

Citizens and Air Quality: The Results of the First Survey Carried Out in the Po River Basin (Northern Italy)

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Abstract

The air quality survey investigated the level of perception and awareness of citizens on the air quality in the 42 cities (provincial capitals) of the Po basin in the north west of Italy. This study means that perceptions could then be compared between in the Po basin and other parts of Italy and Europe. This research was carried out as part of the Life15 IPE IT 013 PREPAIR Project (Po Regions Engaged to Policies of Air), which involves 18 national and international partners, and includes all the regions of the Po Basin. The survey involved around 7331 citizens that live in the Po basin that includes 42 cities (provincial capitals) and a total of 6.5 million inhabitants. A multivariate analysis was applied to identify the main citizens' profiles concerning the topic of air quality and the availability to implement virtuous behaviours to reduce air pollution. Four different profiles emerge from the cluster analysis: "Committed and proactive", "Willing but ...", "Hesitant", "Not willing".

Keywords

Perception, Air, Pollution, Quality Citizens

1. Introduction

Air pollution is a key environmental and social issue and, at the same time, it is a complex problem posing multiple challenges in terms of management and mitigation of harmful pollutants. Air pollutants are emitted from anthropogenic and natural sources; they may be either emitted directly (primary pollutants) or formed in the atmosphere (as secondary pollutants).

Air quality is a major concern for Europeans, and is an area where the EU has been particularly active for more than 30 years. The EU's key objective in relation to air quality is "to achieve levels of air quality that do not result in unacceptable impacts on, and risks to, human health and the environment". The EU has already in place a range of legislation and initiatives to improve air quality by controlling harmful emissions and implementing measures in the transport, industry and energy sectors to protect the environment. In addition, air pollution is one of the key issues included as part of the European Commission's proposal for a new Environment Action Programme (EAP) to 2020, "Living well, within the limits of our planet". A survey by European Commission demonstrates that 56% of Europeans think air quality has deteriorated in the last 10 years, and 16% say it has improved. Emissions from cars and trucks (96%) and emissions from industrial production and fossil fuel power stations (92%) are the most likely to be mentioned as having an impact.

Air quality policies have delivered, and continue to deliver, many improvements. Reduced emissions have improved air quality in Europe, and, for a number of pollutants, exceedances of European standards are rare. However, substantial challenges remain and considerable impacts on human health and on the environment persist. Despite the improvements, a large proportion of European populations and ecosystems are still exposed to air pollution that exceeds European standards and, especially, the World Health Organization (WHO) Air Quality Guidelines (AQGs).

Effective air quality policies require action and cooperation at global, European, national and local levels, which must reach across most economic sectors and engage the public. Holistic solutions must be found that involve technological development and structural and behavioural changes. The aim of the European project PREPAIR is promoting sustainable lifestyles, production and consumption, that is, capable of affecting emissions reduction. To do this, specific awareness-raising and dissemination actions are planned for public, private and local communities.

2. Background

Air pollution is a substantial problem that continues to threaten public health and contributes to climate change. Pollutants such as particulate matter with an aerodynamic diameter smaller than 2.5 μm (PM_{2.5}), nitrogen oxides (NO_x), and tropospheric ozone (O₃) continue to be a cause of cancer, respiratory and cardiovascular disease, and premature death (EEA, 2016). Poor air quality is detrimental to human health, with a number of studies finding short-term and long-term pulmonary and cardiovascular health effects of PM₁₀ and PM_{2.5} [1]. Two main pollutants are considered key indicators of ambient, or outdoor, air quality: fine particle pollution—airborne particulate matter measuring less than 2.5 micrometers in aerodynamic diameter, commonly referred to as PM_{2.5} and ground-level (tropospheric) ozone [2].

The Air quality report in 2017 demonstrated that air quality policies have delivered, and continue to deliver, many improvements. Reduced emissions have improved air quality in Europe, and, for a number of pollutants, exceedances of European standards are rare [3].

Air pollution also incurs major economic costs to the European Union, on the order of billions of Euros a year (EEA, 2016).

In developed countries, trends of urbanization and the associated growth of cities have started to reverse due to severe levels of congestion [4]. However, in developing countries, city's growth tends to be from periphery to core. The ambient air pollution levels at urban hot spots in 20 European cities have exceeded the urban background concentrations due to increase in traffic volume (Mousiopoulos *et al.*, 2005) [5]. In the UK, motorized road transport has been categorized as one of the largest single pollution sources in 92% of declared air quality management areas which accounts for 33% emissions of NO_x and 21% of PM₁₀, and so, frequently violating the national ambient air quality standards/objectives (Faulkner and Russell, 2010) [6]. However, in the recent past, it has been observed that in some mega cities of developed countries, urban air quality is showing signs of improvement on account of efficient implementation of UAQMP (NSW Government, 2010; EEA, 2011a; Parrish *et al.*, 2011; EEA, 2013a) [7] [8]. In the European Environment Agency (EEA) countries, the emission reduction from vehicular exhausts from 1990 to 2009 has been reported to be around 54% for SO₂, 27% for NO_x, 16% for PM₁₀ and 21% for PM_{2.5}. In spite of all these efforts in place, it has been observed that 18% to 49% of the population in these countries is still exposed to PM₁₀ concentrations exceeding the ambient standard [9] [10].

In the last two decades, a variety of studies have been conducted investigating the perceptions of air quality in cities all around the world. Sociodemographic factors such as age, gender, education, and health status have been found to be correlated with perceptions of air quality (Oltra & Sala, 2014) [11]. Guo *et al.* (2016) [12] found that, in their sample, those respondents over the age of 40, with a college-level education, living in an urban residential area, or with a child in poor health condition were more likely to perceive the air quality to be poor. Several studies have found women to be more likely to acknowledge that air pollution will lead to adverse health effects or to perceive the air quality as poor compared with men [13] [14]. In addition, evidence suggests that racial/ethnic minorities and low socioeconomic status populations are disproportionately exposed to certain air pollutants [15] [16]. Disparities in exposure to air pollutants may contribute to racial/ethnic and socioeconomic disparities in adverse health outcomes associated with air pollution exposure [17] [18] [19].

Beyond the direct consequences for human health of air pollution exposure, it is also important to consider public perceptions of air pollution, which may influence behavioral and lifestyle choices that have a direct impact on health and well-being. Public perceptions about air pollution and the associated health risk concerns are influenced by three primary factors: psychological makeup of indi-

viduals; social characteristics of individuals; and environmental conditions in which individuals live, including pollution exposure [20] [21] [22]. Two elements of psychological makeup that influence pollution perceptions and health concerns are knowledge and self-efficacy. Knowledge, or awareness, of air quality amplifies an individual's perception of risk, while self-efficacy is an individual's confidence that they can perform a task to address a given situation, for instance, the ability to personally do something to improve air quality [23]. Some studies have observed associations between public perceptions of air quality and pollution exposure (*i.e.* residents of areas with higher pollution levels perceived poorer air quality) [20] [21] [22] [23], while others do not [21].

3. Method and Research Objective

The objective of this cluster analysis was to bring the 7331 citizens interviewed back to a limited number of groups so as to be able to trace the prevailing profiles and the related trends on the topic of air quality and its possible improvement. The analysis was therefore aimed at detecting similarities and significant differences between the respondents in terms of:

- perception of air quality,
- areas where the challenges on the subject can best be addressed,
- sources of information,
- behaviors and initiatives to be implemented to improve air quality.

These aspects were investigated through 9 variables, which made it possible to distinguish the clusters within the survey sample. Of these variables 3 they consist of questions included in the questionnaire, while 6 variables have been constructed to measure certain behavior trends among the sample. The survey was online. A questionnaire is composed by four sections that allow to investigate the items cited above:

- the assessment of air quality,
- perception on air quality,
- actions to reduce air pollution,
- profile on inhabitant.

Following the main phases of the research method:

- 1) Survey and data collection,
- 2) Qualitative data processing,
- 3) Factorial analysis.

a) The survey took place from 23 November 2018 to 10 January 2019 and aroused great interest in the entire area of the Po basin. 7331 citizens voluntarily filled in the questionnaire.

The 3 questions presented in the questionnaire and used as variables in the cluster analysis were the following:

- Over the past 10 years, how has air quality changed?
- Where can the challenges posed by the issue of air quality be better addressed?
- What are the main sources from which you receive information on air quali-

ty in your city?

b) Collected data were processed to define the perception of air quality among north Italian citizens. The main topic investigated are:

- the assessment of air quality,
- perception on air quality,
- actions to reduce air pollution,
- profile on inhabitant.

c) Applying a factorial analysis to some questions of questionnaire section 3 and 4 emerge four dimensions to fill in the cluster analysis. These dimensions emerged processing the 17 questions that made up these two questionnaire sections, through a factorial analysis carried out with a software for statistical processing (STATA 15). The factorial analysis can be generically thought of as the search for latent variables starting from some observed variables. This technique makes it possible to highlight the existence of factors or dimensions, not directly measurable, within a set of variables. Factor analysis is a way to take a mass of data and shrinking it to a smaller data set that is more manageable and more understandable. It's a way to find hidden patterns, show how those patterns overlap and show what characteristics are seen in multiple patterns. It is also used to create a set of variables for similar items in the set.

Based on these variables and dimensions a cluster analysis is processed by A non-hierarchical method generates a classification by partitioning a dataset, giving a set of (generally) non-overlapping groups having no hierarchical relationships between them.

Table 1 shows the combined questions to develop the new 4 dimensions.

4. Sample Description

The survey took place from 23 November 2018 to 10 January 2019 and aroused great interest in the entire area of the Po basin. A total of 7331 citizens voluntarily filled in the questionnaire ensuring a representativeness of 36.3% compared to the total number of municipalities that make up this area and 77% of the population that is resident (4188 municipalities, with a population of 25.1 million people). All 42 cities (provincial capitals) in the basin were involved, where a total of 6.5 million inhabitants live, equal to 26% of the total population of the area.

The majority of sample lives in the urban centers of the plain: the percentage of respondents living in the countryside is only 11.6%, while 33.3% live in the center and 55.1% in the first belt periphery. We find that around three quarters of the respondents reside in the plains, 19.7% in the hills and 4.6% in the mountains. **Table 2** shows the others sample features (see **Table 2**).

5. Results

Citizens of the Po basin perceive the air quality as deteriorating. The real data, however, show that in Europe emissions of the main pollutants have actually

Table 1. New dimensions emerged from factor analysis.

Main Question	Sub questions	Answers	Emerged dimension
Which of the following behaviors would you be willing to implement to reduce air pollution?	Prefer the use of public transport	Yes, yes under certain conditions	Sustainability in private transport
	Use the bicycle when possible	No I would not be available	
	Choose hybrid/electric vehicles	Yes, yes under certain conditions	Buy efficiently and sustainably
	Buy appliances with low consumption/high efficiency/low emissions	No I would not be available	
	Limit the use of air conditioners at home/work	Yes, yes under certain conditions,	Adopt behaviors that support the energy efficiency
	Lower home temperature	No I would not be available	
	Buy local products		Adopt behaviors for social reasonability and environmental friendly
	Collect information about air quality, follow suggested good practices	Yes, yes under certain conditions, No I would not be available	
	Raise awareness through volunteering/civic initiatives		
	Limit to circulation in urban areas and controls		
Your opinion concerning the following initiatives	Establishment and/or extension of ZTL/pedestrian areas		Sustainable mobility
	Prohibition of circulation of private heavy vehicles in urban areas	Favorable, favorable to certain conditions, contrary	
	Modal shift towards cycle-pedestrian mobility		Better heating efficiency
	Domestic biomass heating limitation	Favorable, favorable to certain conditions, contrary	
	Greater regulation on boiler use		

Table 2. Sample description.

Variable	<i>distribution</i>		
	Number of people	composed the sample	%
Region	Piedmont	1.212	17%
	Valle d'Aosta	202	3%
	Lombardy	1.810	25%
	Trento	370	5%
	Veneto	1.634	22%
	Friuli Venezia Giulia	517	7%
	Emilia Romagna	1.586	22%
	Total	7.331	100%
Age	20 - 39 years old	2.813	38%
	40 - 64 years old	3.091	42%
	65+ years old	739	10%
	n.d.	688	9%
	Totale	7.331	100%
Gender	Female	2.716	37%
	Male	3.838	52%
	n.d.	777	11%
	Total	7.331	100%

decreased. The perception of air quality is negative both in the Po basin, Italy and Europe, highlighting that citizens seem to be more influenced by pre-conceived than any awareness based on up-to-date information.

The survey opened with a question on the “perception of air quality trends over the past 10 years”. 63.3% of respondents said that it has deteriorated, 22.6% think it has remained the same, while 6.3% say it has improved.

Citizens appear to derive their main source of information on air quality from the Internet and social media (a total of 66.2% of respondents), but the respondents still use traditional sources such as TV and newspapers. However, although it is easier to reach citizens via the Internet, there is a risk of “fake news”. In the Po basin there is the perception that local administrations can improve the air quality more efficiently than Italian and European institutions. Given that promoting a change in people’s lifestyles is one of the essential elements for air quality policies, this element of “empowerment” is even more interesting. Furthermore, the citizens of the Po basin see intervening in industrial processes as a priority, but only 11.1% of the sample consider traffic restrictions as an important means for reducing pollution and traffic in reality is a primary cause of pollution (59.8%). The survey on the willingness of citizens to put into practice behaviors and actions to improve air quality is very interesting; in particular, the percentage surveyed on the basis of limited availability reveals a sort of distrust in the implementation of certain behaviors that are required of citizens.

Public transport with 48.1% of conditional approval is an obvious reminder of the need to improve the service. Hybrid electric vehicles, in turn, with a conditional availability of 44.2% and the purchase price are still considered to be too high.

The multivariate analysis highlighted four clusters of citizens divided on the basis of proactivity/availability to implement virtuous behaviours to improve air quality: “Committed and proactive”, “Willing but ...”, “Hesitant”, “Not willing”.

To stimulate a change in the lifestyles of large sections of the population, precise strategies must be adopted and there should be a clear “pact” where each actor plays their part according to their own resources and capacities.

The target of a communication campaign could be to raise the current percentage of 16% of citizens currently “committed and proactive” to 36% (thus affecting the 20% who are “willing, but ...”).

On the other hand, involving up to 68 (including the 32% “hesitant”), would be much more demanding and in this case the communication campaign should be accompanied with other improvement policies such improving the efficiency of local services as well as air quality policies in general. The “unavailable” remain instead a significant and perhaps intangible hard core, if not through compulsory policies or at least a joint effort by all the actors.

It is also clear that the cost of the actions will probably be incremental and proportional to the level of involvement that an individual citizen wishes to achieve and consequently, in a cost-benefit analysis, it might be useful to focus on a target that can be reached, for example by mainly influencing the “willing

but ...” group and giving up on the idea of trying to influence the “unwilling”.

Using many of the variables used to isolate our five “events”, a cluster analysis was carried out which made it possible to identify the prevailing profiles of citizens with respect to the issue of air quality. A cluster analysis is a statistical technique that identifies groups of units similar to each other with respect to a set of variables. The objective of this cluster analysis was to classify the 7331 respondents into a limited number of groups so as to be able to reveal the prevailing profiles. The analysis was therefore aimed at detecting similarities and significant differences between the respondents in terms of:

- perception of air quality,
- areas where the challenges can best be addressed,
- sources of information,
- behaviors and initiatives to be implemented to improve air quality.

These aspects were investigated through nine variables leading to the classification of four groups on the basis of their commitment to reducing air pollution. In fact, the study confirms that citizens tend to be more proactive when they are asked to put into practice virtuous behaviors and initiatives that could affect the quality of the air making it better.

Based on the values of the nine variables selected, four citizen profiles were identified (**Table 3**):

- Engaged and proactive: very willing to implement virtuous behaviors to improve air quality;
- Available, but ...: quite willing to implement virtuous behaviors;
- Hesitant: generally unwilling to implement virtuous behaviors.

Not willing: very low level of willingness to implement virtuous behaviors.

A detailed analysis of the four clusters reveals some substantial differences:

1) Engaged and proactive. This is the least numerous cluster (16%), representing those citizens who are most willing to engage in the improvement of air quality. They generally feel that it is up to EU institutions to tackle the challenges of improving air quality. These citizens are willing to invest in sustainable mobility, responsible behaviour and promotion of sustainability even in their most private sphere such as the use of private transport and the efficiency of heating.

2) Available, but ... The citizens that make up this cluster (20%) are slightly more worried about air quality than those in the “Engaged and proactive” cluster and see supra-regional and regional institutions as the actors who should do more to achieve the goals.

The cluster is composed of citizens who show that they want to commit themselves, albeit in a generic way, without identifying with determination the behaviors and initiatives to be implemented.

3) Hesitant. This cluster brings together citizens who show little willingness to act to improve air quality. These citizens see the European institutions as the actors who should do more to improve air quality. Although this group is more concerned about the quality of the air than those of the other clusters they are not willing to engage in the initiatives and in the proposed behaviours, particu-

larly sustainable mobility.

4) Not willing. There is no commitment to improving air quality by the citizens in this cluster, which is unfortunately the most numerous even though they perceive a continuously deteriorating quality of the air. The citizens of this cluster are essentially unwilling to engage in any the proposed activities particularly sustainable mobility such as traffic free zones (resident traffic only), traffic restrictions etc. (Table 4).

6. Conclusions

There is clear that there are many considerations that could be made and for these we refer to the investigation document in its entirety. Interestingly, some (though not the majority) citizens of the Po basin already appear to be willing to change their lifestyles. To achieve real change, the unity of purpose and clarity with which actions and proposals are presented to citizens appear to be key elements. Even the most responsible and aware citizens, in fact, assesses how much they are subjected not only in terms of technical information but also through their own emotional sphere. The greater the transparency of the process and the commitment of the parties involved, the greater the effectiveness of communication policies is.

Table 3. Classification and number of the four clusters.

Clusters		
Citizen profile	Description of profile	% of each cluster
Engaged and proactive	Citizens who want to take action and encourage others to take action to improve air quality	16%
Available but	Citizens willing to do something to improve the current situation	20%
Hesitant	The situation is getting worse but I am unwilling to do much to change the situation	31%
Not available	Although the situation is getting worse, I don't care	33%

Table 4. Clusteranalysis results.

Cluster	Variables and dimensions													
	Air quality perception in the last ten years	Institutional level that should improve air quality	Information source						Sustainability in private transport	Buy efficiently and sustainably	Adopt behaviors that support the energy efficiency	Adopt behaviors for social reasonability and environmental friendly	Sustainable mobility	Better heating efficiency
			web	newspaper	Mobile application	radio	TV	Social network						
Engaged and proactive	2.49	1.54	0.42	0.28	0.07	0.07	0.34	0.24	0.74	0.35	0.35	0.91	0.99	0.67
Available but ...	2.54	3.85	0.45	0.27	0.08	0.09	0.29	0.28	0.44	0.48	0.39	0.42	0.60	0.67
Hesitant	2.62	1.30	0.49	0.30	0.07	0.11	0.29	0.26	-0.29	-0.25	-0.32	-0.38	-0.40	-0.31
Not available	2.65	3.81	0.50	0.30	0.08	0.10	0.23	0.28	-0.34	-0.26	-0.36	-0.41	-0.48	-0.45

This survey could be repeated in the future with a sample representative of the Italian population. Possible comparisons can be developed between the Po basin sample and the remains of Italy and of Europe samples. In addition, longitudinal studies could be developed to measure the changes in the air perception among Italian and Po basin inhabitants.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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