

# Ischemic cardiovascular disease in workers occupationally exposed to urban air pollution – A systematic review

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## Abstract

**Introduction.** Cardiovascular disease is the first cause of morbidity and mortality worldwide. Among several known risk factors, researchers also focus their attention on the chronic exposure to air pollution. There is much evidence that exposure to air pollution, especially to ultrafine particles, can damage the endothelium and can favour cardiovascular diseases in the general population. Occupational exposition could be an additive risk factor for the cardiovascular system. This article presents a scientific review of the linkage between occupational exposure to air pollution and ischemic heart disease.

**Materials and method.** A scientific review was undertaken, followed by PRISMA Statements. Observational studies were selected from several scientific databases, likesuch as Pubmed, Google Scholar, Nioshtic-2 and Reserchgate, searching for selected key words: police workers, professional drivers, mail carriers, filling station attendants, road cleaners, garage workers, motor vehicles and engine maintenance. All the key words were combined with "Boolean Operators" with the following words: cardiovascular (or cardiac) disease, cardiovascular function, cardiovascular system, ischemic heart disease, coronary disease, myocardial infarction. During the systematic research, the focus was on retrospective and prospective studies from January 1990 – December 2014.

**Results.** Both the retrospective and prospective studies showed an increased risk of ischemic heart disease in occupationally occupied people exposed to air pollution. Only one study presented a ly minor risk.

**Conclusions.** The findings of this systematic review suggest a possible linkage between occupational exposure to urban air pollution, especially to motor exhaust and particulate, and ischemic heart disease.

## Key words

air pollution, infarction, cardiovascular

## INTRODUCTION

The research showed that during the last two decades, exposure to urban pollution could have increased cardiovascular morbidity and mortality, particularly in people already at risk for these conditions. It is not completely clear how the acute and chronic exposure to air pollution, and especially to particulate matter (fine and ultrafine particles: PM 10, PM 2,5), can damage the cardiopulmonary system. There are various hypothesized pathophysiological mechanisms. The PM inhaled could activate an inflammatory process with systemic oxidative stress, increasing the expression of inducible nitric oxide synthase (iNOS) and cyclooxygenase-2 as pro-atherogenic factors. Other pathways are characterized by the induction by PM inhaled of an alteration of the balance of the autonomic nervous system [1–5]. These mechanisms are probably mediated by epigenetic phenomena. Many studies observed that microRNAs (miRNAs), transferred between cells by extracellular vesicles (EVs), may play an important role in PM-induced cardiovascular risk. Other studies have investigated the role of DNA methylation in air pollution

induced cardiovascular diseases. Platelet mitochondrial DNA methylation, for example, is an energy source for platelet function and it could explain, in part, the role of these cells in cardiovascular diseases [6–9].

Although many studies on the general population show an association between exposure to PM derived from urban pollution and cardiovascular disease, few researchers have focused their attention on the occupational exposures.

Many job categories are subjected to urban air pollution, and they are subdivided into two groups: exposed to motor exhaust outdoors: police and traffic officers, all professional drivers, filling station attendants, and many others, and those most frequently exposed to motor exhaust indoors: garages workers, construction and machine repair operators, etc. Worldwide, millions of workers are occupationally exposed to air pollution, and the constancy of this exposition may represent a cardiovascular risk [10, 11].

The aim of the present study is a systematic review of the scientific literature concerning occupational exposures to urban air pollution and cardiovascular disease, with particular attention to ischemic heart disease and infarction, using PRISMA statements [12].

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## MATERIALS AND METHOD

**Search strategy.** Observational studies investigating the association between urban air pollution occupational exposures and ischemic heart disease, including both clinical and intermediate outcomes were selected from several scientific databases, like Pubmed, Google Scholar, Nioshtic-2, Reserchgate.

A search was made for key words: police employees, including police officers, policemen, traffic wardens), professional drivers (including bus drivers, taxi drivers), street vendors (also shop vendors, newspaper vendors), mail carriers (postmen, postal workers), filling station attendants, road cleaners, garage workers, motor vehicle and engine maintenance workers. All the key words were combined with “Boolean Operators” with the following words: cardiovascular (or cardiac) disease, cardiovascular function, cardiovascular system, ischemic heart disease, coronary disease and myocardial infarction.

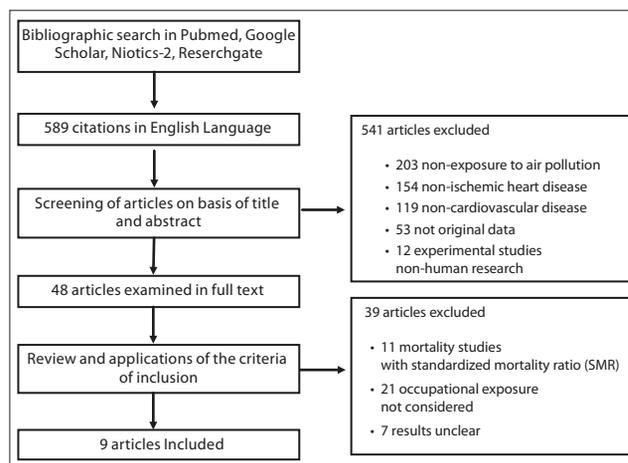
During the systematic research, the focus was on retrospective and prospective studies investigating occupationally-exposed people, published in the English language, from January 1990 – December 2014, and encompassed literature of the last 25 years. Secondary references were also used, cited by articles identified in the first search. Only full text publications were used and included studies where the authors investigated multiple outcomes, not only cardiovascular or ischemic cardiac disease. But in every articles selected, the ischemic heart disease was statistically evaluated, including mortality and incidence of new cases. Clinical outcomes were also identified referring to the International Code Disease version 10 (ICD 10) and using ICD (I20-I25).

Studies were excluded if the exposure to air pollution was not derived from motor exhausts or from urban sources, e.g. industrial emissions, as well as articles that did not contain original research, animal and experimental studies and case reports. Selection of the articles was conducted by an initial screening of titles, abstracts of the articles that fitted the criteria for inclusion, and finally, if the abstract was interesting, the full text was obtained and examined. Because of the small number of studies available for meta-analyses, the results of the studies are illustrated in a forest plot and subsequently simply commented on.

**Data extraction.** For each study responding to the criteria for eligibility, much information was extracted using one Table for data extractions, based on the template of the Cochrane Consumers and Communication Review Group. Information wa collected about the study characteristics (author(s), year and country of publication, study protocol), population characteristics (age, gender, occupational exposition), outcomes and statistical method for evaluating the strength of the association between the study outcomes and the occupational exposure to urban pollution. Statistical association was evaluated using the relative risk (RR) for prospective studies and the odds ratio (OR) for retrospective studies. If several RRs were found for different outcomes, the outcome of specific interest was selected. In particular, only the risk measures for occupational exposition to urban pollution and ischemic heart disease (ICD-10 I20-I25) were selected.

## RESULTS

**Literature search.** The literature search identified 589 citations, of which a large number, after reading the title or the abstract, were immediately excluded because they did not adhere to the criteria for the presented review. The full text of 48 articles were examined and 39 articles. Finally, 9 studies were included in the review (Fig. 1).



**Figure 1.** Flow chart of study selection.

**Study Characteristics.** Study characteristics of each of the 9 studies are presented in Table 1. Six studies were prospective, the others were retrospective. All the studies but one examined professional drivers, in comparison with others jobs. One study [13] evaluated occupational exposure to asphalt fumes. All but 2 of the selected studies had a specific endpoint incidence of ischemic heart disease. In the two cases with several endpoints, only the results about ischemic cardiovascular disease were considered. Where the results were extrapolated for single professional exposure, the single risk index for every typology of professional drivers (taxi drivers, lorry and truck drivers, bus drivers) were recorded [14–16].

In two studies [17, 18], the results for professional exposure to motor exhausts were extracted, excluding the other occupational expositions because they were not in accord with the present study. All the studies used an external reference group, mostly from the general population or from other occupational groups, for statistical comparison.

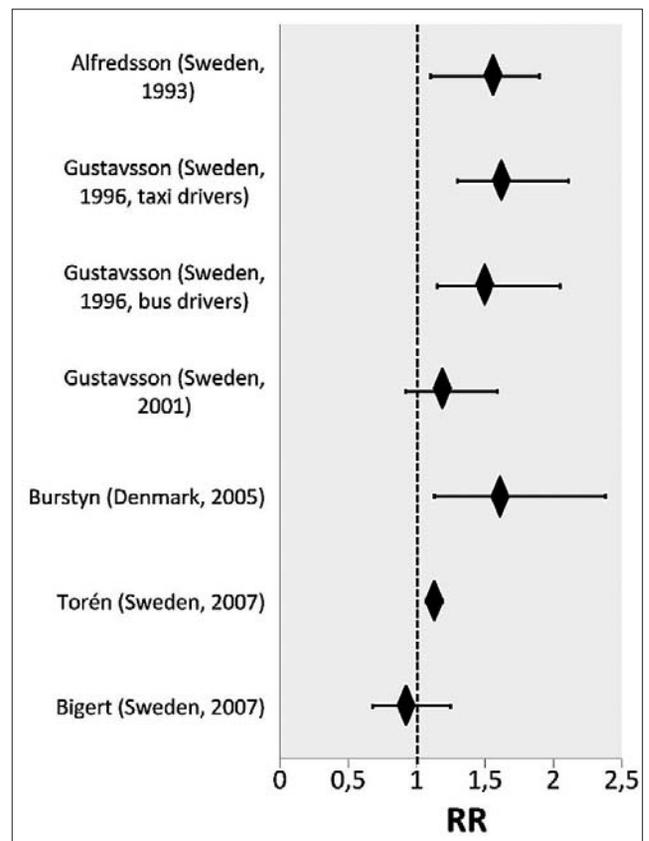
**Effect estimates of prospective studies.** Effects estimates varied widely across the studies. The relative risk (RR) ranged from 0.92 [15] and 1.64 [13] for ischemic heart disease, and specifically infarction, with the most positive association observed for professional drivers exposed to motor exhaust. All the studies had statistically corrected results for tobacco smoke and for the major risk factors of cardiovascular disease. Only in one study the RR was less than one. This study observed the association between myocardial infarction and the occupation of subway drivers in Sweden, considering the occupational exposure of these workers to particulate (PM10). In this case, although very high levels of particulate in the size range 1–10  $\mu\text{m}$  were found in the air of the underground platforms, drivers spent only a small part of their work time on the platforms [20].

**Table 1.** Study characteristics. RR – Relative Risk; OR – Odds Ratio; CI – Confidential Interval

Study	Country	Population and sample size	Exposure	Outcomes investigated	Main results
Rosengren, 1991 [16]	Sweden	Bus and tram drivers (n = 103); taxi drivers (n= 56), Lorry drivers (n= 158)	Air pollution	Incidence of coronary heart disease	Bus and tram drivers: OR 3.3 – C.I. 95% (2.0–5.5); Taxi drivers: OR 3.1 – C.I. 95% (1.6–6.2); Lorry drivers: OR 1.2- C.I. 95% (0.6–2.1)
Alfredsson, 1993 [19]	Sweden	Bus drivers (n=334)	Automobile exhaust fumes	Incidence of myocardial infarction in Stockolm. Mortality for cancer	Myocardial infarction: RR 1.6 –C.I. 95% (1.1–1.9)
Gustavsson, 1996 [15]	Sweden	Urban professional drivers (taxi and bus drivers) (n= 211 bus drivers; n =297 taxi drivers)	Motor exhaust fumes	Incidence of myocardial infarction	Taxi drivers: RR 1.65-C.I. 95% (1.30–2.11) Bus drivers: RR 1.53-C.I. 95% (1.15–2.05)
Gustavsson, 2001 [17]	Sweden	Occupationally exposed to motor exhaust (n= 429)	Motor exhaust fumes	Incidence of myocardial infarction	RR 1.21-C.I. 95% (0.92–1.59)
Bigert, 2003 [14]	Sweden	Bus drivers (n= 77), taxi drivers (n= 78), truck drivers (n= 179)	Motor exhaust fumes	Incidence of myocardial infarction	Bus drivers: OR 2.41-C.I. 95% (1.15–5.06); taxi drivers: OR1.67 – C.I. (0.84–3.31); truck drivers: OR 1.32 –C.I. 95% (0.86–2.03)
Burstyn, 2005 [13]	Denmark Finland, France, Germany Israel, Netherlands and Norway	Asphalt workers (n= 12367 males)	Asphalt fumes	Mortality for ischemic heart disease and cardiovascular disease	RR 1.64 (1.13–2.38)
Bigert, 2007 [20]	Sweden	Subway drivers (n= 54)	Airborne particulates	Incidence of myocardial infarction	RR 0.92 –C.I. 95% (0.68–1.25)
Toren, 2007 [18]	Sweden	Construction workers (n =176,309 exposed and 71,778 unexposed males)	Inorganic dust, fumes, diesel exhaust, asphalt fumes, metal fumes	Incidence of ischemic heart disease and cerebrovascular disease	RR 1.13 C.I. 95% (1.07–1.19)
llar, 2014 [21]	Sweden	Occupational workers exposed to motor exhaust (professional drivers, bus garage workers, construction machine operators)	Motor exhaust fumes	Incidence of myocardial infarction	O.R. 1.21- C.I. 95% (0.91–1.59)

Some authors evaluated the incidence of nonfatal myocardial infarction [13, 15, 17, 20]. Two studies [15, 18] observed just the incidence of myocardial fatal infarction and only one study observed both the mortality for ischemic heart disease and the incidence of ischemic heart disease [19]. The major of RRs, corresponding to 1.64, with confidential interval (C.I.) 95% of 1,13–2.38, was found in one study that evaluated the association between professional exposure to polycyclic aromatic hydrocarbons in male asphalt workers from some North Europe countries, and mortality for ischemic heart disease [13]. All the others studies but one, with RR ranging from 1.6–1.13, observed an association between ischemic heart disease and professional drivers, with occupational exposure to motor exhaust. One study examined Swedish construction workers exposed to many pollutants, like inorganic dust, fumes, diesel exhaust, asphalt fumes [18] (Fig. 2, tab. 2).

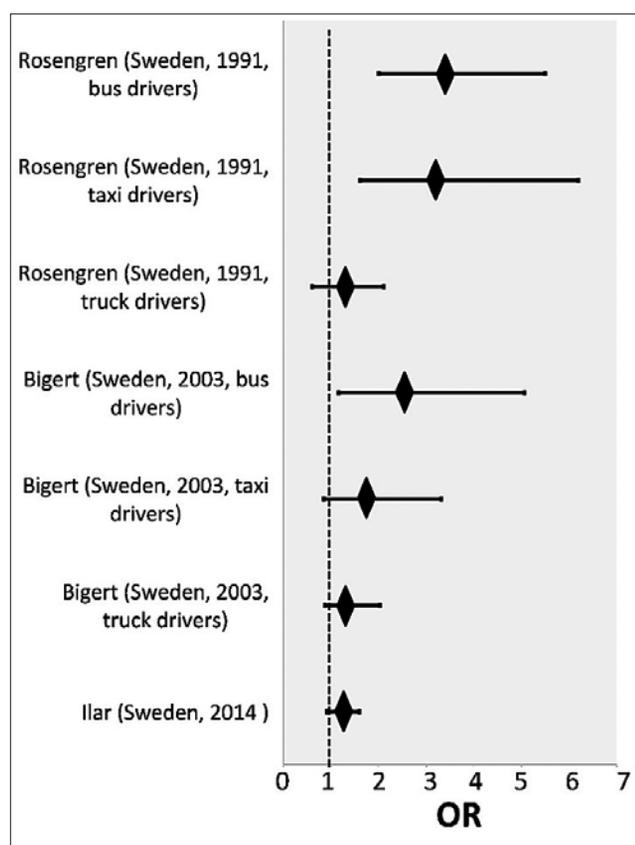
**Effect estimates of retrospective studies.** Few retrospective studies were found which had odds ratio (OR) ranging from 1.2–3.3 [16]. Three different results were extracted from one study on the basis of the occupational group: bus drivers, taxi drivers and truck drivers. This study showed a sensible difference between the various occupational groups of drivers, especially between bus and taxi drivers on the one hand, and truck drivers on the other (Tab. 3). From the Bigert study [14] the results were divided on the basis of the occupational group: bus, taxi and truck drivers, with differences in the OR, major for bus and taxi drivers and less for truck drivers (Tab. 3). One study [21] examined several professional groups with. exposure to motor exhaust including: professional drivers, garage workers and mechanics (Fig. 3).



**Figure 2.** Forest plot of effect estimate of prospective studies. RR – relative risk

**Table 2.** Effect estimate of prospective studies. **R.R** – Relative Risk; **CI** – Confidential Interval

Reference	Occupational group examined	External comparison group	Population characteristics standardized to	Exposure type	Incidence of ischemic heart disease and/or Myocardial infarction -RR (95%CI)
Alfredsson, 1993 [19]	Male bus drivers	Other employed men	Age, Calendar year and Swedish County	Automobile exhaust fumes	1.6 (1.1–1.9)
Gustavsson, 1996 [15]	Male taxi drivers	Other employed men (white collar workers, blue collar workers, unskilled manual workers)	Age, area of residence	Automobile exhaust fumes	1.65 (1.30–2.11)
Gustavsson, 1996 [15]	Male bus drivers	Other employed men (white collar workers, blue collar workers, unskilled)	Age, area of residence	Automobile exhaust fumes	1.53 (1.1–2.05)
Gustavsson, 2001 [17]	Occupational exposed to motor exhaust	General population	Age, sex and year of enrolment and cardiovascular risk factors	Motor exhaust (measured using the dosage of carbon monoxide exposition)	1.21 (0.92–1.59)
Burstyn, 2005 [13]	Male asphalt workers	General population	Age, calendar period, duration of employment, country	Polycyclic aromatic hydrocarbons	1.64 (1.13–2.38)
Toren, 2007 [18]	Male construction workers	White collar workers	Age, hypertension, smoking and body mass index	Fumes, diesel exhaust and asphalt fumes	1.13 (1.07–1.19)
Bigert, 2007 [20]	Subway drivers	Gainfully employer	Calendar year, age	Air particulate	0.92 (0.68–1.25)

**Figure 3.** Forest plot of effect estimate of retrospective studies.

OR – Odds ratio

## DISCUSSION

The findings of the presented systematic review suggest a possible linkage between occupational exposure to urban air pollution, especially to motor exhaust and particulate, and ischemic heart disease. The most important occupational

exposed group to air pollution consists of professional drivers, with particular significance for urban drivers, such as taxi and bus drivers. The most relevant results are the consequence of the prospective studies which examined different types of professional expositions. These results are also probably correlated with the socioeconomic status and the life style of the examined exposed group. These groups are composed of subjects with a sedentary life, unhealthy eating habits and high level of stress. However, it cannot be excluded that the occupational exposition to urban air pollution is an important risk cofactor for ischemic heart disease.

The authors admit that this systematic review is not without limitations and potential biases. Analyzing the biases, it can be asserted that some of them are common to systematic reviews in general. For example, publication bias, which is the tendency for manuscripts with positive findings to be published more than those with negative or null results. However, in the presented review, publication bias was not the most important concern. Of greater concern were the biases and confounding factors inherent in the individual studies, for example, a wide range of exposure assessment methods was used in the different studies, with directly measuring PM or other pollutants in the workplaces. This resulted in the lack of quantitative and qualitative exposure measurements in every study, with the exception of one, where the exposition to carbon monoxide was controlled [17].

Unlike ambient air pollution studies, which can utilize routinely collected environmental monitoring data to study large populations with similar expositions, occupational cohort studies are limited to smaller populations with variable exposure levels, depending on many factors, like tasks, workplace practices and technical controls. In occupational studies, exposures are often difficult to estimate and are assigned to a study cohort by job title. This can lead to exposure misclassification. Another concern is relative to the effect on healthy workers, especially in population mortality and morbidity studies, which can be a protective association when healthy workers are compared to those that also include ill people.

**Table 3.** Effect estimate of retrospective studies. **OR** – Odds Ratio; **CI** – Confidential Interval

Reference	Occupational group examined	External comparison group	Population characteristics standardized to	Exposure type	Incidence of ischemic heart disease and/or Myocardial infarction -OR (95%CI)
Rosengren, 1991 (16)	Male bus drivers	Men in other occupation group	Age and all cardiovascular risk factors	Air pollution	3.3 (2.0–5.5)
Rosengren, 1991 (16)	Male taxi drivers	Men in other occupation group	Age and all cardiovascular risk factors	Air pollution	3.1 (1.6–6.2)
Rosengren, 1991 (16)	Male truck drivers	Men in other occupation group	Age and all cardiovascular risk factors	Air pollution	1.2 (0.6–2.1)
Bigert, 2003 (13)	Professional bus drivers	General population	Socioeconomic status, tobacco smoking, alcohol drinking, physical inactivity, overweight status, diabetes and hypertension	Motor exhaust	2.41 (1.15–5.06)
Bigert, 2003 (14)	Professional taxi drivers	General population	Socioeconomic status, tobacco smoking, alcohol drinking, physical inactivity, overweight status, diabetes and hypertension	Motor exhaust	1.64 (0.84–3.31)
Bigert, 2003 (14)	Professional truck drivers	General population	Socioeconomic status, tobacco smoking, alcohol drinking, physical inactivity, overweight status, diabetes and hypertension	Motor exhaust	1.32 (0.86–2.03)
Ilar, 2014 (21)	Professional drivers, garage workers, construction machine operators	General population	Sex, age, year of enrollment, diabetes, physical inactivity, smoking, hypertension, alcohol drinking and overweight	Motor exhaust	1.21 (0.91–1.59)

Despite these limitations, the collective results from many studies show a positive association between the occupational exposure to air pollution, especially to motor exhaust, and the incidence of ischemic heart disease. No occupational studies about ischemic cardiovascular disease and air pollution were found between the years 2015–2016. Future studies should therefore attempt to overcome the limitations described above. Furthermore, in order to overcome the healthy worker effect, in future studies the authors hope to make a comparison with relatively healthy people selected from among the general population.

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