World Health Organization

REGIONAL OFFICE FOR Europe

Health risks of air pollution in Europe – HRAPIE project

New emerging risks to health from air pollution – results from the survey of experts

By: Susann Henschel and Gabrielle Chan

This publication arises from the HRAPIE project and has received funding from the European Union.

ABSTRACT

This document presents the results of a survey of experts developed and conducted as part of the WHO "Health risks of air pollution in Europe – HRAPIE" project. The survey's objective was to assess and document the views of expert stakeholders regarding "evidence of new emerging issues on risks to health from air pollution, either related to specific source categories (e.g. transport, biomass combustion, metals industry, refineries, power production), specific gaseous pollutants or specific components of particulate matter (e.g. size-range like nano-particles and ultra-fines, rare-earth metals, black carbon (EC/OC))" via an online survey tool. The document describes the methodology applied to develop and implement the survey tool and provides a summary of the findings.

The main findings of the survey are that the majority of respondents identified the general categories of "road traffic", "space heating and air conditioning", and "shipping" as the top three emission source categories of concern associated with emerging issues for public health. The experts felt that fine and ultra-fine particles and their metal content are of greatest concern in relation to health effects. Some of the issues identified are not new but may not have been sufficiently recognized or given priority in the past, while their significance or importance is now coming to the fore. The experts also felt that many well-known issues still require attention. The views of the experts are generally consistent with the findings of the REVIHAAP evidence review.

Keywords

AIR POLLUTION - ADVERSE EFFECTS
ENVIRONMENTAL MONITORING
ENVIRONMENTAL EXPOSURE - ADVERSE EFFECTS
DATA COLLECTION
EUROPE

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Acknowledgements

The WHO Regional Office for Europe developed this publication as part of the joint European Commission–WHO "Health risks of air pollution in Europe – HRAPIE" project. This project was co-funded by the European Union under Contribution Agreement No. 07.0307/2012/626738/SUB/ENV.C3.

The authors would like to thank the project's Scientific Advisory Committee, as well as the following experts who provided comments on the technical content and clarity of the document for various sections of the draft material: Flemming Cassee (the Netherlands), Patrick Goodman (Ireland) and Michal Krzyzanowski (Germany).

Abbreviations

BC	black carbon
BS	black smoke
CO	carbon monoxide
CO_2	carbon dioxide
EC	elemental carbon
EU	European Union
EU28	countries belonging to the EU after July 2013
HCs	hydrocarbons
HRAPIE	Health risks of air pollution in Europe (project)
H_2S	hydrogen sulphide
NH_3	ammonia
NH_4NO_3	ammonium nitrate
NMVOCs	non-methane volatile organic compounds
NO_x	nitrogen oxides
O_3	ozone
OC	organic carbon
PAHs	polycyclic aromatic hydrocarbons
PM	particulate matter
PM_{10}	particulate matter with an aerodynamic diameter below 10 μm
$PM_{2.5}$	particulate matter with an aerodynamic diameter below 2.5 μm
REVIHAAP	Review of evidence on health aspects of air pollution (project)
SAC	Scientific Advisory Committee (of the HRAPIE and REVIHAAP projects)
SOAs	secondary organic aerosols
SO_x	sulphur oxides
UFPs	ultra-fine particles with a diameter <100 nm
VOCs	volatile organic compounds

Executive summary

Background and aims

The WHO Regional Office for Europe implemented the "Review of evidence on health aspects of air pollution – REVIHAAP", and "Health risks of air pollution in Europe – HRAPIE" projects with financial support from the European Commission. These projects provide scientific evidence-based advice on health aspects of air pollution in support of the comprehensive review of the European Union's air quality policies scheduled for 2013.

As part of the HRAPIE project, the authors developed an electronic survey tool using an online platform, with the objective of assessing the views of key stakeholders and expert institutions regarding "evidence of new emerging issues on risks to health from air pollution, either related to specific source categories (e.g. transport, biomass combustion, metals industry, refineries, power production), specific gaseous pollutants or specific components of particulate matter (e.g. size-range like nano-particles and ultra-fines, rare-earth metals, black carbon (EC/OC))". In the context of this survey the term "new emerging issues" was defined as issues that are perceived to be potentially significant but that may not be fully understood. This includes (i) issues that are new and (ii) issues that are not new but may not have been sufficiently recognized or given priority in the past, while their significance or importance is now coming to the fore. This report summarizes the survey findings and discusses the implications of the results.

Methods

The authors developed the HRAPIE survey after reviewing existing surveys (including various European Commission surveys such as Eurobarometer), and discussed and pilot tested it with help from the REVIHAAP and HRAPIE experts and Scientific Advisory Committee members. WHO disseminated the finalized survey to key stakeholders and expert institutions with an interest in air quality issues at the beginning of May 2013. The online tool was available for a limited period of four weeks for input, closing on 2 June 2013. The survey included specific questions about the nature of the professional activity of the respondents, as well as other demographic questions. All answers were treated anonymously and responses were analysed collectively for trends.

Main findings

A total of 100 respondents completed the survey, completing 113 sets of questions.

The top six emission source categories (of a total of 16) posing an emerging health risk identified by respondents were:

1. road transport (40.7%)
2. space heating and air conditioning (15.0%)
3. shipping (8.8%)
4. energy production and distribution (6.2%)
5. industrial processes (metal industries) (6.2%)
6. agriculture (5.3%).

The majority of respondents identified the road transport source category – which includes not only exhaust but also vehicle and road wear emissions – as associated with emerging health risks.

Other key observations

- The combined results revealed a strong signal for finer particulate matter (PM) components, especially for PM with an aerodynamic diameter below 2.5 μm ($PM_{2.5}$) and nano-scale particles (ultra-fine particles and nano-particles) from combustion and non-combustion processes emitted by a variety of source categories.
- A strong signal also emerged in responses to metal components of PM for a number of source categories, such as shipping and road transport (including brake wear and pavement abrasion).
- Respondents expressed concern over the increase in prevalence of certain sources and the subsequent growth in numbers of population exposed.
- Respondents identified cardiovascular, respiratory and neurobehavioural health effects and cancer as key health outcomes of concern associated with the identified sources and corresponding pollutants.

Discussion

The findings of the HRAPIE survey are broadly consistent with the critical data gaps highlighted in the REVIHAAP project's technical report (WHO, 2013).

Certain limitations emerged from the approach adopted.

- The period of four weeks or even less during which the survey was open may have limited the answering rate.
- The length of the questionnaire may have discouraged some respondents and led to a lower response count for some of questions.
- The wording of the demographic questions did not allow the experts to analyse responses on a geographic scale.

Conclusion

- The experts concluded that emissions from a number of sources still pose a serious health threat: road transport and space heating and air conditioning are of particular concern.
- The experts felt that fine and ultra-fine particles are of greatest concern in relation to health effects.
- The experts also felt that the metal content in these fine and ultra-fine particles is very important.
- Despite the evidence already available on the subject, the experts identified significant gaps in knowledge in relation to exposure (such as interactions among and measurement of pollutants), ability to assess health effects and mechanisms of action.

1. Introduction

Recent studies show that ambient air pollution is a significant risk factor for health, contributing to over 430 000 premature deaths and over 7 million years of healthy life lost from exposure to particulate matter with an aerodynamic diameter below 2.5 μm ($PM_{2.5}$) in western, central and eastern Europe in 2010. When the risk factors are ranked by their attributable burden of disease in western Europe, air pollution is in eleventh place, with tobacco smoking – including second-hand smoke – ranking first (Lim et al., 2012).

While much has been done in recent decades to improve air quality and thus to improve human health in Europe, evidence for adverse health effects persists, despite the current air quality standards and historically low levels of air pollution. It is therefore important to identify and document emerging issues on risks to health from air pollution to fill pressing gaps in stakeholders' and policy-makers' knowledge. This will enable them to put forward and implement more effective local, national and European policies.

The aim of the joint European Commission–WHO "Health risks of air pollution in Europe – HRAPIE" and "Review of evidence on health aspects on air pollution – REVIHAAP" projects was to provide scientific evidence-based advice on health aspects of air pollution in order to support the comprehensive review of air quality policies of the European Union (EU) scheduled for 2013. The objective of both projects was to develop responses to 26 policy-relevant key questions formulated by the European Commission and refined by the projects' Scientific Advisory Committee (SAC).

As part of the HRAPIE project, the authors developed an electronic survey to consult and collect input from relevant key stakeholders and expert institutions. It aimed to identify and document new emerging issues on risks to health from air pollution and to answer question D3 of the 26 key questions:

> *Is there evidence of new emerging issues on risks to health from air pollution, either related to specific source categories (e.g. transport, biomass combustion, metals industry, refineries, power production), specific gaseous pollutants or specific components of particulate matter (e.g. size-range like nano-particles and ultra-fines, rare-earth metals, black carbon (EC/OC))?*

In the context of this survey the term "new emerging issues" was defined as issues that are perceived to be potentially significant but that may not be fully understood. This includes (i) issues that are new and (ii) issues that are not new but may not have been sufficiently recognized or given priority in the past, while their significance or importance is now coming to the fore.

2. Methodology

2.1. Development and structure of the survey

The authors developed the survey on new emerging issues on risks to health from outdoor air pollution after a review of existing surveys (including various European Commission surveys such as Eurobarometer). They used an electronic online survey tool, Survey Monkey, and presented the first survey proposal for discussion and consultation with the REVIHAAP and HRAPIE experts and SAC members at the WHO expert meeting in January 2013 (Annex 1 provides a list of participants in the HRAPIE project). An improved and further developed version of the survey underwent two phases of pilot testing by a panel of REVIHAAP and HRAPIE experts and SAC members. The authors made further amendments after each pilot phase, based on the input and feedback of the pilot panel.

The finalized survey consisted of two parts. Part 1 asked the respondent to identify up to three emission source categories posing an emerging risk to health and set out 11 questions per category; Part 2 consisted of three demographic questions about the respondent and an opportunity to make any final comments. The majority of the questions elicited specific responses (mostly using a multiple-choice format) to enable tabulation of the results. Some questions gave the option of specifying an individual answer choice or selecting an "other" option and included a textbox with a set word limit, aimed at gathering more detail on the choices made and individual views. The estimated time to complete all questions per source category identified based on the pilot phase was a maximum of 15 minutes.

WHO launched the survey at the beginning of May 2013; it was available online for four weeks, closing on 2 June 2013. In addition to the online version WHO provided a download link to a printable pdf version for the convenience of respondents (see Annex 2). The WHO Secretariat disseminated an invitation to complete the survey and the points of contact for existing distribution lists sent invitations directly to members of several of the institutions and networks listed in Section 2.2. A reminder e-mail was sent to key stakeholders and expert institutions on the WHO distribution list two weeks after the initial invitation was circulated.

2.2. Target audience

The survey's target audience was key stakeholders and expert institutions with an interest in air quality issues in the WHO European Region. WHO disseminated an invitation to complete the survey to the following stakeholders and institutions:

- REVIHAAP experts and external reviewers;
- a list of focal points from the joint United Nations Economic Commission for Europe/WHO Task Force on Health Aspects of Air Pollutants;
- the European Environment Agency's European environment information and observation network members for air monitoring and modelling;
- European Respiratory Society members;
- the EUROCITIES network;
- the contact list of the EU Directorate-General for Research and Innovation;
- the contact list of the Health and Environment Alliance;
- members of the International Society of Environmental Epidemiology's European Chapter.

2.3. Analysis and presentation of results

The authors extracted the raw data from the online platform, applying filters and using the default analysis tools available in Survey Monkey, after the survey closed. They based the data extraction and filters on the answers to Question 1, which identified the emission source category of concern, with Questions 2–11 characterizing the health risk associated with that category (see Annex 2). They then systematically compiled and analysed the data using templates generated in Microsoft Excel in two formats: first, the overall results including all source categories; and second, results filtered by source category.

It was not possible to calculate the overall response rate: the total number of recipients of the invitation to complete the survey is unknown because of the different methods of dissemination used (see Section 2.1).

Chapter 3 of this report presents the survey results. Section 3.1 gives an overview of all the results and general interpretation of the data, including a summary analysis of the demographic information obtained and all the source categories identified. An overarching analysis of Question 11, which gave respondents the opportunity to formulate recommendations for policy-makers, was not feasible; specific recommendations for the six key source categories identified by the respondents are presented in the corresponding sections of the chapter.

The subsequent sections follow the structure of Section 3.1 and illustrate a more detailed analysis of results for the six source categories that received the highest numbers of clicks (one click refers to a respondent selecting an answering option by ticking the box). The structure of all the results sections follows the course of Questions 1–11.

The authors calculated the percentages for specific answers to a question presented in the individual results sections based on the total number of clicks of all respondents who answered that question, since each respondent had the option to select multiple answers for all questions describing the category identified. In order to reflect the answering rates – i.e. the number of respondents who answered and the number who skipped a question – bar charts supplementing the main plots are included where appropriate.

A discussion of the results and overall conclusions follows the results. The variety of responses given in the text boxes provided at the end of each question was considerable, depending on the nature of the question. This report tries to reflect the range of open answers in the results and discussion chapters.

3. Results

3.1. Overall findings

3.1.1. Respondents' characteristics

This section provides a brief summary of the survey responses received for the demographic questions in Part 2 (Questions 36–38).

100 respondents completed the survey, filling in 113 sets of questions to identify and describe emerging risks to health. Fig. 1 shows the country of residence of the 47% of survey respondents who answered Question 36 and Fig. 2 illustrates the work sector of the 52% of respondents who answered Question 38.The survey was not restricted to expert stakeholders from the countries belonging to the EU after July 2013 (EU28), so the results illustrated in Fig. 1 do not reflect the population distribution in Europe.

The authors believe that the responses provide a good overall perspective of the views of stakeholders and experts on evidence of emerging risks to health from exposure to air pollution. The figures outlined below suggest that the majority of respondents who indicated their background were air pollution scientists from different fields; this was to be expected, given the target audience – the list of institutions and stakeholders of interest developed for dissemination of the survey (see Section 2.2 for details).

Of the 53 respondents who described the type of institution they were affiliated with in Question 37, 57% were working in an academic or research institution; 36% in a governmental institution (at either the national, regional, or local level); 2% in a nongovernmental organization; 2% in a policy-making institution; 2% for a hospital or health care provider; and 2% for an international organization.

Fig. 1. Country of residence of 47% of survey respondents

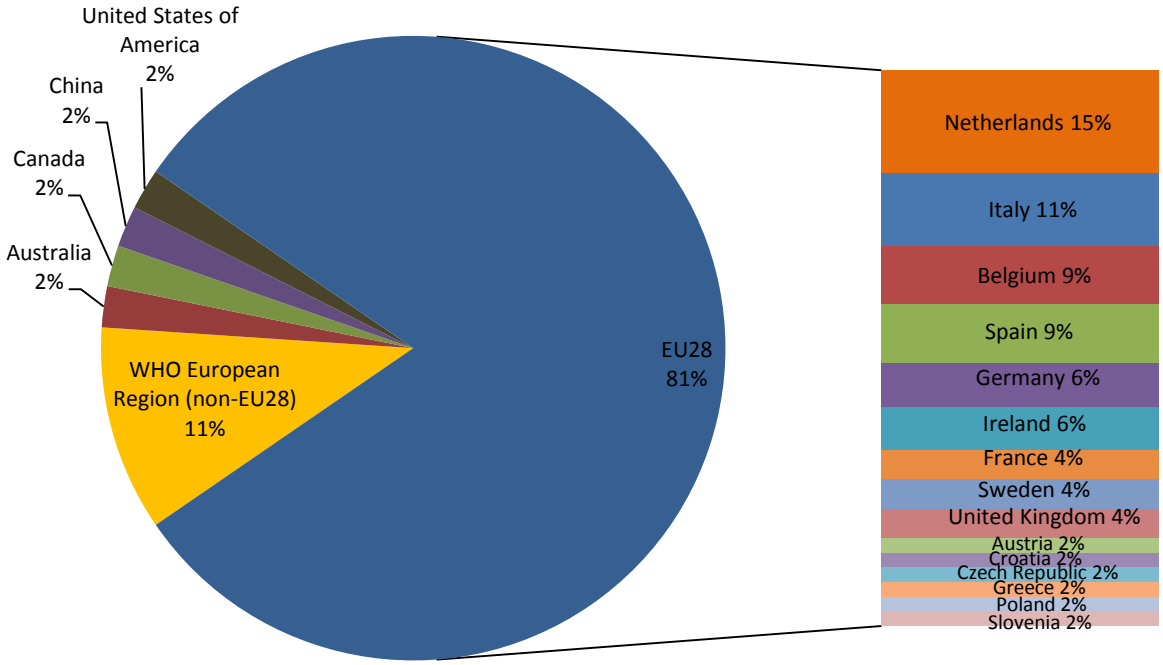
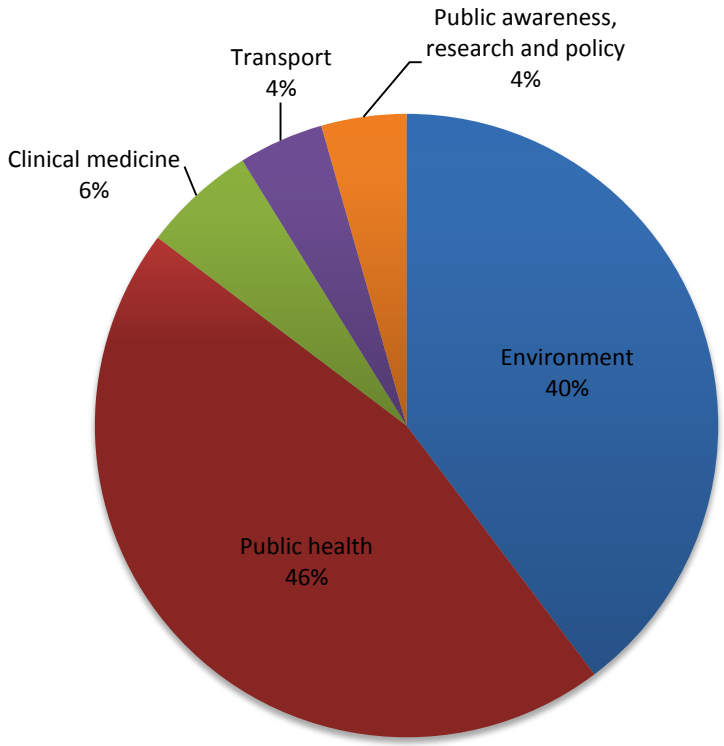


Fig. 2. Work sector of 52% of survey respondents



3.1.2. Source categories and associated ambient air pollutants

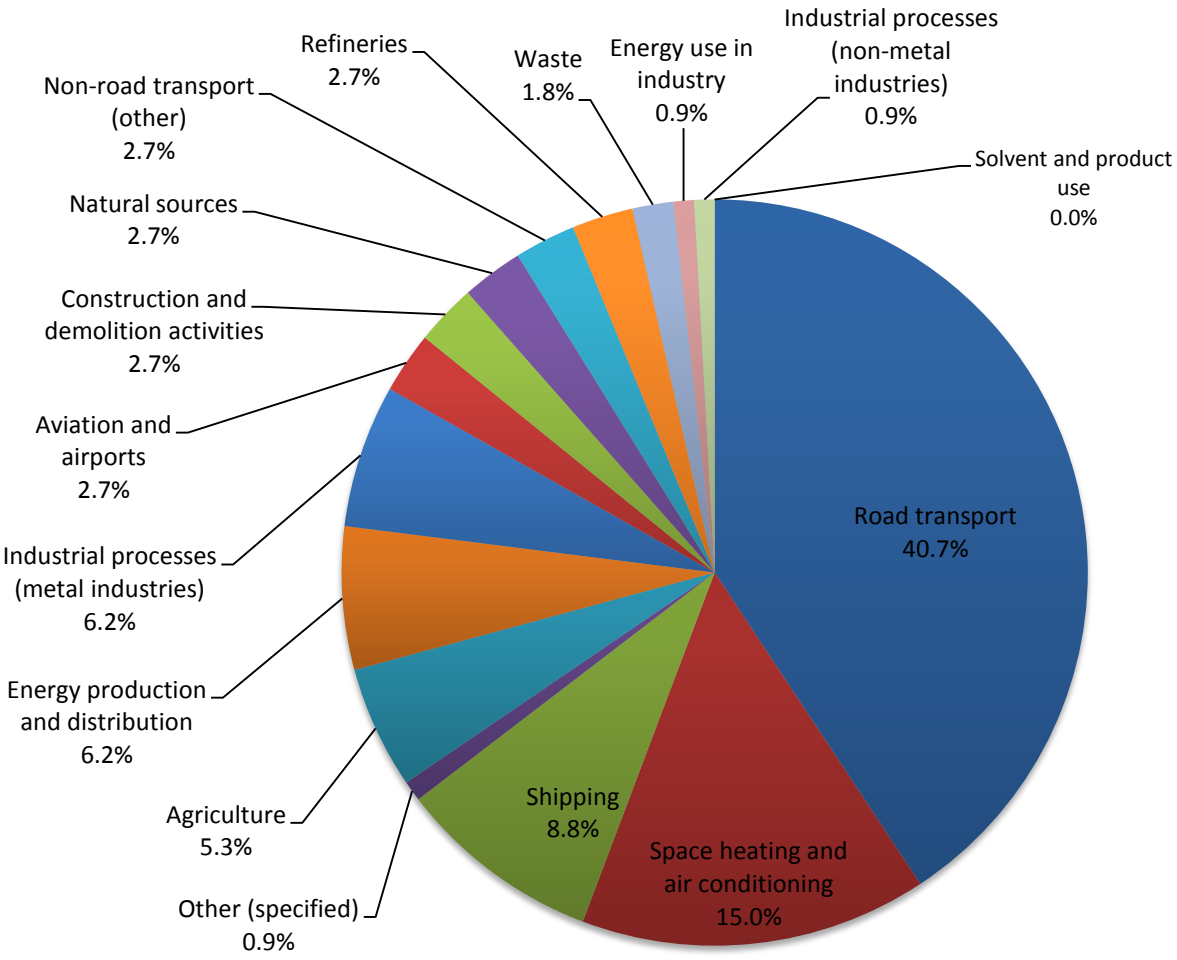
Questions 1 and 2 of the survey asked the respondents' opinions on what source(s) and associated ambient air pollutant(s) pose a new emerging issue on risks to human health. Respondents gave the following six emission source categories (of a total of 16 including an "others" category) the highest number of clicks:

1. road transport (40.7%)
2. space heating and air conditioning (15.0%)
3. shipping (8.8%)
4. energy production and distribution (6.2%)
5. industrial processes (metal industries) (6.2%)
6. agriculture (5.3%).

Most of the respondents identified the road transport source category as associated with emerging health risks. Fig. 3 gives an overview of the percentage of respondents identifying individual source categories (no respondents chose the solvent and product use source category).

In addition, one respondent identified an emerging risk from environmental tobacco smoke. Another highlighted the fact that pollen constituents, which add to particulate matter (PM) – both $PM_{2.5}$ and PM with an aerodynamic diameter below 10 μm (PM_{10}) – should be included as an additional factor of air pollution for consideration in the general classification of the emerging issues.

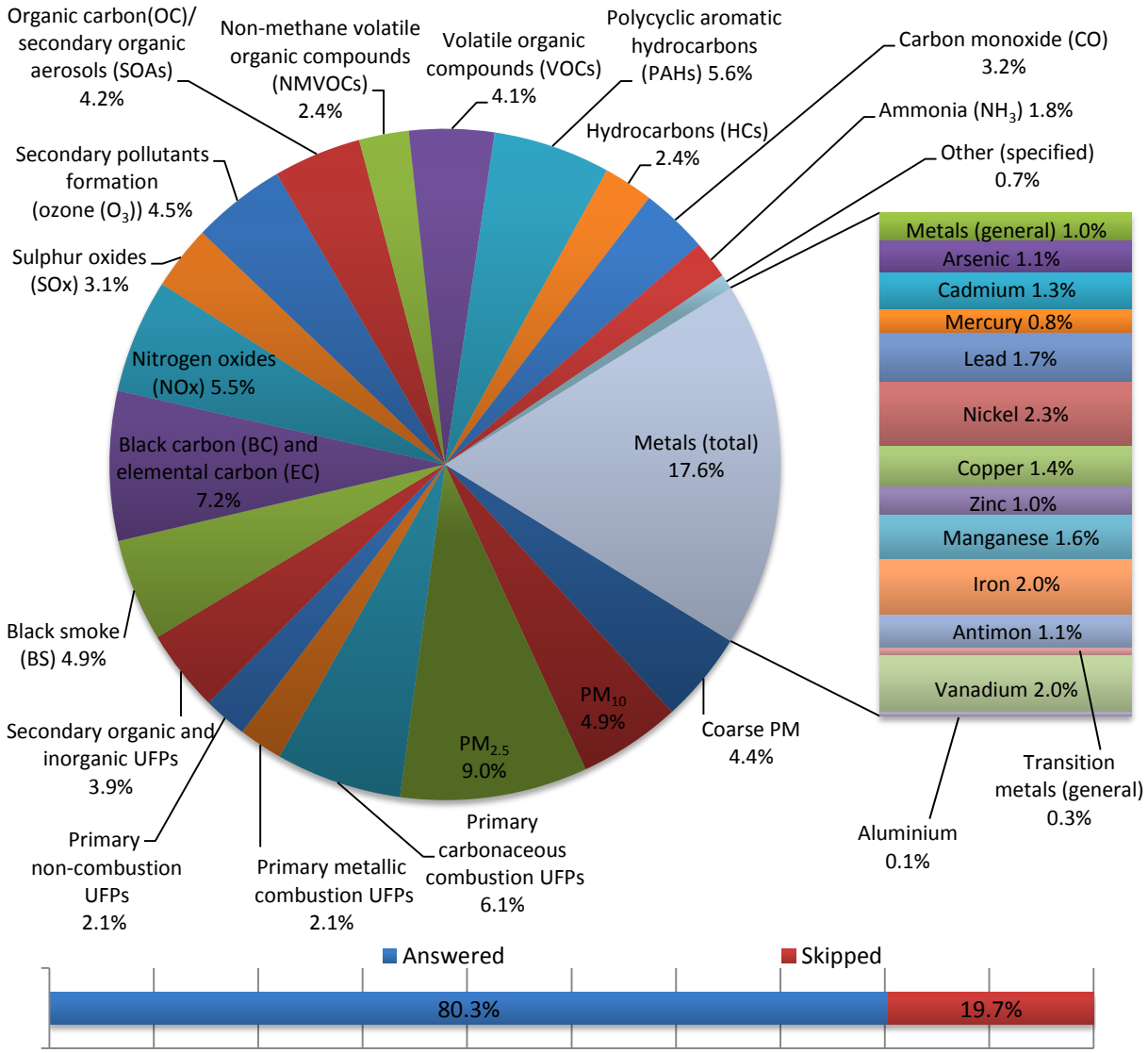
Fig. 3. Overview of response rates identifying individual emission source categories



The respondents identified a number of ambient air pollutants that pose a health risk. Fig. 4 gives an overview of response rates from the combined survey answers for all source categories. Several key findings emerged from the summary analysis.

- The combined results revealed a strong signal for finer PM components, especially for $PM_{2.5}$ and nano-scale particles (ultra-fine particles (UFPs) and nano-particles) from combustion and non-combustion processes emitted by a variety of source categories.
- A strong signal also emerged in responses to metal components of PM for a number of source categories, especially in responses to finer PM components, such as $PM_{2.5}$ and UFPs.
- Air pollutants of concern that were not listed in the answer options but were specified by the respondents in the "others" option included:
    - engineered nano-particles associated with the road transport source category, such as tyre abrasion;
    - dioxins and polychlorinated biphenyls associated with the waste source category;
    - hydrogen sulphide (H_2S) associated with the refineries source category;
    - asbestos associated with the construction and demolition activities source category;
    - biological components associated with the natural sources source category.

Fig. 4. Response rates for ambient air pollutants that pose a health risk (all source categories) and answering rate



3.1.3. Newly identified exposure characteristics

Question 3 of the survey asked respondents to identify the new ambient air pollution and exposure characteristics for the chosen emission source category. Table 1 illustrates the distribution of answers for the combined results and for each of the six key source categories.

The main issues highlighted by the respondents who chose to specify newly identified exposure characteristics were:

- an increase in prevalence of certain sources and the subsequent growth in numbers of population exposed;
- knowledge gaps concerning emissions and health effects due to exposure.

Table 1. Newly identified exposure characteristics of air pollutants associated with overall and individual source categories and answering rate

Exposure characteristic	Number of answers (proportion)						
	Overall	Road transport	Space heating and air condition-ing	Shipping	Energy production and distribution	Industrial process (metal industries)	Agriculture
New property of ambient air pollutant(s) of concern	32 (30%)	17 (40%)	2 (13%)	3 (27%)	1 (20%)	1 (20%)	3 (33%)
Exposure situation/micro-environments	50 (48%)	18 (43%)	10 (63%)	2 (18%)	2 (40%)	4 (80%)	5 (56%)
Other (specified)	23 (22%)	7 (17%)	4 (25%)	6 (55%)	2 (40%)	0 (0%)	1 (11%)
Total (answers/ clicks)	**105**	**42**	**16**	**11**	**5**	**5**	**9**
Answered	81	28	14	8	5	5	6
Skipped	36	18	3	2	2	2	0
Answering rate	69%	61%	82%	80%	71%	71%	100%

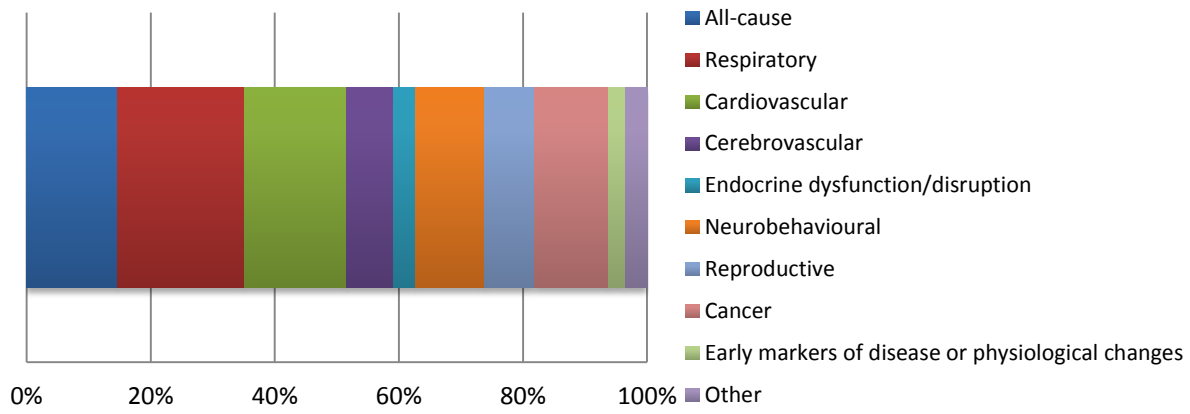
3.1.4. Health effects, population characteristics and scale

Questions 4–6 of the survey asked respondents to identify the health effects of concern; the vulnerable subgroups of population affected by the emission source categories and associated air pollutants; and the geographical location or scale of the emerging risk. All three were multiple-choice questions. Figs. 5–7 display the combined response rates for the answers to each across all source categories. In the context of this survey the term "newly identified health effects" refers to the likelihood that one or more of the known and unknown diseases will be linked to any of the sources identified earlier.

Summarized across all source categories (multiple selections optional) the survey responses highlight the following health effects of concern (Fig. 5).

- Classic health outcomes – including all-cause, cardiovascular, respiratory and cerebrovascular health effects – received approximately 60% of the total number of respondents' clicks.
- Of these, the strongest signal emerged for respiratory health effects (20%).
- Cancer, neurobehavioural and reproductive health effects and health effects due to endocrine dysfunction/disruption received approximately 40% of the total number of clicks.
- Of these, the results revealed the strongest signals for cancer (12%) and neurobehavioural health effects (11%).

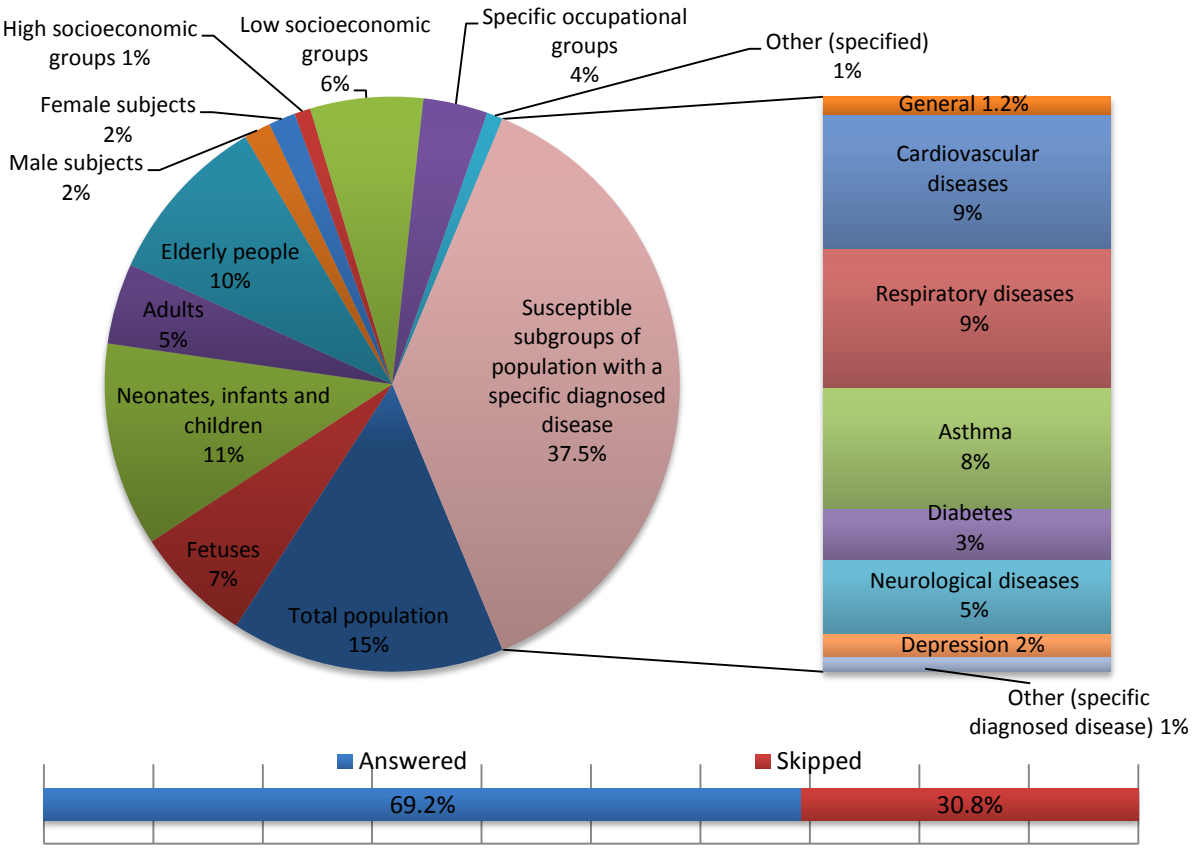
Fig. 5. Response rates for health effects of concern (all source categories)



Owing to the multiple-choice nature of Question 5 there may be some overlap between the specific options selected for vulnerable subgroups of population (Fig. 6). Over 15% of respondents identified the total population as vulnerable to exposure to the identified sources and associated air pollutants and 37.5% identified selected subgroups of population with a specific diagnosed disease:

- cardiovascular diseases in general received 8.8% and diabetes 3.3% of the total clicks;
- respiratory diseases in general received 9.1% and asthma 7.9% of the total clicks.

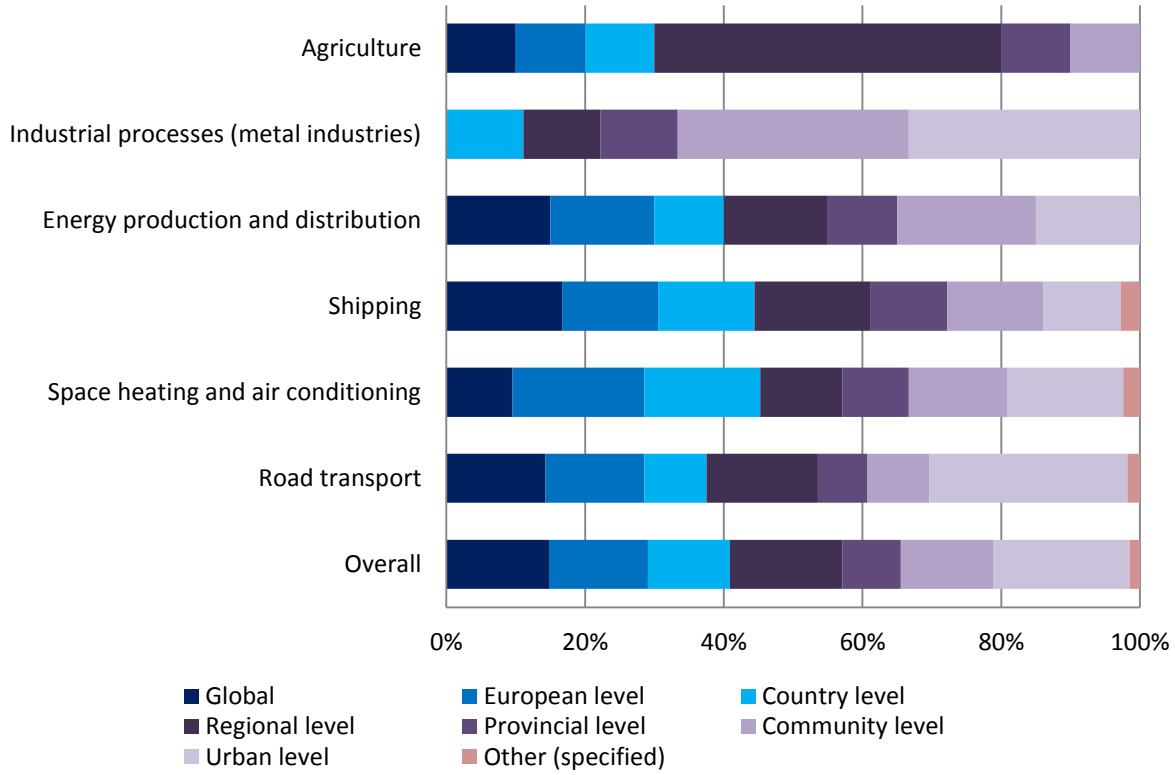
Fig. 6. Response rates for vulnerable subgroups of population (all source categories) and answering rate



A clear trend emerged regarding the geographic scale of the emerging issues (Fig. 7). Summarized across all source categories, about 60% of respondents identified the issues as affecting subgroups of population on a smaller geographic scale – from urban to regional levels.

The results further highlighted the fact that the issues identified are specific to a country or region in the EU; it is thus very difficult to draw general conclusions. Industrial sources of air pollution are predominant in some regions, while traffic-related emissions are predominant in others.

Fig. 7. Response rates for geographic scale of emerging issues by key source category and overall



Over 60% of respondents who answered Question 8 rated the overall significance of the emerging risk's impact on health in a European context as significant to very significant, assigning scores between 4 and 6 on a scale from 0 (insignificant) to 6 (very significant).

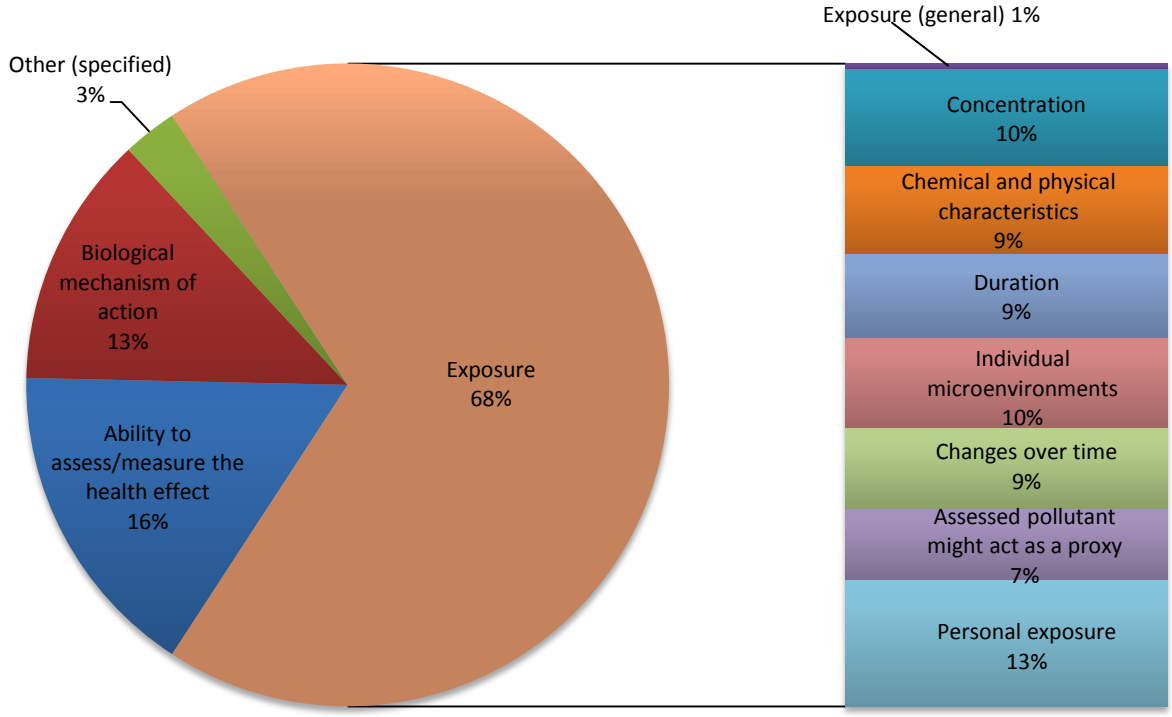
3.1.5. Knowledge gaps and driving forces of the emerging risks

When asked how they became aware of the new emerging issue on risks to health from ambient air pollution (Question 7), the majority of respondents answered that it was through ongoing research (27%), a recently published journal article (25%) or at a conference or meeting (19%).

Nevertheless, the respondents perceived gaps in knowledge requiring further research for all the emerging risks to health identified. The answers to multiple-choice Question 9 on knowledge gaps corroborated the issues highlighted in the comment sections of various other

questions (Fig. 8). The responses revealed a strong signal for exposure, with a total of 68% of clicks, and for its subcategories such as personal exposure (13%), pollutant concentrations (10%) and individual microenvironments (10%).

Fig. 8. Response rates for knowledge gaps requiring further research (all source categories)



The main driving forces of the new emerging risks varied markedly among the key source categories identified. Overall, the strongest signals emerged for technological changes and socioeconomic factors, which received 25% and 21% of the total number of clicks respectively.

3.2. Key source category 1: Road transport

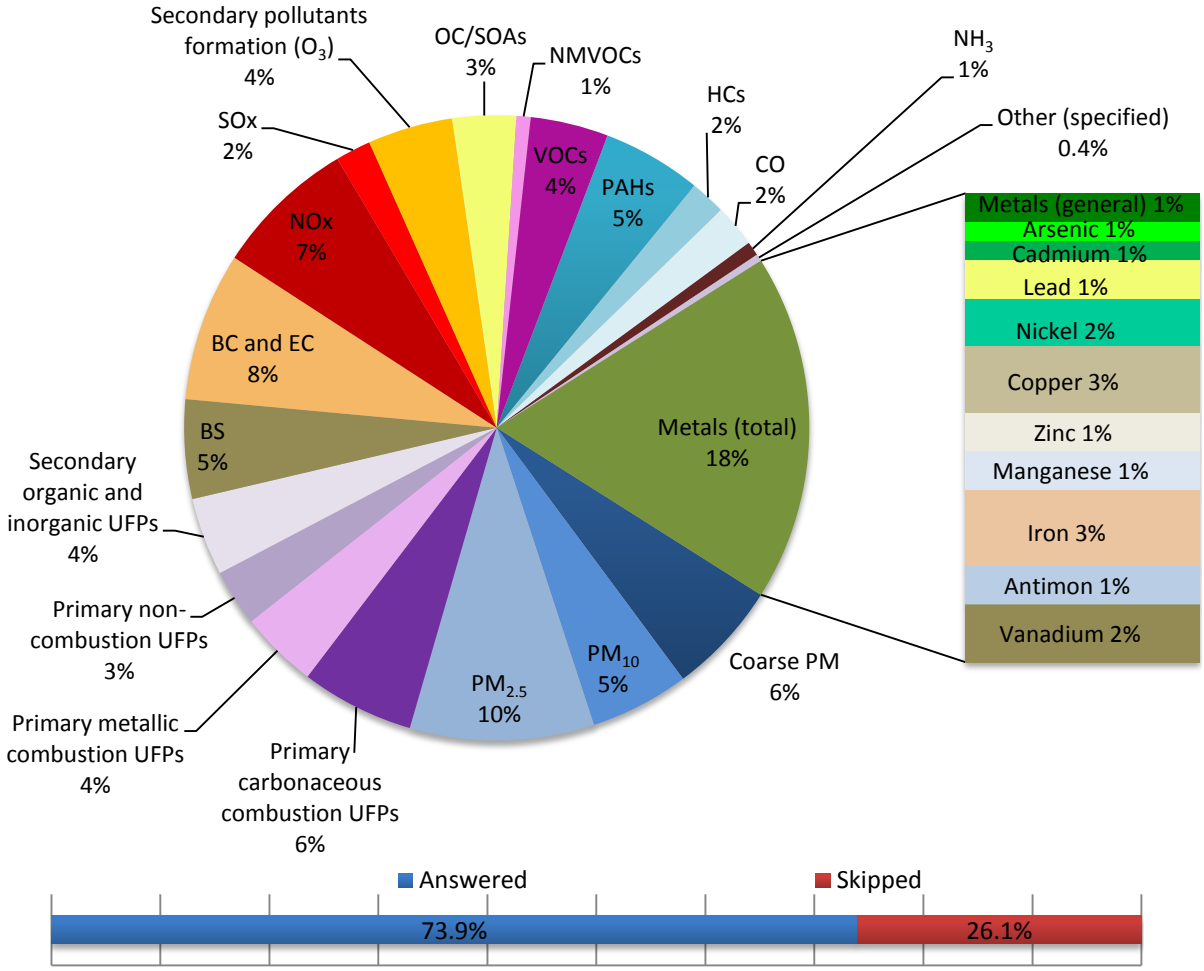
3.2.1. Ambient air pollutants of concern

46 of the 100 survey respondents identified road transport as associated with emerging health risks. The strongest signal in responses to the air pollutants associated with this source category that pose a health risk emerged for PM (Fig. 9):

- PM overall received 37.4% of the total number of clicks;
- its subcategories of finer PM components – especially $PM_{2.5}$ (9.5%) and UFPs (total: 16.8%) – received the majority of these.

A number of respondents used the "other" option to highlight the fact that non-tailpipe emissions such as brake and road wear are very complex and not well characterized.

Fig. 9. Response rates for ambient air pollutants that pose a health risk (road transport) and answering rate



3.2.2. Newly identified exposure characteristics

The majority of respondents identified one of two characteristics as reasons their selections were a new emerging risk to health: a new property of ambient air pollutant(s) of concern or the exposure situation/microenvironments (see Table 1).

The respondents who chose to specify their answer on newly identified exposure characteristics highlighted several issues that future research should address. Issues associated with a new property of the air pollutant(s) were:

- new metrics/characteristics of known air pollutants, such as oxidative potential, certain tracer metals in UFPs, and particle diameters;
- complex mixtures of organics and inorganics;
- fine particles and UFPs in general;
- the growing importance of abrasion emissions that may represent around 70% of PM emissions of a car compared to tailpipe emissions, as no standards or regulations yet address abrasion emissions and these may still be relevant for electric vehicles;

- increasing NH_3 due to elective catalytic reduction systems in future Euro VI diesel engines, which may result in a rapid increase of particulate ammonium nitrate (NH_4NO_3) and consequently of $PM_{2.5}$.

Issues associated with the exposure situation/microenvironments were:

- exposure while travelling, especially on highways, during rush hours and for active transport modes;
- exposure during physical activity (one respondent emphasized that the risk has probably existed for a long time but is only now being acknowledged and studied, as physical activity and active mobility are increasingly promoted as solutions for congestion, air pollution, noise, obesity and cardiovascular disease);
- the continuing heated debate around the best metric to measure health effects, including relevant averaging times.

Other issues identified as requiring attention included:

- new fuel composition (biofuel);
- the mineral type and microbial component of the pollutant.

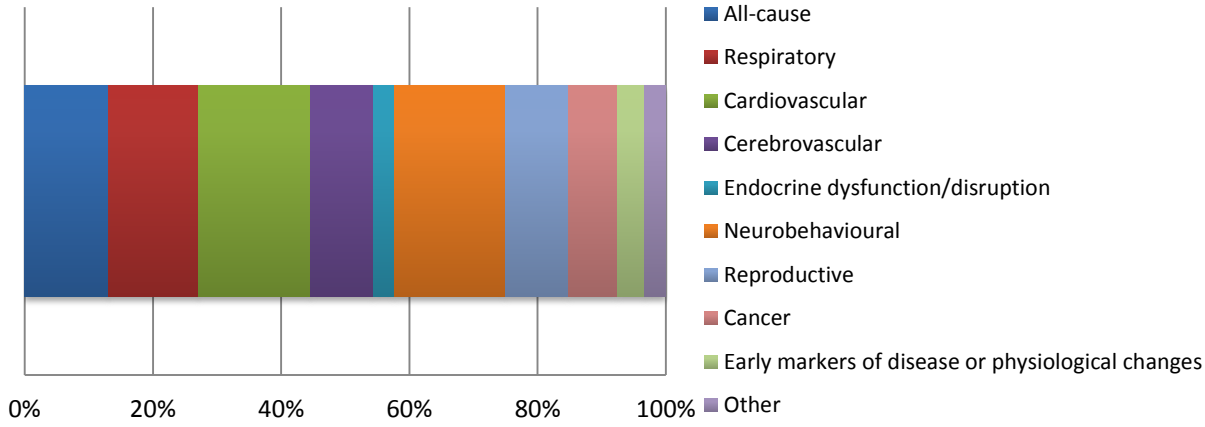
The respondents emphasized that many aspects of risks to human health associated with road transport are not new but are not yet fully understood and lack comprehensive evaluation.

3.2.3. Health effects, population characteristics and scale

The respondents highlighted the following health effects of concern associated with the road transport source category and its associated air pollutants (Fig. 10).

- Cardiovascular and neurobehavioural health effects (such as dementia, neurodegeneration and cognition) received the highest number of clicks (17.4% each).
- One respondent pointed out that endocrine (diabetes) and reproductive (pregnancy outcomes) effects still need more research.
- Another answer proposed a new field of investigation into inflammatory diseases of the musculoskeletal system (rheumatic diseases).

Fig. 10. Response rates for health effects of concern (road transport)



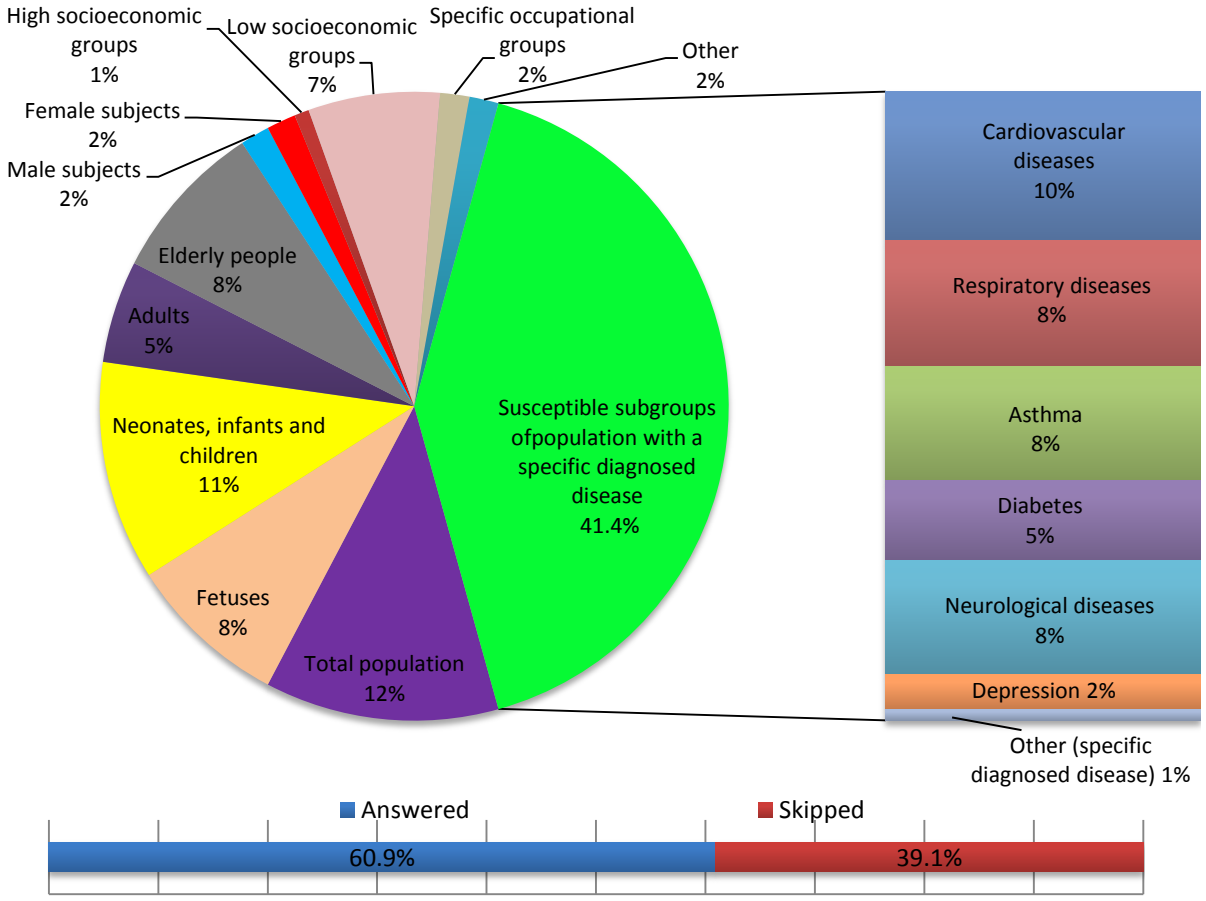
When asked about subgroups of population they considered vulnerable to exposure to road transport and its associated air pollutants, 12% of respondents identified the total population (Fig. 11).

The strongest signals for specific age groups emerged for the youngest age groups: fetuses (8.3%) and neonates, infants and children (11.3%). Subgroups of population with a specific diagnosed disease were selected by 41.4%:

- cardiovascular diseases in general received 9.8% and diabetes 5.3% of the total clicks;
- respiratory diseases in general received 8.3% and asthma 7.5% of the total clicks.

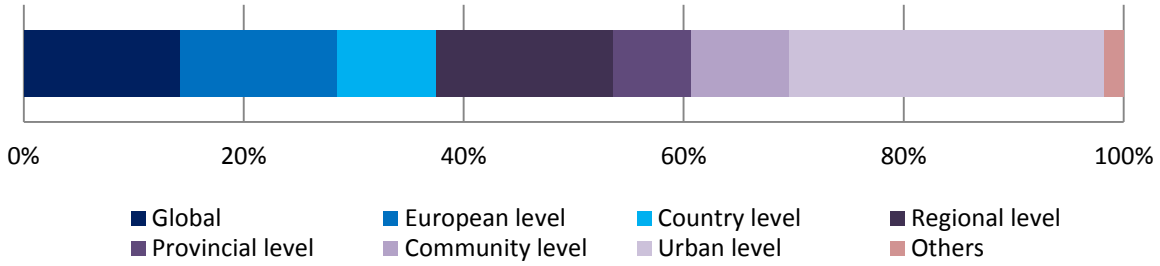
In the comments section of the question respondents specifically emphasized the need for further research into the effects of road transport air pollutants on vulnerable subgroups of population, especially where such groups are not yet or not fully characterized. In particular, they mentioned the effects on children and fetuses and people with specific diseases, and on adult males, who are more likely to travel on highways and more frequently during rush hours.

Fig. 11. Response rates for vulnerable subgroups of population (road transport) and answering rate



A clear trend emerged regarding the geographic scale of the emerging issues: over 60% of the respondents identified the issues as affecting subgroups of population on a smaller geographic scale – from urban to regional levels (Fig. 12).

Fig. 12. Response rates for geographic scale of the emerging issues (road transport)



Of the respondents rating the significance of the emerging risk's impact on health in a European context, 80% rated it as significant to very significant, assigning scores between 4 and 6 on a scale from 0 (insignificant) to 6 (very significant).

At this point respondents again stressed that further research is desirable and necessary, as the exact natures of the identified emerging risk and the health impact on the population are currently unknown. For example, reproductive health outcomes could range in scale from a relatively minor increase in several reproductive endpoints to significant impacts with lifelong consequences and resultant major health impacts for the population.

3.2.4. Knowledge gaps and driving forces of the emerging risks

In their answers to Question 9 on current knowledge gaps the respondents reiterated the areas requiring further research highlighted in the comment sections of various questions (Table 2). The results revealed very strong signals for two categories: ability to assess/measure the health effect and biological mechanism of action.

Table 2. Knowledge gaps with respect to the emerging risks associated with road transport

Knowledge gap	Percentage of clicks
Ability to assess/measure the health effect	14.7
Biological mechanism of action	14.7
Exposure (general)	0.9
Concentration	6.4
Chemical and physical characteristics	11.0
Duration	10.1
Individual microenvironments	9.2
Changes over time	5.5
Assessed pollutant might act as a proxy	10.1
Personal exposure	13.8
Other not-yet-assessed health outcomes might be affected by the described source and/or air pollutant(s)	3.7

One respondent stressed in the comments section of the question the importance of setting up limit values for NH_3 to maintain low ambient levels. Respondents also emphasized the need

to assess exposure during physical activity, as well as the role of pollutants and their association and mechanism of action on psychiatric illness (such as dementia). Respondents felt that methodological limitations, limitations in imagination or a lack of earlier focus were the limiting factors for both measuring the effect of the emerging risks – which, if they exist, have most likely been there all along – and for examining the exposure–response relationship.

The main driving forces of the new emerging risks identified by the respondents were:

1. technological changes (29% of the total number of clicks);
2. changes in behaviour of individuals (21%);
3. socioeconomic factors (18%);
4. political changes (16%);
5. societal changes (11%);
6. other forces (5%).

3.2.5. Recommendations to policy-makers

Question 11 of the survey asked the respondents whether they had any recommendations to make to policy-makers, based on their knowledge of the newly emerging risk described. This section outlines the recommendations made for the road transport source category.

Respondents recommended that policy-makers:

- increase epidemiological research and research on mechanisms;
- perform new exposure and health assessments as technologies change and advance;
- support more research on the personal exposure of specific target groups, especially exposure of children and while travelling – one respondent commented that exposure to BC in particular is currently severely underestimated because of its properties (such as fast decay away from roads);
- gain more information on the determinants of internal (inhaled) doses using markers such as airway macrophage carbon loading;
- improve information flow to provide and spread information about preventive features to practising doctors;
- not only focus on road traffic and combustion engines but also consider vehicle wear and pavement abrasion products from tyres, brakes and pavements, which are just as important – in this context additional recommendations included:
    - research on the contribution of UFPs;
    - improving and/or maintaining high-quality roads;
    - implementing standards devised from the abrasion emissions that may represent around 70% of PM emissions of a car, and which may still be relevant for electric vehicles – one respondent mentioned that the health effects of this type of high metal-loaded PM are relatively well known and it is an important air quality issue.

The answers also suggested that policy-makers consider:

- endorsing cleaning air actions;
- furthering sound spatial planning and zoning in urban areas;
- increasing taxes on petrol and putting legislation forward to ensure better quality of fuels;
- improving and promoting public transport;

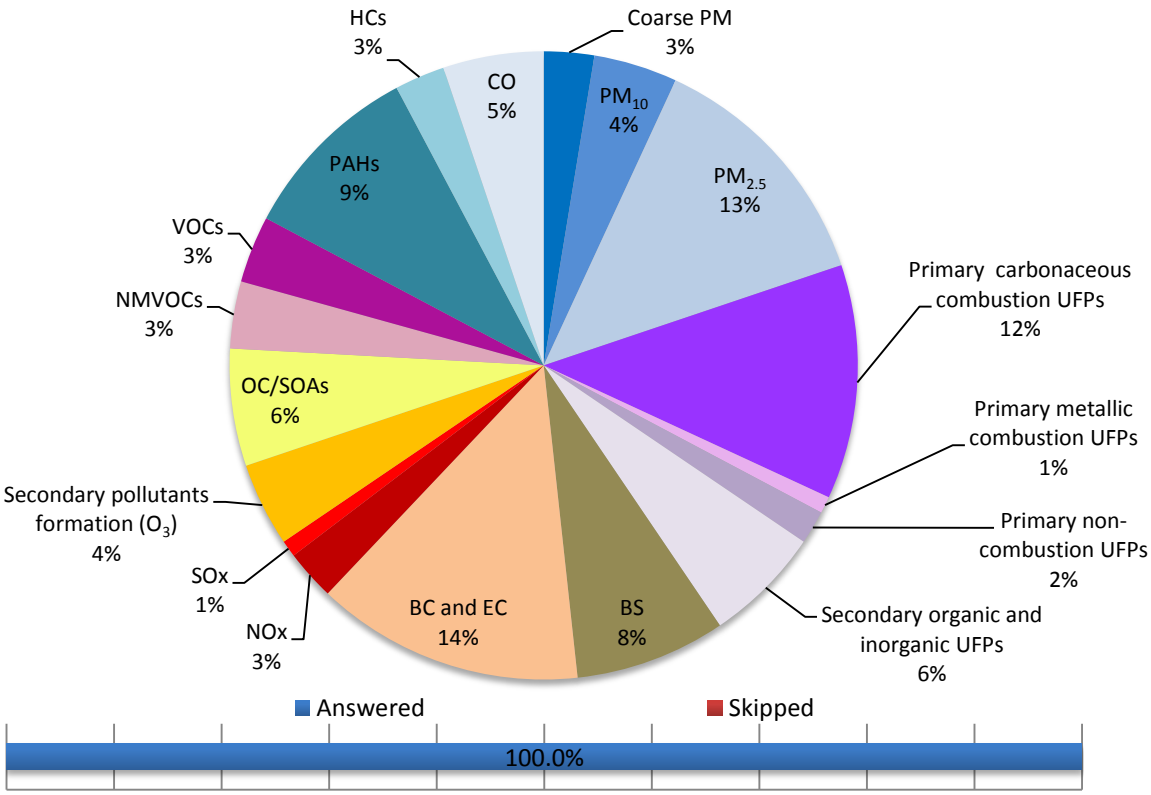
- regulating speed limits for driving based on the scientific evidence on driving speed and impacts on health of populations in cities;
- stopping promotion of diesel as the technology of choice for internal combustion engines;
- regulating UFPs and BC based on the compelling scientific evidence, as these are not currently covered by EU guidelines (only some black smoke limit values are in place);
- broadening and improving the monitoring of air pollutants to measure whether minerals are polluting a specific area, and if so, to identify (i) which mineral particles are involved, (ii) their potency and (iii) whether they are contaminated with microbial components;
- considering the personal exposure of specific target groups in policies in order to be both effective and efficient;
- creating a balance between socioeconomic factors (including unemployment, industrial development, and so on) and human health – ensuring preference is given to long-term health effects rather than short-term economic profit;
- implementing stricter guidelines on air quality.

3.3. Key source category 2: Space heating and air conditioning

3.3.1. Ambient air pollutants of concern

17 of the 100 survey respondents identified space heating and air conditioning as associated with emerging health risks. The strongest signals in responses to air pollutants associated with the source category emerged for PM overall, BC and EC (Fig. 13).

Fig. 13. Response rates for ambient air pollutants that pose a health risk from space heating and air conditioning and answering rate



- PM overall received 40.5% of the total number of clicks;
- its finer PM component subcategories – especially $PM_{2.5}$ (12.9%) and UFPs (total: 20.7%) – received the majority of these;
- most UFP clicks were for the subcategory of primary carbonaceous combustion UFPs (12.1%);
- BC and EC received 13.8% of the total number of clicks.

3.3.2. Newly identified exposure characteristics

The majority of respondents (63%) identified the exposure situation/microenvironments as the reason their selections were a new emerging risk to health (see Table 1).

The respondents who chose to specify their answer on newly identified exposure characteristics highlighted various issues that future research should address.

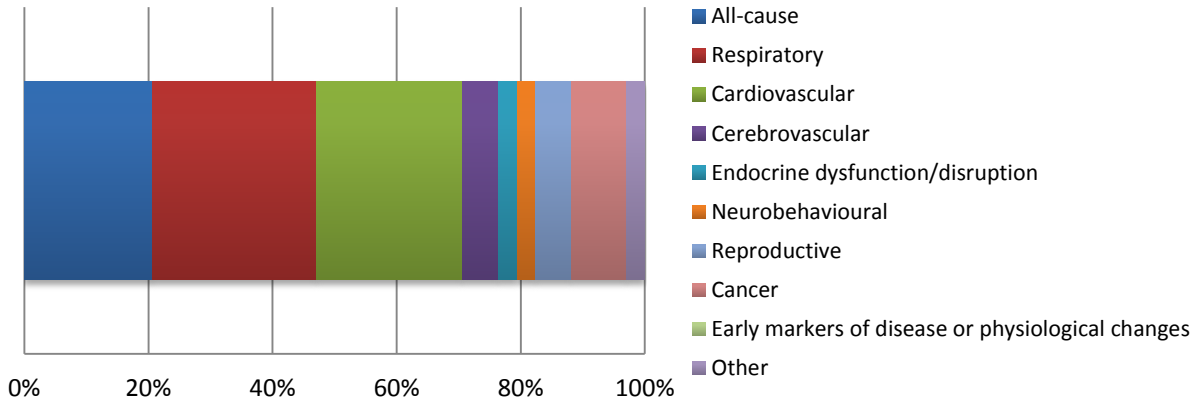
- Changes and shifts have occurred in fuel use as the price of fossil fuels rises: for example, use of biomass solid fuels – such as wood – for heating has increased as a result of climate policy and economic reasons (including the increased price of other fuels).
- Biomass (wood and peat) emits much more PM and PAHs per kJ of heat than many other fuels. In addition, a shift in fuel use may lead to an increase in BC and higher SOAs from VOCs and an increase in precursors of O_3.

3.3.3. Health effects, population characteristics and scale

The respondents highlighted the following health effects of concern associated with the space heating and air conditioning source category and its associated air pollutants (Fig. 14).

- Respiratory (26.5%), cardiovascular (23.5%) and all-cause (20.6%) health effects received the highest number of clicks.
- Respondents also pointed out that there are still gaps in understanding of the dose–effect relationship.

Fig. 14. Response rates for health effects of concern (space heating and air conditioning)

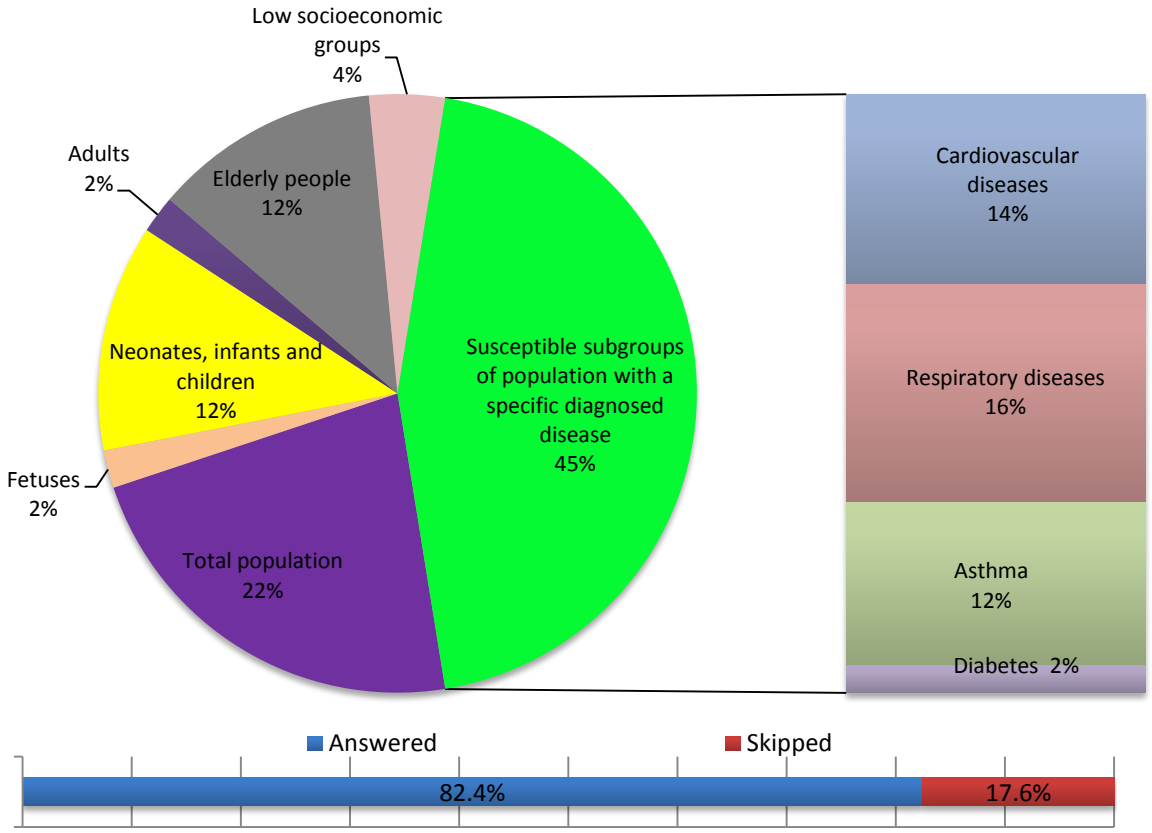


When asked about subgroups of population they considered vulnerable to exposure to space heating and air conditioning and their associated air pollutants, 22.4% of respondents identified the total population (Fig. 15).

The strongest signals for specific age groups emerged for neonates, infants and children (12.2%) and elderly people (12.2%). Subgroups of population with a specific diagnosed disease were selected by 44.9%:

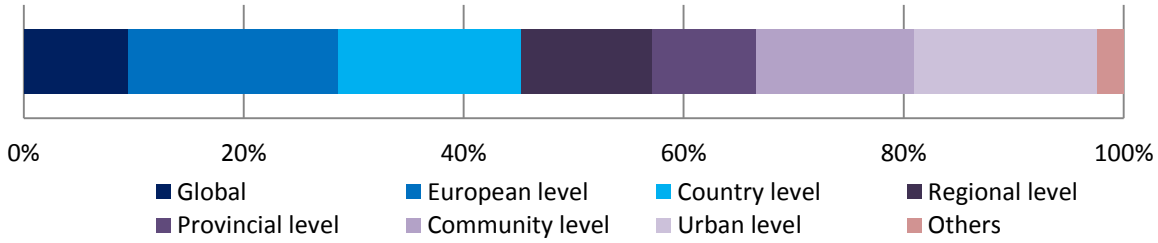
- respiratory diseases in general received 16.3% and asthma 12.2% of the total clicks;
- cardiovascular diseases in general received 14.3% and diabetes 2% of the total clicks.

Fig. 15. Response rates for vulnerable subgroups of population (space heating and air conditioning) and answering rate



A clear trend emerged regarding the geographic scale of the emerging issues: about 55% of the respondents identified the issues as affecting subgroups of population on a smaller geographic scale – from urban to regional levels (Fig. 16). One respondent also specifically pointed out that the issue affects rural populations as well.

Fig. 16. Response rates for geographic scale of the emerging issues (space heating and air conditioning)



Of the respondents rating the significance of the emerging risk's impact on health in a European context, 70% rated it as significant to very significant, assigning scores between 4 and 6 on a scale from 0 (insignificant) to 6 (very significant).

One respondent also pointed out that wood burning is an old problem, but understanding of its complexity and appreciation of the subsequent implications have only developed recently.

3.3.4. Knowledge gaps and driving forces of the emerging risks

In their answers to Question 9 on current knowledge gaps the respondents reiterated the areas requiring further research highlighted in the comment sections of various questions (Table 3). The results revealed very strong signals for three categories: ability to assess/measure the health effect, changes in exposure over time and personal exposure.

One respondent stressed in the comments section of the question the importance of addressing indoor as well as outdoor concentrations. Another comment highlighted the need to assess the real-life impact on air quality of stoves labelled "low emission".

Table 3. Knowledge gaps with respect to the emerging risks associated with space heating and air conditioning

Knowledge gap	Percentage of clicks
Ability to assess/measure the health effect	18.2
Biological mechanism of action	9.1
Exposure (general)	0.0
Concentration	13.6
Chemical and physical characteristics	4.5
Duration	9.1
Individual microenvironments	4.5
Changes over time	18.2
Assessed pollutant might act as a proxy	0.0
Personal exposure	18.2
Other not-yet-assessed health outcomes might be affected by the described source and/or air pollutant(s)	4.5

The main driving forces of the new emerging risks identified by the respondents were:

- socioeconomic factors (28% of the total number of clicks);
- political changes (24%);
- changes in behaviour of individuals (21%);
- technological changes (14%);
- societal changes (7%);
- other forces (7%).

In the comments section of the question respondents highlighted the impact of increasing fuel costs and climate change policies, and the subsequent move away from oil for space heating, combined with a lack of awareness of the impacts on air quality.

3.3.5. Recommendations to policy-makers

Question 11 of the survey asked the respondents whether they had any recommendations to make to policy-makers, based on their knowledge of the newly emerging risk described. This section outlines the recommendations made for the space heating and air conditioning source category.

Respondents recommended that policy-makers fund a research programme to finance studies on exposure and epidemiological studies on the health effects of biomass burning, in order to:

- improve knowledge on emissions of specific fuels;
- consider the role of indoor air quality, as many people spend more time indoors than outdoors;
- consider the health effects on the entire population from those households that choose to heat their homes by burning solid fuels (such as biomass or coal), because:
    - even if they use advanced stoves or heaters that keep smoke out of their house, the smoke from the fire is likely to contribute significantly to regional and local air pollution problems; and
    - open fireplaces also increase exposure to PM indoors.

One detailed recommendation was that policy-makers should assess the real-life impact on air quality of stoves labelled "low emission". Many Member States support biomass burning for domestic and residential heating as a way of recycling carbon dioxide (CO_2) and thereby abating greenhouse gas emissions, especially when certifying the climate or energy efficiency features of a building; indeed, some standards suggest that it offers a high level of energy efficiency. If highly incentivized in urban areas, however, this may lead to important air quality problems. The health effects of biomass burning emissions are well known and many countries qualify the efficiency labelling of stoves according to their emissions, but the efficiencies are difficult to monitor once in operation. An example of the possible future effects is currently discernible in Athens, where as a result of the financial crisis an increase in biomass burning is causing high levels of pollution.

The respondents also suggested that policy-makers consider:

- implementing measures restricting small-scale wood burning and the use of small-scale (<500kW) biomass boilers in residential areas;
- analysing policies that encourage the use of biofuels, and making it mandatory to assess both the impact on air quality and the emissions of health-relevant pollutants;
- including requirements around efficiencies of combustion equipment and combustion methods in all policies and measures that involve solid fuel to support the development of low-emission high-efficiency wood stoves (stoves that burn at a high temperature) as residential wood burning gains popularity for economic reasons;
- ensuring that legislative authorities take into consideration the fact that space heating using biomass is affected by two factors – not only the technical requirements at installation but also user behaviour;
- increasing public awareness campaigns on using fuel efficiently, communicating risks in order to promote the use of clean(er) combustion technologies – for example, not using wet wood – and introducing a technological improvement path (like the European emissions standards for vehicles).

3.4. Key source category 3: Shipping

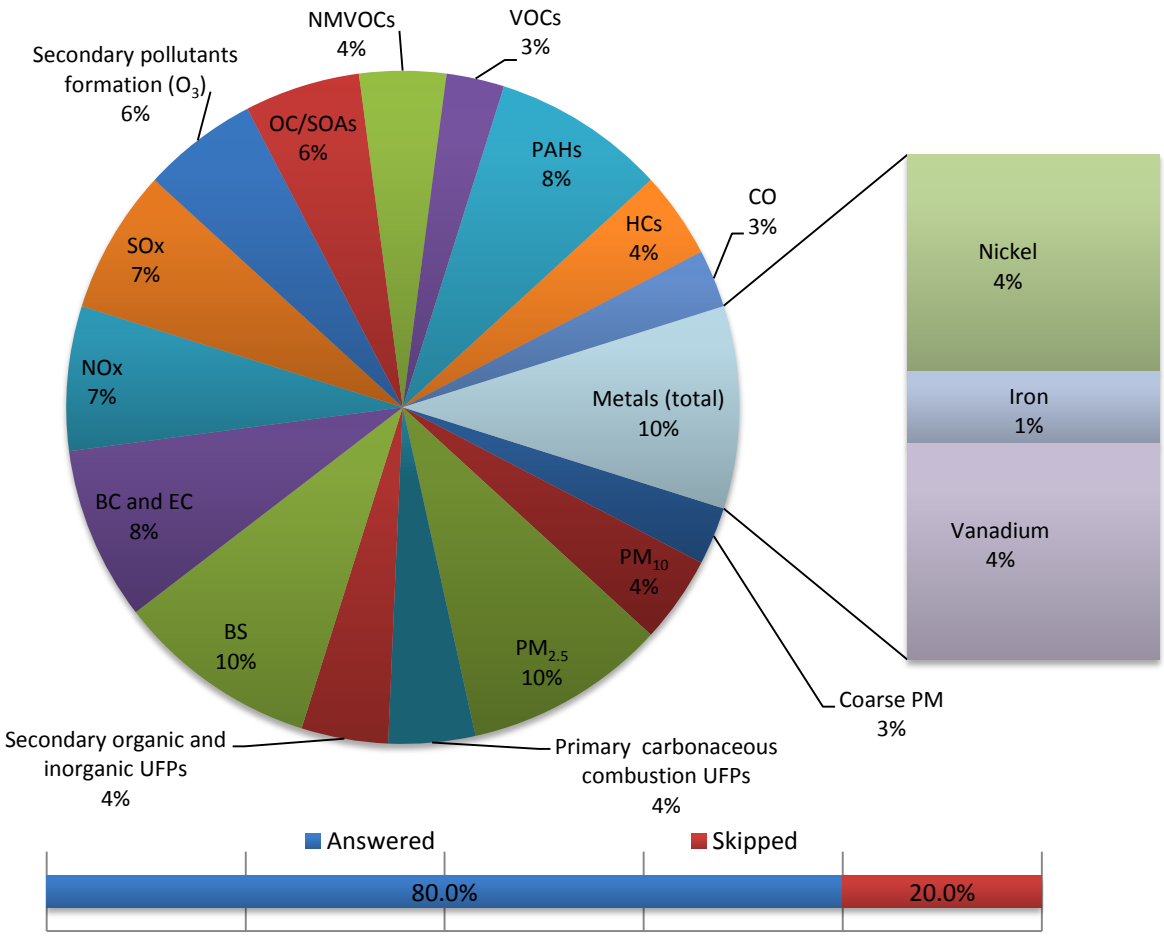
3.4.1. Ambient air pollutants of concern

10 of the 100 survey respondents identified shipping as associated with emerging health risks. One respondent also emphasized the importance of ship transport on rivers as a subcategory of the source.

The strongest signals in responses to air pollutants associated with the source category emerged for PM overall, BS and metals (Fig. 17):

- PM overall received 25% of the total number of clicks;
- its finer PM component subcategories – especially $PM_{2.5}$ (9.7%) and UFPs (total: 8.4%) – received the majority of these;
- BS received 9.7% of the total number of clicks;
- metals overall also received 9.7% of the total number of clicks, with vanadium (4.2%) and nickel (4.2%) receiving the majority.

Fig. 17. Response rates for ambient air pollutants that pose a health risk from shipping and answering rate



3.4.2. Newly identified exposure characteristics

The majority of respondents identified one of two characteristics as reasons their selections were a new emerging risk to health: a new property of ambient air pollutant(s) of concern or other issues (see Table 1). The other issues specified included:

- the growth of shipping as a source of pollution;
- the source's pervasiveness;
- the possible impact of metal emissions from shipping on health and their influence on UFP;
- the fact that the motors of river transport boats and seagoing ships use low quality or polluted fuel, and are not designed to prevent pollution.

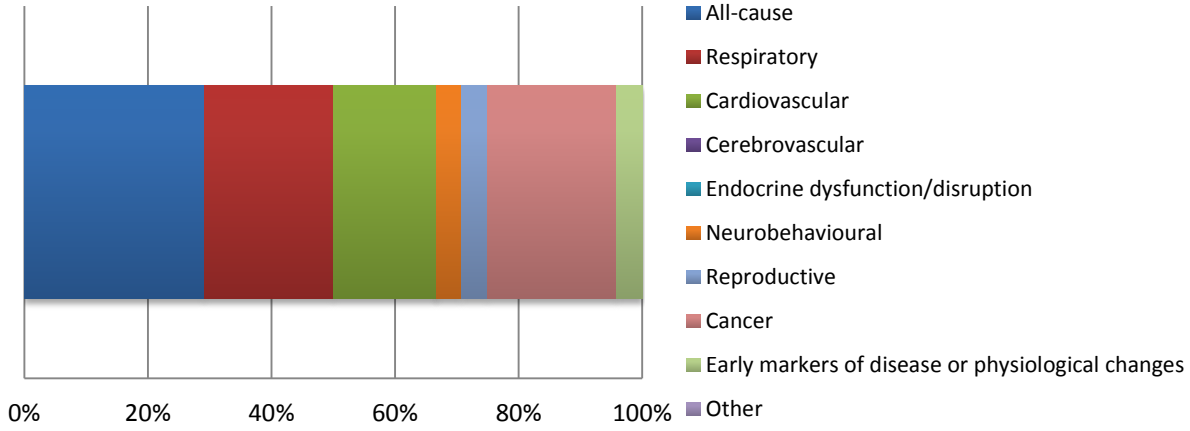
Regarding the exposure situation/microenvironments characteristic, respondents highlighted the lack of strong characterization for both emissions and exposure.

3.4.3. Health effects, population characteristics and scale

The respondents highlighted the following health effects of concern associated with the shipping source category and its associated air pollutants (Fig. 18).

- All-cause (29.2%) and respiratory (20.8%) health effects and cancer (20.8%) received the highest number of clicks.

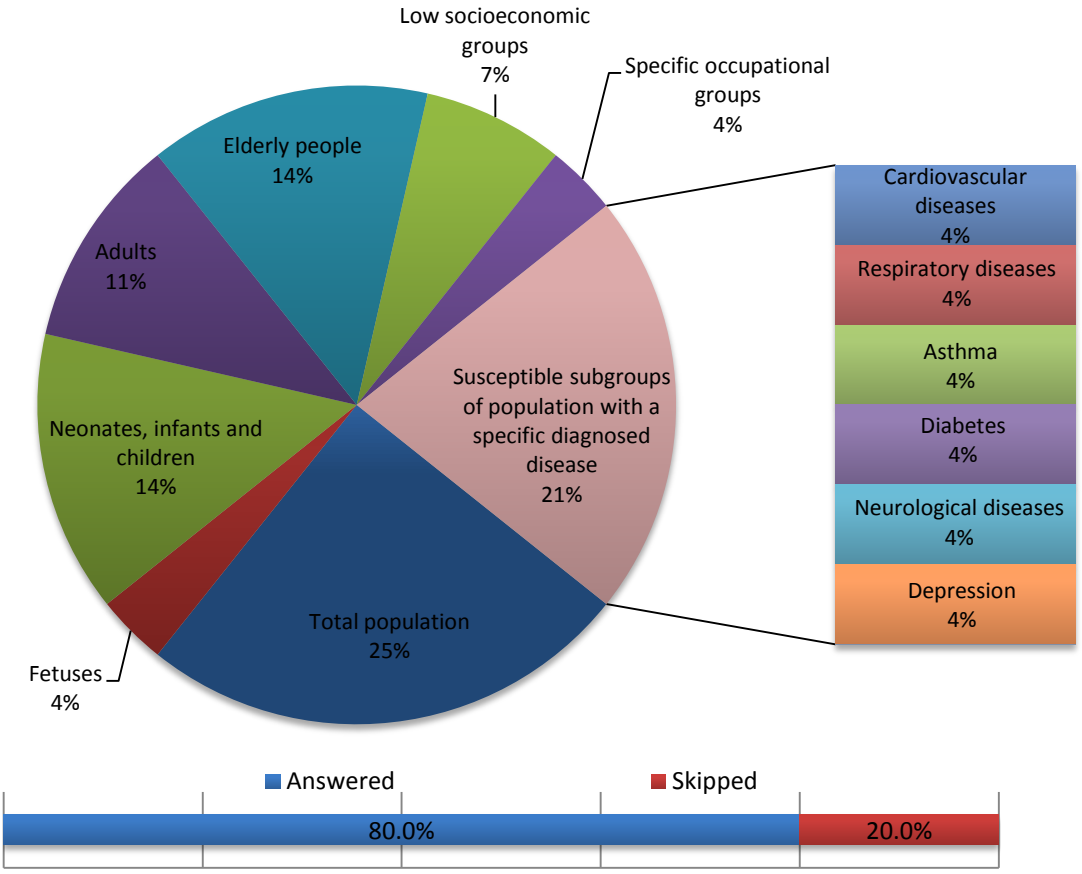
Fig. 18. Response rates for health effects of concern (shipping)



When asked about subgroups of population they considered vulnerable to exposure to shipping and its associated air pollutants, 25% of respondents identified the total population (Fig. 19).

The number of clicks was evenly balanced among the specific age groups neonates, infants and children (14.3%), adults (10.7) and elderly people (14.3%). Subgroups of population with a specific diagnosed disease were selected by 21.4% and the identification of specific disease groups and diseases also received an even spread of total clicks.

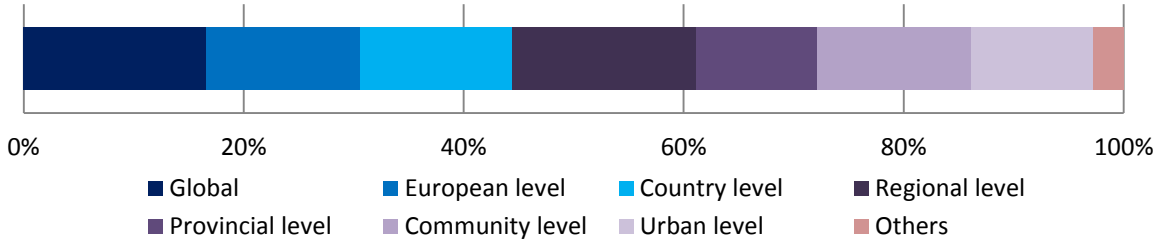
Fig. 19. Response rates for vulnerable subgroups of population (shipping) and answering rate



A clear trend emerged regarding the geographic scale of the emerging issues: about 55% of the respondents identified the issues as affecting subgroups of population on a smaller geographic scale – from urban to regional levels (Fig. 20).

Respondents again emphasized that the emerging issues caused by shipping emissions are strongest in locations near harbours and rivers (primary), but that it must be borne in mind that emissions also contribute to background levels.

Fig. 20. Response rates for geographic scale of the emerging issues (shipping)



Of the respondents rating the significance of the emerging risk's impact on health in a European context, 50% rated it as significant to very significant, assigning scores between 4 and 6 on a scale from 0 (insignificant) to 6 (very significant). Reasons for this relatively low

proportion may include (i) the low response rate overall and the low number of respondents selecting shipping as a source category associated with an emerging risk to human health and/or (ii) the very localized nature of the risk, which is highest in cities with ports, and thus might not be applicable, depending on the geographic location of an individual population.

3.4.4. Knowledge gaps and driving forces of the emerging risks

In their answers to Question 9 on current knowledge gaps the respondents reiterated the areas requiring further research highlighted in the comment sections of various questions (Table 4). The results revealed very strong signals for two categories: ability to assess/measure the health effect and chemical and physical characteristics of pollutant exposure.

One respondent stressed in the comments section of the question the importance of assessing the real-life impact on future air quality of UFPs arising from shipping. Another comment emphasized that shipping emissions are not to date part of standard exposure models and may therefore be underestimated.

Table 4. Knowledge gaps with respect to the emerging risks associated with shipping

Knowledge gap	Percentage of clicks
Ability to assess/measure the health effect	20.7
Biological mechanism of action	13.8
Exposure (general)	6.9
Concentration	10.3
Chemical and physical characteristics	13.8
Duration	3.4
Individual microenvironments	3.4
Changes over time	6.9
Assessed pollutant might act as a proxy	3.4
Personal exposure	10.3
Other not-yet-assessed health outcomes might be affected by the described source and/or air pollutant(s)	6.9

The main driving forces of the new emerging risks identified by the respondents were:

- societal changes (25% of the total number of clicks);
- socioeconomic factors (25%);
- technological changes (20%);
- political changes (20%);
- changes in behaviour of individuals (5%);
- other forces (5%).

In the comments section of the question one respondent highlighted the unwillingness to ban bunker fuels for shipping.

3.4.5. Recommendations to policy-makers

Question 11 of the survey asked the respondents whether they had any recommendations to make to policy-makers, based on their knowledge of the newly emerging risk described. This section outlines the recommendations made for the shipping source category.

Respondents recommended that policy-makers support and initiate research on exposure to shipping emissions and the resultant health effects. They emphasized that the impact of shipping emissions on air quality will increase in significance for two major reasons.

- Regional background levels of vanadium and nickel are relatively high, especially surrounding the Mediterranean basins; this is mostly attributable to intense shipping emissions. Since industrial emissions are well monitored and controlled these emissions will gain relative relevance.
- Emission abatement measures have yielded (and will yield) reductions in PM levels. As the environment becomes cleaner the chances of nucleation episodes (new particle formation from gas to UFP) occurring grow, with increases of <20 nanometre-sized UFP. According Kulmala et al. (2004) the conversion of sulphur dioxide into sulphuric acid is the main cause of nucleation episodes, but this mostly occurs in clean atmospheres: in highly polluted environments condensation on the surface of existing particles prevails over new particle formation. In urban areas with harbours, sulphur dioxide emissions from shipping are already the cause of nucleation bursts (Reche et al., 2011). The health impact of such nano-particle pollution episodes is unknown but may be relevant. Once the nano-particle forms, it grows fast by condensation of VOCs such as hydrocarbons.

The respondents also suggested that policy-makers consider the following joint actions for Europe:

- supporting further research into “dirty” fuel use and implementing legislation to reduce it;
- supporting research and technological innovations concerning motors for river boats.

3.5. Key source category 4: Energy production and distribution

3.5.1. Ambient air pollutants of concern

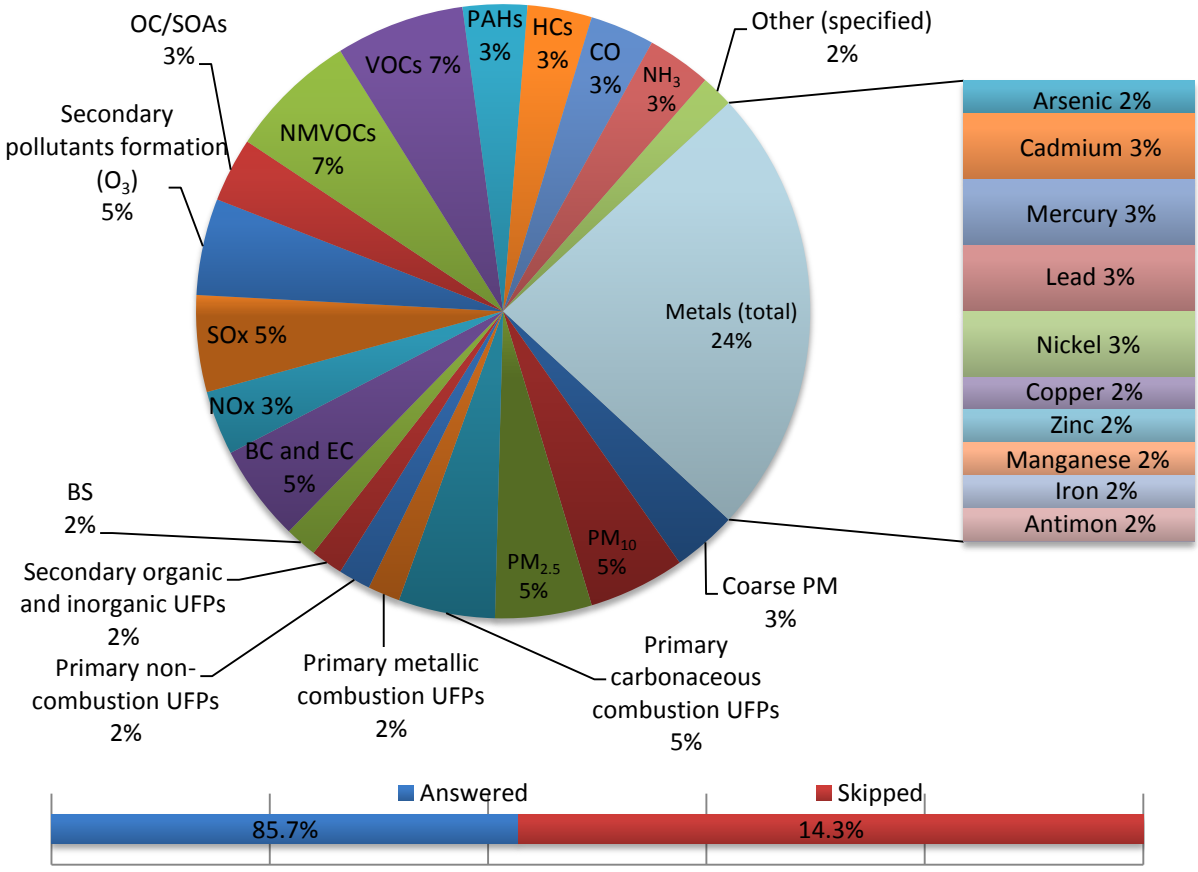
7 of the 100 survey respondents identified energy production and distribution as associated with emerging health risks.

The strongest signals in responses to air pollutants associated with the source category emerged for metals and PM overall (Fig. 21):

- metals overall received 23.7% of the total number of clicks;
- respondents identified a whole array of individual metals but none was especially prominent, each receiving about 2–3% of the total number of clicks;
- PM overall received 23.7% of the total number of clicks;
- none of the PM subcategories received significantly more clicks than the others.

In addition, one respondent identified an emerging risk from bioaerosols (airborne biological agents) associated with this source category.

Fig. 21. Response rates for ambient air pollutants that pose a health risk from energy production and distribution and answering rate



3.5.2. Newly identified exposure characteristics

The majority of respondents identified one of two characteristics as reasons their selections were a new emerging risk to health: the exposure situation/microenvironments or other issues (see Table 1). The other issues specified included:

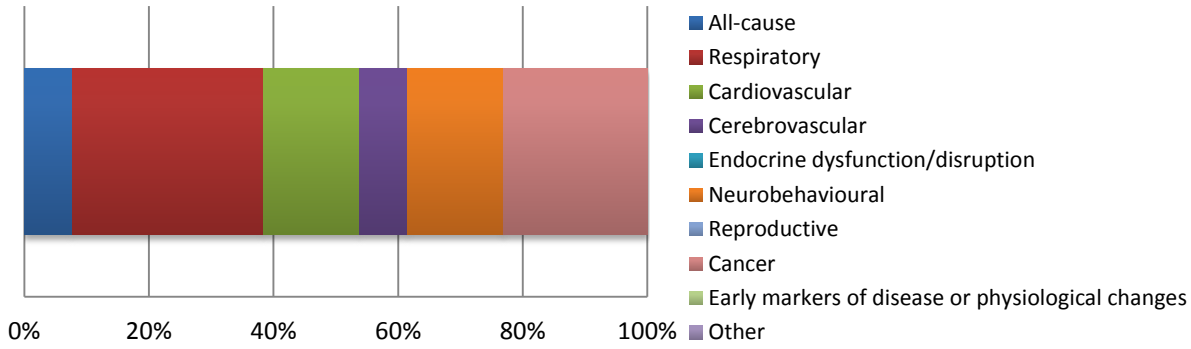
- expanding use of the extracted fuel;
- the extraction processes themselves, on which little information exists to date.

3.5.3. Health effects, population characteristics and scale

The respondents highlighted the following health effects of concern associated with the energy production and distribution source category and its associated air pollutants (Fig. 22).

- Respiratory health effects (30.8%), cancer (23.1%) and cardiovascular and neurobehavioural health effects (15.4% each) received the highest number of clicks.
- One respondent also pointed out that the health effects related to this source category and its emitted air pollutants are largely unknown, and that future research should be undertaken to address these gaps in knowledge. Increasing demand has led to the development and implementation of new, but little or no information on exposures and health risks is yet available.

Fig. 22. Response rates for health effects of concern (energy production and distribution)

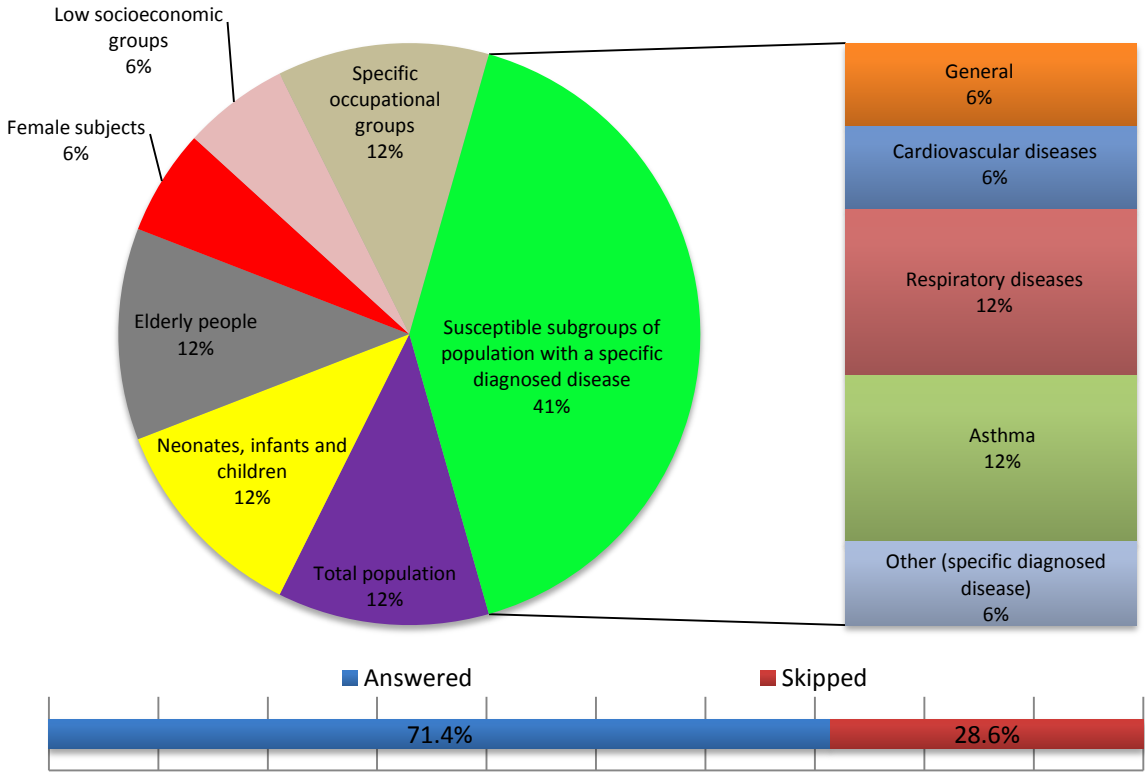


When asked about subgroups of population they considered vulnerable to exposure to energy production and distribution and its associated air pollutants, 12% of respondents identified the total population (Fig. 23).

The number of clicks was evenly balanced among the specific age groups neonates, infants and children and elderly people (11.8% each). Subgroups of population with a specific diagnosed disease were selected by 41.2%:

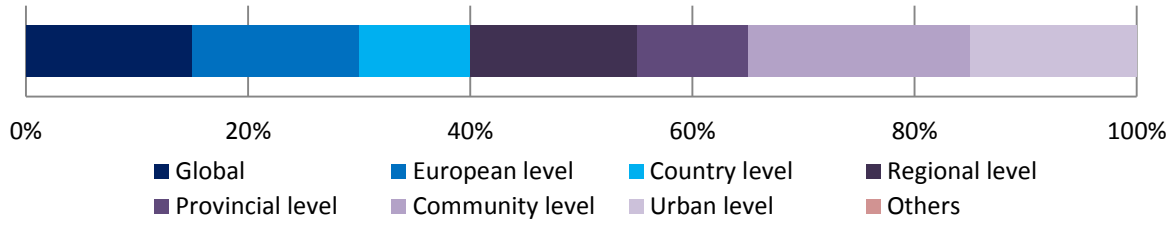
- respiratory diseases in general and asthma received 11.8% each.

Fig. 23. Response rates for vulnerable subgroups of population (energy production and distribution) and answering rate



A clear trend emerged regarding the geographic scale of the emerging issues: over 60% of the respondents identified the issues as affecting subgroups of population on a smaller geographic scale – from urban to regional levels (Fig. 24).

Fig. 24. Response rates for geographic scale of the emerging issues (energy production and distribution)



All the respondents rating the significance of the emerging risk's impact on health in a European context rated it as of medium significance, assigning scores between 3 and 4 on a scale from 0 (insignificant) to 6 (very significant). Respondents again highlighted the need for further research in the comments section of the question, as much of the health impact and hence the significance of the emerging health risk is still unknown.

3.5.4. Knowledge gaps and driving forces of the emerging risks

In their answers to Question 9 on current knowledge gaps the respondents reiterated the areas requiring further research highlighted in the comment sections of various questions (Table 5). The results revealed very strong signals for four categories: ability to assess/measure the health effect, exposure concentration, assessed pollutant might act as a proxy and personal exposure.

Table 5. Knowledge gaps with respect to the emerging risks associated with energy production and distribution

Knowledge gap	Percentage of clicks
Ability to assess/measure the health effect	19.0
Biological mechanism of action	4.8
Exposure (general)	0.0
Concentration	14.3
Chemical and physical characteristics	4.8
Duration	9.5
Individual microenvironments	9.5
Changes over time	9.5
Assessed pollutant might act as a proxy	14.3
Personal exposure	14.3
Other not-yet-assessed health outcomes might be affected by the described source and/or air pollutant(s)	0.0

The main driving forces of the new emerging risks identified by the respondents were:

- political changes (38% of the total number of clicks);
- technological changes (25%);
- socioeconomic factors (25%);
- changes in behaviour of individuals (13%).

3.5.5. Recommendations to policy-makers

Question 11 of the survey asked the respondents whether they had any recommendations to make to policy-makers, based on their knowledge of the newly emerging risk described. This section outlines the recommendations made for the energy production and distribution source category.

Respondents recommended that policy-makers:

- extend monitoring programmes spatially and by species;
- apply the precautionary principle when faced with policy options on fracking (horizontal hydraulic fracturing to recover oil and natural gas).

3.6. Key source category 5: Industrial processes (metal industries)

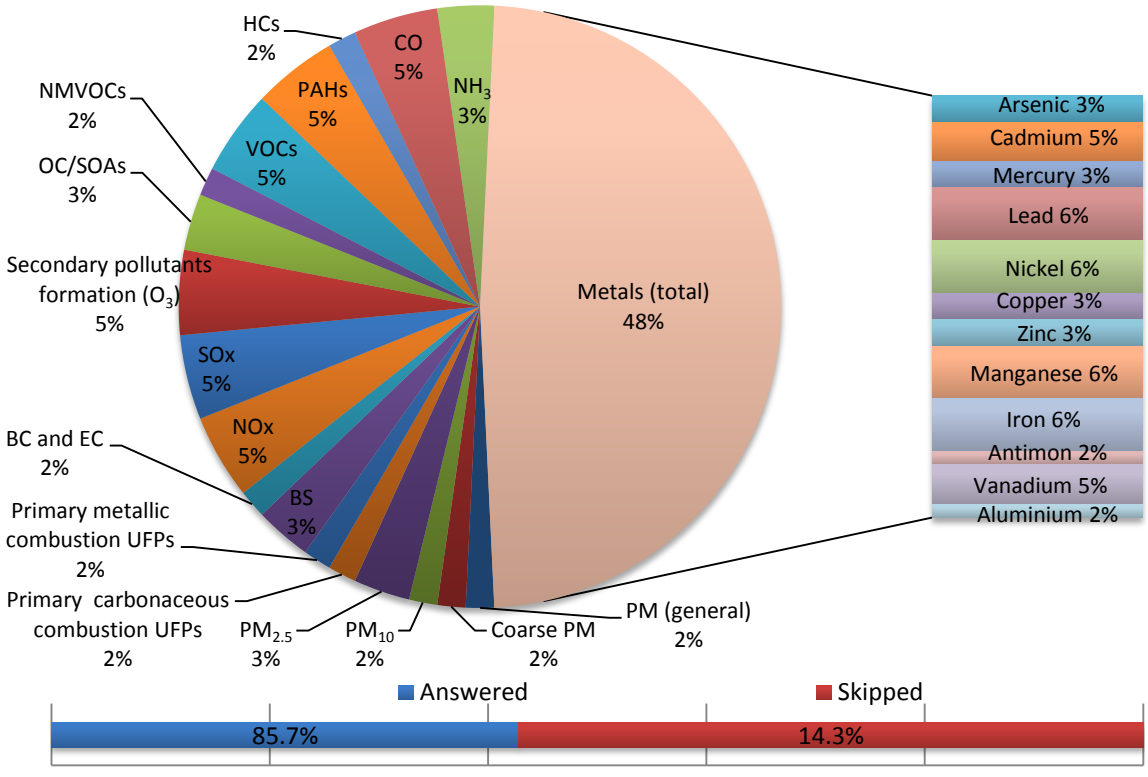
3.6.1. Ambient air pollutants of concern

7 of the 100 survey respondents identified industrial processes (metal industries) as associated with emerging health risks.

The strongest signal in responses to air pollutants associated with the source category emerged for metals (Fig. 25):

- metals overall received almost 50% of the total number of clicks;
- respondents identified a whole array of individual metals but none was especially prominent, each receiving about 2–6% of the total number of clicks.

Fig. 25. Response rates for ambient air pollutants that pose a health risk from industrial processes (metal industries) and answering rate



One respondent further specified that ferroalloy production is an emission source of particular concern.

3.6.2. Newly identified exposure characteristics

The majority of respondents (80%) identified the exposure situation/microenvironments as the reason their selections were a new emerging risk to health (see Table 1).

The respondents who chose to specify their answer on newly identified exposure characteristics highlighted one issue that future research should address:

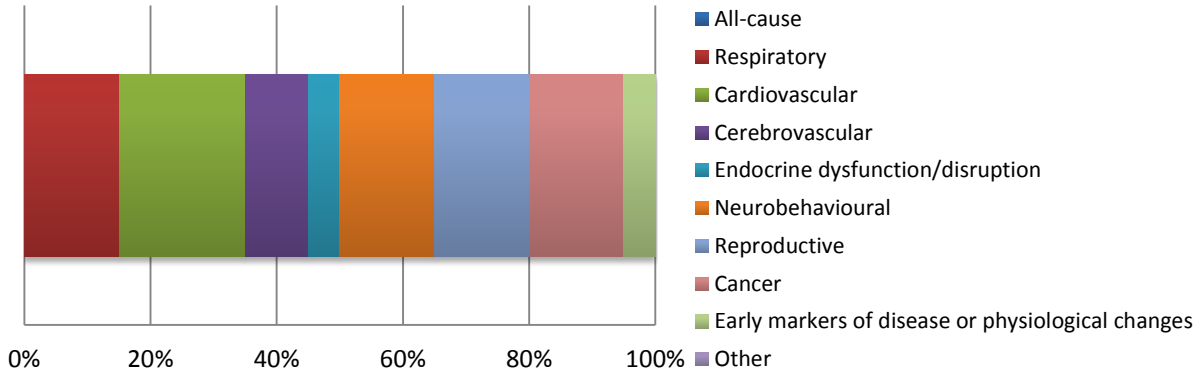
- the current lack of an efficient air quality monitoring system for pollutants of concern.

3.6.3. Health effects, population characteristics and scale

The respondents highlighted the following health effects of concern associated with the industrial processes (metal industries) source category and its associated air pollutants (Fig. 26).

- Cardiovascular health effects (20%), cancer (for example, effects on the immune system) and respiratory, neurobehavioural (for example, neurodegeneration leading to parkinsonism) and reproductive health effects (15% each) received the highest number of clicks.

Fig. 26. Response rates for health effects of concern (industrial processes (metal industries))



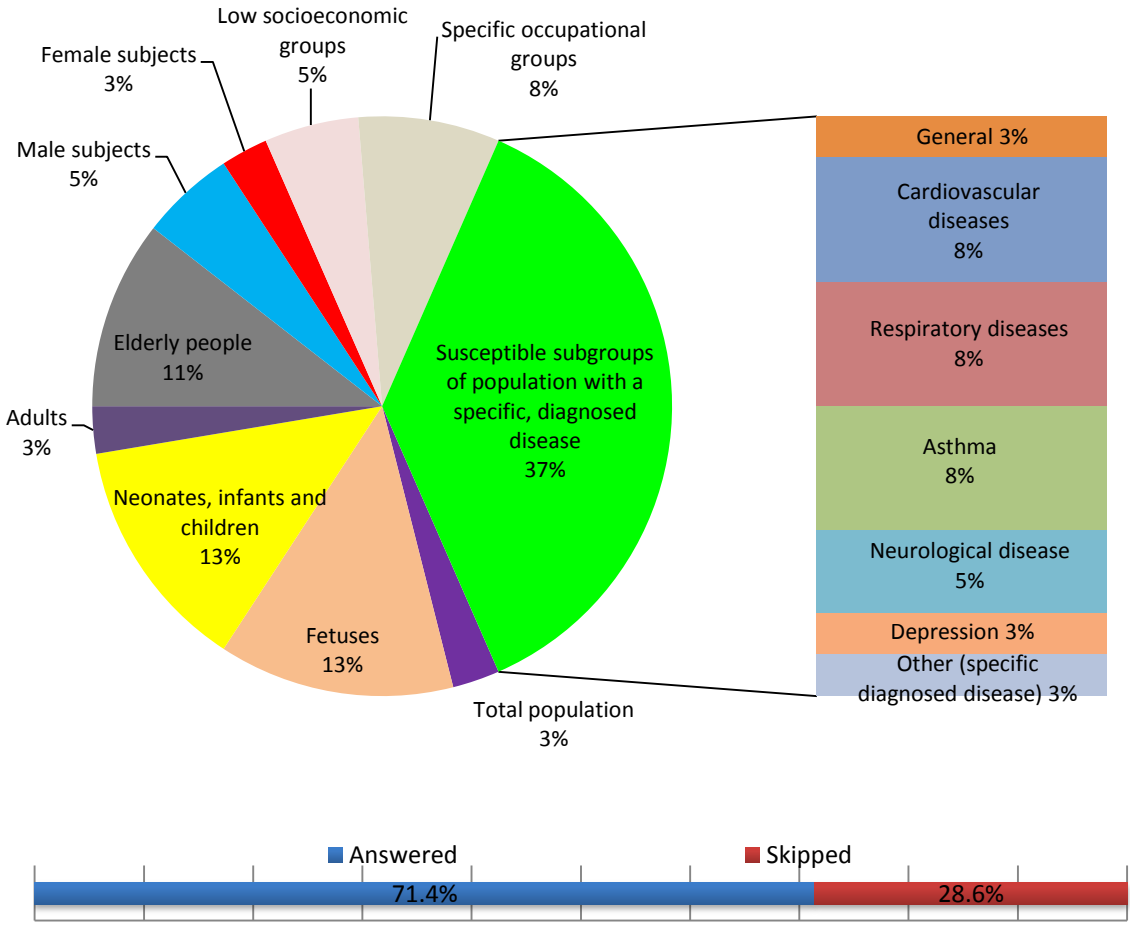
When asked about subgroups of population they considered vulnerable to exposure to industrial processes (metal industries) and its associated air pollutants, 2.6% of respondents identified the total population (Fig. 27).

The strongest signals for specific age groups emerged for neonates, infants and children and foetuses (13.2% each) and elderly people (10.5%). Subgroups of population with a specific diagnosed disease were selected by 36.8%:

- cardiovascular diseases in general received 7.9% of the total clicks;
- respiratory diseases in general and asthma received 7.9% each of the total clicks;
- neurological diseases in general received 5.3% and depression 2.6%.

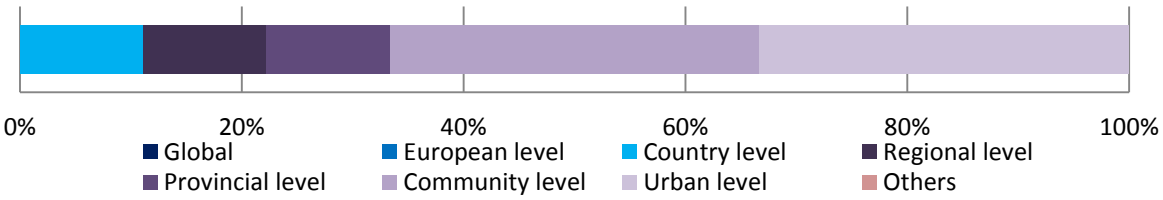
In the comments section of the question one respondent highlighted liver diseases as an area of concern that future research should address.

Fig. 27. Response rates for vulnerable subgroups of population (industrial processes (metal industries)) and answering rate



A clear trend emerged regarding the geographic scale of the emerging issues: about 90% of the respondents identified the issues as affecting subgroups of population on a smaller geographic scale, predominantly from urban to community levels (Fig. 28).

Fig. 28. Response rates for geographic scale of the emerging issues (industrial processes (metal industries))



All the respondents rating the significance of the emerging risk's impact on health in a European context rated it as of medium-low to medium significance, assigning scores between 2 and 3 on a scale from 0 (insignificant) to 6 (very significant). Again, respondents highlighted the need for further research in the comments section of the question, stating that while the health effects appear evident, their public health significance is unclear.

3.6.4. Knowledge gaps and driving forces of the emerging risks

In their answers to Question 9 on current knowledge gaps the respondents reiterated the areas requiring further research highlighted in the comment sections of various questions (Table 6). The results revealed very strong signals for four categories: ability to assess/measure the health effect, exposure duration, changes in exposure over time and personal exposure.

In the comments section of the question one respondent emphasized the need to assess the dose–response relationship for adults and children.

Table 6. Knowledge gaps with respect to the emerging risks associated with industrial processes (metal industries)

Knowledge gap	Percentage of clicks
Ability to assess/measure the health effect	13.6
Biological mechanism of action	9.1
Exposure (general)	0.0
Concentration	9.1
Chemical and physical characteristics	9.1
Duration	13.6
Individual microenvironments	9.1
Changes over time	13.6
Assessed pollutant might act as a proxy	9.1
Personal exposure	13.6
Other not-yet-assessed health outcomes might be affected by the described source and/or air pollutant(s)	0.0

The main driving forces of the new emerging risks identified by the respondents were:

- technological changes (36% of the total number of clicks);
- political changes (18%);
- socioeconomic factors (18%);
- changes in behaviour of individuals (9%);
- societal changes (9%);
- other forces (9%).

3.6.5. Recommendations to policy-makers

Question 11 of the survey asked the respondents whether they had any recommendations to make to policy-makers, based on their knowledge of the newly emerging risk described. This section outlines the recommendations made for the industrial processes (metal industries) source category.

Respondents recommended that policy-makers:

- increase research funding in order to conduct more population studies to see the connections between health risks and air pollution;

- improve public health management by implementing human health risk assessment methodology, starting at the local level in every country;
- implement remediation policies.

3.7. Key source category 6: Agriculture

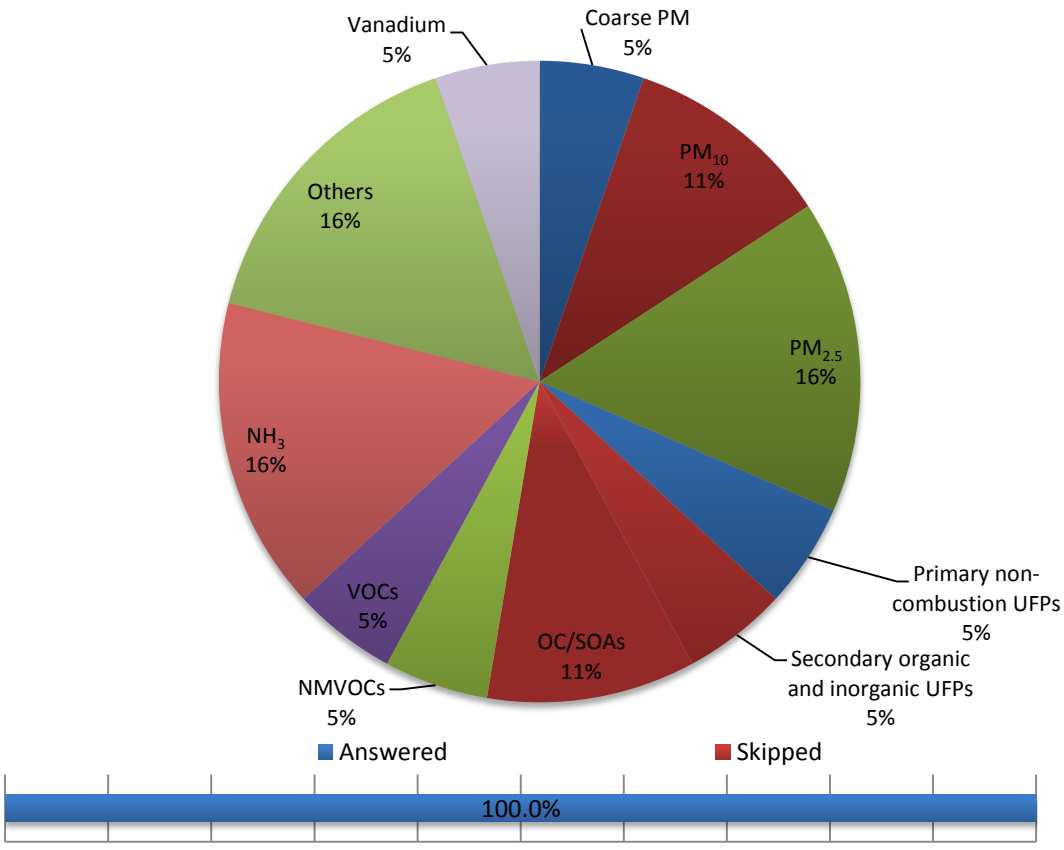
3.7.1. Ambient air pollutants of concern

6 of the 100 survey respondents identified agriculture as associated with emerging health risks.

The strongest signals in responses to air pollutants associated with the source category emerged for PM, NH_3 and other air pollutants (Fig. 29):

- PM overall received almost 42.9% of the total number of clicks;
- its finer PM component subcategories – especially $PM_{2.5}$ (15.8%) and UFPs (total: 10.6%) – received the majority of these;
- NH_3 received 16% of the total number of clicks;
- other air pollutants of concern (16%) identified by the respondents included:
    - viruses;
    - bioaerosols – bacteria, microbial compounds and other biological materials;
    - toxic chemicals (pesticides and other chemicals to protect plants).

Fig. 29. Response rates for ambient air pollutants that pose a health risk from agriculture and answering rate



3.7.2. Newly identified exposure characteristics

The majority of respondents (56%) identified the exposure situation/microenvironments as the reason their selections were a new emerging risk to health (see Table 1).
The respondents who chose to specify their answer on newly identified exposure characteristics highlighted several issues that future research should address:

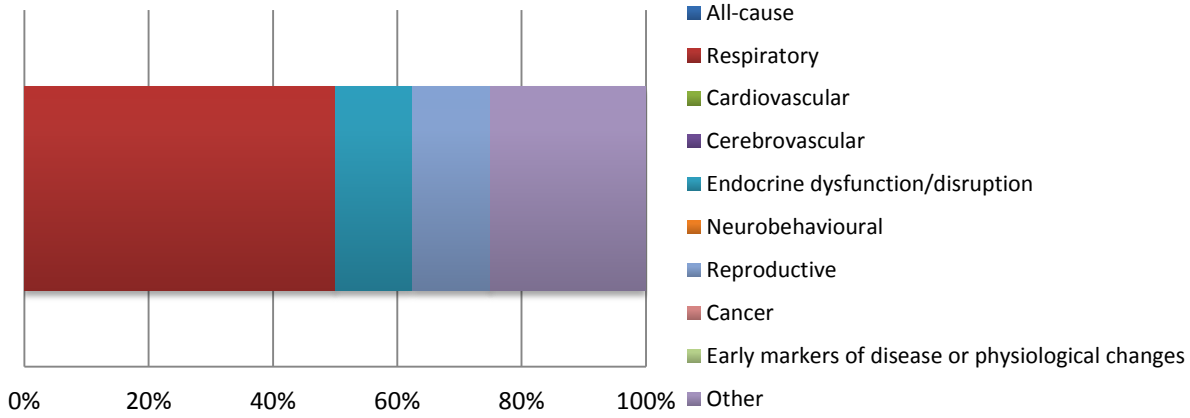
- microbial compounds attached to PM;
- biological agents that can combine and form new properties and hence a new exposure situation from air pollution, animals, manure, and so on – agents can cause illnesses (zoonoses) and substances can cause allergies;
- the different policies among EU Member States, which lead to huge differences in exposure;
- the effects of pesticides on residents caused by exposure without protection;
- the issue of all nitrogen deposition rather than just the direct health effects due to NH_3.

3.7.3. Health effects, population characteristics and scale

The respondents highlighted the following health effects of concern associated with the agriculture source category and its associated air pollutants (Fig. 30).

- Respiratory health effects received the highest number of clicks (50%).
- Other health effects (25%) specified included new illnesses and infectious diseases such as zoonoses and Q fever.
- All-cause and reproductive health effects and health effects due to endocrine dysfunction/ disruption received 12.5% each.
- In addition, one respondent pointed out that much is still unknown about unintended exposure as most studies of chemicals focus on their use in work situations. Future research should therefore address this issue.

Fig. 30. Response rates for health effects of concern (agriculture)

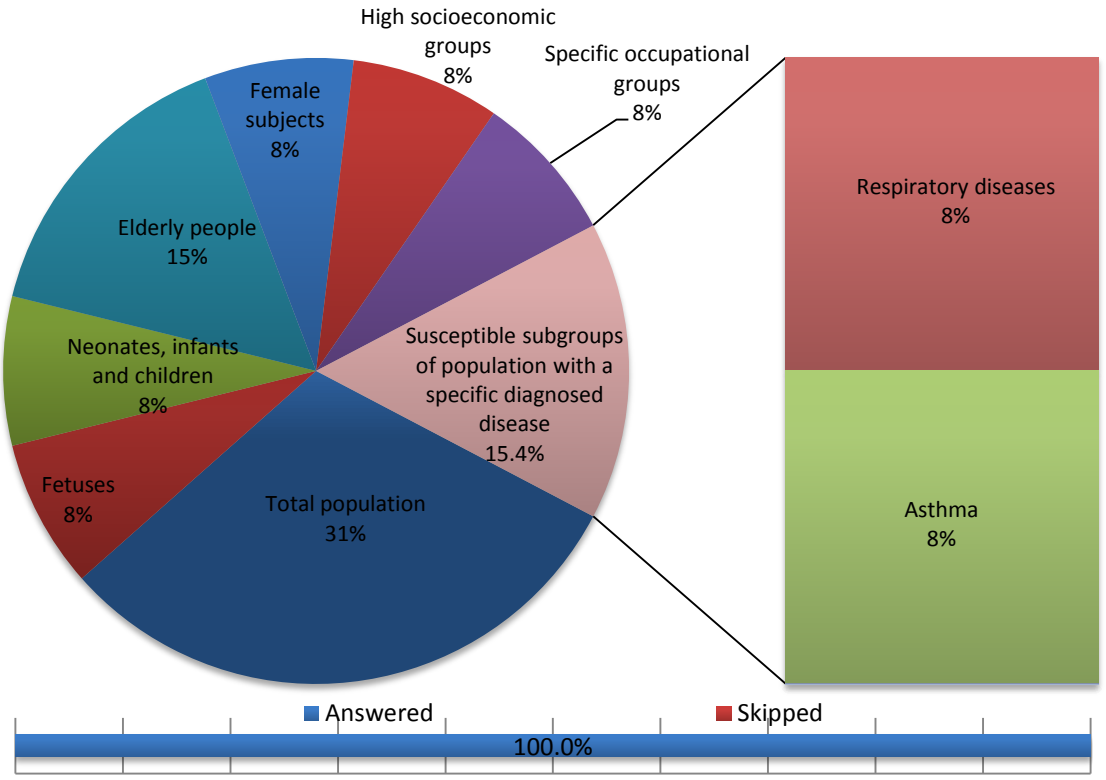


When asked about subgroups of population they considered vulnerable to exposure to agriculture and its associated air pollutants, 30.8% of respondents identified the total population (Fig. 31).

The strongest signals for specific age groups emerged for elderly people (15.4%) neonates, infants and children and fetuses (7.7% each). Subgroups of population with a specific diagnosed disease were selected by 15.4%:

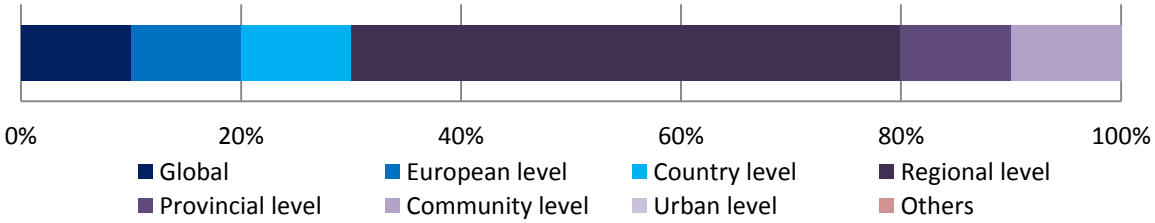
- respiratory diseases in general and asthma each received 7.7% of the total clicks.

Fig. 31. Response rates for vulnerable subgroups of population (agriculture) and answering rate



A clear trend emerged regarding the geographic scale of the emerging issues: 70% of the respondents identified the issues as affecting subgroups of population on a smaller geographic scale, with the majority selecting the regional level (Fig. 32).

Fig. 32. Response rates for geographic scale of the emerging issues (agriculture)



In the comments section of the question one respondent pointed out that most evidence comes from Europe and North America, but some is also now available from other continents; this shows that the problem is mostly an urban or regional one, especially (for example) in regions where a lot of pesticides are used, such as in bulb farming areas.

All the respondents rating the significance of the emerging risk's impact on health in a European context rated it as of medium significance to significant, assigning scores between 3 and 5 on a scale from 0 (insignificant) to 6 (very significant).

Respondents further highlighted the fact that the risk associated with the agriculture source category is rather small on a European scale, but could easily spread and have a large impact. They also pointed out that much is unknown about some of the identified risks associated with agriculture – for example, with respect to infectious diseases such as Q fever – and how they affect people living or staying in an area with a density of high livestock.

3.7.4. Knowledge gaps and driving forces of the emerging risks

In their answers to Question 9 on current knowledge gaps the respondents reiterated the areas requiring further research highlighted in the comment sections of various questions (Table 7). The results revealed very strong signals for six categories: ability to assess/measure the health effect, exposure concentration, biological mechanisms of action, exposure duration, exposure in individual microenvironments and personal exposure.

Table 7. Knowledge gaps with respect to the emerging risks associated with agriculture

Knowledge gap	Percentage of clicks
Ability to assess/measure the health effect	18.8
Biological mechanism of action	12.5
Exposure (general)	0.0
Concentration	18.8
Chemical and physical characteristics	6.3
Duration	12.5
Individual microenvironments	12.5
Changes over time	6.3
Assessed pollutant might act as a proxy	0.0
Personal exposure	12.5
Other not-yet-assessed health outcomes might be affected by the described source and/or air pollutant(s)	0.0

The main driving forces of the new emerging risks identified by the respondents were:

- societal changes (31% of the total number of clicks);
- technological changes (31%);
- political changes (15%);
- socioeconomic factors (15%);
- changes in behaviour of individuals (8%).

3.7.5. Recommendations to policy-makers

Question 11 of the survey asked the respondents whether they had any recommendations to make to policy-makers, based on their knowledge of the newly emerging risk described. This section outlines the recommendations made for the agriculture source category.

Respondents recommended that policy-makers:

- support and initiate more research to assess the possible health risks of allowing a high density of livestock close to inhabited areas;
- enforce regulations concerning the density of livestock, including ensuring lower concentrations of large amounts of livestock;
- enforce regulations that protect residents from pesticide drift;
- improve the consideration of NH_3 exceedances in policies by establishing an international agricultural policy.

4. Discussion

4.1. Emission source categories

The findings of this report highlight the complexity of the (newly) identified and emerging issues surrounding risks to human health. They also show that research is needed to provide reliable information and tools for policy formulation in order to address a wide range of emission sources and related air pollutants in a consistent way.

The finding that respondents identified road transport as the major air pollution source affecting health in Europe is consistent with the results of the recently published REVIHAAP report (WHO, 2013). It should be noted, however, that consistency with the REVIHAAP report findings might arise partly from the fact that the REVIHAAP experts and external reviewers constituted part of the target audience for this survey.

The results of the Eurobarometer survey on attitudes of Europeans towards air quality, which interviewed 25 525 European citizens, showed a clear trend that respondents perceived industrial activities (71%) and transport activities (63%) as the main threats to air quality in their countries (EC, 2013a). Several of the key source categories identified as associated with emerging risks to health – namely, the road transport, shipping, agriculture and small/medium combustion sectors – were thematically addressed by targeted questions in a European Commission consultation to gather experts' and stakeholders' views on the review of the EU's Thematic Strategy on Air Pollution and related policies (EC, 2013b). This consultation's respondents expressed concern about the risks associated with those source categories; the resulting recommendations for policy-makers are generally consistent with the recommendations made by respondents to the HRAPIE survey.

4.2. Pollutants (including gases and constituents of PM)

The findings show that difficulties exist in choosing the "right" metric(s) to describe exposure to UFPs, as highlighted by a number of respondents throughout the survey, especially in relation to road transport. This is consistent with issues discussed by Kuhlbusch (2013), who emphasized that traffic is the major emission source with respect to nano-scale particles, UFPs and nano-particles, and pointed out that while measurement techniques are available, standards are needed for non-regulated compounds.

The HRAPIE survey respondents felt that bioaerosols are an emerging risk associated with various emission source categories (including agriculture, natural sources, and energy production and distribution) and suggested that these might warrant treatment as a separate

source category. This is consistent with observations by Szewzyk (2013), who highlighted a clear issue with respect to bioaerosols: in contrast to the case of other air pollutants, there is no dose–response relationship, so implementation of a limit value is not feasible.

The respondents' concern about the emerging risk from a shift in fuel usage – the increased use of biomass solid fuels such as wood for heating due to climate policy and economic reasons – is consistent with observations by Pfeffer et al. (2013). It also tallies with comments made by experts and stakeholders participating in the European Commission consultation on the EU's Thematic Strategy on Air Pollution and related policies (EC, 2013b).

4.3. Health outcomes and exposure

The main health outcomes affected by the emerging sources and corresponding pollutants identified by the participating stakeholders and experts included all-cause, cardiovascular and respiratory health effects, cancer, neurobehavioural and reproductive health effects and health effects due to endocrine dysfunction/disruption.

The findings of the HRAPIE survey underscore the need for future research activities to investigate various different aspects of the emerging risks identified. These include:

- individual sources – for example, examining the consequences of an increase in prevalence of specific sources (such as biomass solid fuel use for space heating) and the subsequent growth in the size of population exposed;
- associated air pollutants, such as emerging pollutants – for example, engineered nano-particles and the metal content of PM;
- their impact on various health outcomes.

In addition, the survey results underline the importance of assessing both the overall health impact on the whole population and the individual impact on vulnerable subgroups.

Current knowledge gaps requiring further research into the emerging risks to health identified through the HRAPIE survey include exposure in general and its subcategories (such as personal exposure, pollutant concentrations and individual microenvironments). These findings are broadly consistent with the critical data gaps highlighted in the REVIHAAP report (WHO, 2013).

Throughout the survey respondents highlighted the complex pollutant mixture emitted by a source category and the resulting issues around measuring its effect and characterizing its health impact in an adequate fashion. As outlined in the REVIHAAP report, the "one-atmosphere concept" is a new approach that could be adapted as a novel way to investigate the effects on health of such complex mixtures.

4.4. Limitations

The HRAPIE survey produced valuable information as a tool to document new and emerging issues of interest concerning risks to health from air pollution, as well as the thoughts and comments of experts; however, the approach adopted had some limitations with respect to the survey's design.

The set time frame of four weeks or even less was most likely not enough time to enable proper distribution to all relevant stakeholders, which was dependent on the mode of distribution of the survey (direct e-mail distribution via WHO or e-mail distribution to respondents through expert institutions and groups). The dissemination strategy meant that most of the respondents were likely to be air pollution scientists working in different fields.

In addition, the length of the questionnaire may have discouraged some respondents and led to a lower response count for some of questions. The majority of respondents (96) identified one risk; only 12 and 5 identified a second and third risk respectively. If they identified more than one risk, respondents in general offered more thoughts and suggestions on the first risk than the second and/or third. No information is available, however, on whether they identified one emerging risk because they were genuinely aware of only one or because the length of the survey deterred them.

The wording of the demographic questions did not allow the authors to analyse responses on a geographic scale: for example, looking at trends or differences in the emerging risks identified between different regions of Europe. Nevertheless, an analysis of answers stratified by European region was not one of the objectives of this survey; instead, it is an additional and interesting aspect to consider for future questionnaires and analysis.

Finally, there were some limitations in the survey design due the limited options for structuring questions in Survey Monkey.

5. Conclusions

Assessment of the views of experts and stakeholders through the HRAPIE survey shows that the identified new emerging issues on risks to health from air pollution relate to several factors.

- Specific emission source categories: the majority of respondents identified the road transport source category (including both tailpipe and vehicle and road wear emissions) as associated with emerging and continuing health risks. They also identified the following source categories, listed in descending order according to the percentage of clicks: space heating and air conditioning, shipping, energy production and distribution, industrial processes (metal industries) and agriculture.

- Specific pollutants: the results revealed the strongest signals for NH_3 and OC/SOAs associated with the agriculture source category, and for BS, BC and EC (all three are considered metrics of BC particles and represent more or less the same type of combustion-derived PM, but are measured in different ways) associated with the space heating and air conditioning, road transport and shipping source categories.

- Specific components of PM: a strong signal emerged to varying extents in responses for finer PM components – especially for $PM_{2.5}$ and nano-scale particles (UFPs and nano-particles) from combustion and non-combustion processes (engineered nano-particles) – emitted by a variety of source categories. In addition, the overall analysis revealed a strong signal in responses for the metal components of PM, especially those associated with the road transport, energy production and distribution, industrial processes (metal industries) and shipping source categories.

The findings of this report affirm that experts and stakeholders do not perceive current air quality standards to be "safe": adverse impacts on human health from air pollutants emitted by various sources are still observed at current levels. Pollution concentrations are still too high and affect human health. Despite the growing knowledge of air pollution-related health impacts, experts feel that important gaps in knowledge still exist. More research is required to fill these knowledge gaps concerning the identified emerging risks of air pollution on health.

References

EC (2013a). *Attitudes of Europeans towards air quality: report*. Brussels, European Commission (Flash Eurobarometer No. 360; http://ec.europa.eu/public_opinion/flash/fl_360_en.pdf, accessed 19 September 2013).

EC (2013b). *Report on the consultation on options for revision of the EU Thematic Strategy on Air Pollution and related policies*. Rotterdam, European Commission (http://ec.europa.eu/environment/air/pdf/review/TSAP%20Consultation%20report.pdf, accessed 19 September 2013).

Kuhlbusch TAJ (2013). Small particles: from the car into the lung [PowerPoint presentation]. *Green Week Conference, Brussels, 4–7 June 2013*. (http://ec.europa.eu/environment/greenweek/sites/default/files/content/presentations/2-3_kuhlbusch_en.pdf, accessed 19 September 2013).

Kulmala M et al. (2004). Formation and growth rates of ultrafine atmospheric particles: a review of observations. *Journal of Aerosol Science* 35(2), 143–76.

Lim SS et al. (2012). A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet* 380(9859): 2224–60.

Pfeffer U, Schuck T, Breuer L (2013). Fireplaces: good for your CO_2 footprint, bad for air quality. [PowerPoint presentation]. *Green Week Conference, Brussels, 4–7 June 2013*. (http://ec.europa.eu/environment/greenweek/sites/default/files/content/presentations/2-3_pfeffer_en.pdf, accessed 19 September 2013).

Reche C et al. (2011). New considerations for PM, Black Carbon and particle number concentration for air quality monitoring across different European cities. *Atmospheric Chemistry and Physics* 11, 6207–27.

Szewzyk R (2013). Bioaerosols: a new threat? [PowerPoint presentation]. *Green Week Conference, Brussels, 4–7 June 2013*. (http://ec.europa.eu/environment/greenweek/sites/default/files/content/presentations/2-3_Szewzyk_en.pdf, accessed 19 September 2013).

WHO (2013). *Review of evidence on health aspects on air pollution – REVIHAAP project: technical report*. Copenhagen, WHO Regional Office for Europe (www.euro.who.int/__data/assets/pdf_file/0004/193108/REVIHAAP-Final-technical-report.pdf, accessed 11 September 2013).

Annex 1

LIST OF PARTICIPANTS IN THE HRAPIE PROJECT

Scientific Advisory Committee

This Committee supervises the implementation of the HRAPIE project and ensures the highest possible quality and relevance of its outputs.

- Hugh Ross Anderson, United Kingdom
- Bert Brunekreef, The Netherlands
- Aaron Cohen, United States
- Klea Katsouyanni, Greece
- Daniel Krewski, Canada
- Nino Künzli, Switzerland
- Xavier Querol, Spain

Authors

The authors are involved in the design, analysis and reporting of the survey on new emerging issues on risks to health from air pollution, as part of the HRAPIE project.

- Susann Henschel, Ireland
- Gabrielle Chan, Germany

Observers at WHO expert group meetings

The following individuals participated as observers in at least one of the WHO expert group meetings organized for the HRAPIE project.

- Markus Amann, International Institute for Applied Systems Analysis
- Arlean Rhode, Conservation of Clean Air and Water in Europe
- Michael Holland, Ecometrics Research and Consulting
- André Zuber, European Commission

WHO Secretariat

The WHO European Centre for Environment and Health, Bonn, WHO Regional Office for Europe, coordinated the work and the development of this publication.

- Svetlana Cincurak
- Marie-Eve Héroux (project leader)
- Elizabet Paunovic
- Helena Shkarubo

Annex 2

PRINTABLE VERSION OF THE HRAPIE SURVEY

Survey on Emerging Issues on Risks to Health from Ambient Air Pollution

Introduction to purpose & objectives of the survey

The WHO Regional Office for Europe is currently implementing projects HRAPIE ("Health risks of air pollution in Europe") and REVIHAAP, in order to provide scientific evidence-based advice on health aspects of ambient air pollution in support of the comprehensive review of European Union's air quality policies scheduled for 2013. The projects' objectives are to develop responses to twenty-six policy-relevant key questions that were formulated by the European Commission. Both REVIHAAP and HRAPIE projects were carried out with funding by the European Union and the World Health Organization Regional Office for Europe.

As part of the HRAPIE project, an electronic survey tool has been developed to engage key stakeholders and expert institutions with an interest in ambient air quality issues. We invite you to share your expert opinion and complete this survey, in order to help us answer the following general question: *"Is there evidence of new emerging issues on risks to health from air pollution, either related to specific source categories (e.g. transport, biomass combustion, metals industry, refineries, power production), specific gaseous pollutants or specific components of particulate matter (e.g. size-range like nano-particles and ultra-fines, raw earth metals, black carbon (EC/OC)?"*

This survey contains 11 questions for each risk you wish to identify and 4 further demographic questions. You will have the option to identify up to 3 risks and it should take no more than 15 minutes to complete a set of question per identified risk.

Please note that all answers will be treated strictly confidentially and no personal information will be published or shared with others.

The views expressed herein can in no way be taken to reflect the official opinion of the European Union.

Many thanks for your participation!

For more information on the REVIHAAP/HRAPIE project please follow this link

If you have any questions, please contact us at hrapie@ecehbonn.euro.who.int

Survey on Emerging Issues on Risks to Health from Ambient Air Pollution

General Instructions

You may wish to **download the text of the questionnaire** from here in order to examine the questions and elaborate on your replies before starting an on-line session.

If your browser is closed it might be possible to recover answers, but this however cannot be guaranteed. For this reason, we encourage you not to interrupt the session once you have started the questionnaire.

In order to progress through this survey, please use the following navigation links:

Click the **"Next"** button to continue to the next page.
Click the **"Prev"** button to return to the previous page.
Click the **"Done"** button at the end to submit your survey.

Note: For multiple choice questions, clicking on empty spaces will select the answer nearest to the click. Therefore **please double check your answers before proceeding to the next question and make sure that all boxes checked are your intended answers**.

This survey and the information it contains do not represent an official position of WHO or the European Union. It is meant as a tool to explore the views of stakeholders and experts. The suggestions contained in this document do not prejudge the form or content of any future recommendations or policies by the European Commission and/or WHO.

Survey on Emerging Issues on Risks to Health from Ambient Air Pollution

Section 1

Your opinion on what source(s) and associated ambient air pollutant(s) pose a new emerging risk.

The following set of questions will ask you to:

Select ONE emission source category from the drop down list or describe it in the comment field, that in your opinion poses or is associated with an emerging risk and specify the ambient air pollutant(s) associated with it in the following questions. This will be followed by a set of questions to characterize that risk further.

Note: **Each set of question corresponds to one risk. You will be asked at the end of the first set of questions if you wish to identify a second risk. If you wish to identify more than one risk, you will have the opportunity to complete the following set of questions up to three times. Please start with the risk that you deem to be the MOST IMPORTANT.**

Please note the emerging health risk that you are identifying here can be a newly identified source emitting a known pollutant, or an emerging pollutant emitted by either a known or a new source.

1. Emission source categories:

If the emission source that you wish to describe is not listed in the drop-down menu above, please specify (within 10 words):

Source categories:
Road transport, e.g. exhaust emissions, road abrasion, fuel evaporative emissions
Shipping, e.g. national navigation
Aviation and airport emission, eg aircraft emissions, surface and aircraft de-icing, ground support equipment emissions
Non-road transport (other), e.g. off-road vehicles, trains
Energy production and distribution, e.g. pipelines
Energy use in industry, e.g. for production processes
Industrial processes (Metal industries), e.g. Zinc, Copper, Lead production
Industrial processes (Non-metal industries), e.g. pulp and paper, food and drink,
Refineries, e.g. petroleum refining
Agriculture, e.g. livestock, fertilizer use
Space heating and air conditioning emissions, i.e. residential, commercial, institutional
Waste, e.g. waste treatment, incineration (small scale, industrial etc.)
Solvent and product use, e.g. paint, pesticides
Natural sources, e.g. as volcanic eruptions, windblown dust, sea-salt spray
Construction and demolition activities, eg dust, material handling, machinery emissions

2. The following ambient air pollutant(s) emerging from the source you have selected pose a health risk

(please check all boxes that apply)

☐ **1. Particulate Matter (PM)**

Please specify:

☐ ***1.1 Coarse PM (with aerodynamic diameter between 2.5 µm and 10 µm)***

☐ ***1.2 PM_{10} (with aerodynamic diameter below 10 µm)***

☐ ***1.3 $PM_{2.5}$ (with aerodynamic diameter below 2.5 µm)***

☐ ***1.4 Ultra-Fine Particles (UFP)(thermodynamic diameter <100 nm particles).***

Please specify:

☐ 1.4.1 Primary (= UFP emitted as particles into the atmosphere) carbonaceous combustion UFPs

☐ 1.4.2 Primary metallic combustion UFPs

☐ 1.4.3 Primary non combustion UFPs

☐ 1.4.4 Secondary (=UFP in the atmosphere formed from gaseous precursors) organic and inorganic UFPs

☐ **2. Black Smoke (BS)**

☐ **3. Black Carbon (BC) and Elemental Carbon (EC)**

☐ **4. Nitrogen Oxides (NOx)**

☐ **5. Sulphur Dioxide/Oxides (SOx)**

☐ **6. Secondary Pollutants Formation (Ozone (O3))**

☐ **7. Organic Carbon (OC)/Secondary organic aerosols(SOA)**

☐ **8. Non-Methane Volatile Organic Compounds (NMVOCs)**

☐ **9. Volatile Organic Compounds (VOCs)**

☐ **10. Polycyclic Aromatic Hydrocarbons (PAHs)**

☐ **11. Hydrocarbons (HC)**

☐ **12. Carbon Monoxide (CO)**

☐ **13. Ammonia (NH3)**

☐ **14. Metals** Please specify:

☐ ***14.1 Arsenic (As)***

☐ ***14.2 Cadmium (Cd)***

☐

Note: the list continues next page

- [ ] ***14.3 Mercury (Hg)***
- [ ] ***14.4 Lead (Pb)***
- [ ] ***14.5 Nickel (Ni)***
- [ ] ***14.6 Copper (Cu)***
- [ ] ***14.7 Zinc (Zn)***
- [ ] ***14.8Manganese (Mn)***
- [ ] ***14.9 Iron (Fe)***
- [ ] ***14.10 Antimon (Sb)***
- [ ] ***14.11 Transition metals***
- [ ] ***14.12 Vanadium***

Other (please specify)

Please indicate why the source and ambient air pollutant(s) you selected should be identified as a new emerging risk to health from ambient air pollution:

There will be 3 subsections to this question:

(3) Ambient air pollution and exposure characteristics

(4) Health effects

(5) Population characteristics

At the end of each question, there will be a textbox for further specification of your choice(s). If you want to elaborate on more than one answer from the list, please indicate clearly to which of your answers you are referring to.

3. Why is it new: Ambient air pollution and exposure characteristics

(Please check all boxes that apply)

☐ **New property of ambient air pollutant(s) of concern (e.g. oxidative potential; SOA formation)** **Please specify in the text box below**

☐ **Exposure situation/ Micro-environments eg commuting level**

☐ **Other** **Please specify in the text box below**

If you wish to further specify any of your choices made above (optional, within 5 words):

4. Why is it new: Health effects

(Please check all boxes that apply)

- [ ] All-cause
- [ ] Respiratory
- [ ] Cardiovascular
- [ ] Cardio-respiratory
- [ ] Cerebrovascular
- [ ] Endocrine dysfunction/disruption
- [ ] Neurobehavioral
- [ ] Reproductive
- [ ] Cancer
- [ ] Early markers of disease or physiological changes
- [ ] Other, if possible please specify in the textbox below*

If you wish to further specify any of your choices made above (optional):

5. Why it is new: Vulnerable subgroup of population.

Please specify, if possible, by checking all boxes all apply:

- [ ] **1. Total population**
- [ ] **2. Fetuses**
- [ ] **3. Newborns, infants and children**
- [ ] **4. Adults**
- [ ] **5. Elderly**
- [ ] **6. Male subjects**
- [ ] **7. Female subjects**
- [ ] **8. High socio-economic groups**
- [ ] **9. Low socio-economic groups**
- [ ] **10. Specific occupational groups**
- [ ] **11. Susceptible sub-populations with a specific, diagnosed disease:**
  - [ ] 11.1 Cardiovascular diseases
  - [ ] 11.2 Respiratory diseases
  - [ ] 11.3 Asthma
  - [ ] 11.4 Diabetes
  - [ ] 11.5 Neurological disease
  - [ ] 11.6 Depression
  - [ ] 11.7 Other, if possible please specify in textbox below
- [ ] **12. Other, if possible please specify in textbox below**

If you wish to further specify any of your choices made above (optional):

6. Please describe the geographic location/scale, where the new evidence of emerging health risks was observed:

Please specify, if possible, by checking all boxes all apply:

- [ ] Global
- [ ] European level
- [ ] Country level
- [ ] Regional level
- [ ] Provincial level
- [ ] Community level
- [ ] Urban level

Other (please specify)

7. How did you become aware of the new emerging issue on risks to health from ambient air pollution that you just outlined in your answers in the previous questions?

Please specify, if possible, by checking all boxes all apply:

- ☐ Recent published journal article
- ☐ Ongoing research
- ☐ Website
- ☐ Report
- ☐ At a conference/meeting
- ☐ Anecdotal evidence
- ☐ Other, please specify

If you wish to add references of evidence or information, please use the fill-in text box below. Please keep your text within 50 words.

Section 1.2 Your Expert Opinion

8. How would you rate the overall significance of the emerging health risk with respect to its impact on health in the European context? Please indicate by choosing a corresponding value on the scale below:

No significance						Very significant
0	1	2	3	4	5	6
◯	◯	◯	◯	◯	◯	◯

If you wish to make further comments, please use the fill-in text box below. Please limit your comments to less than 20 words.

9. In your opinion, what are the current knowledge gaps, which require further research with respect to the emerging risks to health you described in the previous questions?

Please check all boxes that apply.

- [ ] **Ability to assess/measure the health effect**
- [ ] **Biological mechanism of action**
- [ ] **Exposure, Please specify further, if possible:**
  - [ ] - Concentration
  - [ ] - Chemical and physical characteristics
  - [ ] - Duration
  - [ ] - Individual microenvironments
  - [ ] - Changes over time
  - [ ] - Assessed pollutant might act as a proxy
  - [ ] - Personal exposure
- [ ] **Other not-yet-assessed health outcomes might be affected by the described source and/or air pollutant(s)**

Other, please specify:

10. In your opinion, what are the driving forces of the identified new emerging risk?

Please check all boxes that apply.

- [ ] **Political changes**
- [ ] **Technological changes**
- [ ] **Societal changes**
- [ ] **Socio-economic factors**
- [ ] **Changes in behaviour of individuals**

Other, please specify:

11. Regarding your knowledge of the newly emerging health risk(s) do you have any recommendations to give to policymakers?

Please limit your answer to be within 50 words.

You may enlarge the size of the text box below by dragging the bottom right corner.

12. This is the end of the set of questions for the FIRST emerging risk. Do you wish to describe a SECOND new emerging issues on risks to health from air pollution?

◯ Yes - you will be guided through a new set of questions to allow you to describe the SECOND emerging risk

◯ No - proceed to the final section of this survey

NOTE: The above set of questions repeats for the SECOND and THIRD risk if you wish to identify them. The repeated questions are taken out in this printable version.

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Section 2 About yourself

36. Country of residence

37. Please indicate which of the following sectors best describe your organization

Please check all boxes that apply

- [ ] An international organization
- [ ] A governmental institution (at either national, regional, or local level)
- [ ] A non-governmental organization (NGO)
- [ ] An academic/ research institution
- [ ] A policy-making institution
- [ ] A patients' organization
- [ ] A hospital or health care provider
- [ ] A private entity

Other (please specify)

38. You work in

Please check all boxes that apply

- [ ] The environment sector
- [ ] The public health sector
- [ ] The clinical medicine sector
- [ ] The transport sector
- [ ] The industrial sector
- [ ] The public awareness, research and policy sector

Other (please specify)

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Final Comments

39. Please feel free to provide any further comments related to the new emerging issues of interest on risks to health from air pollution.

Please limit your comments within 50 words.

40. If you would like to receive information about publications related to the results of this survey, please enter your email address below. Your email address will NOT be used for any other purposes.

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End of survey

Please be aware that by clicking the "Done" button, the survey is completed and no more changes are possible

If you want to edit your answers, please click the “Prev” button.
Please note that answers are **NOT** saved if you exit this survey or close the browser.

Are you sure the survey is completed? If so, please press "Done".

Thank you for your participation.