 (0.73–5.6)	1.6 (1.1–2.4)*	1.6 (1.1–2.4)*
CRP >10 mg/l†[3]	0.50 (0.14–1.7)	1.0 (0.18–6.0)	1.2 (0.68–2.2)	1.2 (0.64–2.1)
Elevated ALAT (>45) & GGT (>50 U/l)[3]	1.1 (0.39–3.2)	0.82 (0.22–3.0)	1.4 (0.92–2.2)	1.5 (0.95–2.3)
≥1 autoantibody§[4]	1.3 (0.72–2.3)	0.77 (0.38–1.5)	0.87 (0.67–1.1)	0.89 (0.69–1.2)
Subjective health:				
≥1autoimmune-like symptoms§[4]	3.1 (1.9–5.1)***	3.2 (1.7–6.0)***	2.7 (2.2–3.4)***	2.6 (2.1–3.3)***
≥3physical symptom categories§[5]	4.4 (2.3–8.5)***	3.5 (1.5–7.8)**	3.2 (2.5–4.2)***	3.0 (2.3–3.9)***
General health: poor or fair vs. (very) good or excellent§[6]	8.8 (1.9–40.8)**	3.5 (0.72–17.5)	2.6 (1.7–4.0)***	2.7 (1.7–4.0)***
Role-limitation due to physical and/or emotional problem§[6]	1.6 (0.89–3.0)	1.6 (0.72–3.4)	1.9 (1.5–2.4)***	1.9 (1.5–2.4)***

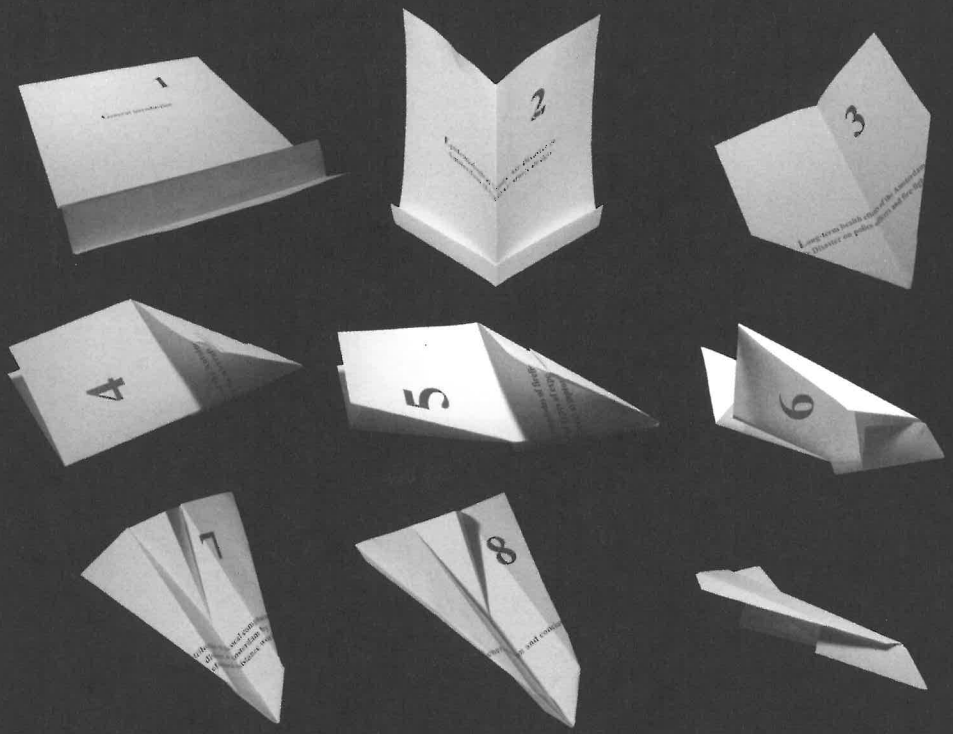
Abbrevations: ALAT, alanine-amino-transferase; CRP, C-reactive protein; GGT, gamma glutamyl-transferase.
*p<0.05; **p<0.01; ***p<0.001. †Adjusted for age, level of education, cigarette smoking, alcohol consumption, executive function, level of physical activity, and, among police officers, sex and ethnicity. ‡Albumin/creatinine ratio= (microalbumin in urine [mg/l]) / (creatinine in urine [mmol/l] using Jaffé's method). §Adjusted for age, level of education, cigarette smoking, alcohol consumption, executive function, and, among police officers, sex and ethnicity, if applicable.

Table F.3: Results of the adjusted comparisons between exposed and nonexposed hangar workers regarding main physical health outcomes, using questionnaire-based and employer-based exposure status, in sample without visitors (n=345) and in total sample (n=503)

	Odds ratio (95% confidence interval)		
	Sample of hangar workers without visitors (n=345)		All hangar workers (n=503)
Health outcome [number refers to relevant chapter]	Questionnaire-based: exposed (n=241) vs. nonexposed (n=104)	Employer-based: exposed (n=214) vs. nonexposed (131)	Employer-based: exposed (n=298) vs. nonexposed (205)
Laboratory outcomes:			
Elevated Albumin/ creatinine ratio (≥2)†‡[3]	0.40 (0.15–1.1)	0.57 (0.21–1.5)	0.66 (0.30–1.4)
Elevated leukocyte count (>3x10^9/l)†[3]	0.76 (0.28–2.0)	1.2 (0.44–3.1)	1.2 (0.47–2.8)
Low % neutrophils (<45%)†[3]	0.25 (0.052–1.2)	0.26 (0.047–1.4)	0.41 (0.13–1.3)
Low % lymphocytes (<20%)†[3]	2.2 (0.95–5.0)	2.7 (1.2–6.0)*	1.9 (1.1–3.6)*
Elevated % monocytes (>10%)†[3]	0.66 (0.27–1.6)	0.70 (0.30–1.6)	0.79 (0.41–1.5)
CRP >10 mg/l †[3]	1.0 (0.34–3.1)	1.1 (0.39–3.3)	1.1 (0.47–2.8)
Elevated ALAT (>45) & GGT (>50 U/l)†[3]	1.3 (0.56–3.3)	0.79 (0.35–1.8)	0.78 (0.40–1.5)
≥1 Autoantibody§[4]	0.74 (0.39–1.4)	0.99 (0.53–1.8)	1.0 (0.60–1.6)
Subjective health:			
≥1 11 autoimmune-like symptoms§[4]	3.6 (2.1–5.9)***	2.4 (1.5–3.9)***	2.1 (1.5–3.1)***
≥3 physical symptom categories§[5]	5.2 (2.8–9.5)***	3.7 (2.2–6.3)***	3.6 (2.3–5.5)***
General health: poor or fair vs. (very) good or excellent§[6]	2.5 (1.2–5.3)*	2.1 (1.1–4.2)*	2.8 (1.6–5.0)***
Role-limitation due to physical and/or emotional problems§[6]	2.4 (1.4–4.0)**	2.0 (1.2–3.2)**	2.0 (1.4–3.0)**

Abbrevations: ALAT, alanine-amino-transferase; CRP, C-reactive protein; GGT, gamma glutamyl-transferase.
*p<0.05; **p<0.01; ***p<0.001. †Adjusted for age, level of education, cigarette smoking, alcohol consumption, executive function, level of physical activity, and ethnicity, if applicable. ‡Albumin/creatinine ratio= (microalbumin in urine [mg/l]) / (creatinine in urine [mmol/l] using Jaffé's method). §Adjusted for age, level of education, cigarette smoking, alcohol consumption, executive function, and ethnicity, if applicable.

Summary en Samenvatting



Summary

Background

On October 4, 1992, an El Al Boeing 747-F cargo aircraft crashed into apartment buildings in the suburb Bijlmermeer of the Dutch capital Amsterdam. The disaster killed 43 people, and destroyed 266 apartments. This direct impact was followed by an extended and troublesome aftermath. The public and political unrest eventually called for a parliamentary enquiry in 1998. This enquiry evoked much media attention and public discussion and it led to investigations into the cause of the accident, the contents of the cargo, and exposure to hazardous materials. Retrospective risk evaluations predicted no excess in chronic morbidity due to noxious exposures. Nevertheless, a seemingly growing number of affected residents and assistance workers attributed health complaints to the disaster.

Previous scientific research into the consequences of disasters mainly focused on the psychological consequences (notably posttraumatic stress disorder [PTSD]), and predominantly involved those directly affected by disasters. Scientific literature on the health effects of disasters in professional assistance workers is scarce, in particular with regard to the long-term consequences and physical health. In general, potential health consequences of disasters include those related to exposure to physical harm (such as fractures and burns), to psychotraumatic and stressful experiences (for example PTSD), and to hazardous materials (for example the health effects related to the disasters with toxic exposure, such as in Seveso and Bhopal). Furthermore, it is increasingly recognised that both disasters and real or perceived exposure to hazardous materials, may also lead to physical symptoms, which lack sufficient medical or toxicological explanation. These symptoms are referred to as (medically) 'unexplained physical symptoms'.

The Epidemiological Study Air Disaster in Amsterdam (ESADA)

Starting in 2000, the Epidemiological Study Air Disaster in Amsterdam (ESADA) aimed to assess the long-term health effects of occupational exposure to this disaster in professional assistance workers (Chapter 2). This concerned three occupational groups: professional firefighters (of Amsterdam), police officers (of the regional Amsterdam-Amstelland police force) and so-called hangar workers, who had been exposed to the aircraft wreckage. Historic registers of employment were used to identify the complete cohort of professional assistance workers who were employed at the time of the disaster. Hence, these cohorts consisted of both the workers who were occupationally exposed to the disaster and their colleagues who were not (reference group). Because almost the entire fire department of Amsterdam had been involved in the disaster, this reference group also includes firefighters who joined this department after the disaster. The cohort of police officers was limited to those who were not only employed there at the time of the disaster but also at the start of the ESADA. The reference group of the hangar workers comprised a random sample of the registered employees who did report

to have performed any disaster-related tasks. In total, 3742 professional assistance workers were thus identified, of whom 3642 (97%) could be located and invited to participate in the ESADA in 2000. Eventually, 2567 (70%) of them did participate.

Data collection took place on average 8.5 years after the disaster (from January 1, 2000 to March 1, 2002) and concerned a variety of questionnaire data, and clinical parameters in blood, urine, and saliva samples. Questionnaires were used to assess details on occupational exposure to the disaster, background characteristics, and current ('long-term') perceived health. The selection of health outcomes was largely based on results of previous scientific research following disasters in general and the air disaster in Amsterdam specifically. The autoimmune outcomes, for example, belong the latter.

This thesis focuses on the long-term physical health effects of occupational exposure to the air disaster in Amsterdam. Measures of these physical health effects concern clinical parameters in blood and urine, as well as self-reported physical symptoms, health-related quality of life, and the extent to which exposed workers related ('attributed') their physical health complaints to the disaster, including its aftermath.

The data of 528 firefighters, 1468 police officers, and 503 hangar workers could be used in the statistical analysis. Those workers who reported to have performed at least one disaster-related task were defined as being (occupationally) 'exposed' to the disaster (n=334, n=834, and n=241, respectively). In order to assess the relationship between occupational exposure to the disaster and physical health outcomes, two comparisons are made per occupational group. Firstly, between exposed and nonexposed workers. Secondly, between exposed workers with a particular type of exposure and the other exposed workers. Regarding the latter, type of exposure has been characterised according to a series of disaster-related tasks (for example firefighting, security, and sorting the aircraft wreckage); having witnessed the immediate disaster scene; having a close one who was affected by the disaster; and the overall perceived severity of the disaster, including its aftermath. The most frequently reported tasks by exposed workers were: firefighting, rescuing people, and cleaning-up the disaster site (firefighters); supporting injured victims and workers, and securing of the disaster area (police officers); and transporting, securing, and sorting of the aircraft wreckage in hangar 8 at Schiphol Airport (hangar workers).

Research questions and results

The main hypothesis of this thesis is that occupational exposure to the air disaster in Amsterdam has resulted in long-term 'unexplained physical symptoms' among professional assistance workers. To test this hypothesis the following five research questions have been addressed:

1. Do professional firefighters and police officers who were occupationally exposed to the air disaster in Amsterdam differ from nonexposed colleagues with respect to long-term physical symptoms and clinical parameters in blood and urine? (Chapter 3)

Compared with their nonexposed colleagues, exposed firefighters and police officers statistically significantly more often reported symptoms in the following 5 of 7 categories: general and non-specific (e.g. fatigue), cardiovascular (e.g. heart pounding/racing), musculoskeletal (e.g. chronic low back pain), neurological (e.g. loss of strength), and skin symptoms (e.g. eczema-like symptoms). Regarding police officers, this also holds for symptoms relating to the digestive system (e.g. oral ulcers), and the respiratory tract (e.g. chest tightness). In contrast, no consistent, statistically significant differences were found between exposed and nonexposed workers with respect to the clinical parameters in blood and urine. These consisted of haematological and biochemical parameters regarding kidney, liver, and thyroid function. Based on these results, the excess in various categories of long-term physical symptoms found among exposed workers, cannot be attributed to long-term disaster-related systemic or organ-specific pathological processes.

2. Do professional assistance workers who were occupationally exposed to the air disaster in Amsterdam differ from nonexposed colleagues with respect to long-term autoimmune-like symptoms and autoantibody serology? (Chapter 4)

All three groups of exposed workers reported a statistically significant higher number of autoimmune-like symptoms than their nonexposed colleagues. Of the 11 autoimmune-like symptoms that were addressed, exposed workers reported the following significantly more often: tingling sensations, muscle pain, loss of strength, easily fatigued, and a feeling of sand in the eyes (all groups); infection proneness (firefighters); skin abnormalities and nocturnal transpiration (police officers and hangar workers); and vasculitis-like symptoms and Raynaud discolouring (police officers). In contrast, no statistically significant difference was found between exposed and non-exposed workers in autoantibody prevalence (i.e. antinuclear antibodies, rheumatoid factor, and antineutrophil cytoplasmic and anticardiolipin antibodies). Based on these results, the excess in long-term autoimmune-like symptoms found among exposed workers, cannot be attributed to long-term disaster-related systemic autoimmune disorders.

3. Is there an association between occupational exposure to the air disaster in Amsterdam and multiple long-term physical symptoms in professional firefighters and police officers, and do long-term posttraumatic stress symptoms play a role in this association? (Chapter 5)

Exposed firefighters and police officers reported multiple physical symptoms statistically significantly more often than their nonexposed colleagues. Furthermore, firefighters who rescued people reported multiple physical symptoms significantly more often than their exposed colleagues who performed other tasks. Among exposed police officers multiple physical symptoms were statistically significantly more often reported by those who supported injured victims and workers, who were involved in the

identification and recovery of, or search for, victims and human remains, who witnessed the immediate disaster scene, or those who had a close one affected by the disaster.

These associations did not essentially change when high levels of posttraumatic stress symptoms were taken into account. No statistically significant interactions between exposure status and high levels of posttraumatic stress symptoms were found. These results show that high levels of long-term posttraumatic stress symptoms did not substantially contribute to the excess in multiple long-term physical symptoms among exposed compared to nonexposed firefighters and police officers, and among exposed workers with certain types of exposure.

4. Is there an association between occupational exposure to the air disaster in Amsterdam and the long-term health-related quality of life in professional firefighters and police officers? (Chapter 6)

Compared to their nonexposed colleagues, exposed firefighters and police officers reported a statistically significant lower long-term health-related quality of life regarding the following of 8 aspects: physical function, bodily pain, general health, role-physical, and vitality (both groups); and mental health, social function, and role-emotional (police officers only). Furthermore, among exposed firefighters, a lower health-related quality of life regarding these aspects was statistically significantly more often reported by those who rescued people, cleaned-up the disaster site, witnessed the immediate disaster scene, or had a close one affected by the disaster. Among exposed police officers, a lower health-related quality of life was statistically significantly more often reported by those who had supported injured victims and workers, had a close one affected by the disaster, or perceived the disaster as the worst thing that had ever happened to them.

5. To what extent do professional assistance workers, who were occupationally exposed to the air disaster in Amsterdam, attribute long-term physical complaints to this disaster and its aftermath, and is such an attribution associated with certain types of exposure and background characteristics? (Chapter 7)

72% of the exposed workers reported long-term physical health complaints. 45% of the exposed workers with physical health problems attributed these to the disaster, including its aftermath. About a quarter of them (23%) reported this to be a (very) strong relationship. The more physical health complaints were reported, the stronger these were attributed to the disaster, including its aftermath. These results were very similar across the three occupational groups.

Attribution of physical complaints to the disaster, including its aftermath, was statistically significantly associated with rescuing people among firefighters, and with almost all types of exposure among police officers. Age, sex and level of education were not significantly associated with such attribution.

General discussion

In the general discussion (Chapter 8) it is mentioned that one of the strong features of the ESADA is that it concerns an epidemiological study with a historically-defined cohort of professional assistance workers, including those who were not occupationally exposed to the disaster and who served as a reference group. By these means, the ESADA was the first study able to assess group level associations between exposure to the disaster and health outcomes. Its study design has characteristics of both historic cohort studies and of cross-sectional studies.

Subsequently, the representativeness of the study population is discussed. Selection bias is minimised in the ESADA in two ways. Firstly, by using historic employment registers to identify all workers who were employed at the time of the disaster. Note that the reference group of firefighters also includes workers who joined the fire department of Amsterdam after the disaster, because almost this entire department was involved in the disaster. As a consequence, the exposed firefighters were on average more than 10 years older than the nonexposed firefighters. The comparison of these two groups is statistically adjusted for. Another point of attention is that, for practical reasons, the cohort of police officers had to be limited to those who were employed at the time of the disaster and at the start of the ESADA. This may have led to selection bias if quitting the police force was associated with health or with exposure to the disaster. However, there were no indications for such associations.

Secondly, selection bias was minimised by achieving the response requirements that were set in the ESADA protocol (meaning that ≥90% of the identified workers could be located, and ≥70% of them participated). A concise non-response analysis still revealed a few differences between participating and non-respondent firefighters and hangar workers regarding perceived health and background characteristics. The results may therefore not be entirely representative for the complete cohort of professional assistance workers. However, it is unlikely that these limited differences have meaningfully affected the overall, consistent results of the ESADA.

Methodological issues concerning the assessment of exposure to the disaster is then discussed. It is first commented that this assessment was based on self-report, which is prone to information bias. However, misclassification with regard to the distinction between exposed and nonexposed workers appears unlikely, because it seems reasonable to assume workers could recall whether they performed any as opposed to no disaster-related tasks. It is also acknowledged that the assessment focused on exposure to aspects of the disaster, yet it is difficult to separate the health impact of the disaster and that of its aftermath. This is due to the fact that the ESADA was performed on average 8.5 years after the disaster.

With respect to the assessment of health outcomes it is commented that the ESADA used established, validated clinical laboratory measures and questionnaires as much as possible. Regarding the physical symptoms, a questionnaire was drawn up for the ESADA, in order to also assess those kind of symptoms that were attributed to the disaster by affected residents and workers in a previous health inventory.

A final remark concern the fact that the comparisons of exposed and nonexposed workers have been statistically adjusted for the potential influence of background characteristics, such as age, gender, smoking habits, and level of education.

Conclusion and recommendations

It is concluded that the results presented herein support the main hypothesis that occupational exposure to the air disaster in Amsterdam has resulted in long-term 'unexplained physical symptoms' among these professional assistance workers. Therefore, this epidemiological study demonstrates that professional assistance workers involved in a disaster are at risk of long-term subjective physical health problems, which cannot substantially be attributed to disaster-related long-term pathological processes, or to posttraumatic stress symptoms. These results are in line with previous studies among civilian and military populations that were exposed to disastrous events with or without (perceived) exposure to hazardous materials.

At the end of this thesis some recommendations for future research on health consequences of disasters are put forward. These concern general recommendations, as each disaster has specific circumstances and characteristics. It is recommended to measure as soon as possible, at an individual level, and, if possible, longitudinally, the extent of exposure to: (a) physical damage, (b) stressful experiences, and (c) hazardous materials due to the disaster. Experts on risk communication should be involved from an early stage on in the aftermath of disasters, to provide adequate information and prevent unnecessary concerns.

With respect to the physical health outcomes to be studied, it is recommended to at least include the following three types of outcomes: (a) those health outcomes that are logical and relevant form a medical-toxicological perspective; (b) a general measure of subjective physical symptoms, and (c) psychological symptoms (notably PTSD), to enable the assessment of their potential role in physical health problems. Further research is needed to standardise a general measure of 'unexplained physical symptoms', and the assessment of their 'unexplained' nature.

Furthermore, a longitudinal study design could enable examining the course of, mechanisms involved in, and risk factors for 'unexplained physical symptoms' after disasters. To this end, a useful strategy might be the combination of studies using data of existing electronic medical registries (such as those of general practitioners and occupational physicians), and population-based epidemiological studies.

Samenvatting

Achtergrond

Op 4 oktober 1992 stortte een EL AL Boeing 747 vrachtvliegtuig neer op twee flatgebouwen in de Bijlmermeer te Amsterdam. De vliegramp Bijlmermeer kostte 43 mensen het leven en verwoestte 266 appartementen. Naast deze directe gevolgen had de ramp ook een langdurige, problematische nasleep. De maatschappelijke en politieke onrust gaf uiteindelijk in 1998 aanleiding tot de parlementaire enquête vliegramp Bijlmermeer. De ramp kreeg tijdens deze enquête opnieuw veel aandacht in de media en er werden diverse onderzoeken verricht, onder andere naar de toedracht van de ramp, de inhoud van de lading en blootstelling aan schadelijke agentia tijdens de ramp. Retrospectieve risico-inschattingen wezen uit dat er geen langdurige of blijvende gezondheidsklachten te verwachten waren voor grote groepen. Desalniettemin groeide het aantal bewoners en hulpverleners dat gezondheidsklachten in verband bracht met de ramp.

Eerder wetenschappelijk onderzoek naar gezondheidsgevolgen van rampen was voornamelijk gericht op de psychische gevolgen (met name posttraumatische stress disorder [PTSD]) en vond hoofdzakelijk plaats onder direct getroffenen. Wetenschappelijke literatuur over de gezondheidsgevolgen van rampen voor professionele hulpverleners is schaars, zeker over gevolgen op de lange termijn en ten aanzien van de lichamelijke gezondheid. Tot de gezondheidsgevolgen van rampen behoren in het algemeen de gezondheidseffecten veroorzaakt door blootstelling aan fysiek geweld (zoals botbreuken en brandwonden), aan psychotraumatische en stressvolle gebeurtenissen (bijvoorbeeld PTSD), en aan schadelijke agentia (zoals de toxische gevolgen van giframpen zoals die in Seveso en Bhopal). Daarnaast groeit het besef dat rampen alsmede al dan niet vermeende blootstelling aan gevaarlijke stoffen ook kunnen leiden tot lichamelijke klachten, waarvoor geen afdoende medische of toxicologische verklaring te vinden is. Deze klachten worden wel (medisch) 'onverklaarde lichamelijke klachten' genoemd.

Het Medisch Onderzoek Vliegramp Bijlmermeer – Epidemiologie (MOVB-E)

In 2000 werd het Medisch Onderzoek Vliegramp Bijlmermeer – Epidemiologie (MOVB-E) gestart met als doelstelling de relatie te onderzoeken tussen beroepsmatige betrokkenheid bij deze ramp en de lange termijn gezondheid van professionele hulpverleners (Hoofdstuk 2). Dit epidemiologische onderzoek vond plaats binnen het overkoepelende Medisch Onderzoek Vliegramp Bijlmermeer (MOVB). Het MOVB behelsde daarnaast een individueel medisch onderzoek dat aangeboden werd aan alle mensen die zich getroffen voelden door de ramp; een epidemiologisch onderzoek onder bewoners van gedefinieerde zones rond de rampplek; en een onderzoek naar het effect van het MOVB op de gezondheidsbeleving van een selectie van deelnemende bewoners en hulpverleners. Al deze deelonderzoeken van het MOVB zijn inmiddels afgerond. Het

epidemiologische onderzoek onder bewoners moest gestaakt worden, omdat een onvoldoende aantal van de uitgenodigde bewoners deelnam.

Voor het MOVB-E werd de groep (cohort) professionele hulpverleners uitgenodigd die ten tijde van de ramp in dienst waren conform registraties van hun werkgevers. Dit zijn dus zowel de werknemers die beroepsmatig betrokken waren bij de ramp, als ook hun collega's, die niet ingezet werden ten behoeve van de ramp (referentiegroep). Het ging om drie beroepsgroepen: brandweermedewerkers (van het professionele brandweerkorps Amsterdam), politiemedewerkers (van de Regiopolitie Amsterdam-Amstellanden) en zogenoemde 'hangarmedewerkers', die in contact waren geweest met het vliegtuigwrak bij hangar 8 van Schiphol. Omdat vrijwel het gehele brandweerkorps betrokken was bij de ramp, zijn ook brandweermedewerkers die later in dienst kwamen in de referentiegroep opgenomen. Het politie cohort bestond uit de werknemers die ten tijde van de ramp én bij aanvang van het MOVB-E in dienst waren. Tenslotte werd voor de referentiegroep van de hangarmedewerkers een aselecte steekproef getrokken uit de medewerkers die niet aangaven dat zij taken met betrekking tot de ramp verricht hadden. Van de 3742 aldus geïdentificeerde hulpverleners konden 3643 (97%) in 2000 gelokaliseerd en uitgenodigd worden voor deelname aan het MOVB-E. Van hen nam uiteindelijk 70% deel aan het onderzoek (n=2567).

De gegevensverzameling vond gemiddeld 8,5 jaar na de ramp plaats (van 1 januari 2000 tot 1 maart 2002) en betrof een scala aan vragenlijstgegevens en klinische parameters in urine-, bloed-, en speekselmonsters. Met behulp van vragenlijsten werden details bepaald over de betrokkenheid bij de ramp, achtergrondkenmerken en de huidige ('lange termijn') ervaren gezondheid. De selectie van de gezondheidsuitkomsten was grotendeels gebaseerd op bevindingen van voorgaand wetenschappelijk onderzoek na rampen in het algemeen en de vliegramp Bijlmermeer in het bijzonder. Tot deze laatste groep behoren bijvoorbeeld de auto-immuunuitkomsten.

Dit proefschrift is gericht op de lange termijn lichamelijke gezondheidseffecten van beroepsmatige betrokkenheid bij de vliegramp Bijlmermeer. Indicatoren voor deze lichamelijke gevolgen betroffen klinische parameters in urine en bloed, en met vragenlijsten bepaalde lichamelijke klachten, de gezondheidsgerelateerde kwaliteit van leven en de mate waarin betrokkenen hun lichamelijke gezondheidsproblemen relateren (attribueren) aan de ramp, inclusief de nasleep daarvan.

In de statistische analyse konden de gegevens van 528 brandweer-, 1468 politie- en 503 hangarmedewerkers gebruikt worden. Degenen die aangaven tenminste één taak met betrekking tot de ramp te hebben verricht, zijn gedefinieerd als 'beroepsmatig betrokken' (respectievelijk n=334, n=834, en n=241). Teneinde de relatie tussen beroepsmatige betrokkenheid bij de ramp en de lichamelijke gezondheid op lange termijn te onderzoeken, zijn per beroepsgroep twee vergelijkingen gemaakt. Ten eerste tussen betrokken en niet-betrokken hulpverleners. Ten tweede tussen betrokken hulpverleners met een bepaald type betrokkenheid en de andere betrokkenen. Hierbij werd de betrokkenheid getypeerd aan de hand van een serie van rampgerelateerde taken (zoals blussen, beveiliging, en het sorteren van het wrak); het getuige zijn geweest van

de rampplek kort na het neerstorten; het hebben van een naaste die getroffen was door de ramp; alsmede de ervaren ernst van de ramp, inclusief de nasleep. De meest frequent gerapporteerde taken van de betrokken hulpverleners waren: blussen, redden, en puinruimen (brandweermedewerkers); opvangen van gewonde slachtoffers en hulpverleners en beveiligen van het rampgebied (politiemedewerkers); en het vervoeren, beveiligen, en sorteren van het vliegtuigwrak in hangar 8 (hangarmedewerkers).

Vraagstellingen en resultaten

De hoofdhypothese van dit proefschrift is dat beroepsmatige betrokkenheid bij de vliegramp Bijlmermeer op de lange termijn bij deze hulpverleners geresulteerd heeft in 'onverklaarde lichamelijke klachten'. Om deze hoofdhypothese te toetsen zijn vijf onderzoeksvragen opgesteld en beantwoord:

1. Verschillen brandweer- en politiemedewerkers die beroepsmatig betrokken waren bij de vliegramp Bijlmermeer van hun niet-betrokken collega's wat betreft lichamelijke klachten en klinische parameters in bloed en urine? (Hoofdstuk 3)

Ten opzichte van niet-betrokken collega's, rapporteerden betrokken brandweer- en politiemedewerkers statistisch significant vaker lichamelijke klachten uit de volgende 5 van 7 categorieën: algemeen en niet-gespecificeerd (o.a. vermoeidheid), cardiovasculair (o.a. hartkloppingen), bewegingsapparaat (o.a. chronische lage rugpijn), neurologie (o.a. verlies van kracht), en huid (o.a. eczeemachtige klachten). Bij de politiemedewerkers gold dit ook voor klachten ten aanzien van het spijsverteringskanaal (o.a. zweren in de mond), en de luchtwegen (o.a. benauwdheid). Er werden tussen betrokkenen en niet-betrokkenen geen consistente, statistisch significante verschillen gevonden ten aanzien van de klinische parameters in bloed- en urine. Het ging hierbij om hematologische parameters en biochemische parameters ten aanzien van de functie van de nieren, lever en schildklier. Op basis van deze resultaten kan de hogere prevalentie van diverse lichamelijke klachten onder beroepsmatig betrokken hulpverleners niet worden toegeschreven aan met de ramp gerelateerde systemische of orgaanspecifieke pathologische processen.

2. Verschillen hulpverleners die beroepsmatig betrokken waren bij de vliegramp Bijlmermeer van hun niet-betrokken collega's wat betreft auto-immuunachtige klachten en auto-antistof serologie? (Hoofdstuk 4)

In alledrie de beroepsgroepen rapporteerden de betrokkenen een statistisch significant hoger aantal auto-immuunachtige klachten dan hun niet-betrokken collega's. Van de 11 nagevraagde auto-immuunachtige klachten, werden de volgende statistisch significant vaker aangegeven door betrokken hulpverleners: tintelingen, spierpijn, verlies van kracht, snel vermoeid zijn, zandgevoel in de ogen (alle groepen); gevoeligheid voor infecties (brandweermedewerkers); huidklachten en nachtelijk transpireren (politie- en hangarmedewerkers); vasculitisachtige klachten en het fenomeen van Raynaud (politiemedewerkers). Er werd tussen betrokkenen en niet-betrokkenen geen statistisch

significant verschil gevonden in de prevalentie van auto-antistoffen (i.e. anti-nucleaire antistoffen (ANA en ENA), reumafactoren, anti-neutrofiele cytoplasmatische (ANCA) en anti-cardiolipine (ACA) antistoffen). Op basis van deze resultaten kan het hogere aantal en de hogere prevalentie van auto-immuunachtige klachten onder betrokken hulpverleners niet toegeschreven worden aan met de ramp gerelateerde systemische auto-immuunstoornissen.

3. Is beroepsmatige betrokkenheid bij de vliegramp Bijlmermeer bij brandweer- en politiemedewerkers geassocieerd met een hoog aantal lichamelijke klachten; en spelen posttraumatische stressklachten een rol in deze associatie (Hoofdstuk 5)?

Betrokken brandweer- en politiemedewerkers rapporteerden significant vaker een hoog aantal lichamelijke klachten dan hun niet-betrokken collega's. Brandweermedewerkers die betrokken zijn geweest bij het redden van mensen, hadden statistisch significant vaker een hoog aantal lichamelijke klachten dan betrokken collega's die andere taken verricht hadden. Onder de betrokken politiemedewerkers werd een hoog aantal lichamelijke klachten significant vaker gerapporteerd door degenen die betrokken zijn geweest bij de opvang van gewonde slachtoffers en hulpverleners of bij het identificeren en bergen van, of het zoeken naar, slachtoffers en menselijke resten; degenen die getuige waren geweest van de rampplek kort na het neerstorten; en degenen van wie een naaste getroffen was door de ramp.

De gevonden associaties veranderden nauwelijks als rekening werd gehouden met posttraumatische stressklachten, en er werden ook geen statistisch significante interacties gevonden tussen betrokkenheid bij de ramp en posttraumatische stressklachten. Op basis van deze resultaten kan gesteld worden dat posttraumatische stressklachten geen substantiële rol spelen in de hogere prevalentie van een hoog aantal lichamelijke klachten onder betrokken brandweer- en politiemedewerkers ten opzichte van niet-betrokken collega's, en onder betrokken hulpverleners met een bepaald type betrokkenheid.

4. Is beroepsmatige betrokkenheid bij de vliegramp Bijlmermeer geassocieerd met de lange termijn gezondheidsgerelateerde kwaliteit van leven van brandweer- en politiemedewerkers? (Hoofdstuk 6)

Ten opzichte van hun niet-betrokken collega's rapporteerden betrokken brandweer- en politiemedewerkers een statistisch significant lagere gezondheidsgerelateerde kwaliteit van leven, ten aanzien van de volgende van acht aspecten: lichamelijk functioneren, lichamelijke pijn, algemene gezondheidsbeleving, rolbeperkingen door lichamelijke problemen, en vitaliteit (zowel brandweer- als politiemedewerkers); en mentale gezondheid, sociaal functioneren, en rolbeperkingen door emotionele problemen (politiemedewerkers). Onder de betrokken brandweermedewerkers werd een lagere score op deze aspecten statistisch significant vaker gerapporteerd door degenen die mensen gered hadden, puin geruimd hadden, getuige waren geweest van de rampplek kort na het neerstorten, of van wie een naaste getroffen was door de ramp. Onder

betrokken politiemedewerkers werd een lagere gezondheidsgerelateerde kwaliteit van leven statistisch significant vaker gerapporteerd door degenen die gewonde slachtoffers en hulpverleners opgevangen hadden, van wie een naaste getroffen was door de ramp, of voor wie de ramp het ergste was dat zij ooit hadden meegemaakt.

5. In hoeverre attribueren hulpverleners die beroepsmatig betrokken waren bij de vliegramp Bijlmermeer hun lichamelijke gezondheidsproblemen aan deze ramp, inclusief de nasleep daarvan; en hangt dergelijke attributie samen met een bepaald type betrokkenheid en achtergrondkenmerken? (Hoofdstuk 7)

72% van de alle betrokken hulpverleners rapporteerde lange termijn lichamelijke gezondheidsproblemen. 45% van de betrokkenen met lichamelijke gezondheidsproblemen attribueerde deze klachten aan de ramp, inclusief de nasleep daarvan. Ongeveer een kwart (23%) van deze hulpverleners die attribueerden gaf aan dat dit een sterk tot zeer sterk verband betrof. Hoe meer lichamelijke gezondheidsproblemen werden aangegeven, hoe sterker deze geattribueerd werden aan de ramp, inclusief de nasleep daarvan. Deze resultaten waren zeer vergelijkbaar in de drie beroepsgroepen.

Het attribueren van lichamelijke gezondheidsproblemen aan de ramp, inclusief de nasleep daarvan, was statistisch significant geassocieerd met het redden van mensen door brandweermedewerkers, en met vrijwel alle typeringen van de betrokkenheid van de politiemedewerkers. Leeftijd, geslacht en opleidingsniveau waren niet statistisch significant geassocieerd met een dergelijke attributie.

Algemene discussie

In de algemene discussie (Hoofdstuk 8) wordt gewezen op het sterke punt dat het MOVB-E een epidemiologisch onderzoek betreft met een historisch gedefinieerd cohort hulpverleners, inclusief de hulpverleners die niet voor de ramp ingezet werden en die als referentiegroep fungeerden. Hierdoor is dit het eerste onderzoek dat op groepsniveau relaties tussen betrokkenheid bij de vliegramp Bijlmermeer en gezondheidsuitkomsten kon onderzoeken. De onderzoeksopzet vertoont kenmerken van zowel historisch cohort als dwarsdoorsnede onderzoek.

Ten aanzien van de representativiteit van de onderzoekspopulatie wordt besproken dat in het MOVB-E op twee manieren vertekening door selectie (selectiebias) geminimaliseerd is. Ten eerste door gebruik te maken van historische registraties van werkgevers om alle werknemers die ten tijde van de ramp in dienst waren te identificeren, ongeacht betrokkenheid bij de ramp en gezondheidstoestand. Daarbij wordt aangetekend dat in de referentiegroep van de brandweer ook medewerkers die na de ramp in dienst kwamen opgenomen zijn, omdat vrijwel het gehele korps betrokken was bij de ramp. Bij gevolg was de betrokken brandweergroep gemiddeld meer dan tien jaar ouder dan de niet-betrokken brandweergroep. In de vergelijking van deze twee groepen is statistisch gecorrigeerd voor dit leeftijdsverschil. Een kanttekening bij het politiecohort is dat dit om praktische redenen beperkt is tot degenen die ten tijde van de

ramp én ten tijde van de start van het MOVB-E in dienst waren. Dit houdt de kans in op selectiebias, indien uitdiensttreding tussen de ramp en het MOVB-E gerelateerd was met gezondheid of betrokkenheid bij de ramp. Er waren echter geen aanwijzingen voor een dergelijke selectieve uitstroom.

Ten tweede is selectiebias geminimaliseerd door het behalen van de per protocol gestelde minimale responseisen (aldus kon ≥90% getraceerd worden en nam ≥70% daarvan deel). Een beknopt non-respons onderzoek suggereerde niettemin dat deelnemers en non-respondenten in geringe mate van elkaar verschilden in gezondheidsbeleving en achtergrondkenmerken. Mogelijk zijn de resultaten daardoor niet volledig representatief voor alle hulpverleners in deze beroepsgroepen. Echter, deze geringe verschillen zullen het algemene, consistente beeld niet beïnvloed hebben.

Tevens worden enkele methodologische kanttekeningen geplaatst bij de bepaling van de betrokkenheid bij de ramp. Allereerst is deze gebaseerd op zelfrapportage, welke vertekend kan zijn (informatiebias). Misclassificatie wat betreft de tweedeling in betrokkenen en niet-betrokkenen lijkt onwaarschijnlijk, omdat het aannemelijk is dat de hulpverleners zich konden herinneren of zij wel of geen rampgerelateerde taken verricht hadden. Daarnaast wordt opgemerkt dat deze gericht geweest is op aspecten van de ramp zelf, maar dat het niet goed mogelijk is onderscheid te maken tussen gezondheidseffecten van de ramp en van de nasleep daarvan. Dit komt omdat het onderzoek 8,5 jaar na dato plaatsvond.

Ten aanzien van het meten van gezondheidsuitkomsten wordt gesteld dat in het MOVB-E zoveel mogelijk gekozen is voor gangbare, gevalideerde klinische laboratoriumbepalingen en vragenlijsten. Voor de lichamelijke klachten is een vragenlijst ontworpen voor het MOVB-E, zodat ook het type lichamelijk klachten gemeten kon worden dat volgde uit een eerdere inventarisatie van gezondheidsklachten die door getroffenen aan de ramp toegeschreven werden.

Tot slot wordt opgemerkt dat in de statistische vergelijking van betrokken en niet-betrokken hulpverleners rekening is gehouden met de mogelijke verstorende invloed van achtergrondvariabelen, zoals leeftijd, geslacht, rookgewoonten en opleidingsniveau.

Conclusie en aanbevelingen

Geconcludeerd wordt dat de resultaten de hoofdhypothese ondersteunen dat beroepsmatige betrokkenheid bij de vliegramp Bijlmermeer op de lange termijn bij deze hulpverleners geresulteerd heeft in 'onverklaarde lichamelijke klachten'. Dit epidemiologische onderzoek toont daarmee aan dat hulpverleners die beroepsmatig betrokken zijn bij een ramp op de lange termijn risico lopen op ervaren lichamelijke gezondheidsproblemen, die niet substantieel toegeschreven kunnen worden aan met deze ramp gerelateerde pathologische processen, of aan posttraumatische stressklachten. Deze bevindingen komen overeen met eerder wetenschappelijk onderzoek onder civiele en militaire populaties die blootgesteld werden aan rampzalige gebeurtenissen, al of niet met reële of vermeende blootstelling aan schadelijke agentia.

Ter afsluiting van dit proefschrift worden enkele aanbevelingen voor toekomstig wetenschappelijk onderzoek naar gezondheidsgevolgen van rampen gedaan. Deze zijn van algemene aard, omdat elke ramp specifieke omstandigheden kent. Aanbevolen wordt om zo spoedig mogelijk, op individuele basis, en zo mogelijk longitudinaal, de blootstelling aan (a) fysieke schade, (b) stressvolle gebeurtenissen en (c) schadelijke stoffen ten gevolge van de ramp te meten. Voor een goede informatievoorziening en ter preventie van onnodige ongerustheid zouden deskundigen op het gebied van risicocommunicatie al in een vroeg stadium betrokken moeten worden bij de afwikkeling van rampen.

Wat betreft de te onderzoeken lichamelijke gezondheidseffecten wordt aanbevolen in elk geval drie typen uitkomsten te meten: (a) de op medisch-toxicologische gronden te verwachten gezondheidseffecten; (b) een algemene maat voor ervaren lichamelijke gezondheidsklachten; en (c) psychische klachten (met name PTSD), zodat de rol daarvan in de lichamelijke gezondheidsproblemen onderzocht kan worden. Er is nader onderzoek nodig om het concept 'onverklaarde lichamelijke klachten' en de bepalingswijze van hun 'onverklaardheid' te standaardiseren.

Voorts zou een longitudinale onderzoeksopzet meer inzicht kunnen geven in het beloop, de ontstaanswijze en de risicofactoren voor 'onverklaarde lichamelijke klachten' na rampen. Een nuttige strategie daarbij zou kunnen bestaan uit het combineren van enerzijds onderzoek gebaseerd op gegevens van elektronische medische registraties, zoals die van de huisartsen en bedrijfsartsen, en anderzijds epidemiologisch onderzoek dat gebaseerd is op populaties.

Bedankt!

Veel dank aan allen die mij bijgestaan hebben en aan allen die dit onderzoek mogelijk hebben gemaakt. En dat waren er velen!

Allereerst natuurlijk de deelnemende hulpverleners. Ik dank de betrokken hulpverleners voor hun inzet voor de vliegramp Bijlmermeer en hun deelname aan het onderzoek (MOVB-E). Dat laatste geldt in het bijzonder ook voor hun collega's die niet betrokken waren bij deze ramp en toch zonder persoonlijk belang alle vragenlijsten ingevuld en bloed-, urine-, en speekselmonsters ingeleverd hebben. Dat getuigt van een bijzondere collegialiteit. Moge het onderzoek in elk geval de duidelijkheid gegeven hebben die nodig was.

Zoals het bewuste vacature emailtje van Tjabe destijds al aankondigde heb ik mij de afgelopen jaren in een 'schil van ervaren onderzoekers' begeven. En wat voor een schil! Als eerste (schil) waren er mijn (ex)(co)promotoren (Tjabe, Willem, Nynke, Jos, Anja). Jullie hadden elk duidelijk een eigen rol hadden in het Bijlmerproject en mijn promotie. Ontzettend bedankt allemaal voor deze leerzame, bijzondere samenwerking. In goede en in slechte tijden, door dik(ke rapporten) en dun(nere artikelen). Bedankt voor het vertrouwen dat jullie in mij toonden en de vrijheid die jullie mij gaven.

Anja, als 'spin in het web' heb jij me destijds ingesponnen in het MOVB-E web. Hartstikke bedankt voor je jarenlange inzet. Ik heb je graag als paranimf een mooie plek in mijn promotie willen geven en ben blij je ook hier aan mijn zijde te weten.

Tjabe, mijn leermeester. Altijd in voor gewoon een praatje of een goed gesprek, wetenschappelijk inhoudelijk, maar ook levensbeschouwelijk. Ik voelde me door jou gewaardeerd en heb ook jou zeer gewaardeerd. Je bleek ook een fijn congresmaatje, en ik zie er naar uit je ook in de toekomst te ontmoeten. Het ga je goed!

Willem, promotor op wat meer afstand, die weet van knopen doorhakken, toch op de hoogte wil blijven, als het er op aankomt ronduit zegt dat hij achter je staat. Bedankt!

Jos, je niet aflatende methodologische input was altijd volkomen duidelijk, helder en concreet; wat wil een promovenda nog meer? Ik heb veel van je geleerd, veel dank daarvoor. Ik vergeet ook nimmer je gepassioneerde relaas over voetbal van weleer. Succes als prof en ik kom je vast nog wel eens tegen, ergens, in Noord-Holland ofzo…

Nynke, je kwam als laatste aan boord en ik ben blij jou als kapitein meegemaakt te hebben. Een ware coach, een super gedreven wetenschapper, en bovenal ook een warm en hartelijk gezelschapsmaatje. Je was er voor mij (zelfs tijdens het wandelen in Noorwegen!), daarover liet je geen twijfel bestaan. En je wees me de weg. Dat alles was fijn. En ik ben toch mooi wel even jouw eerste promovenda! Succes meis!

Ten tweede waren er de andere leden van het MOVB-E projectteam (Joost, Lex, en de collega's bij medische psychologie, Anke, Inge, Henk, en Eloenore). Anke, wat hebben we als promovendi veel beleefd in het MOVB-E project! Veel succes met jouw boekje,

maak er wat moois van. Lex, je was er als het nodig was; veel dank! Joost, ik leerde je kennen toen je nog Medisch Hoofd van het MOVB was en tot het eind toe bleek je het geheugen te zijn voor allerhande details over de gang van zaken. Erg bedankt voor je vriendelijke, deskundige ondersteuning bij de berg aan laboratoriumbepalingen en de contacten die je daartoe legde. Daarbij wil ik met name Willem Lems noemen en bedanken voor zijn enthousiasme voor het reumatologische vraagstuk. Zo ook Ingrid van Hoogstraten. En Paul Savelkoul, bedankt voor het vele werk dat je in het Mycoplasma onderzoek gestoken hebt en succes met die publicatie.

En ten derde waren er natuurlijk alle andere EMGO- en SG-collega's. Veel dank voor de prettige samenwerking en stimulerende werkomgeving. Daaraan hebben ook zeker mijn ganggenoten bijgedragen: bedankt voor jullie ervaringsdeskundigheid, de vele lunchwandelingen, en de videoavonden. En Petra: heel veel dank voor je hulp bij alles wat in de laatste fase om me afkwam wat betreft regeldingen, deadlines, pedel, opmaken en drukken van dit boekje. Dat heeft me veel stress gescheeld. Het was fijn deze klus niet alleen te hoeven klaren. Ik licht ook graag even mijn (ex)kamergenoten eruit. Michel, je had altijd een luisterend oor en hebt me steeds gesteund als buitenstaande senior, al of niet tijdens een lunchwandeling en met een kwaliteitsknipoog. En dat heb ik erg gewaardeerd. Het allerbeste! Sander-één-Sloot-één-Maker, ik kon me werkelijk geen fijnere kamergenoot wensen. Ja, toegegeven het begon hectisch met je vele onderzoeksassistenten en stagiaires, maar dat was ook leerzaam. Bedankt voor je gezelligheid en support in alles, te allen tijde. Zet 'm op hé!

Maar er waren ook onderzoekers van buiten deze schillen die ik wil bedanken. Bellis, bedankt voor onze bespiegelingen over (M)UPS! Succes met jouw boekje over de ramp in Enschede. Yonne, bedankt voor je input om mij in het begin op gang te helpen. Ook dank aan de andere CGOR en BRON collega's. Marike, bedankt voor je helaas vergeefse geavanceerde zoektocht naar een Bijlmerramp klachtencluster.

Tevens ben ik de leden van de leescommissie en de oppositie (prof.dr.ir. H.C.W. de Vet, respectievelijk dr. A.J. van der Beek, prof.dr. Ph. Spinhoven, dr C.J. IJzermans, prof.dr. J.A. Knottnerus, Prof.dr. D. Heederik, en prof.dr. J.W.M. van der Meer) erkentelijk voor hun nauwkeurige lezing en beoordeling van mijn werk.

Vanuit het Bijlmerproject verschenen eerder al twee Nederlandstalige rapporten. Daarin zijn nog vele andere mensen genoemd als blijk van dank voor hun bijdrage voor het MOVB(-E), waaronder de financiers, de opdrachtgever en collega's bij KLM Health Service, de leden van de Commissie van Deskundigen en de Begeleidingscommissie, en alle medewerkers van de toenmalige Uitvoeringsorganisatie die de omvangrijke gegevensverzameling verzorgd hebben. Ik sluit mij daar van harte bij aan. Enkele mensen met wie ik persoonlijk te maken heb gehad, wil ik ook hier even noemen. Pim, Robert, David: bedankt heren voor de prettige samenwerking en gezellige etentjes. Philip en Margot van het MOVB-Effectonderzoek bedank ik voor de collegiale contacten die we door de jaren heen hadden. Ook Daniëlle, Mariëlle, Ellen, Marijke en Inge: bedankt voor jullie administratieve, secretariële (en andersoortige) ondersteuning!

En dan nu alles behalve werk!
Lieve ouders, zussen, familie, lieve vrienden en vriendinnen, waarde zinloze wandelaars. Bedankt allemaal voor alles wat jullie in mijn leven inbrengen. Op dit soort momenten openbaart zich het intense besef van hoeveel ik mij ongemerkt, maar ook bewust, gesteund voel door jullie. Ik zou eenieder van jullie graag een persoonlijke noot schrijven, maar dit is niet de plek om zulke gevoelens onder woorden te brengen. Nou goed dan, toch enkele woorden.

Lieve pappa en mamma, met jullie is het allemaal begonnen, aan jullie heb ik alles te danken. Het is van onschatbare waarde te weten en merken dat jullie altijd voor me klaar staan, me steunen en zoveel vertrouwen in mij hebben. Bedankt voor dat alles!

Lieve Karin, mijn levensvriendin, mijn anker. Het is heerlijk om jou in mijn leven te hebben, met jou mee te leven, ook in deze roerige jaren, en niet in de laatste plaats vanwege de levensvreugd die jouw kleine Anouk ook mij geschonken heeft. Lieve Michelle, bedankt voor jouw bijzondere verrijking van mijn leven. Lieve Paul, bedankt voor de mooie tijden. Lieve Peter, we kunnen zo lekker praten en verschillend zijn en toch zoveel op elkaar lijken; fijn, zo'n vriend als jij! Lieve Annelies, we hebben dankzij dit boekje samen West-Australië doorkruist en dat heeft onze vriendschapsband alleen maar versterkt. Je ben een schat, je was er altijd voor me, en ook nu, hier, als paranimf.

En dan tot slot, lieve Jeroen, als laatste kwam je in mijn leven. En hoe! Mijn geschenk uit de hemel, met beide benen op de grond, vol goede moed, geduld en liefde. Je kwam precies op tijd. Jij maakte de finish draaglijk. Dankjewel.

Nu is het af.