



## Low-cost sensors for determining the impact of air quality components in workers' health: protocol for a systematic review

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### Abstract

Due to the disproportionate growth of the population, human needs have been changing drastically, thus breaking their expected balance with nature. The demand for new technology in the industry contributes to a decrease of the air quality, affecting the quality of life and the variation in Earth's climate system. This has a serious impact on both people's health and national economies because of the increase of absenteeism and mortality rates of workers caused by diseases related to exposure to high amounts of pollutants. The increased tourism in coastal areas requires the efficient attendance of these needs as there is nowadays a great variety of activities that emit atmospheric pollutants in those areas (grills, recreational activities, transportation). A systematic review is proposed to identify the methods used in the monitoring and control of the amounts of outdoor air pollutants, specifically CO<sub>2</sub> and PM<sub>2.5</sub>, to determine the relationship between workers' exposure to the bad air quality in coastal areas during their working days and respiratory and cardiovascular diseases, that would allow creating programs and actions to reduce these negative effects. As a result, this systematic review protocol aims to define the criteria to develop research able to fulfill this purpose. It is based in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols (PRISMA-P) Statement.

## 1. INTRODUCTION

### 1.1. Background

Air pollution is one of the most dangerous problems affecting the environment. Due to the excessive growth of the populations, the needs of the human being have been changing drastically, thus breaking his expected balance with nature. The industrialization and demand for new technologies imply the implementation of processes that require more energy, and the use of this energy in an unsustainable way contribute to the decrease of air quality, which affects the quality of life of the people, the condition of ecosystems and the state of the Earth's climate system (Bernard, Samet, Grambsch, Ebi, & Romieu, 2001).

Air pollution is the emission into the air of dangerous substances at a rate that exceeds the capacity of natural processes in the atmosphere to transform them, precipitate them (rain or snow), and deposit or dilute them by wind and air movement (Yassi A, 2002).

According to Cannistraro the main pollutant emissions of the present day are produced by combustion products that are generated in the production of energy, air conditioning of the environment and by the transport sector (Cannistraro, Ponterio, & Cao, 2018). The pollution produced by man (pollution of anthropogenic origin) is emitted mainly from large fixed sources (industries, production plants of electricity and incinerators); small fixed sources (domestic heating systems) and mobile sources (road traffic). Most environmental chemical pollutants produce harmful effects depending on their concentration, so it is necessary to identify their existence and control their levels to prevent those negative consequences. (Amable Álvarez *et al.*, 2017).

According to the World Health Organization the main air pollutants are: Particulate matter (PM), Carbon dioxide (CO<sub>2</sub>), Ozone (O<sub>3</sub>), Nitrogen dioxide (NO<sub>2</sub>) and Dioxide Sulfur (SO<sub>2</sub>) (WHO, 2005). Around the world, there are numerous studies that consider the exposure of human beings in their daily activities to these contaminants to determine the consequences to their health and quality of life. These studies have shown that air pollution is a major risk factor for human health and, in particular, is related to respiratory and cardiovascular problems (Ghorani-Azam, Riahi-Zanjani, & Balali-Mood, 2016; Monteiro *et al.*, 2015; Norbäck *et al.*, 2019; Schulte *et al.*, 2016). Contaminants present in the air can cause health effects both in the short and long term, and the health impact related to exposure varies for each type of pollutant (Sanyal, Rochereau, Maesano, Com-Ruelle, & Annesi-Maesano, 2018).

Referring to a report from the World Bank, air pollution is the fourth mortal health risk in the world (World Bank, 2016). This institution estimates that the 5.5 million premature deaths associated with air pollution in 2013 led to a loss of 225 billion in revenue. These costs only consider the loss of income due to premature deaths, but air pollution also reduces worked hours and productivity as a result of the loss of working days, which the Organization for Economic Co-operation and Development (OECD) in 2012 estimates at 1.2 billion of dollars. Therefore, the environment and the world of work are closely linked. Environmental degradation can, in the long term, impact jobs through two channels. On the one hand, it can deteriorate ecosystem infrastructure and capacity to provide services (i.e., ecosystem services), affecting many jobs continuity. On the other hand, environmental degradation has a direct impact on people's health (Montt, 2018).

With all the above, it can be stated that the issue has a serious impact on people's health and the economy of the countries because of workers' present absenteeism or death from diseases caused by exposure to contaminants in amounts higher than the permissible limits. In response to these problems, many countries nowadays have a growing need to create projects and actions aimed at monitoring and reducing air pollution levels. Also, a series of air quality programs have been implemented (Laumbach, Meng, & Kipen, 2015). WHO recommends acceptable levels of air pollutants and includes policies on its agenda to encourage countries to control pollution. (WHO, 2005)

However, the compilation of data for the creation of actions and programs has been done mainly in industrial zones or cities centers, and there are few studies focused on coastal areas, where there is currently a large concentration of mainly commercial activities which generate and enhance environmental pollution (Bei *et al.*, 2018; Scerri *et al.*, 2018).

Traditionally, for the analysis of air quality, stationary, costly, complex stations operated by highly skilled workers, are utilized. The results obtained by these professional teams refer to their surrounding areas, excluding the most remote areas, for which the data are obtained by modeling based on the results retrieved from stationary spots (Rogulski, 2018).

Low-cost, portable and self-contained sensors have the potential for taking equivalent measures, while more effectively capturing spatial variability and personal exposure (Piedrahita *et al.*, 2014).

## 1.2. Objectives

This protocol is proposed to identify the methods used in the monitoring and control of the amounts of outdoor air pollutants, specifically CO<sub>2</sub> and PM<sub>2.5</sub>, to determine the relationship between workers' exposure to the bad quality air in coastal areas during their working days and respiratory and cardiovascular diseases, that would allow creating programs and actions to reduce these negative effects.

As a result, the following specific goals will be pursued:

1. To determine the methods used to monitor and measure the amounts of CO<sub>2</sub> and PM<sub>2.5</sub> outdoors.
2. To identify low-cost CO<sub>2</sub> and PM<sub>2.5</sub> sensors.
3. To select low-cost sensors that can be used in an outdoor environment and are able to resist to conditions of humidity and wind.
4. To determine the relationship between the workers' exposure to these pollutants in equal to or greater amounts than the permissible and the potential occurrence of respiratory and cardiovascular diseases.

5. To gather conclusions in terms of potential actions to prevent exposure to these air pollutants.

## 2. METHODS

### 2.1 Research Framework

This systematic review protocol is based on the guidelines outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols (PRISMA-P) Statement (Moher *et al.*, 2015; Shamseer *et al.*, 2015).

### 2.2 Eligibility criteria

#### *Type of studies*

Throughout this review, only published or in press journal articles with an experimental approach will be selected. Theoretical or review studies will be excluded.

Inclusion criteria were determined as follows:

- The study must include the application of atmospheric low-cost sensors in outdoors settings.
- Only articles published within the last five years will be considered.
- Only articles written in English will be selected.

#### *Context*

Any publication using low-cost atmospheric sensors to measure outdoors air pollutants, prioritizing those sensors found to be resistant to environmental conditions such as extreme temperatures and wind. Primarily, investigations developed in field conditions will be selected.

#### *Type of participants*

The research will be focused on studies developed within workers who are extensively exposed to air conditions that are potentially affected by pollutant sources. It will include both female and male samples without any age restriction since the focus will be on the exposure levels of air pollutants during working shifts.

#### 2.2.1 Information sources

The research will be performed within four electronic databases: SCOPUS, Web of Science, Science Direct, and PubMed. It will be conducted on journal articles from 2015 to 2019 with the aim of compiling the up-to-date devices to monitor and control the air pollutants.

Furthermore, this study will also look through the reference lists of the collected articles to search for additional records found to be relevant for the goals of the review. The procedure will be repeated until no more relevant outcomes are obtained.

#### 2.2.2 Search strategy

Keywords selected to conduct this review, will be combined as follows:

*((Contamination AND CO2) OR ("carbon dioxide")) AND (("air pollution" AND "health workers")) AND (("coastal zones" AND pollution AND air)) AND ((coast AND zones AND pm2,5)) AND ((quality AND air AND CO2 AND pm2,5)) AND (("air quality" AND diseases AND workers)) AND (("air pollution sensors" AND health)) AND (("electronic sensors" AND pollution AND air)).*

The query will be adapted to the different databases engine specifications applying the aforementioned eligibility criterions: published or in press journal articles, published within the last five years and written in English.

Later, on a second phase, while the selected articles are analyzed, potential new keywords will be identified, and a new search will be performed. Correspondingly, references will also be

consulted in order to identify older articles that could provide complementary information. This procedure will be repeated in the newly found records until no more relevant results are obtained.

Furthermore, other studies from the authors of the primary articles included in the review will be accessed in order to find related investigations that fulfill the inclusion criteria.

### 2.2.3 Study records

#### *Data management*

After completing the search, and the number of identified articles is recorded in Table 1 (Annex 1), selected investigations from each of the four databases will be exported (and when necessary will be added manually) for screening and eliminating duplicated records.

Additional literature sources, such as the references identified in the first articles, will also be added manually. At this point, both titles and abstracts will be examined. Then, the number of records from every filter stage will be registered to assure the reproducibility and traceability of the conducted review. Endnote will be the tool supporting data management.

#### *Selection process*

Two reviewers will separately search through selected databases and journals. After the combination of keywords is inserted, three phases of exclusion will take place:

1. Through search filters, the following criterions will be considered:
  - Date: Last five years, from 2015 to 2019
  - Type of articles: Articles and Articles in Press
  - Source type: Journals.
  - Language: English.
2. Duplicated articles will be removed.
3. Studies will be excluded if any of these two conditions is verified:
  - They pursue only climatological goals.
  - They apply only stationary and/or expensive equipment of measurement.

#### *Data collection process*

From the final selected publications, full-texts will be examined to extract information of interest. This information will mainly include:

- General study information: authors, year, and geographic area of application.
- Context: characteristics of the application of atmospheric low-cost sensors in field conditions.
- Study characteristics: applicability of atmospheric low-cost sensors for monitoring of CO<sub>2</sub> and PM, reliability of sensors measurements, conclusions on the consequences from the exposure to these air pollutants.

### 2.2.4 Data items

Summary tables will be elaborated with the topics referred in the above section:

Country, sample's age and gender, permissible air pollutants levels, objectives, potential health consequences, conclusions, and applied technologies.

### 2.2.5 Outcomes and prioritization

From this projected systematic review, the following primary outcomes are expected:

1. To identify the atmospheric sensors that prove to be the most reliable and suitable for monitoring outdoor air pollutants.

2. To determine the viability and applicability of the measurements.
3. To identify the potential health impairments caused by long exposure to CO<sub>2</sub> and PM<sub>2.5</sub>.
4. To retrieve the levels of exposure and compare them to the permissible standard levels.
5. To identify the most frequently assessed pollutants and if possible, to compare the related outcomes among studies.

#### **2.2.6 Risk of bias in individual studies**

The characteristics of each study will be identified and analyzed according to the objectives pursued by this review. The evaluated topics will include the applied methods, equipment, and technology, studied air pollutants, and duration of data collection.

Taking in consideration the Cochrane Collaboration's tool for assessing risk of bias, a series of questions arisen from the topics covered in this tool will be compiled, and each study will be evaluated through them. Answers will be ranged by 'yes', 'no' or 'unclear', this last one indicating that the information is not enough to determine the fulfillment of the criteria.

Studies presenting more positive answers to the established criteria will be the ones considered as the most suitable for the objectives of this review.

#### **2.2.7 Data Synthesis**

If retrieved data permits it, a meta-analysis will be performed. Otherwise, a narrative synthesis will be conducted with basis on assembled data tables (with information from the selected publications), in which the main objective will be to present the analyzed parameters, methods and derived conclusions.

The checklist from The Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) Statement is going to delimitate this process (Moher, Liberati, Tetzlaff, Altman, & The, 2009).

#### **2.2.8 Meta-bias (es)**

If obtained results permit it, a meta-bias will be performed later.

#### **2.2.9 Confidence in cumulative evidence**

This parameter is not applicable to this review.

### **AUTHORS' CONTRIBUTIONS**

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## **Annex 1**

