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STUDY

Chimney Sweeps' Work Environment

A knowledge review

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Linköping University 2017

Martina Berglund

This report reviews research studies examining risks and diseases related to the working environment of Swedish chimney sweeps. Chimney sweeps are exposed to soot and solvents in their work, and studies show that they have an increased risk of cancer, heart disease, and respiratory diseases. Chimney sweeping also involves working at high-altitude with a risk of falling accidents. Chimney sweeps' exposure to harmful substances at work need to be decreased.

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MSB's contact person:
Andreas Nilsson, +46 10 240 26 38

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Preface

The author would like to express a warm thank you to several people who have contributed to this knowledge review. Andreas Nilsson, the Swedish Civil Contingencies Agency (MSB), has followed the work along the way and contributed with valuable comments, ideas and description of chimney sweeps' duties; Per Eriksson, librarian at Linköping University library has been a support in the literature search; Jonny Jakobsson, ombudsman at the chimney sweeps' trade union (Kommunal) has provided material and contributed with tips on sources; Mattias Löfroth, the chimney sweeps' employer organization (Sveriges Skorstensfejeremästares Riksförbund), has provided the magazine 'Sotaren'; and Karin Broberg, professor and researcher at Karolinska Institutet, has shared research findings. In addition, PeO Axelsson, Ph.D. and accident investigator at the Roof Security Committee has contributed with information and materials on roof work safety, and Simon Farnebo, associate professor and university surgeon at Linköping University Hospital, has clarified medical concepts and the emergence of cancer. Finally, the author wishes to thank the chimney sweep Ubbe Sotare, who shared his time, knowledge and experience during a one-day study visit in Östergötland, Sweden.

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Abstract

Chimney sweeping has, for a long time, been associated with difficult working conditions, with soot, dirt and high-altitude work. This knowledge review aims to summarise the knowledge we have today about chimney sweeps' working environment. It is based on published results of scientific studies regarding work-related diseases and risks to Swedish conditions, but also presents situations involving high-altitude casualties and accidents. Chimney sweeping involves exposure to several different risk factors. Sweeps are exposed to carbon particles, polycyclic aromatic hydrocarbons (PAHs), metals and metalloids, combustion gases and dust, solvents and to some extent, asbestos. In addition, high-altitude work involves a risk of falling. Overall, studies of causes of death for sweeps indicate that they have been affected by various types of serious disease and accidents. They have an increased risk of heart disease, which is believed to be due to exposure to dust, PAH and various metals. Sweeps are also affected to a greater extent by various types of cancer such as lung, urinary bladder, esophagus, liver and colon, which are related to exposure to harmful substances which contribute to processes that among other things, damage the genetic heritage of the cells. Chimney sweeps also experience problems with eyes and respiratory tracts, these decrease when they work less with black soot sweeping and more with ventilation and fire protection, as well as office work. Chimney sweeps operate at high altitudes, which means a risk of serious accidents, both when accessing ceilings and working on roofs. The knowledge overview shows that several falls occur, many of which are in connection with portable ladders. Safety assessment responsibility rests on the individual chimney sweep, who usually works alone, and time pressure has been identified as a risk factor in the work. It is important that sweeps use protective equipment. Studies show that the use of protective gloves, masks and socks has increased. However, it is important to continue work on reducing the exposure to pollutants and harmful substances. In the case of high-altitude work, it is important that chimney sweeps have good knowledge ladder design, regulations and risk factors. Protective equipment should be used according to the regulations of roof work.

1. Introduction

Today there are about 1,500 chimney sweeps in Sweden[1]. The chimney sweep profession has been around for centuries[2] and it has been associated with difficult working conditions, soot, dirt and high roof work[3]. It is also a profession of strong tradition, the chimney sweeps have their own language, traditional tools and symbols of work identity[4].

Throughout the ages, workforce diseases and injuries have been reported. The first report came in 1775 in England and described the incidence of scrotum cancer among chimney sweeps[5]. The classic report was the first ever to describe serious health concerns associated with various occupations. A number of studies on occupational diseases and risk factors for sweeps have been reported over the years from different countries showing increased incidence of cancer, cardiovascular disease and respiratory diseases[6,7,8,9].

Sweeping work contains different tasks which can be divided into two areas. The first includes sweeping/cleaning and fire-safety inspection of combustion plants and their exhausts ducts as well as flue systems in catering kitchens. This work is carried out in accordance with the Swedish Act on Protection against Accidents. During the so called 'black sweeping', soot is removed from oil, wood and pellet fired boilers and fireplaces[10]. In industrial contexts, black soot sweeping involves removing soot from large heaters and associated flues. Sometimes in a municipality, there is one operator who does the sweeping/cleaning and another who does the fire-safety inspection. The second area consists of work performed in the open market with free pricing. This includes cleaning of ventilation systems and mandatory ventilation checks, inspections of fireplaces and flue installations, and flue systems in both catering kitchens and private homes. These requested jobs also include status checks, transfer inspections, so called 'explosion inspections', as well as the installation of ventilation systems and fire detectors.

Considering the reported increase of diseases among chimney sweeps and a stated exposure to various substances in the working environment, there are strong reasons to continue investigating the working environment of chimney sweeps, partly to identify risks at work and partly to create better working conditions.

The aim of this knowledge review is to summarise the knowledge we have today about the Swedish chimney sweeps' working environment. The review is based on reports and studies regarding Swedish conditions. It focusses on the results of scientific studies investigating occupational diseases and risks, as well as the situation regarding falls and high-altitude work.

The remaining report is divided into the following sections:

- Method: A description of how the knowledge review was conducted and what it is based upon.

- Chimney sweeps' exposure to factors in the work environment: Here, a shorter description is given of workplace factors that may affect chimney sweeps' health.
- Medical risks: A description of the diseases and medical risks identified in various scientific studies based on Swedish sweeps. The chapter is divided into a number of sub-chapters: general causes of death, cardiovascular disease, various forms of cancer, and eye and respiratory problems.
- Falling accidents and high-altitude work: Here, statistics regarding falls for chimney sweeps are presented with examples of past instances where accidents have occurred.
- The use of personal protective equipment: Here, a description of studies regarding the use of personal protective equipment and regulations for high-altitude work is provided.
- Conclusions and comments: Here is a summary of current knowledge. In addition, ongoing research studies are described along with efforts regarding high-altitude work and new workplace issues which have been raised with regards to chimney sweeping.
- References: A list of scientific publications, other literature and oral sources, which form the basis of this review.

2. Method

The knowledge review is based on a literature search of library databases containing scientific publications and other literature regarding Swedish chimney sweeps' health and working conditions throughout the years. The scientific publications, which are described in more detail in the report, are authored by Swedish researchers, and are based on differing numbers of Swedish chimney sweeps as indicated for each study. The scientific publications are published in English in established international scientific journals, and have thus been reviewed by other researchers before being published. This is common practice for the international dissemination of scientific results. For a brief overview of the medical studies described in more detail in the report, see Table 1 below.

Table 1: Overview of the medical studies which are presented in more detail in the report

Study	Study focus	Studied time period/s	Number of studied chimney sweeps
Hogstedt et al (1982)	Cause of death	1951-1979	2048
Gustavsson et al (1987)	Cause of death	1951-1982	5464
Jansson et al (2012)	Cause of death	1952-2006	6374
Hogstedt et al (2013)	Cancer	1958-2006	6320
Gustavsson et al (2013)	Cardiovascular disease	1991-2005	4436
Alhamdow et al (2016)	Eye and respiratory problems	1975-1999, 2000-2009, 2011	483

The author has also been in contact with representatives of the chimney sweeps' trade union (Kommunal), the Swedish chimney sweeps' employer organization (Sveriges Skorstensfejaremästares Riksförbund), the Swedish Civil Contingencies Agency (MSB), and the Roof Safety Committee (Taksäkerhetskommittén), thereby gaining access to the magazine 'Sotaren' (The Chimney Sweep), which contains additional literature and tips on people dealing with issues related to the chimney sweeps' working environment. The author also had the opportunity to accompany a chimney sweep in the Swedish region Östergötland during one working day to get a picture of what a typical day for a chimney sweep might look like.

3. Chimney sweeps' exposure to work environment factors

Chimney sweeps are exposed to factors in the working environment that increase the risk of illness and accidents. In addition to being exposed to substances that can be harmful, they also work at high altitudes which pose a risk of falling.

In Sweden, wood, pellets, coal, coke, oil and natural gas are used as combustion materials[11]. Until 1947, wood and coal were mainly used, thereafter oil became most common[12]. Since 2000, the use of oil has decreased while pellets and wood have increased[10]. Depending on the fuel used, different types of toxic substances and quantities are left in the remaining soot[13].

Studies show that chimney sweeps are exposed to several harmful substances during black sweeping, such as carbon particles and multi-benzene ring derivatives of polycyclic aromatic hydrocarbons (PAH). They are a group of different aromatic substances found in coal and petroleum, and formed by insufficient organic combustion. In Sweden, wood burning and exhaust gases are the main sources of PAH. Exposure to materials containing PAH have been linked to increased risk of cancer[14]. In addition to these substances, chimney sweeps are also exposed to metals and metalloids (e.g. nickel, arsenic, lead, chromium and cadmium) as well as combustion gases (carbon monoxide, carbon dioxide, sulfur compounds and nitrogen oxides)[11,13,15]. Measurements also show that chimney sweeps are exposed to large amounts of dust when chimney sweeping (Figure 1). When soot sweeping in private homes, the chimney sweep is exposed to 3.8 mg/m^3 inhalable dust during an eight hour working day[16], while industrial soot sweeping can result in exposure to more than 1g/m^3.

Figure 1: Exposure to dust in chimney sweeps' daily work. (Photo: Gösab Sotning AB)

Chimney sweeps are also exposed to organic solvents and detergents used for degreasing, as well as asbestos from pipes and insulation materials in fireplaces[13,17,18]. Exposure to these chemicals occurs by inhalation, ingestion and contact with the skin, potentially causing various health problems.

Chimney sweeping includes roof work and therefore high-altitude work. Working at high-altitude means a risk of falling with potentially very serious consequences. When sweeping in private homes, the chimneys are often reached by climbing the roof via ladders provided by the property owner. Here, inadequate design of the ladder and the way it is placed or mounted on the roof can contribute to the risk of falling when the chimney sweep climbs up or down the steps (with equipment in one hand).

Summary – Chimney sweep work involves exposure to various risk factors:

- Black-soot sweeping involves exposure to
  - Carbon particles
  - Polycyclic aromatic hydrocarbons (PAH)
  - Metals and metalloids
  - Combustion gases
  - Dust
- Organic solvents and detergents are used in degreasing
- Asbestos occurs in pipes and insulation materials in fireplaces
- Working at high-altitude poses a risk of falling

4. Medical risks

4.1 Overall studies on mortality among chimney sweeps

As mentioned earlier, there are several studies indicating that chimney sweeps suffer from various diseases to a greater extent than the average population. The first study from 1775 described the occurrence of scrotal cancer[5], and it has been followed by several international studies on various types of cancer, cardiovascular disease and respiratory diseases affecting chimney sweeps. Since the choice of fuel results in different types of toxic substances in the soot, it is interesting to look at studies based on Swedish chimney sweeps and Swedish conditions.

Extensive studies have been conducted regarding the mortality rate of Swedish chimney sweeps. The first comprehensive study was conducted in the 80's. It was based on 2048 men who had worked for at least 10 years as chimney sweeps and died between the years of 1951 and1979[12]. In the study, the cause of death among these men was compared with what could be expected in the general population. The study showed a higher mortality rate among chimney sweeps than the expected rate of men in the general population: 230 chimney sweep deaths, compared with an expected 197.6. The increased mortality of chimney sweeps was predominantly due to cancer of the lungs and esophagus, as well as respiratory diseases (chronic bronchitis, emphysema and asthma). Gastrointestinal cancer and chronic respiratory diseases were mainly found in those who had worked for a longer period of time (longer than 10 years). The study also showed that there were more smokers (including former smokers) among the chimney sweeps than other Swedish men. The conclusion, however, was that the soot exposure to PAH, nitrogen compounds, arsenic and asbestos in combination with sulfur dioxide could explain the higher mortality rate of the chimney sweeps[12].

Another study of 5464 men also showed increased mortality rates among chimney sweeps due to heart disease, respiratory diseases and several types of malignant tumors[19]. Cases of lung cancer increased in relation to the number of years in the profession, and there was a fivefold increased risk of cancer of the esophagus and liver. The study concluded that increased mortality was related to the presence of combustion products in the working environment rather than due to smoking habits. A later extended study investigated the cause of death of 6374 chimney sweeps who died between 1952 and 2006. This study also included chimney sweeps who were employed after 1950 when oil became the main fuel[20]. Results again showed an increased mortality rate among chimney sweeps, 1841 deaths compared to an expected 1422. Various causes of death were identified including different types of cancer, mental illness, circulatory system and respiratory diseases, as well as accidents, see Table 2 for a selection of causes.

Table 2: A selection of causes of death between 1952 and 2006, where the number of cases exceeded the expected number. For a complete list of causes of death, see Jansson et al (2012)[20]

Cause of death	Observed number of cases	Expected number of cases
All	1841	1421,8
Malign tumours, out of which	484	347,3
Oesophageal cancer	18	8,4
Gastric cancer	33	26,3
Bowel cancer	46	26,7
Liver cancer	22	9,9
Lung cancer	123	63,3
Psychological diseases, out of which	59	30,9
Alcoholism	39	17,2
Diseases in the circulatory system, out of which	724	613,2
Ischemic heart disease*	462	383,7
Respiratory diseases, out of which	113	74,1
Asthma, bronchitis, emphysema	35	18,8
Chronic obstructive pulmonary diseases	14	9,2
Diseases in the digestive organs, out of which	97	56,8
Cirrhosis	45	21,5
External causes, out of which	263	178,9
Suicide	87	64,2
Fall accidents	22	14,5

*Ischemic heart disease = e.g. angina and myocardial infarction

A comprehensive health survey of 1040 chimney sweeps in 1972 showed that there was a greater proportion of smokers among chimney sweeps compared to the rest of the population. As lung cancer is related to smoking a calculation which took into consideration the greater number of smokers was used. This showed that an overrepresentation of lung cancer remained among the chimney sweeps, and that this was related to the working environment. The study also found that there was no major difference in the causes of death for chimney sweeps who started their career before or after 1950, indicating that the shift in fuel did not have any impact from a health perspective.

Cancer in the esophagus and liver as well as ischemic heart disease (e.g. angina and myocardial infarction) are generally related to high alcohol consumption. The study showed that there was a greater number of cases of alcoholism and cirrhosis than expected among chimney sweeps who had worked less than 30 years in the profession. However, this was not the case for chimney sweeps who had worked for more than 30 years. Since overrepresentation of alcoholism and cirrhosis was not present in the latter

group, yet high incidence of cancer of the esophagus and liver as well as ischemic heart disease was still found, one can conclude that the latter diseases were due to work related factors.

The researchers also pointed out that chimney sweeps in general may belong to a group that is healthier than other men of the same age, especially when it comes to those who have worked for more than 30 years as chimney sweeps. As a result, there could be an underestimation of the risks for the chimney sweeps, i.e. the risk of suffering from work-related illnesses could be even greater than the study showed.

In view of the increased health risks, study researchers pointed out the importance of using protective equipment and thinking about smoking and alcohol consumption, which could negatively interact with harmful substances in the workplace.

Summary – Overall studies on mortality indicate that chimney sweeps are overrepresented in samples of those affected by serious illnesses and accidents. These include:

- Several types of cancer
- Ischemic heart disease (e.g. angina and myocardial infarction)
- Respiratory diseases
- Falls

4.2 Heart disease

As described earlier, studies on mortality among chimney sweeps generally show an excess of cardiovascular disease[20]. In a study of the incidence of myocardial infarction (both mortal and non-fatal), chimney sweeps were compared with a control group with similar socioeconomic status (high-quality manual work) to reduce the likelihood of lifestyle factors affecting the result. The study, based on 4436 male chimney sweeps, showed how many that had suffered from myocardial infarction in relation to the number of years of employment as a chimney sweep, see Table 3. The study showed that regardless of the number of years of employment, there was a higher number of chimney sweeps who had suffered from myocardial infarction compared with the control group.

Table 3: Observed and expected number of cases of myocardial infarction among chimney sweeps divided by number of years of employment[21]

Number of years of employment	Observed number of cases	Expected number of cases
0-9	137	89,7
10-19	67	52,2
20-29	45	38,0
> 30	69	49,6

The overrepresentation was particularly evident for chimney sweeps who had worked less than nine years, or more than 30 years in the profession. If there was no connection to working environment factors, the number of cases would not have increased among those who had worked for more than 30 years. The researchers explained this by referring to the so-called Healthy Worker Survivor Effect (HWSE). HWSE means that a high incidence of diseases among those who have been employed for a shorter period may be due to the fact that people with less healthy living are overrepresented in short-term employment of different kinds. This group is therefore not included in the statistics of people who have worked for a long time. Another factor that contributes to HWSE, is that people who suffer from ill health caused by their work tend to seek alternative employment. This reasoning means that the HWSE leads to an overrepresentation of healthy persons among those who have worked for a long time. In this study, it was found that those employed as chimney sweeps for a longer time (more than 30 years) also had an increased incidence of myocardial infarction. This means that workplace factors do have an impact. The researchers concluded that the high incidence of myocardial infarction among those with shorter employment time could be explained by smoking and alcohol consumption, but that myocardial infarction among those with long employment could be explained by exposure to dust, PAH and various types of metals. The researchers also pointed out the importance of reducing chimney sweeps' exposure to hazardous substances urgently.

Another more recent study[22] focused on the relation between early markers of cardiovascular disease and occupational exposure to PAH. The aim of the study was to measure PAH metabolites in 151 chimney sweeps' urine, identify the work tasks where the chimney sweeps could be exposed to PAH, and estimate the risk of chimney sweeps contracting cardiovascular diseases. This risk was assessed by measuring the blood pressure and early serum biomarkers. The chimney sweeps were compared to a control group of 152 males. The study showed that the amount of PAH metabolites in the urine increased with the length of time spent soot sweeping, and that the chimney sweeps had up to seven times higher urinary PAH metabolites than the control group. The study further showed that the chimney sweeps had higher levels of the biomarkers homocysteine and cholesterol than the control group, which indicated a risk of cardiovascular disease. This was also indicated regarding diastolic blood pressure. The study supported the earlier calls to reduce chimney sweeps' exposure to PAH.

Summary – Chimney sweeps have an increased risk of myocardial infarction

- Regardless of employment time, there is an increased risk of myocardial infarction
- The risk of myocardial infarction is assumed to be due to exposure to dust, PAH and different types of metals
- Chimney sweeps' exposure to harmful substances at work needs to be reduced

4.3 Cancer

As mentioned earlier, the occurrence of scrotal cancers among chimney sweeps was reported in England in 1775[5]. It then also affected young boys who naked swept chimneys and fireplaces. This led to gradual improvements in clothing and hygiene. The presence of several other types of cancer among chimney sweeps has been reported. In Sweden, several studies have shown an increased occurrence of various types of lung cancer, esophageal cancer, bladder cancer and various types of blood cancer among chimney sweeps[14], which in a follow-up study also included increased occurrence of prostate cancer[23].

Cancer occurs when cells in any part of the body begin to divide and grow in an uncontrolled manner[24] due to damage to the cell's gene pool. The change in the gene pool affects the cell division so that it gains extra survival characteristics. This causes the tumor cell to survive when the normal cell would ordinarily die. Normal cells are programmed to die in response to cell pool changes, but tumor cells survive as a result. In this way cells accumulate, new blood vessels are formed and a tumor develops[24].

The latest study investigating the incidence of cancer in Swedish chimney sweeps was based on 6320 chimney sweeps in the years from 1958 to 2006[16]. Data for the study was collected from the Swedish Cancer Register, and figures for causes of death among the chimney sweeps were compared to those of control groups. The study showed an increased incidence of cancer among the chimney sweeps compared to the rest of the population (a total of 813 cases compared with the expected 625.7 cases). Table 4 shows the number of cases observed and the number of expected cases for various types of cancer. Complete results for all identified cancer cases are found in the scientific article[16].

Table 4: Observed and expected number of cases in different types of cancer that have affected chimney sweeps in 1958-2006[16]

Type of cancer	Observed number of cases	Expected number of cases
All, out of which	813	625,7
Esophageal	16	7,7
Stomach	36	26,8
Colon	55	40,6
Liver (primary) and bile ducts	38	19,6
Larynx	10	6
Bronchus and lung (primary)	231	107,9
Pleura	9	2,6
Prostate	173	154,7
Kidneys	27	21,8
Bladder	70	38,9
Blood cancer (different types)	75	58,1

4.3.1 Cancer in lungs and pleura

The latest study[16] showed an increased risk of pleura cancer (9 cases compared to expected 2.6 cases). Mesothelioma was the type of pleura cancer found among chimney sweeps. The increased risk was primarily among chimney sweeps who had worked for a long time in the profession. Mesothelioma is a very rare form of cancer and previous research has shown that cancerous mesothelioma in the lungs is strongly related to exposure to asbestos, while tobacco smoking is not a pronounced risk factor[25]. In the case of asbestos and cancer, asbestos fibers, find their way into the lungs and cause scar tissue (fibrosis). In areas where fibrosis is present, the lung cannot function and there is an increased risk of lung cancer. This cancer can develop 20-40 years after exposure.

Regarding different types of lung cancer, researchers in the current study found that the increased risk of lung cancer (231 cases versus 107.9 cases) could be explained by the chimney sweeps' exposure to cancerous substances including PAH (polycyclic aromatic hydrocarbons), arsenic, nickel, chromium and asbestos[16]. They also believed that the increased risk of lung cancer in the study was far too large to be related to tobacco smoking alone, though any interaction between tobacco smoke and exposure to cancerous substances at work could not be assessed in the study.

4.3.2 Bladder cancer

The latest study[16] also showed an increased risk of bladder cancer (70 observed cases compared to expected 38.9 cases). The risk increased in line with employment duration and was therefore higher for the chimney sweeps employed before 1951. Increased incidence of bladder cancer has also been noted among chimney sweeps in Denmark, Norway and Finland[26].

Aromatic amines have been linked to urinary bladder cancer, but no research has been conducted to check for exposure among chimney sweeps. Tobacco smoking has also been linked to urinary bladder cancer[27], but the researchers said that it could only have limited impact when assessing the risks in the current study.

4.3.3 Esophageal cancer

The latest study[16] also showed increased risk of esophageal cancer (16 cases compared to expected 7.7 cases), which could be explained by the chimney sweeps' exposure to PAH and combustion products. PAH and dust can accumulate in the respiratory system. If they are then swallowed they come into direct contact with the mucous membrane of the esophagus, which can contribute to esophageal cancer. Although smoking and alcohol consumption are well-known risks, these were not considered to be influencing factors in this study. The overconsumption of alcohol in older chimney sweeps (noted in previous studies from 1972) was not considered to be valid since these men were no longer included in the study. Nor was there any overrepresentation in mortality due to cirrhosis or alcoholism among the chimney sweeps who had worked for more than 30 years in the study of causes of death mentioned earlier[20].

4.3.4 Cancer in liver and bile ducts

The study[16] also showed that the risk of primary cancer in liver and bile ducts was significantly increased for chimney sweeps with both shorter and longer employment time (in total 38 cases compared to the expected 19.6 cases). (This number did not include metastases in the liver which is a common consequence of other cancers.)

Chimney sweeps are exposed to organic solvents when they clean greasy ventilation pipes, which could explain the increased risk. Liver cancer is related to high alcohol consumption, but with the same reasoning as for esophageal cancer, this was not a relevant explanation for the high incidence of primary liver cancer in this study[16].

4.3.5 Colon cancer

The study[16] also revealed a risk of colon cancer which is increased with the duration of employment, this may indicate that it is work-related. The largest known work-related risk for colon cancer is sedentary work. This is not characteristic of the chimney sweeps' work, since they are in motion for the majority of their working hours. Some studies[20] indicate a correlation between colon cancer and exposure to asbestos. In instances where increased risk of colon cancer is assumed to be work related, the exposure to asbestos, albeit small, is still thought to be linked to the increased cancer risk.

Summary – Chimney sweeps have an increased risk of a variety of cancers, including:

- Cancer in lungs and pleura due to exposure to polycyclic aromatic hydrocarbons (PAH), arsenic, chromium and asbestos
- Bladder cancer
- Esophageal cancer as PAH and dust are accumulated in the respiratory system and swallowed
- Cancer in liver (primary) and bile ducts due to exposure to organic solvents
- Colon cancer which may be related to exposure to asbestos

4.4 Eye and respiratory problems

Previous studies from Sweden and Denmark have shown that chimney sweeps have an increased risk of asthma[29] and prolonged coughing with mucus, shortness of breath and discomfort behind the sternum[30]. A recent study based on 483 Swedish chimney sweeps investigated the incidence of eye and respiratory problems in relation to the amount of time spent on different types of tasks[10]. Eye problems included watery eyes, itching and pain, and nose problems included runny nose, itching, colds and sneezing, as well as nose bleeds. The researchers also measured problems with wheezing and coughing.

The study showed that coughing increased in relation to longer hours spent on black sweeping (both in private housing and in industrial contexts). Similarly, coughing decreased as the chimney sweeps spent more time performing ventilation controls.

Eye and nose problems decreased when chimney sweeps performed office duties. In addition, reduced eye problems were noted when chimney sweeps performed more fire protection controls. Like previous studies, the researchers emphasized the importance of using personal protective equipment and finding alternative methods of black sweeping in industrial contexts.

The study also showed that chimney sweeps today do not smoke to the same extent as before. In the current study, 13% of the chimney sweeps smoked, which was slightly lower than the national average for Sweden's population, which was 14% (Statistics Sweden's figures for 2012). This can be compared with studies from 1972 which showed that 67% of Swedish chimney sweeps smoked[32].

Summary – Chimney sweeps' eye and respiratory problems depend on the working environment

- Black sweeping causes increased problems with coughing
- Increased working hours with ventilation controls, office work and fire protection control reduce the risk of coughing and eye and nose problems

5. Fall accidents and high-altitude work

Chimney sweeps perform a significant part of their work on roofs, which means working at high-altitude (see Figure 2).

Figure 2: Chimney sweep working at high-altitude

There are several different professions involving roof work. The Taksäkerhetskommittén[33] is a venture between different industry partners and organizations (the Swedish National Board of Housing, Building and Planning, the Swedish Association of Local Authorities and Regions, and the Swedish Work Environment Authority) who work to prevent and reduce the risk of accidents when working on roofs. They have developed an Industry Safety Standard[34] which describes risks for different occupational categories and details how these risks can be reduced. For chimney sweeps, risks relate to both accessing and working on the roof. When accessing the roof chimney sweeps are at risk of:

- Slipping on the ladder to the attic and falling
- Falling on the roof, tripping or slipping
- Getting strain injuries when lifting equipment
- Cutting oneself on sharp edges
- Falling from free standing ladders due to missing or insufficient slip protection
- Falling from the free standing ladders

- Injury due to loose roof ladders
- Falling when moving around on the roof (being anchored or not being anchored)

When chimney sweeps work on the roof there are further identified risks including:

- Falling to lower levels from the chimney (anchored or not anchored)
- Falling to lower levels, due to insufficient anchorage or equipment
- Falling through the roof, glass, plastics, etc.
- Strain injury
- Falling tools, people or parts of the chimney may hit others below
- Hitting one's head on a television antenna or other obstacle
- Cutting oneself on sharp edges, such as hoods
- Inhalation of smoke or soot particles

As described above, there are risks of differing types. In addition, there is a risk of falling when conducting fire protection control and entering the attic through outside gable hatches in private homes (personal communication). Statistics from AFA Insurance show several reported chimney sweep casualties between 2008 and 2014, see Figure 3. AFA Insurance[35] is a company owned by employer and employee organizations which, through collective agreements, insures more than four million people in Sweden. The statistics show only the casualties related to insurance claims, which means that there are potentially further accidents which have not been reported. The reported casualties mainly involved free standing ground ladders slipping, but also problems with roof ladders and general falls.

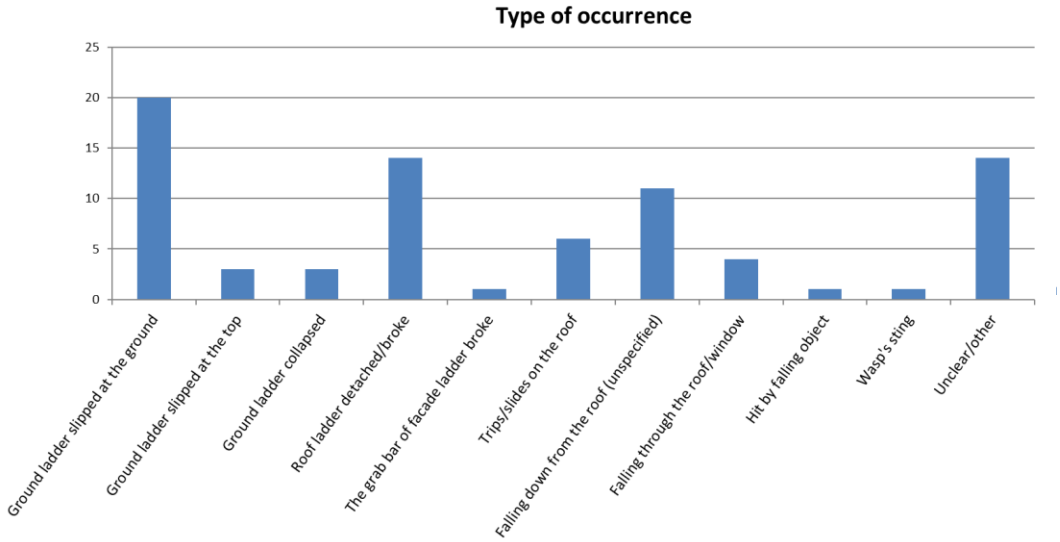

Figure 3: Causes of reported falls for chimney sweeps 2008-2014. Source: Taksäkerhetskommittén (Roof Safety Committee)

The statistics show that a number of falls were related to free standing ground ladders. Accidents with portable ground ladders occur frequently in several industries. AFA Insurance and the Swedish construction industry's

organization for research and development SBUF (Svenska Byggbranschens Utvecklingsfond) therefore published a report in 2016 on work accidents and portable ladders. The report deals with all occupational groups who perform roof work. Portable ladders have been used for hundreds of years, and are common tools in many industries with a wide range of application. As such there are many ladder manufacturers resulting in high market competition. Therefore, it is vital to educate ladder manufacturers and designers of the importance of safety.

In addition to the actual design of the steps on the ladder, there is an increased risk if: the ladder is placed improperly, the work is carried out alone, and if the work is performed under time pressure. Time pressure has increased in Swedish working life, which may influence the employee to neglect safety measures[36].

For chimney sweeps, portable ladders are often used to access the roof. Chimney sweeps also carry equipment as they climb up the ladder. Equipment is balanced with one hand leaving only one hand available during all movements on the roof, see Figure 4.

Figure 4: Use of loose ground ladders and carrying equipment

The Work Environment Authority has compiled ladder related work injury statistics which show that chimney sweeps and sanitation workers suffered from 51 accidents from 2010 to 2015. Serious accidents linked to ladders have also been described in detail in the 'Occupational Accidents & Ladders'[36] report, of which two accidents were related to chimney sweeps:

- Fall 1: Loose ladder leaning towards broken gutter

  The accident involved a chimney sweep with 47 years of professional experience who was sweeping on the roof of a two-story private house. The chimney sweep used a five-meter extension ladder that was placed on a wooden porch, leaning against a gutter with a fixed sliding protection. The gutter turned out to be broken and the upper section of the ladder slipped whilst the chimney sweep was three meters up in the air. He fell onto lime plates and suffered multiple fractures to the body, arms and wrist, which required surgery and the insertion of rails and screws. The accident required more than nine months of sick leave.

- Fall 2: Loose ladder without gliding protection, dangerous winter weather conditions

  The accident involved a chimney sweep with 25 years of professional experience who was sweeping in a private home. In this case, a 4.5-meter extension ladder was used, which was placed on stone plates and leant against a gutter without gliding protection. There was snow on the ground. The accident occurred when the chimney sweep was on the roof with tools in his hands after he had gone up and down several times. The ladder slipped at the top and the chimney sweep fell onto the hard ground from an altitude of four meters. He cracked his skull which resulted in internal bleeding. He also had fractures to the shoulder, ribs and wrist, and severe wounds on the face. The accident required care at specialist clinics for 18 months and sick leave thereafter.

In an interview after the accident, the two chimney sweeps described their view of what had happened. The first chimney sweep explained that he was usually careful when anchoring ladders, however time pressure sometimes made him miss things. The second chimney sweep, on the other hand, stated that ladders are such common tools in his work that he had not thought about how risky they could be. He said that he was surprised any time he encountered a fixed ladder on the facade or a solid ladder from gutter to chimney.

Summary – Chimney sweeps' work at high altitudes, leading to:

- Risk of falling
  - When stepping on to the roof or into the attic
  - During work on roofs
- Several accidents occur in relation to portable ground ladders
- The accident risk increases when working alone and under time pressure

6. Use of safety equipment

As described earlier, chimney sweeps are exposed to several different substances that can cause serious diseases and medical problems. Several researchers have pointed out how important it is to use protective equipment at work. A study published in 2016 investigated the use of protective clothing and protective equipment for chimney sweeps over three periods: 1975-1999, 2000-2009 and during 2011 (12 months).

The study showed that the use of protective gloves had generally increased over time (86.9% use for 2011) and that gloves were used twice as often for black sweeping in private homes and industries compared to other tasks[10]. The use of protective masks had also increased over time. Simple masks where used more often when cleaning ventilation ducts and during black and white sweeping. Advanced masks were used to a much greater extent during black sweeping in industry compared with other tasks. 80% of the chimney sweeps did not use either simple or advanced masks during fire protection control or cleaning of exhaust ducts. The study also showed that younger chimney sweeps used both protective gloves and masks to a greater extent than older ones.

The use of long-sleeved clothing and long trousers had decreased slightly with time. However long trousers were used to a great extent (about 95%) for black sweeping in private homes and industries. Protective equipment covering the whole body was rarely used, except for industrial black sweeping, where it was used in about 20% of cases. The study also showed that the use of vacuum machines for black sweeping had increased significantly since 2000. In 2011, 71.7% of chimney sweeps used them for sweeping in private homes and 65.9% used them for black sweeping in industry.

High-altitude work also requires protective equipment. Sliding protection for ground ladders is a requirement for houses with a height of less than four meters. It is the property owner's responsibility to arrange this. Sliding protection should also be available for ground ladder when accessing the attic (for fire protection) and the access door should be at least 0.7 m x 1.2 m (personal communication).

Chimney sweeps usually work alone. This means that they themselves have responsibility to judge if it is safe to work on the roof and use the ladders provided. This requires a high level of personal knowledge. This also requires the employer’s support and provision of training to ensure good workplace practices, and to equip the individual chimney sweep to handle situations that may arise.

There is a recently revised regulatory framework which has sharpened the rules regarding roof work. It also imposes sanction fees if the rules are not met[1], however there are some exceptions. Chimney sweeping is one example

of work that is not subject to sanction fees when it is not performed as part of construction work. The work should nevertheless be carried out with fall protection. The Swedish Work Environment Authority generally recommends that collective fall protection including fixed guard rails, should be used prior to personal protective equipment (personal communication). The industry standard for roof safety proposes the following measures to reduce the risk of accidents, which means that the chimney sweep should:

- Check access areas, gliding protection, ground ladder, facade ladder, attic ladder, roof ladder, working platform and anchoring devices for personal fall protection before use
- Be anchored the whole time with personal fall protection during movements and work
- Attend suitable training for the use of personal fall protection equipment
- Have a rescue plan
- Anchor equipment and material. The ground area should be blocked if necessary
- Avoid solitary work (other employees must be contactable)

Summary – It is important that the chimney sweeps use protective equipment

- The use of protective gloves has generally increased
- The use of protective masks has increased
    - Simple masks are used for cleaning of ventilation ducts and black sweeping
    - Advanced masks are used primarily for black sweeping in industry
- Young chimney sweeps use protective gloves and masks to a greater extent than older ones
- Protective equipment covering the whole body is rarely used, except within the black sweeping in industry
- The use of vacuum machines has increased significantly since 2000
- To avoid fall accidents, there should be sliding protection for ground ladders, which is the property owner's responsibility
- The rules for roof work set by the Swedish Work Environment Authority apply to chimney sweeps. Collective protection should be used prior to individual protective equipment.

7. Conclusions and comments

This knowledge review shows that chimney sweeps are exposed to several types of risks in their daily work. Several scientific studies indicate that chimney sweeps have an overrepresentation of mortality caused by several types of cancer, heart disease, respiratory diseases and falls.

The development of cancer depends on several factors. As described earlier, chimney sweeps are exposed to a variety of harmful substances such as soot particles, solvents and to some extent, asbestos, all of which contribute to processes that cause genetic cell damage and increased chronic burns. In addition, there are ongoing studies investigating chimney sweeps' working environment. In a 2016 ongoing Swedish project conducted by researchers at Karolinska Institutet, there is a focus on chimney sweeps' exposure to polycyclic aromatic hydrocarbons (PAH). In the three-year research project, chimney sweeps are compared with warehouse workers who are not exposed to PAH in their working environment. The researchers investigate whether chimney sweeps have early DNA changes, which may be a sign of increased cancer risk[35].

The reported high incidence of myocardial infarction among chimney sweeps is also considered to be due to exposure to dust, PAH and various types of metals. Studies also show that chimney sweeps have problems with eyes and respiratory tracts and that these problems decrease if the chimney sweep spends less time black sweeping.

In view of reports of risk factors at work, mortality and the increased incidence of several serious diseases, it is important to improve the chimney sweeps' working environment, to develop alternative working methods, as well as to utilize and further improve protective equipment. Regarding the use of personal protective equipment, chimney sweeps have a significant personal responsibility. The same applies for reducing the risk of accidents.

Although property owners are required to provide appropriate protective equipment, and work rules are continuously being reviewed and sharpened, it still remains that the chimney sweep is his/her own safety representative carrying personal responsibility to assess safety risks. This can be problematic since sweeps are subject to tough market competition and time constraints which may pressure them to "kindly" accept the working environment as it is.

Aside from the above medical and fall risks mentioned above, additional questions have been raised within the chimney sweep union organization. One question concerns the risk of working in close proximity to radio masts and radiation from mobile transmitters when radio antennas are set next to chimneys[37] (as well as oral communication). Another emergent question is the increased stress that many chimney sweeps experience. Since the municipalities often make their procurement based on price, it leads to price

pressure and a reduction in the time available for chimney sweeps to do their work[38]. Another factor contributing to the perceived stress is the organization of the chimney sweep work, which involves performing increasing levels of administrative work, such as managing customers who call the chimney sweep directly (personal communication).

Overall, the knowledge review shows that there remains a need to improve the physical environment of chimney sweeps in order to reduce their exposure to harmful substances and accidents. Furthermore, there is a need to consider current issues related to the psychosocial work environment.

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Personal communication:

PeO Axelsson, Taksäkerhetskommittén

Jonny Jakobsson, Ombudsman, Arbetsplats- och avtalsenheten, Kommunal

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