META-ANALYSIS: CARDIOVASCULAR EFFECTS IN WORKERS OCCUPATIONALLY EXPOSED TO URBAN POLLUTION

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Key words: cardiovascular system, cardiovascular diseases, urban pollution

Parole chiave: sistema cardiovascolare, malattie cardiache, inquinamento urbano
Abstract

**Background:** Many studies showed a connection between exposition to high levels of urban pollution (especially to particulate and traffic noise) and the onset of even deadly cardiovascular diseases.

**DESIGN:** Meta-analysis of case-control design.

**Objectives:** The aim of this study is to estimate the association between cardiovascular effects and occupational exposition to atmospheric pollution in urban environment.

**Methods:** DATA SOURCES: Biomedcentral, MEDLINE/ PubMed, MEDLINE/ National Library of Medicine (NLM), MEDLINE Plus, Nioshtic-2, Scopus, TOXNET/Toxline, unpublished studies known by the authors and acts of national and international conferences between 1988 and May 2010 included. There has not been any kind of language or typological restriction.

**CRITERIA OF ELEGIBILITY:** The research on cardiovascular effects includes control cases of workers exposed to urban pollution, compared with non-exposed subjects.

**PARTICIPANTS AND INTERVENTIONS:** The selected studies present outdoor workers exposed to urban pollution (drivers and petrol pump attendants) and a control group of indoor workers (managers, university students and other selected subjects).

**STUDY APPRAISAL AND SYNTHESIS METHODS:** The evidences (independently token from two different authors) have been grouped in two classes, the first one formed by continuous variables (systolic blood pressure, diastolic blood pressure, heart rate, total cholesterol, HDL cholesterol, LDL cholesterol, triglycerides) and the second one by discontinuous variables (electrocardiographic abnormalities prevalence, hypertension prevalence, hypercholesterolemia prevalence).

The studies related to both classes and presenting more than one variable for each class have been included and used, in order to elaborate the results. We calculated heterogeneity in each variable (ES calculation for continuous variables and OR calculation for discontinuous variables).

**Results:** On 378 publications, we have selected and included 16 articles. The variables show statistically irrelevant differences between exposed group and control group, except regarding the triglycerides. Limitations. The controlled studies are limited and characterized by a non-homogeneous evaluation of both expositional times of workers to urban pollution and of professional expositional values.

**Conclusions:** Considering the heterogeneity and the lack of studies, it is impossible at the moment to document effects on the cardiovascular system in workers exposed to urban pollution. The results of this meta-analysis only suggest the association of urban pollution with alteration of triglycerides blood levels (referring to just three studies). As reported in scientific literature on this subject, it is necessary to conduct a future professional investigation on this subject with more qualified and homogeneous studies.

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**Introduzione:** Numerosi studi hanno dimostrato un’associazione tra esposizione ad elevati livelli di inquinamento urbano (nella fattispecie l’esposizione al particolato sia a breve che a lungo termine e il rumore da traffico veicolare) e insorgenza nonché mortalità per patologie cardiovascolari.

**DESIGN:** meta-analysis of case-control design.
**Obiettivi:** Valutare l’associazione esistente tra effetti cardiovascolari ed esposizione occupazionale ad inquinamento atmosferico in ambiente urbano.


STUDY ELIGIBILITY CRITERIA: sono stati inclusi gli studi caso-controllo in cui i lavoratori esposti ad inquinamento urbano sono stati comparati con quelli non esposti in relazione agli effetti sull’apparato cardiovascolare.

PARTICIPANTS, AND INTERVENTIONS: sono stati selezionati gli studi in cui la popolazione degli esposti all’inquinamento urbano era costituita da addetti ad attività in ambiente outdoor, viabilisti, benzinarai ed autisti professionisti mentre il gruppo dei controlli era rappresentato da addetti ad attività indoor, amministrativi, studenti universitari e soggetti selezionati tra la popolazione generale.

STUDY APPRAISAL AND SYNTHESIS METHODS: i dati, estratti da due autori diversi in modo indipendente, sono stati raggruppati in due classi di variabili, la prima costituita da variabili continue (pressione arteriosa sistolica, pressione arteriosa diastolica, frequenza cardiaca, colesterolo totale, colesterolo HDL, colesterolo LDL, trigliceridi) e la seconda da variabili discontinue (alterazioni elettrocardiografiche, ipertensione, ipercolesterolemia, ipertrigliceridemia). Gli studi che riportavano i dati relativi ad entrambe le classi e per ciascuna classe più variabili sono stati inseriti e quindi utilizzati più volte per l’elaborazione dei risultati. Per ciascuna variabile è stata calcolata l’eterogeneità, per le variabili continue è stato effettuato il calcolo dell’ES mentre per le variabili discontinue è stato effettuato il calcolo dell’OR e della sua significatività.

**Risultati:** Su un totale di 378 pubblicazioni, sono stati selezionati ed inclusi nella meta-analisi 16 articoli. Le variabili studiate non mostrano differenze statisticamente significative nel gruppo degli esposti rispetto ai controlli tranne che per i trigliceridi.

LIMITATIONS: gli studi controllati risultano essere limitati e sono caratterizzati da una non omogenea valutazione sia dei tempi di esposizione dei lavoratori all’inquinamento urbano sia dei valori di esposizione professionale.

**Conclusioni:** Considerata l’eterogeneità e la scarsità degli studi, soprattutto per alcuni parametri, al momento non è possibile documentare, nei lavoratori professionalmente esposti all’inquinamento urbano, la presenza di effetti avversi sull’apparato cardiovascolare. Infatti l’analisi dei risultati ottenuti con la nostra meta-analisi suggerisce la sola associazione tra inquinamento urbano e alterazioni dei livelli ematici di trigliceridi, il risultato è inoltre relativo perché riferito a tre studi. A fronte di quanto riportato in materia dalla letteratura scientifica relativamente alla popolazione generale, è necessario che la ricerca futura approfondisca tale tematica in ambito professionale con studi condotti in maniera più idonea ed omogenea.

**Introduction**

Urban pollution is a considerable health problem all-over the world (1).

Many observational and experimental studies in general population found an association between urban pollution and mortality due to cardiovascular diseases, considering urban pollution a possible joint cause of their onset(2-7). Even if the process implying this connection is not yet fully explained, it is possible to recognize some risk factors, such as the exposition to chemical agents short-term (2,8-11) and long-term (2, 5, 12-15) exposition to particulate matter, lead, (16-21)cadmium (4), carbon monoxide(22) and to traffic noise (12-13,23-24). The aim of this meta-analysis is to conduct a systematic revision of the scientific evidence on cardiovascular effects in workers exposed to urban pollution (25).
The intention is to determine possible cardiovascular effects and especially modifications of risk factors (as blood pressure, heart rate, lipid blood levels) of urban pollution on workers.

Methods
The study has been conducted and reported as in the MOOSE Consensus Statement (26). We did a systematic research of observational studies (control-cases from January 1988 to May 2010) reporting cardiovascular effects in exposed (cases) and non-exposed (control) subjects to urban pollution. We also considered known but not yet published data and acts of national and international conferences. A further examination of the bibliography in previously published articles, reviews and meta-analysis on this subject has been conducted, in order to find other useful publications. There has not been any kind of language or typological restriction to the research. The utilizable works have been identified with a systematic research on the following on-line search engines: Biomedcentral, MEDLINE/ PubMed, MEDLINE/ National Library of Medicine (NLM), MEDLINE Plus, Nioshtic-2, Scopus, TOXNET/Toxline.

The research has been conducted introducing the following keywords, combined with "Boolean Operators":

- police workers (or police officers or traffic police or traffic wardens) AND cardiac function, cardiovascular function, heart disease, cardiac diseases, cardiovascular diseases, cardiac system, cardiovascular system, blood pressure, heart rate, electrocardiogram, electrocardiography, hypertension;
- mail carriers (or postal workers) AND cardiac function, cardiovascular function, heart disease, cardiac diseases, cardiovascular diseases, cardiac system, cardiovascular system, blood pressure, heart rate, electrocardiogram, electrocardiography, hypertension;
- street vendors (or shop vendors) AND cardiac function, cardiovascular function, heart disease, cardiac diseases, cardiovascular diseases, cardiac system, cardiovascular system, blood pressure, heart rate, electrocardiogram, electrocardiography, hypertension;
- bus drivers AND cardiac function, cardiovascular function, heart disease, cardiac diseases, cardiovascular diseases, cardiac system, cardiovascular system, blood pressure, heart rate, electrocardiogram, electrocardiography, hypertension;
- taxi drivers AND cardiac function, cardiovascular function, heart disease, cardiac diseases, cardiovascular diseases, cardiac system, cardiovascular system, blood pressure, heart rate, electrocardiogram, electrocardiography, hypertension;
- filling station attendants (or petrol station attendants or gas station attendants or gasoline station attendants) AND cardiac function, cardiovascular function, heart disease, cardiac diseases, cardiovascular diseases, cardiac system, cardiovascular system, blood pressure, heart rate, electrocardiogram, electrocardiography, hypertension;
- road sweepers (or street sweepers or road cleaners or street cleaners) AND cardiac function, cardiovascular function, heart disease, cardiac diseases, cardiovascular diseases, cardiac system, cardiovascular system, blood pressure, heart rate, electrocardiogram, electrocardiography, hypertension.

Selection process and Data abstraction
Two reviewers independently evaluated title, abstract and keywords in each resulting study and applied criteria of exclusion and inclusion. The same procedure was applied to full texts and used for the choice of the relevant data, in order to increase the reliability of the study. We included control-case studies dealing with both outdoor workers (cases – as local policemen and professional drivers) and indoor workers (controls – as administrative local agents, employees, university students and other selected subjects). Firemen and street maintenance staff were excluded, considering that their exposition to urban pollution is occasional and added to other harmful specific pollutions that can have effects on the cardiovascular system. We only considered the research in which the connection between urban pollution and cardiovascular effects had been studied according to at least one of the following variables: systolic blood pressure (SBP) and diastolic blood pressure (DBP) or hypertension prevalence, heart rate (HR), electrocardiographic abnormalities (ECGA).
We also considered blood lipids levels as total cholesterol (TCHO), LDL cholesterol (LDL) and HDL cholesterol (HDL), triglycerides (TRY) or prevalence hypertriglyceridemia or hypercholesterolemia, considering their importance in cardiovascular pathologies. All the articles not concerning our aim were excluded (articles not specifically dealing with the above-mentioned tasks, not based on the control-case system and with incomplete or lacking data).

**Data analysis**

The Effects Size (ES), reflecting the strength of the relationship between two variables, was performed by Standardized Mean Difference (SMD) or Weighted Mean Difference (WMD), at the presence of heterogeneity, when the data were expressed in the media and Standard Deviation, for continuous variables (Class I). While it was expressed by Odds Ratio (OR) when the data were expressed as frequency, for the discontinuous variables (Class II). For measures of ES based on the Odd Ratio (OR), a ratio of 1.0 indicates the lack of differences among the studied groups. The heterogeneity among the used data, referring to the variability or differences among studies in estimating the effect, was assessed with the Index of Inconsistency ($I^2$). Using $I^2$ we calculated the percentage of variance due to heterogeneity rather than the real case. If the value of $I^2$ was close to zero the observed variance was due to chance, if it was higher the variance was due to several factors that need to be investigated. The calculation of ES was made using the Random Effects Model (REM) for high values of $I^2$ and the Fixed Effects Model (FEM) for $I^2$ values close to zero (40).

**Results**

With the application of this criteria, we chose 378 publications. All the articles not inherent with our research were excluded. We examined the full texts of 80 potentially acceptable articles and 16 of them (reported on table 1) respected the criteria for inclusion. All the subjects (7714 workers) were divided into two groups, the exposed (EX – 3699 outdoor workers) and the control group (C – 4015 indoor workers).

**Table 1 - Characteristics of included studies**

<table>
<thead>
<tr>
<th>Study</th>
<th>Country</th>
<th>Participants</th>
<th>Study design</th>
<th>Outcomes</th>
<th>Method</th>
<th>Main results</th>
<th>Evaluated Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biava 1992 [27]</td>
<td>Italy</td>
<td>292 traffic policemen / 60 hospital employees used as control group</td>
<td>Cross-sectional study</td>
<td>The effects caused by exposition to urban pollutants (chemical matters, IPA, benzene, asbestos, lead, monoxide).</td>
<td>Objective examination Spirometry Electrocardiogram Neurological visit Determination of motor conduction's velocity of median nerve Psychological questionnaire Blood lead levels Blood carboxyhemoglobin levels Chemistry exam (blood test)</td>
<td>There is a statistically significant difference between exposed group and control group about musculo-skeletal disorders and about blood lead level.</td>
<td>Cardiac disorders EX Male 2/179 (1.2), EX Female 0/113 (-) C Male: 1/36 (2.7), C Female 1/24 (4.1)</td>
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<tr>
<td>Bigert 2003 [28]</td>
<td>Swedish</td>
<td>106 professional drivers / 1482 control group selected from general population</td>
<td>Observation study</td>
<td>Heart attack risk in professional drivers (bus, taxi and truck drivers)</td>
<td>Valuation of heart attack risk factors: • smoke cigarette’s habit • alcohol’s consumption • physical exercise during spare time • overweight • diabetes mellitus</td>
<td>Results of this study show that Odds Ratio for heart attack in bus drivers is 2.14 (IC 95% 1.34-3.41), in taxi drivers heart attack is 1.88 (IC 95% 1.19-2.98) and in truck drivers heart attack is 1.66 (IC 95% 1.22-2.26)</td>
<td>Prevalence hypertension EX 30/106 C 23/1482</td>
</tr>
<tr>
<td>Study (Year)</td>
<td>Country</td>
<td>Sample Size</td>
<td>Study Design</td>
<td>Exposure/Sample</td>
<td>Outcome Measures</td>
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<tr>
<td>Cervone 1993</td>
<td>Italy</td>
<td>28 men traffic policemen / 14 control group selected from general population</td>
<td>Observation study</td>
<td>Effects of exposure to urban pollution on health and the activation of immune system in traffic policemen</td>
<td>Anamnestic questionnaire, Blood pressure, Chemistry exams (blood test), Urinary lead levels, Lymphocyte subpopulations' study. Urinary lead values are significantly increased in exposed group compared to control group (p&lt;0.01).</td>
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<tr>
<td>Hedberg 1993</td>
<td>Sweden</td>
<td>440 men professional drivers / 1000 men subjects control group</td>
<td>Observation study</td>
<td>Risk factors of cardiovascular disease in professional drivers.</td>
<td>Anamnestic questionnaire, Objective examination, Blood pressure, Chemistry exams (blood test). Results of this study show that Odds Ratio (OR) for cardiovascular risk in professional drivers is 3.18 (IC 95% 2.41-4.20) compared to control group.</td>
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<tr>
<td>Mormonto y 2006</td>
<td>Peru</td>
<td>52 traffic policemen / 50 police officers employed in indoor activity</td>
<td>Cross-sectional study</td>
<td>Blood lead levels and the effects of exposure to vehicular traffic on cardiovascular system</td>
<td>Anamnestic questionnaire, Blood pressure, Chemistry exams (blood test), Blood lead levels. Blood lead levels are statistically increased in exposed group compared to control group.</td>
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<tr>
<td>Pala 2002</td>
<td>Turkey</td>
<td>78 traffic policemen / 21 police officers employed in indoor activity</td>
<td>Observation study</td>
<td>Blood lead levels and the effects of exposure to vehicular traffic on cardiovascular system</td>
<td>Anamnestic questionnaire, Blood pressure, Chemistry exams (blood test), Blood lead levels. Results of this study show that there is not a statistically significant difference between exposed group and control group about blood pressure and blood lead levels.</td>
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<tr>
<td>Sakata 2007</td>
<td>Nepal</td>
<td>27 men taxi drivers / 9 men university students and farmhands</td>
<td>Observation study</td>
<td>The dose-response relationship between blood lead levels and erythropoietin serum concentration in taxi drivers exposed to lead of vehicular emission.</td>
<td>Blood pressure, Chemistry exams (blood test), Heart rate, Erythropoietin serum levels, Urine analysis. Erythropoietin serum levels are significantly reduced in exposed group compared to control group. Blood lead levels are increased in exposed group compared to control group.</td>
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<tr>
<td>Sancini 2010</td>
<td>Italy</td>
<td>115 traffic policemen / 115 police officers employed in indoor activity smokers 280 traffic policemen</td>
<td>Observation study</td>
<td>Blood pressure changes and electocardiographic abnormalities in traffic policemen exposed to urban pollution</td>
<td>Anamnestic questionnaire, Objective examination, Blood pressure, Electrocardiogram. Blood systolic pressure average value at rest and electocardiographic abnormalities/frequency is statistically increased in non smoker male subjects of exposed group.</td>
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</tbody>
</table>

**Meta-analysis: cardiovascular effects in workers occupationally exposed to urban pollution**
<table>
<thead>
<tr>
<th>Study</th>
<th>Country</th>
<th>Subjects</th>
<th>Methodology</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sardelli 1995 [35]</td>
<td>Italy</td>
<td>120 traffic policemen / 30 administrative workers</td>
<td>Observation study</td>
<td>Health effects of exposure to urban pollution and noise in traffic policemen. Blood pressure, Cardiology visit, Electrocardiogram, Otorhinolaryngology visit, Chest radiography, Audiology, Chemistry exams, Pneumotacograph. Blood cholesterol levels are significantly increased in exposed group compared to control group. Spirometry shows that obstructive diseases are increased in exposed group compared to control group and that mild hypertension is increased in exposed group more than control group. EX: prevalence hypercholesterolemia 80/120. Prevalence Hypertension moderate: N. 14. ECG Abnormalities prevalence: N. 28. C: prevalence hypercholesterolemia 8/30. Prevalence Hypertension moderate: N. 2. ECG Abnormalities prevalence: N. 8.</td>
</tr>
<tr>
<td>Tomao 2002[14]</td>
<td>Italy</td>
<td>118 men traffic policemen / 118 police officers employed in indoor activity</td>
<td>Observation study</td>
<td>Lipid metabolism in traffic policemen exposed to urban pollution. Anamnestic questionnaire, Objective examination, Blood cholesterol values are significantly reduced in exposed group compared to control group, instead triglycerides average values are significantly increased in exposed group compared to control group. EX: CHOL TOT 208.2 (46.4), HDL 29.9 (7.2), TRY 173.8 (168.9). C: CHOL TOT 202.6 (36.8), HDL 55.3 (9.9), TRY 138.1 (88.7).</td>
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<tr>
<td>Tomei 2004[12]</td>
<td>Italy</td>
<td>77 non smokers traffic policemen / 87 non smokers police officers</td>
<td>Observation study</td>
<td>Blood pressure changes in traffic policemen exposed to urban pollution through. Anamnestic questionnaire, Objective examination, Chemistry exams (blood test), Blood pressure Monitoring of. Blood systolic pressure average value monitored during 24 hours is statistically increased in non smoker male subjects of exposed group compared to men smokers of exposed group. ECG abnormalities prevalence: 4 (5.4). C Female: CHOL TOT m 225.8 (55.2), CHOL TOT f 188.6 (40.7), CHOL HDL m 43.4 (5.8), CHOL HDL f 188.6 (40.7).</td>
</tr>
<tr>
<td>Study</td>
<td>Country</td>
<td>Number of subjects</td>
<td>Methods</td>
<td>Results</td>
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<tr>
<td>Volpino 2004</td>
<td>Italy</td>
<td>68 men traffic policemen / 62 police officers employed in indoor activity</td>
<td>Observation study</td>
<td>The effects of exposure to urban pollution on cardiovascular and respiratory systems in traffic policemen. Anamnestic questionnaire, Objective examination, Chemistry exams, Blood pressure, Heart rate, Respiratory frequency, Electrocardiogram. Diastolic pressure average values during rest period are statistically increased in exposed group compared to control group. EX: Prevalence Hypertension 16/68, SBP 130 (12.6), DBP 85.7 (8.5), C: Prevalence Hypertension 16/62, SBP 127 (8.4), DBP 81.9 (6.8).</td>
</tr>
<tr>
<td>Zefferino 2003</td>
<td>Italy</td>
<td>30 traffic policemen, studied during a working day / 30 traffic policemen studied during a day off.</td>
<td>Observation study</td>
<td>The effects of exposure to urban pollution on heart rate in policemen employed in emergency care. Anamnestique questionnaire, Objective examination, PSS test (Professional Stress Scale Test), Cortisol salivary levels, Salivary IL-1B levels, Electrocardiogram, Study of heart rate variability. Cortisol levels are significantly higher at the beginning of work shift than at the end. In the morning during holiday, average cortisol concentration is statistically decreased compared to cortisol concentration in the afternoon. T test shows statistically significant difference between average cortisol levels at the same time. EX HR during work 78.53 (10.47), C: HR during holiday 74.46 (8.84).</td>
</tr>
</tbody>
</table>
We grouped the studies according to the nature of each investigated variable and identified two classes of variables: continuous variables (systolic blood pressure, diastolic blood pressure, heart rate, total cholesterol, HDL cholesterol, LDL cholesterol, triglycerides) and discontinuous variables (electrocardiographic abnormalities prevalence, hypertension prevalence, hypercholesterolemia prevalence).
Even if at first we identified a prevalence of hypertriglyceridemia, we did not conduct statistical analysis on it, because it was treated in one work only. The studies that reported data for both classes and several variables for each class were entered and processed more than once for the elaboration of results. Evaluating the parameters for Class I, we included a total of 3774 workers divided into two groups: 2037 subjects in the exposed group (EX) and 1737 subjects in the control group (C). In the assessment of parameters related to discontinuous variables we included a total of 11737 workers: 6978 EX and 4759 C. Table 2-3 summarise the results of studies.

Results of Continuous variables: Class I
Systolic and diastolic blood pressure, evaluated in eight studies (12,13,29,31,32,33,34,38), and heart rate, in two studies (33,37), show no statistically significant differences in the exposed compared to controls. The studies were heterogeneous between them.

For the lipid parameters, total cholesterol (measured in four studies (12,14,29,33), and LDL cholesterol, measured in one study (12) show no statistically significant differences and are characterized by a low index of heterogeneity. HDL cholesterol (measured in three studies, (12,14,33) shows no statistically significant differences, but is characterized by a high level of heterogeneity. Regarding triglycerides, measured in three studies (12,14,29), there is a statistically significant difference in the exposed compared to controls, with a low index of heterogeneity.

Table 2 - The results of Class I (continuous variables)

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>NUMBER OF SUBJECTS</th>
<th>P</th>
<th>I² %</th>
<th>Meta-analysis index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systolic blood pressure</td>
<td>EX: 518 C: 417</td>
<td>P 0.239</td>
<td>37.4</td>
<td>SMD 0.093 [-0.062; 0.247]</td>
</tr>
<tr>
<td>Diastolic blood pressure</td>
<td>EX: 518 C: 417</td>
<td>P 0.126</td>
<td>47.8</td>
<td>SMD 0.121 [-0.34; 0.275]</td>
</tr>
<tr>
<td>Heart rate</td>
<td>EX: 57 C: 39</td>
<td>P 0.126</td>
<td>47.8</td>
<td>WMD 0.121 [-0.34; 0.275]</td>
</tr>
<tr>
<td>Total cholesterol</td>
<td>EX: 293 C: 257</td>
<td>P 0.358</td>
<td>0.00</td>
<td>WMD 0.094 [-0.106; 0.295]</td>
</tr>
<tr>
<td>HDL cholesterol</td>
<td>EX: 265 C: 243</td>
<td>P 0.43</td>
<td>98.4</td>
<td>SMD 0.897 [-3.171; 1.37]</td>
</tr>
<tr>
<td>LDL cholesterol</td>
<td>EX: 120 C: 116</td>
<td>P 0.87</td>
<td>0.00</td>
<td>WMD 0.054 [-0.485; 0.378]</td>
</tr>
<tr>
<td>Triglyceridae</td>
<td>EX: 266 C: 248</td>
<td>P 0.009</td>
<td>0.00</td>
<td>WMD 0.280 [0.070; 0.489]</td>
</tr>
</tbody>
</table>

EX = Experimental Group  
C = Control Group  
P: = Probability  
I² = Heterogeneity Index  
SMD = Standardized Mean Difference  
WMD = Weighted Mean Difference
Results of Not-continuous variables: Class II

Prevalence of electrocardiographic abnormalities, evaluated in five studies (12,27,35,36,39) took twice and the prevalence of hypertension (assessed in two studies (35,36), do not give statistically significant differences in the exposed compared to controls, with a high degree of heterogeneity.

Regarding the data on the prevalence of hypercholesterolemia (evaluated in two studies (35,36), there are not statistically significant differences in the exposed compared to controls, with a high degree of heterogeneity.

Table 3 - The results of Class II (not-continuous variables)

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>NUMBER OF SUBJECTS</th>
<th>P</th>
<th>I²%</th>
<th>Meta-analysis index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrocardiographic alterations</td>
<td>EX: 2602 C: 1083</td>
<td>P 0.702</td>
<td>73.0</td>
<td>OR = 1.165 [0.53; 2.55]</td>
</tr>
<tr>
<td>Hypertension</td>
<td>EX: 2495 C: 3110</td>
<td>P 0.169</td>
<td>86.3</td>
<td>OR = 1.39 [0.86; 2.33]</td>
</tr>
<tr>
<td>Hypercholesterolemia</td>
<td>EX: 1881 C: 566</td>
<td>P 0.37</td>
<td>87.6</td>
<td>OR = 1.73 [0.51; 5.86]</td>
</tr>
</tbody>
</table>

EX = Experimental Group
C = Control Group
n.s. = not significant
P = Probability
I² = Heterogeneity Index
ES = Effect Size
OR = Odd ratio

Conclusions

Many studies in the general population show the association between exposure to urban pollution and cardiovascular effects, such as hypertension (41), ischemic heart disease, arrhythmias, heart failure, stroke and sudden death (3), probably for alterations of the cardiac autonomic and myocardial perfusion and electrical instability (3, 5, 42, 43). In addition, airborne particulates, according to the theory of Twickler et al (44), conveyed by the lipids, would be able to infiltrate the vessel intima by promoting the formation of atherosclerotic plaques. Hence the importance of early assessment in subjects exposed to any load changes in heart rate, blood pressure, lipid blood levels and electrocardiogram.

The meta-analysis shows that the association between occupational exposure to urban air pollution and cardiovascular effects gives statistically significant values in outdoor workers only for the blood levels of triglycerides. This value is however relative, as reported in only three studies (12,14,29).

The result is confirmed by the work of Wang, that was not included in the meta-analysis because it is a single work. The study, conducted on a large number of subjects, reports a statistically significant difference in the prevalence of hypertriglyceridemia between bus drivers and skilled workers.

We found the same limitation of controlled studies also in the evaluation of other examined variables. Reviewed studies are heterogeneous, as to the outcomes. Among 16 studies of our meta-analysis, only five focused on the association between urban pollution and effects on the cardiovascular system (12,13,30,31,34). One of the remaining studies (36), (analyzing the incidence of coronary heart disease in professional drivers) identified among
the potential risk factors both urban pollution and specific work factors. Four studies assessed the effects of urban pollution on health, including the cardiovascular system (27,29,35,39).

One study (14) investigated the effects of urban pollution on the lipidic asset; this alteration is a known cardiovascular risk factor. In their work, Pala and Sakata (32,33), evaluated blood lead levels respectively in policemen and taxi drivers; the first incorporated blood pressure within the parameters of the assessment. The second incorporated heart rate and the lipidic asset.

In conclusion, three more studies (28,37), dealing with subjects professionally exposed to urban pollution, attributed the cardiovascular effects in outdoor workers to stress.

Even in literature it comes out stress is higher in workers exposed to urban pollution (45-48).

A non-uniform assessment of both time of exposure to pollution of urban workers, sometimes not even mentioned, and of values of occupational exposure (environmental monitoring and / or organic) is a further problem. With the exception of Sardelli and Zhang who quoted environmental measures [Sardelli P et al., 1995; Zhang W et al.,1994]) and Volpino, Tomei and Sancini who evaluated biological indicators (Sancini A et al., 2010; Tomei F at al., 2004, Volpino P et al., 2004), other authors recruited subjects only considering their work task, simply monitoring the exposure on the base of questionnaires or assuming Mormontoy (Mormontoy W et al., 2006) that traffic police officers are exposed to pollution from vehicular traffic.

Therefore, considering data from the scientific literature, related to the general population, which impute adverse cardiovascular effects to urban pollution and given the data emerging from our meta-analysis on population occupationally exposed, we believe it very important to carry on research occupationally exposed groups. To increase the reliability of the parameters relating to the effects of urban pollution on the cardiovascular system, studies should pay particular attention to procedures ascertaining level and type of pollutants, duration and terms of exposure, age of the subjects evaluated, type of job and presence of other environmental stressors, as well as personal ones, that can affect cardiovascular function, such as smoking, incorrect eating habits and excess fat mass (49).

References
Articles marked with an asterisk are those used for the meta-analysis


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