Questionnaires for subway users

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CSIC

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CONTENT

1. SUMMARY OF QUESTIONNAIRES 5

1.1. TMB QUESTIONNAIRE 5
1.1.1. SUBWAY AIR QUALITY CONCERN AND PERCEPTION 6

1.2. WEBPAGE QUESTIONNAIRE 7
1.2.1. INFORMATION ON SURVEY RESPONDENTS 7
1.2.2. AMBIENT AIR QUALITY CONCERN AND PERCEPTION 10
1.2.3. SUBWAY AIR QUALITY CONCERN AND PERCEPTION 11

2. REFERENCES 15

1. SUMMARY OF QUESTIONNAIRES

Two differently designed questionnaires were utilised during the project in order to evaluate public perception of Air Quality in underground subways. One of the questionnaires was performed by *Transports Metropolitans de Barcelona* (TMB) and was aimed specifically at subway users in Barcelona, through personal interviews in the subway facilities. The second one was publicized through the webpage of the project (http://improve-life.eu/) in English and Spanish and from the project participants to their social networks. Volunteers had to complete it through an online application available in the webpage of the project.

Participants of the questionnaires carried out by TMB are considered to have been more representative of the general population, while the one carried out via the webpage of the project has been mostly addressed by people specialized in the field study or already sensitized with the issue. Despite this, the results from both types of questionnaires demonstrate what is perhaps a surprising degree of concern of participants about exposure to air pollutants, with few people perceiving urban air quality as good, neither outdoors nor in subway facilities. It seems that public awareness of air quality issues in Spain has grown considerably over recent years, probably in response to extensive media coverage of events such as traffic-related anticyclonic air pollution episodes in Barcelona and Madrid.

1.1. TMB questionnaire

In the framework of the IMPROVE LIFE project, three questions related to the Air Quality matter were introduced to the public questionnaire that TMB carries out annually in order to know the degree of satisfaction of subway users with different aspects of the subway services, such as accessibility, train frequency, etc. This questionnaire is an essential contribution of the company within the study of the estate of service provision.

The questionnaire was performed for the first time in October 2015 (10 months after the beginning of the sampling campaigns) and was repeated in October 2017. Information on survey respondents, including age, education or profession was not available in any case. Totally 646 responses were collected in 2015, and 2025 responses in 2017. The mean number of subway users in a typical working day during October is around 1,200.000. The sampling design was stratified based on proportionality according to the user's demand per platform and time range. In order to improve the quality of the obtained data, face-to-face, telephone and computer supervision studies were also carried out. Final results show a sample error lower than 2.2%.

The three selected questions for the Air Quality issue were: (1) have you ever thought about how is the air quality we breathe in the metro facilities? (2) could you assess the air quality we breathe in the Metro on a scale of: very good, good, acceptable, bad, or very bad? and (3) do you know about the work that TMB and CSIC are doing to improve the air quality in the Metro?

1.1.1. Subway air quality concern and perception

The survey participants were asked: *Have you ever thought about how is the air quality we breathe in the metro facilities?*

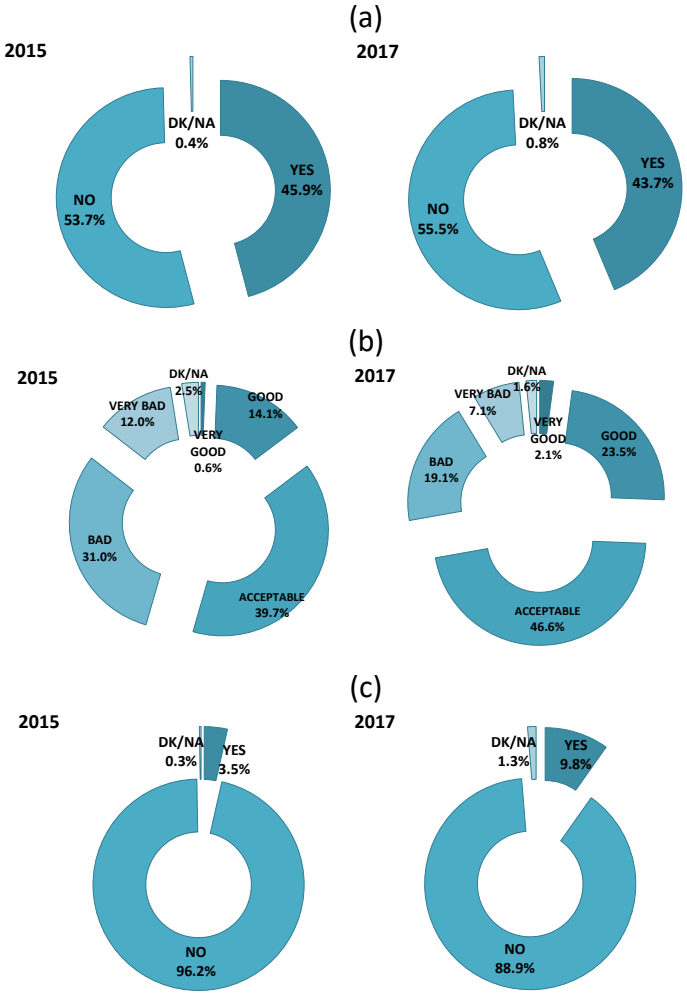

Figure 1. Results of the questions carried out within the TMB questionnaire in October 2015 and October 2017. (a) Have you ever thought about how is the air quality we breathe in the metro facilities?; (b) Could you assess the air quality we breathe in the Metro on a scale of: very good, good, acceptable, bad, or very bad?; (c) Do you know about the work that TMB and CSIC are doing to improve the air quality in the Metro?

Both in 2015 and 2017, more than 40% of the responders expressed concern about the state of air quality in the subway system (Figure 1a), a result that highlights an increasing awareness of the population on this topic, which is likely to be related at least in part to social campaigns in the media and the string of interviews and discussion meetings involving interaction of the IMPROVE LIFE scientists with the press, radio and TV.

Regarding air quality perception (Figure 1b), most of the survey responders perceive the status as acceptable (39.7-46.6%). While in the first round of questions only 14.7% of responders answered that air quality in the subway facilities is good or very good, this percentage increased up to 25.6% in the second one.

The awareness about the research work carried by CSIC and TMB in order to improve air quality at the Barcelona subway system showed an increase from 2015 to 2017. In 2017, the percentage of subway users that know about the project was about 10%. They may have got to know about the work via information panels displayed on various platforms and the videos shown in trains of the Barcelona metro system, in addition to knowledge transfer via the media and social networks.

1.2. Webpage questionnaire

The online questionnaire has been available through the webpage of the project (http://improve-life.eu/es/) since January 2017, both in English and Spanish, and has been publicized through social networks. Volunteers completed it using an online application, where they were firstly asked about the city where they live/work, followed by nine questions about their concern and general perception of air quality, and particularly about air quality state in subway facilities. Currently, the total number of survey responders is 164. The results should not be intended as representative of the general population. For specific questions, the results will be distinguished according to their city of residence/work.

1.2.1. Information on survey respondents

The age of the survey respondents was mostly within 30 and 50 years old (Figure 2), representing 75% of participants. Most of participants live or work in Barcelona (50%), where the research project was implemented (Figure 3), followed by Stockholm (10%), Porto (10%), and Madrid (5%). For the rest of the cities, the representativeness is very scarce.

The most frequent answers to the question *how did you get to know IMPROVE-Life Project* were through a friend, through social networks and at work.

Survey participants were asked about their frequency of use of several commuting modes; responses are reported in Figure 4, where they are shown considering the city of residence/work. As observed, the preferred transport mode for Barcelona's participants is the subway system (35%), followed by bus (21%), and bicycle (15%). In general, the selected modes differ widely among cities, which firstly depend on the availability. Nonetheless, subway seems to be the most preferred mode when available.

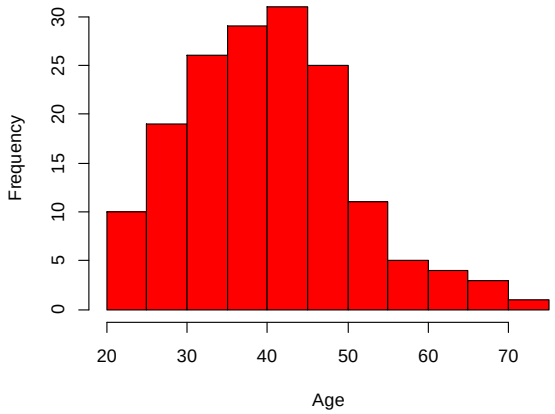

Figure 2. Age of the IMPROVE LIFE webpage survey respondents

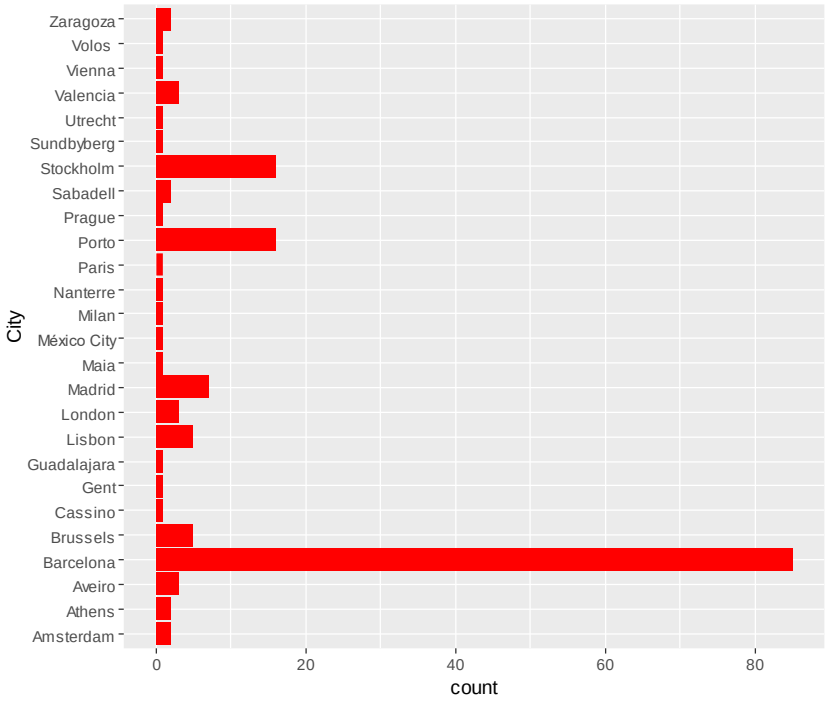

Figure 3. City of residence/work of the IMPROVE LIFE webpage survey respondents.

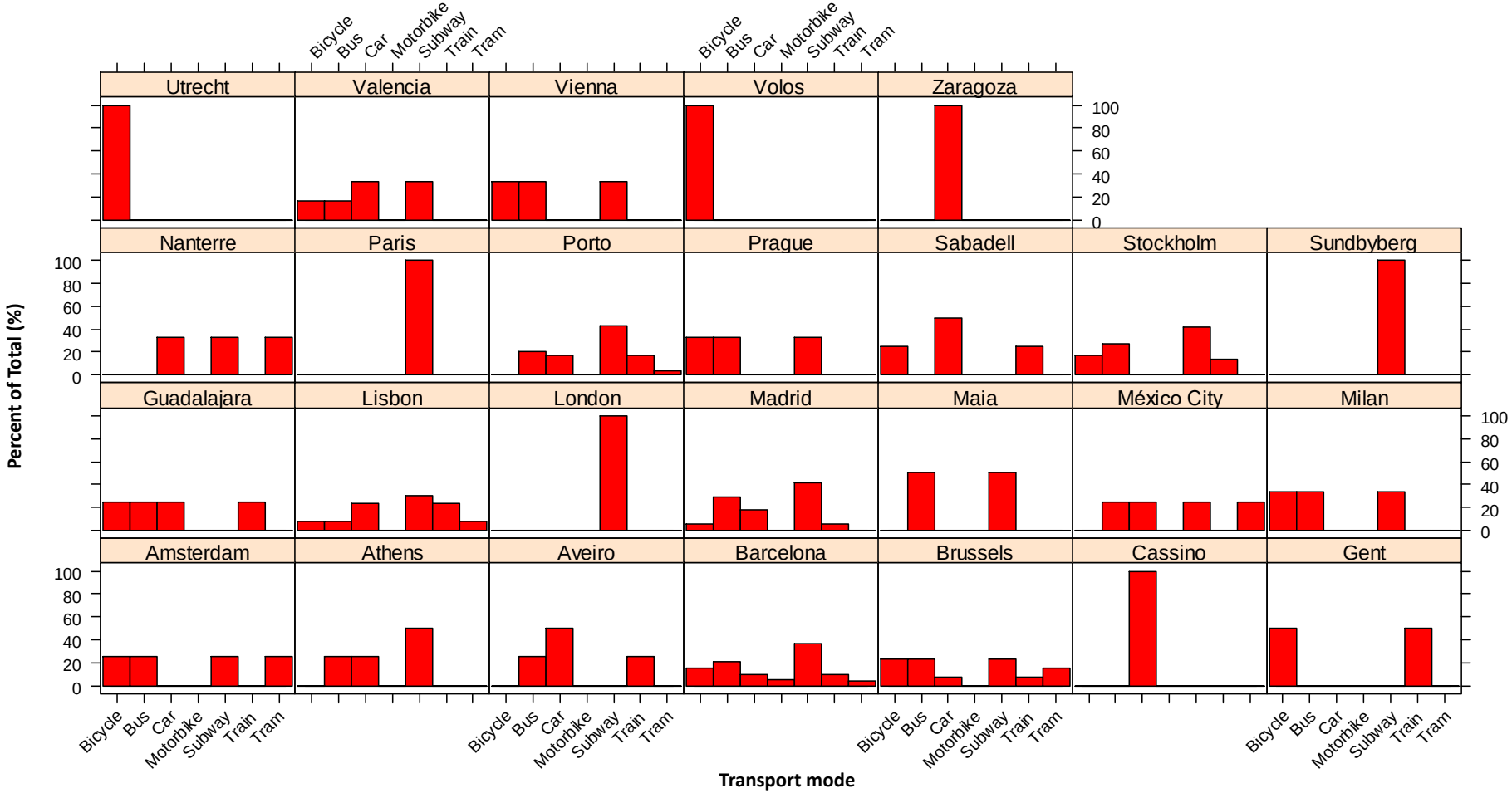

Figure 4. Commuting modes that survey participants used more often, stratified by city of residence/work.

1.2.2. *Ambient air quality concern and perception*

The survey participants were asked three questions on general ambient air quality: (1) *how often do you think about ambient air quality? (2) the World Health Organization has proved that breathing poor quality air can reduce your life expectancy, did you know this? (3) do you think you breathe clean air in the city?* The summary of answers is reported in Figure 5.

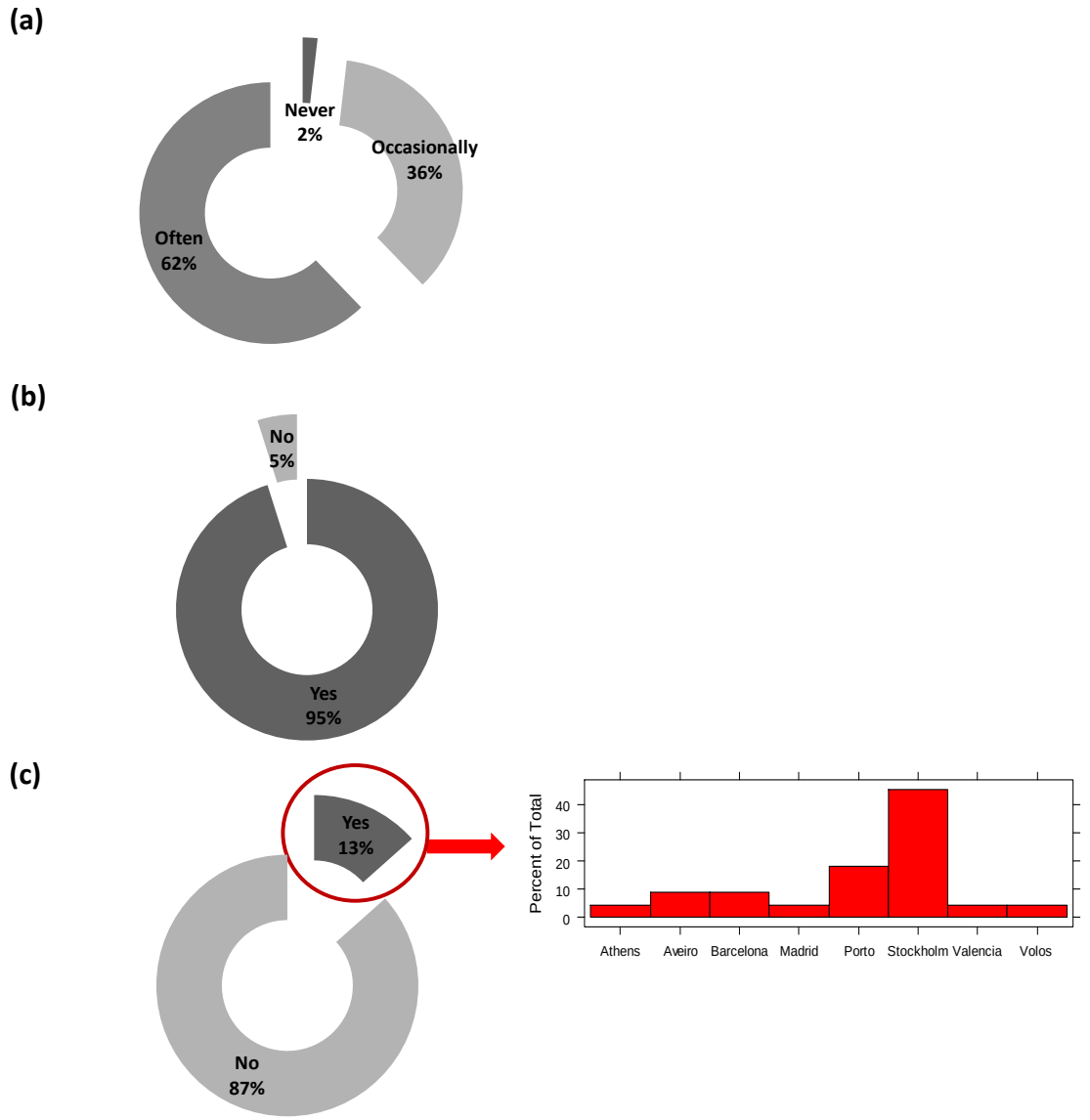

Figure 5. Percentage of survey respondents based on their answers to the questions: (a) how often do you think about ambient air quality?; (b) the World Health Organization has proved that breathing poor quality air can reduce your life expectancy, did you know this?; (c) do you think you breathe clean air in the city? The red histogram shows the distribution of participants who think breathing clean air, according to their city of residence/work.

Considering all responses, we can deduce that the vast majority of participants had knowledge and a prior concern about the topic of the study. Indeed, more than 60% of participants often think about the state of ambient air quality, while only 2% never think about it. Another indicator of the especial sensitization of participants is that around 95% were aware of the proven relationship between air quality and human life expectancy, as recently reported by the World Health Organization.

It is remarkable that only 13% of responders perceive that they breathe clean air in their cities. When the city of residence/work of this minority percentage of responders is analyzed, it can be observed that they mostly live/work in Stockholm (45%), followed by Porto (18%). Only 2% of participants from Barcelona think that they breathe clean air (Figure 5).

Regarding the opinion of respondents about the cleanest transport mode from an air quality perspective, high agreement was obtained between cities. Bicycle was selected as the most appropriate mode by 40% of participants (Figure 6). The second selected mode was subway (22%), followed by tram (20%). It is interesting to mention in this context that this perception of participants is in agreement with actual results reported by recent scientific works, based on measurement of a number of air quality parameters while commuting (e.g. Karanasiou et al., 2014; Moreno et al., 2015).

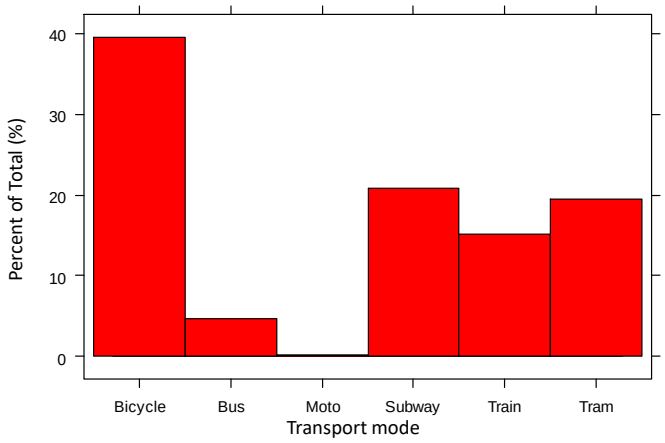

Figure 6. Percentage of survey respondents according to their opinion about the most appropriate transport mode in terms of air quality.

1.2.3. Subway air quality concern and perception

Additionally, survey participants were specifically asked about their concern and perception of air quality at the subway system. For this porpoise, three questions were selected: *(1) what is your opinion about the subway air quality? (2) where do you believe the air is cleaner: on the platform or inside the train? (c) do you think subway air quality*

can be improved? If so, how? Results on these questions are summarized in Figure 7 and Figure 8.

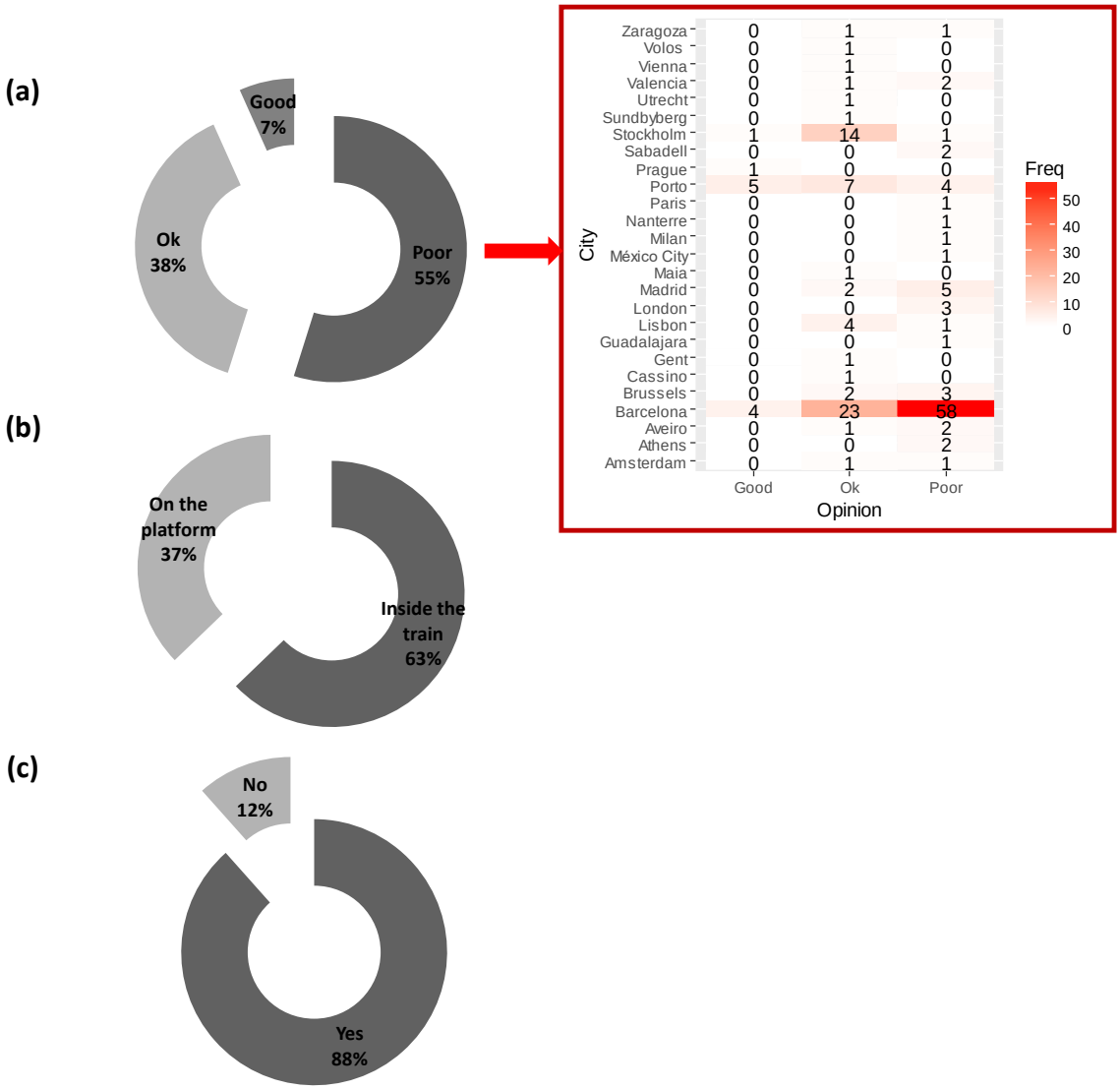

Figure 7. Percentage of survey respondents based on their answers to the questions: (a) what is your opinion about the subway air quality? (b) where do you believe the air is cleaner? (c) do you think subway air quality can be improved? The heatmap graph reports the number of participants by their perception of subway air quality (Good, Ok, Poor) and by their city of residence/work.

More than 50% of total participants think that the state of air quality at the subway facilities is poor, while 38% perceive it as ok or acceptable. Only 7% consider that the state can be classified as good (Figure 7). The analysis of this perception by the city of residence/work (Heatmap in Figure 7) indicates that in the city of Barcelona almost 70% of respondents think that the state of air quality is poor.

On the other hand, respondents mostly think that air is cleaner inside the train (63%; Figure 7), compared to the state of the air on the platform. This perception has been actually confirmed as fact by a number of scientific reports on Barcelona subway air quality, which associate this observation with the presence of air conditioning systems inside trains and with the sealing of trains' windows (e.g. Martins et al., 2015).

The vast majority of survey participants think that air quality at subway facilities could be improved (88%; Figure 7). This percentage of respondents was also asked about possible measures to improve air quality, but few of them were able to suggest an answer, although most of those who did respond proposed more than one measure. All responses are summarized in Figure 8. Many of the participants seem to consider that the major source of pollutants at subway facilities is indoor generated and associated with trains' circulation. In this context, measures related to the improvement or installation of forced ventilation systems are the most popular (62 participants), followed by the installation of air filtering systems (23). The installation of platform screen doors to separate tunnel and platforms, as already performed in the newest lines of the metro of Barcelona, and the use of less polluting materials for trains' components, were also proposed by 4 respondents. All these measures have been evaluated in the framework of the IMPROVE LIFE project, obtaining very promising results in most cases, especially regarding the role of forced ventilation. However, the installation of air filtering systems (air purifiers) at platforms during the project demonstrated that the effect of this measure is very dependent on the distance to the passengers and on the flow rate.

On the other hand, 3 respondents associated air pollution in subway facilities with outdoor sources, and proposed the application of abatement measures against the entry of outdoor air pollution. According to the results obtained during the IMPROVE LIFE project, outdoor sources can certainly have an important effect in the exposure of subway users to pollutants, especially regarding fine and ultrafine atmospheric particles, and when stations are located near roads with high traffic density. It should be highlighted that most of participants point to factors that have been demonstrated to be key in determining the state of air quality. In summary, they include ventilation, platform design, number of passengers, trains frequency, trains' materials, brake systems and power supply. It seems certainly not to be the case that the majority of subway commuters ride the trains unaware of air quality issues. Not only have most subway users thought about the subject, but when asked many can suggest solutions that are commonly in agreement with the scientific findings.

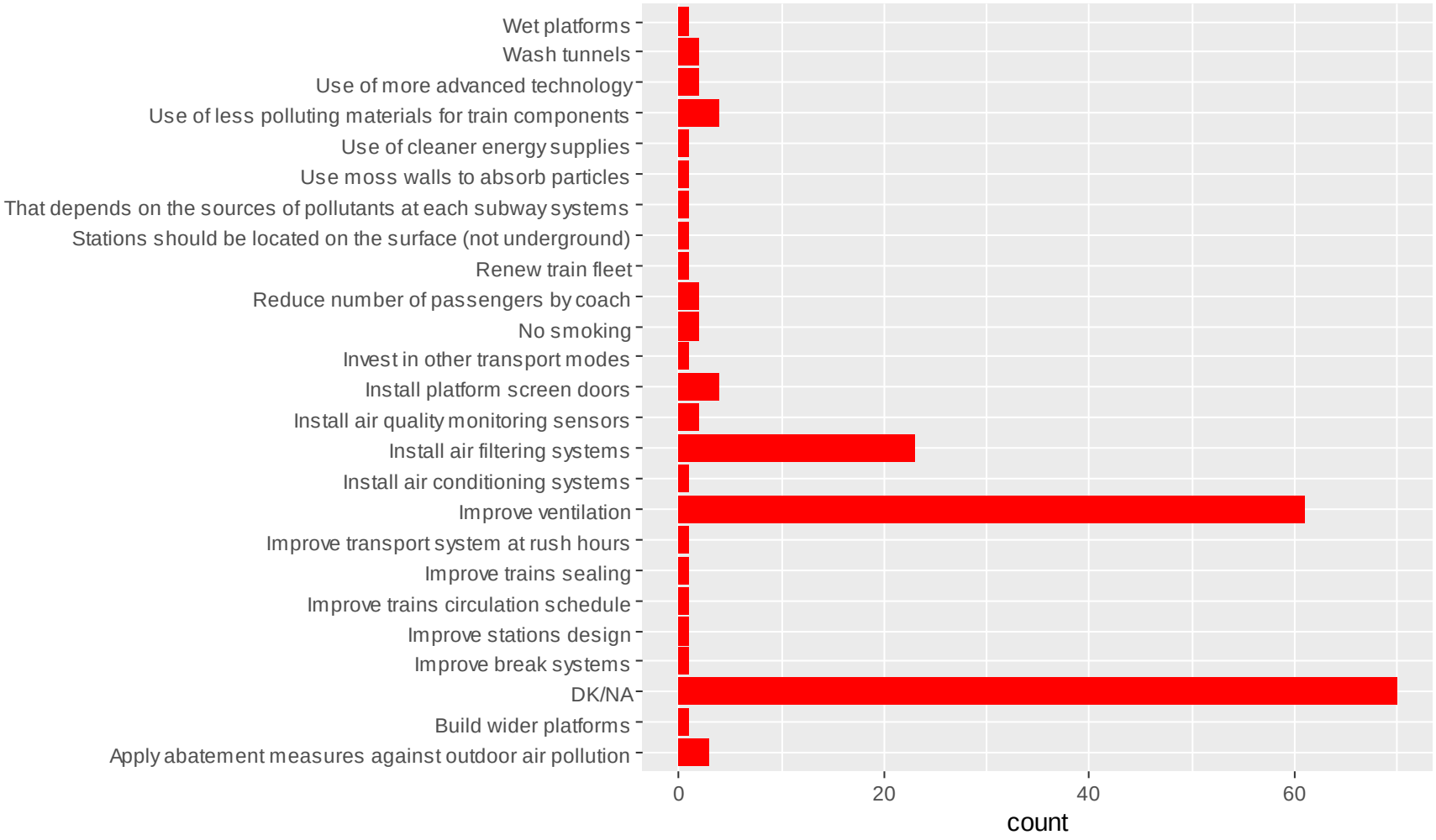

Figure 8. Summary of measures proposed by survey participants to improve air quality at subway facilities.

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