WHO ambient air quality database, 2022 update: status report

World Health Organization

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1. Introduction

This document describes the latest WHO database on ambient air quality. Since 2011, WHO has been compiling and publishing ground measurements of air quality and, specifically, the annual mean concentrations of particulate matter with a diameter ≤ 2.5 μm ($PM_{2.5}$) and ≤ 10 μm (PM_{10}). The objective – beyond summarizing the current state of air quality – is to collect data on air quality that could be used to derive robust estimates of population exposure for studies of the burden of disease analysis due to ambient air pollution (*1, 2*). The database thus fulfils part of WHO's custodial role for indicators 11.6.2 (Air Quality in cites) and 3.9.1 (Mortality from air pollution) of the Sustainable Development Goals.

The recent update of the WHO air quality guidelines, a set of evidence-based recommendations for limit values of specific air pollutants, provides clear evidence of the damage that air pollution inflicts on human health, at even lower concentrations than previously recognized. The guidelines recommend new air quality levels to protect the health of populations. Moreover reducing the levels of key air pollutants will also contribute to slowing climate change (*3*). Pollutants for which new guidelines for annual mean values have been set are $PM_{2.5}$, with a guideline value half the previous one, PM_{10}, which is decreased by 25 %, and that for nitrogen dioxide (NO_2), which is four times lower than the previous guideline (Table 1).

Table 1. Recommended levels and interim targets (in μg / m³) for an annual averaging time

Pollutant	Interim target				AQG (2021)	AQG (2005)
	1	2	3	4		
$PM_{2.5}$	35	25	15	*10*	**5**	10
PM_{10}	*70*	50	30	*20*	**15**	20
NO_2	*40*	30	20		**25**	40

AQG : WHO air quality guidelines.

The new guidelines are designed to help countries achieve air quality that protects public health. They have been welcomed by the health community, medical societies and patient organizations (*4*). The guidelines are not legally binding but serve as benchmarks to guide countries in setting national air quality standards.

As indicated in a recent report by the United Nations Environment Programme, “ there is no common legal framework for Ambient Air Quality Standards (AAQS) globally and that effective enforcement of AAQS remains a signifi ant legal challenge. Many countries lack legislation that sets AAQS or requires air quality monitoring and only a few address transboundary air pollution ” (*5*).

In its previous versions (2011, 2014, 2016 and 2018), the database contained data only on particulate matter ($PM_{2.5}$ and PM_{10}). Data on NO_2 are now included in this fifth upd e.

The early focus on PM reflec ed its worldwide ubiquity, and it is the most widely used indicator for assessing the health effects of exposure to air pollution. PM originates from many different sources, such as transport, power plants, agriculture, waste burning, industry and natural sources (*6*). PM may be emitted directly or may be a product of chemical processes in the atmosphere, where it may be transported over long distances. A consequence of the latter is transboundary PM, which makes it even more difficult o control local air quality (*7*). PM can penetrate deep into the lung and enter the bloodstream, causing cardiovascular, cerebrovascular (stroke) and respiratory diseases (*8*). There is emerging evidence that PM also affects other organs and diseases (*9, 10*).

NO_2 originates primarily from anthropogenic fuel combustion (e.g., from traffic and is especially common in urban areas. Exposure to NO_2 is associated with respiratory diseases (including asthma), with symptoms such as coughing, wheezing and difficulty in b eathing and more hospital admissions and visits to emergency rooms (*11*) ; it may also contribute to the development of asthma (*12*) and increase susceptibility to respiratory infections (*13*). This pollutant is also correlated with carbon dioxide and contributes to the formation of ozone and $PM_{2.5}$; therefore, any reduction in NO_2 can have co-benefits or health and the climate.

2. Availability of data

The 2022 version of the WHO ambient air quality database status report includes annual means for PM_{10}, $PM_{2.5}$ and NO_2 for the years between 2010 and 2019, and it covers 6 743 human settlements in 117 countries worldwide.

The settlements range in size from < 100 to > 30 million inhabitants. As more than 50 % of the settlements have over 50 000 inhabitants and are designated as urban centres or cities by the United Nations Statistical Commission (*14*) (Table 2), the database is often referred to as an " urban air quality database ". However, > 25 % of settlements covered in the database have fewer than 15 000 residents, and a limited proportion (mostly in Europe) have fewer than 1 500 inhabitants. These town and rural settlements may, however, be located near larger urban agglomerations.

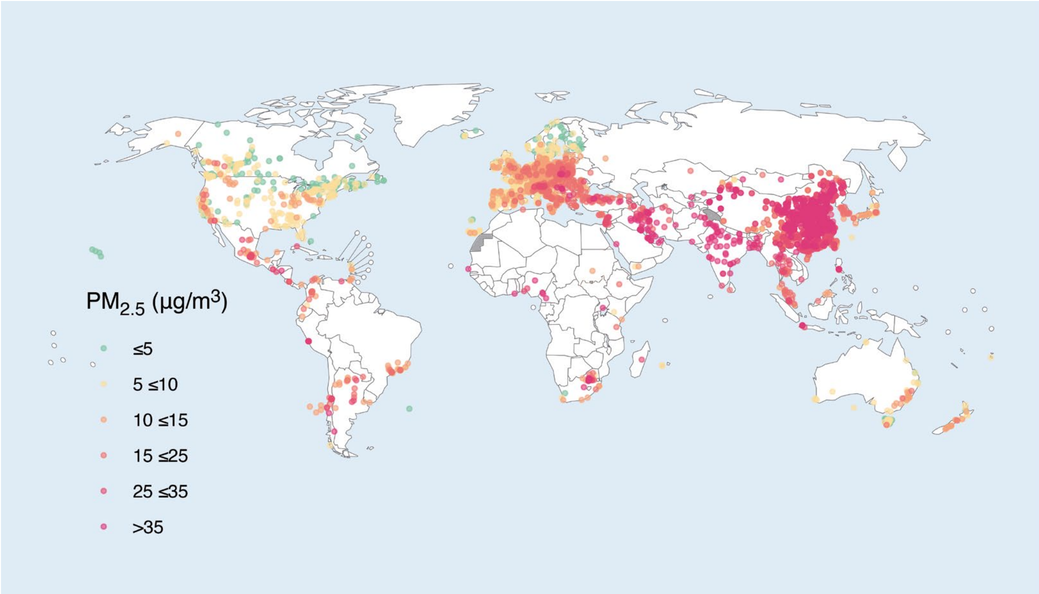
Table 2. Distribution of settlements size

% of settlements with no. of inhabitants < to settlement size listed in the adjacent column	Settlement size
	with PM_{10}, $PM_{2,5}$ or NO_2 data
0	0
5	1 027
10	2 962
25	14 666
50	56 847
75	304 344
90	955 041
95	1 978 502
99	8 051 068
Mean settlement size	480 332
No. of settlements	6 743

For NO_2, data are available for 3 976 human settlements in 74 countries. Most of the data for both pollutants were retrieved from monitoring stations and aggregated at city level. The settlements ranged in size from < 100 inhabitants to > 30 million, but most are urban (see Table 2) and are therefore generally referred to as " human settlements " or " towns and cities ".

Fig. 1. Locations of settlements with data on (a) $PM_{2.5}$ and (b) PM_{10} concentrations, 2010–2019

a. $PM_{2.5}$



b. PM_{10}

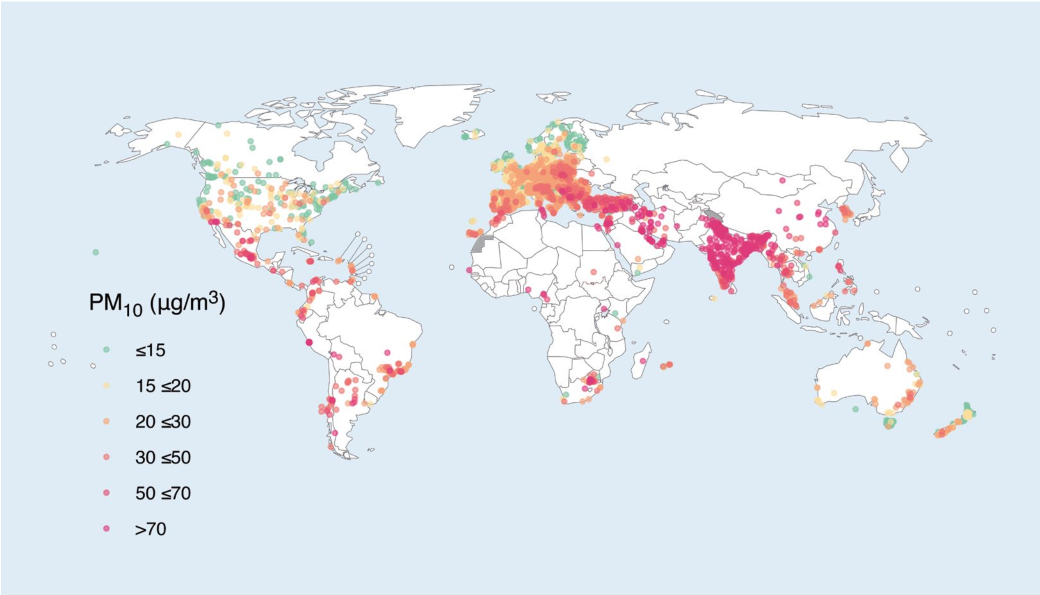
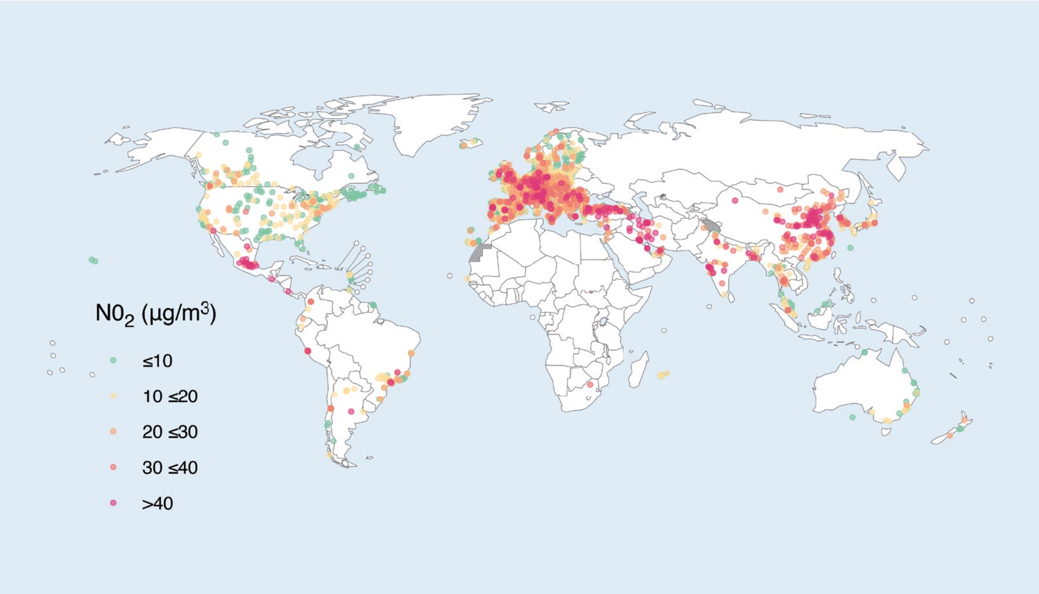


Fig. 1 shows that the coverage of ground measurements of $PM_{2.5}$ and PM_{10} is still not homogeneous around the globe. More ground measurements are generally found in high- and middle-income countries, in China, Europe, India and North America. A similar pattern is observed for NO_2 (Fig. 2), with greater densities of ground monitors in high- and middle-income countries.

Fig. 2. Locations of settlements with data on NO_2 concentrations, 2010–2019



The regional distribution documented in the database and the numbers of settlements for which data were available are shown in Table 3 and Fig. 3, respectively.

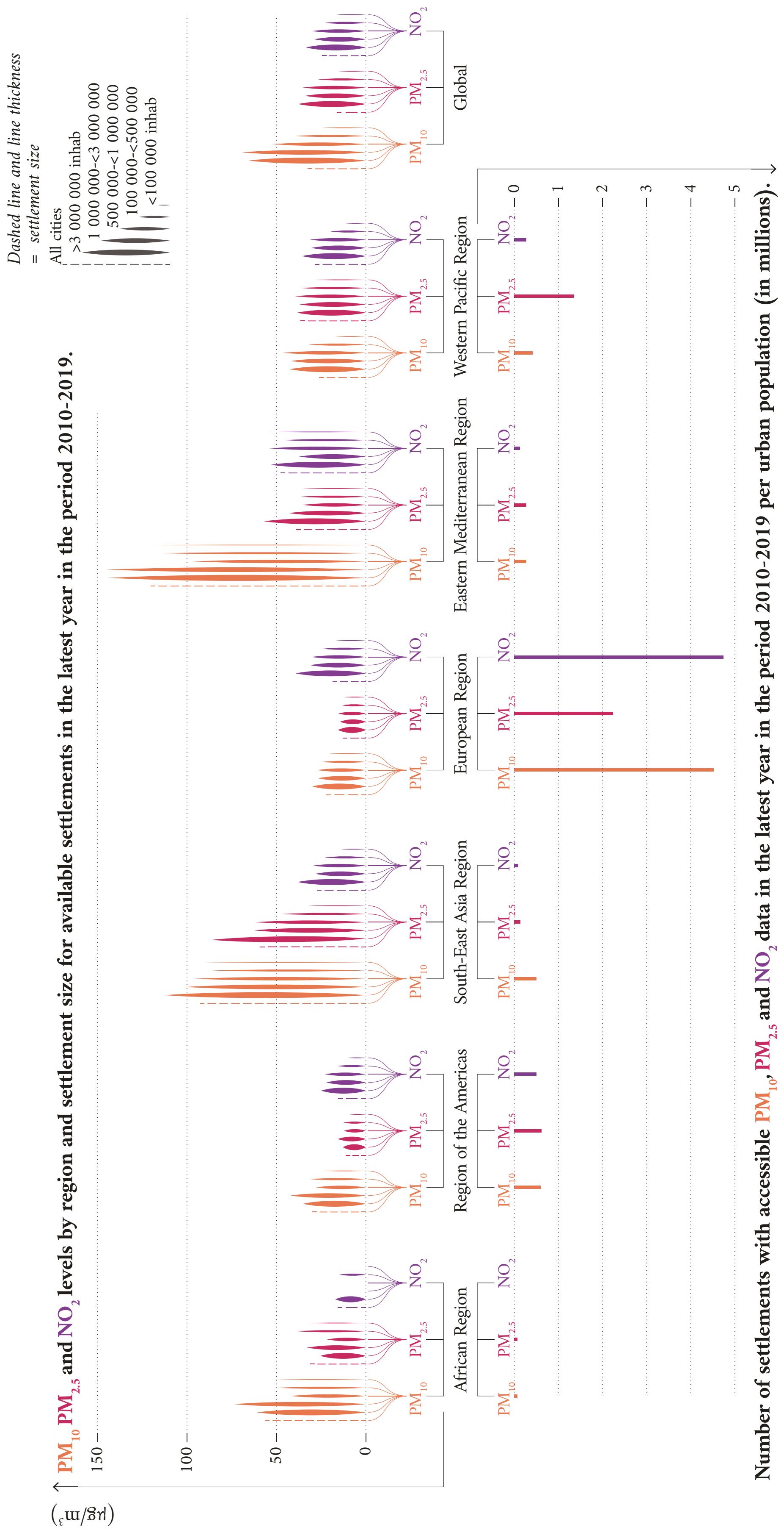
Table 3. Total numbers of human settlements in the database, 2022 version, by region

WHO regions and classification by income[a]	No. of settlements	No. of countries with data	Total number of countries
WHO regions			
African Region	59	12	47
Region of the Americas	781	22	35
South-East Asia Region	398	9	11
European Region	3 654	48	53
Eastern Mediterranean Region	158	14	21
Western Pacific Region	1 693	12	27
Income level[a]			
High	4 226	51	57
Low and middle	2 517	66	145
Total	6 743	117	194

[a] See Annex 1 for regional groupings .

As $PM_{2.5}$ measurements can be used to estimate health impacts directly, they are of particular interest as compared to PM_{10}. $PM_{2.5}$ is measured widely in high-income countries (HIC), and, while $PM_{2.5}$ measurements are still not available in many low- and middle-income countries (LMIC), there have been improvements in the past few years. When $PM_{2.5}$ measurements are not available, PM_{10} measurements should be converted to $PM_{2.5}$ for estimation of health impacts.

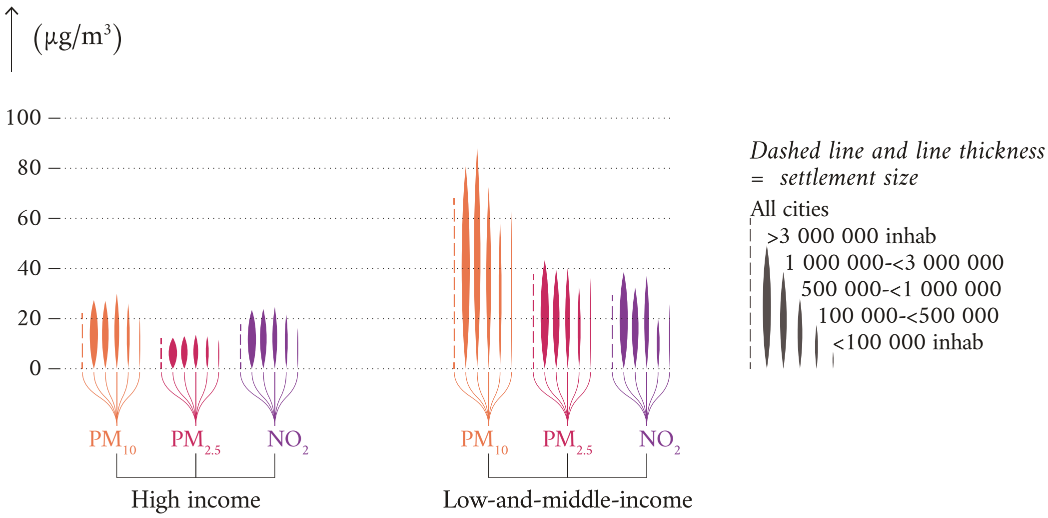
Fig. 3. PM_{10}, $PM_{2.5}$ and NO_2 annual means and data accessibility, by region and settlement size



3. Summary of data

The database can be consulted on the WHO website at: *www.who.int/data/gho/data/themes/air-pollution/who-air-quality-database*. An overview of PM_{10}, $PM_{2.5}$ and NO_2 levels in the WHO regions and in selected cities is presented in Figs 3–5 and in Annex 2.

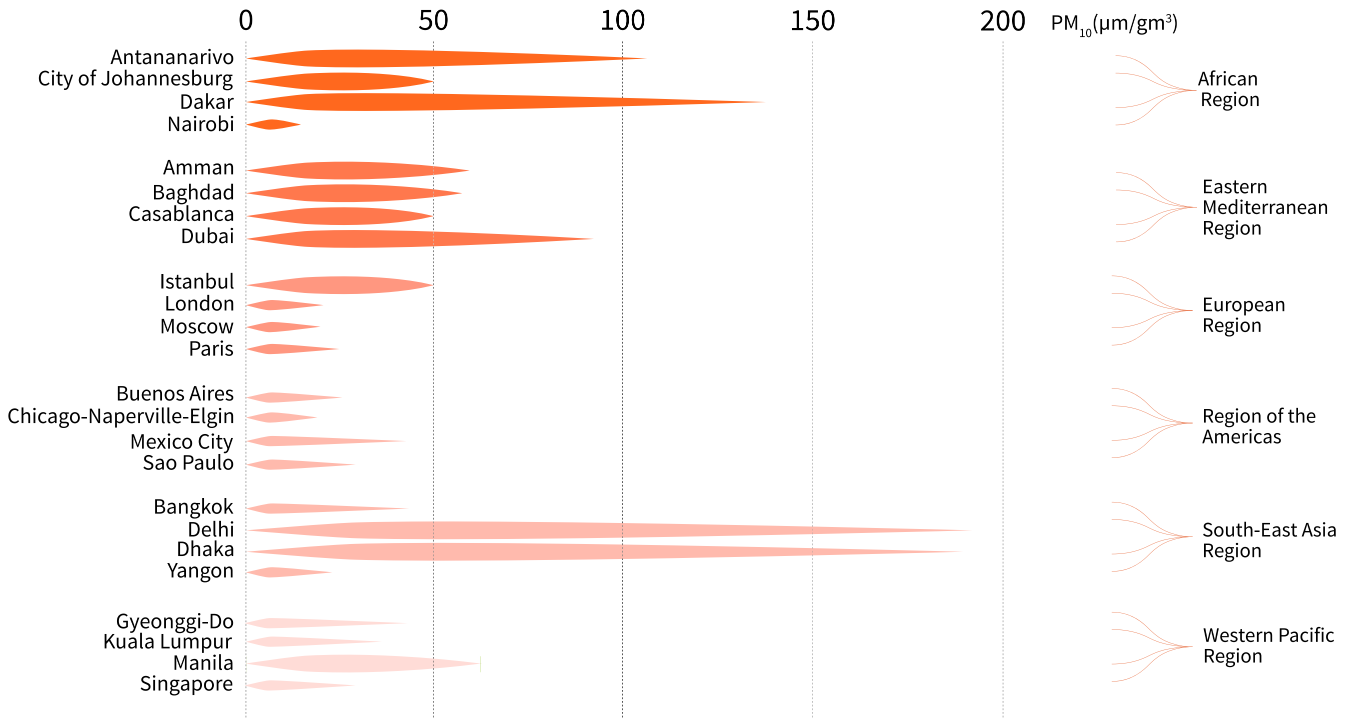
Fig. 4. PM_{10}, $PM_{2.5}$ and NO_2 annual means by income level and settlement size, for settlements for which data were available in the latest year between 2010 and 2019

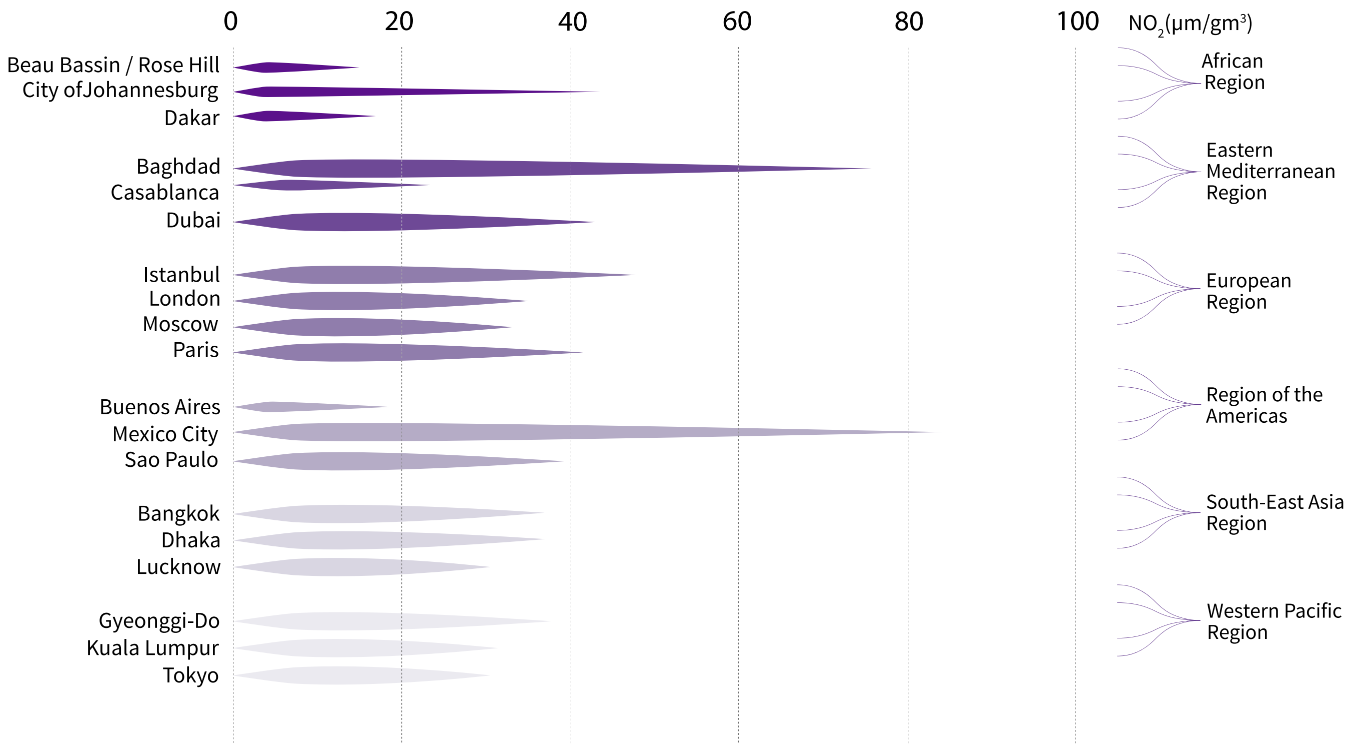


Comparison of $PM_{2.5}$ and PM_{10} levels by income group shows greater exposure in LMIC than in the world as a whole, by a factor of about 3 in comparison with HIC (Fig. 4).

A different pattern is observed for NO_2 levels, HIC and LMIC reporting more homogeneous concentrations than global averages (Fig. 4). Overall, the NO_2 concentrations in LMIC were only about 1.5 times higher than in HIC. It is noteworthy to mention that only 37% of settlements that recorded air quality levels were in LMIC.

Fig. 5. PM_{10} and NO_2 annual means in populous cities by region for which data were available in the latest year between 2017 and 2019





Selection criteria : for the latest year of measurement, but not older than 2017, for each city included in the database, the largest city in each country in a region was selected.

PM_{10} levels were above the global average in the Eastern Mediterranean and South-East Asia regions in human settlements of all sizes (Fig. 3) and were six to eight times greater than the AQG value. These regions receive large quantities of desert dust particles. The pattern of $PM_{2.5}$ levels is similar, although the African and Western Pacific egions had levels that were nearly fi e times higher than the AQG (Fig. 3). Modelled estimates of $PM_{2.5}$ supplemented by satellite data reflec ed similar regional patterns (*15, 16*).

A similar pattern was observed for annual average NO_2 concentrations, with settlements in the Eastern Mediterranean Region having higher concentrations than the global average, while all the other regions had lower, homogeneous levels (Fig. 3). The lowest levels of PM and NO_2 were observed in Europe and the Americas, respectively (as data from Africa are limited, regional interpretation is difficult). While P_{10} levels varied widely by region, NO_2 levels appeared to be more homogeneous. The homogeneity of NO_2 concentrations in different regions may be due to the local nature of the sources of NO_2 and its reactive chemical nature. Modelled estimates of global NO_2 reported recently (*12*) indicate that the highest concentrations occur in the most populated regions of the world.

With regard to exposure levels in human settlements of different sizes, the NO_2 concentration tended to increase with settlement size, which might reflect larger emissions from traffic *17*), whereas the highest PM concentrations were found in settlements that varied in size from 500 000 to 3 million inhabitants.

It is interesting to focus also on PM_{10} and NO_2 concentration in the most populous cities, with sizes ranging from 1 million to 26 million habitants (Fig. 5). The annual levels of PM_{10} and NO_2 varied widely by city size and income level in a given region. This is probably because the data from each city are not from the same year, temporal coverage or spatial coverage. While the data for each city indicate the air quality in the region, they are not comparable with data for other cities in the same region and even less so with data for other regions.

A comparison of the levels in mega-cities in the 2018 and 2022 versions of the database showed that the annual mean PM concentrations are relatively constant, only a few cities (e.g., Delhi) having improved their air quality. The mega-cities that recorded high PM_{10} concentrations, such as Beijing, Delhi and Dhaka, also had elevated NO_2 concentrations (data not shown).

4. Compliance with the WHO air quality guidelines

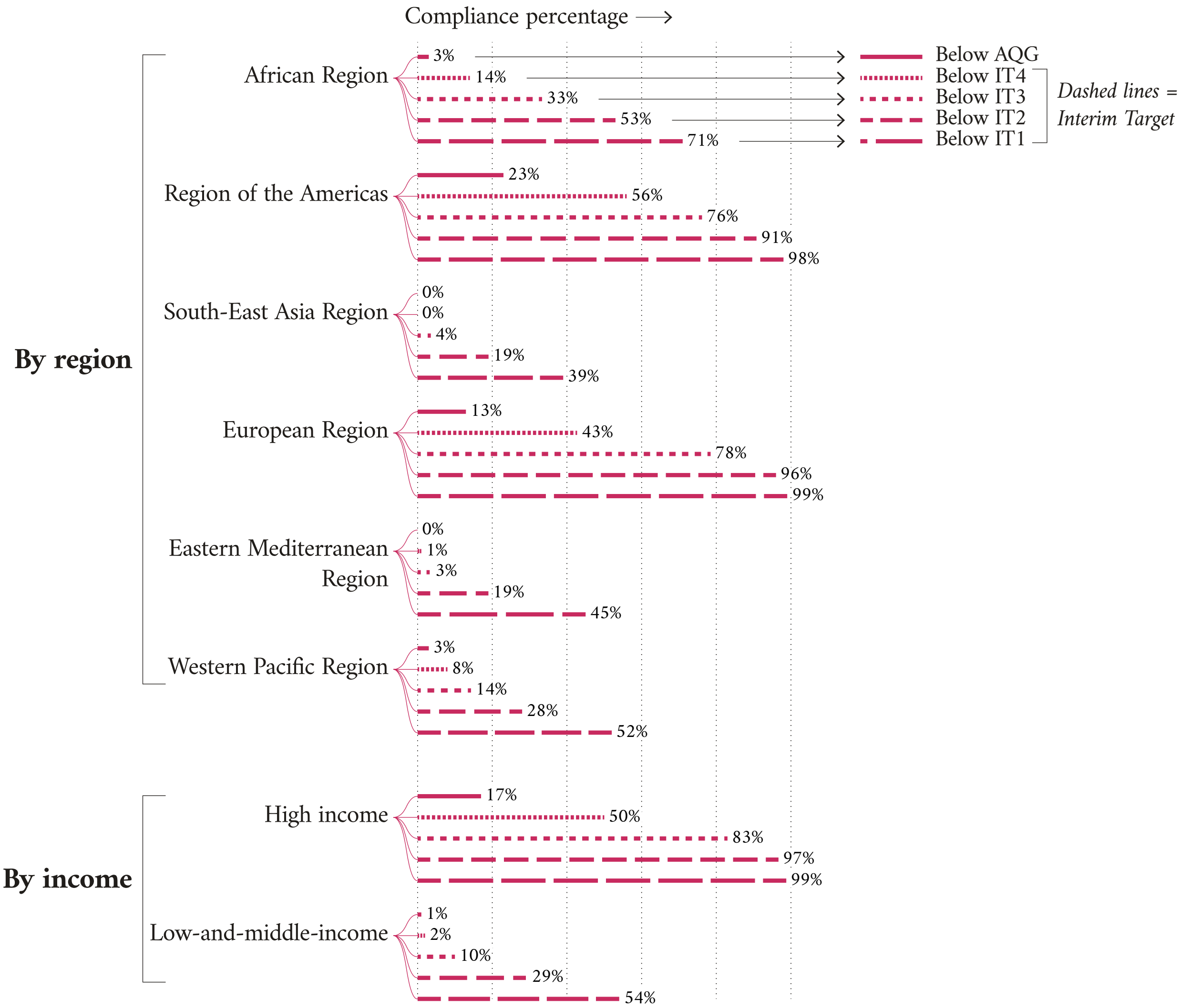
Fig. 6 and 7 show the regional percentages settlements with measurements of PM_{10} or $PM_{2.5}$ and NO_2 that experienced air pollution levels that met the WHO AQG, i.e., annual mean values of 10 µg/m³ for NO_2, 15 µg/m³ for PM_{10} and 5 µg/m³ for $PM_{2.5}$ (see Table 1).

Globally, only the population of 10 % of the assessed settlements are exposed to annual mean levels of PM_{10} or $PM_{2.5}$ that complied with the AQG (Fig. 6). The proportion increased to 31 % for interim target (IT) 4 (i.e., IT-4 : 20 µg/m³ for PM_{10} and 10 µg/m³ for $PM_{2.5}$) of the AQG, 54 % for IT 3 (30 µg/m³ for PM_{10} and 15 µg/m³ for $PM_{2.5}$), 70 % for IT 2 (50 µg/m³ for PM_{10} and 25 µg/m³ for $PM_{2.5}$) and 81% for IT 1 (70 µg/m³ for PM_{10} and 35 µg/m³ for $PM_{2.5}$).

For NO_2, only the population of 23 % of the assessed settlements are exposed to annual mean levels that complied with AQG levels (Fig. 7). The proportion increased to 59 % for IT 3 (20 µg/m³), 83 % for IT 2 (30 µg/m³) and 95 % for IT 1 (40 µg/m³).

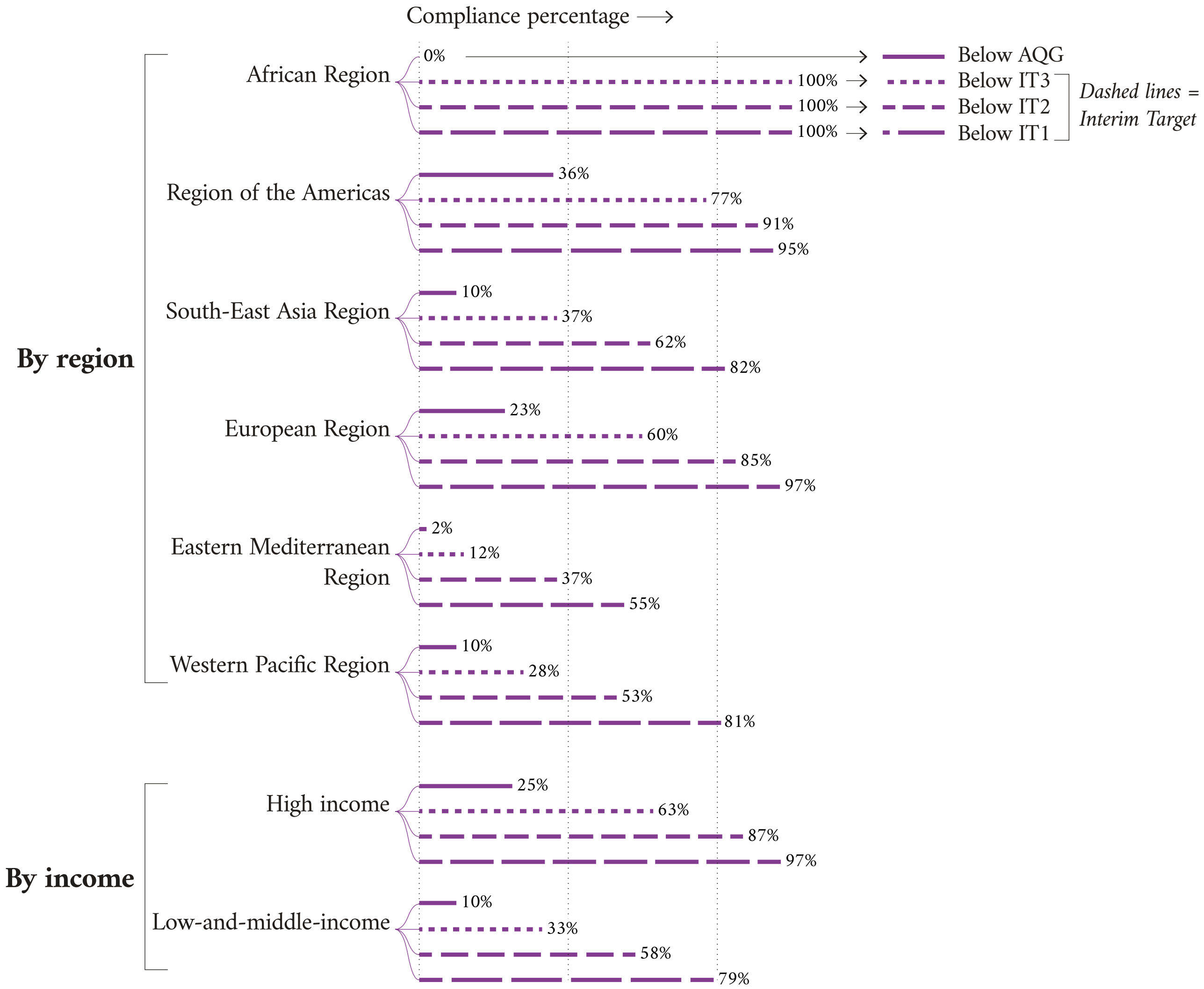
The Region of the Americas recorded the best compliance with the WHO AQG for NO_2 with 36 % of their cities recorded air quality levels below those set by the AQG followed by the European Region. Interestingly, NO_2 compliance with AQG is more homogenous across geography and income regions as compared to PM.

Fig. 6. Percentage of settlements assessed that complied with the WHO air quality guidelines and interim targets for annual mean PM



AQG: WHO air quality guidelines. IT: interim target; PM: particulate matter.
Note: For settlements for which both PM_{10} and $PM_{2.5}$ values were available, $PM_{2.5}$ values were used. Only the latest data available between 2010 and 2019 were used for the analysis.

Fig. 7. Percentage of settlements assessed that complied with the WHO air quality guidelines and interim targets for annual mean NO_2



AQG: WHO air quality guidelines. IT: interim target; NO_2: nitrogen dioxide.
Note: Only the latest data available between 2010 and 2019 were used for the analysis.
For Africa, the analysis was based on few cities, hence the data may not be representative.

5. Methods

The database includes annual mean concentrations of PM_{10}, $PM_{2.5}$ and NO_2 based on ground measurements of these pollutants. It provides an average for a city or town as a whole rather than at individual stations. Most of the measurements were collected between 2010 and 2019.

5.1. Data sources

The primary sources of data were official ountries reports sent to WHO upon request, official national and subnational eports, national and subnational websites that contain measurements of PM_{10} or $PM_{2.5}$ and ground measurements compiled in the framework of the Global Burden of Disease project (*18*). For NO_2, ground measurements compiled for research by Larkin et al. in 2017 (*19*) were obtained. Measurements reported by the following regional networks were also used: Clean Air for Asia (*20*), the Air quality e-reporting database of the European Environment Agency (*21*) for Europe and the AirNow Programme from the United States embassies and consulates (*22*). When such official da a were not available, values from peer-reviewed journals were used.

5.2. Search strategy

When official eporting from countries to WHO were not available, we screened the websites of national ministries of the environment and health and statistics offi es for publicly available data. The web searches were conducted with the terms “air quality”, “air pollution”, “suspended particles”, “monitoring”, “PM_{10}”, “$PM_{2.5}$” and “NO_2”. The languages chosen were English, French, Portuguese and Spanish. Only measurements up to 2019 were included, although some late searches included 2020.

5.3. Type of data

Annual mean concentrations of particulate matter (PM_{10} or $PM_{2.5}$) and NO_2 derived from daily stationary measurements or data that could be aggregated into annual means, were used. In the absence of annual means, measurements from a limited part of the year were used exceptionally to derive the annual mean, if the different seasons were represented.

In order to present air quality data that represent human exposure, we used mainly urban measurements, comprising urban background, residential areas, commercial and mixed areas or rural areas and industrial areas close to urban settlements. Only data from stationary measurements, as opposed to mobile stations, were included.

Air quality stations that covered particular “hot spots” and exclusively industrial areas were not included in the analysis, as such measurements often represent areas with the highest exposure and not mean population exposure. “Hot spots” were either designated as such in the original reports or were qualifie as such because they were near exceptionally busy roads, for example. It should be noted however, that the omission of these measurements might have resulted in the underestimation of the mean air pollution level in a city.

When data from various sources were available for an urban area, only the latest, most reliable sources were used. For locations for which no new data were available, data from the previous version of the database were used in the analysis.

It is important to note that we could not retrieve or use all the publicly available data of interest, because they were not in one of the four languages selected for the search (i.e., English, French, Portuguese and Spanish) or the public data contained incomplete information (such as the omission of the reference year or station coordinates). Data were used as presented in the original sources. Furthermore, the number of monitors cited in this report do not necessarily correspond to the number of operational stations in a city as only the stations used to derive a long-term mean, which is needed to assess the heath impact from human exposure to air pollution, were included.

5.4. City data processing and reporting

When they were available, means for cities and towns reported in the original sources were included. When a mean for the city was not provided, data from the eligible monitoring station in the city or town were averaged. As monitoring stations may be placed in locations that do not represent the level of background pollution, aggregation of their data may not necessarily represent mean air pollution in a city. This risk was partly mitigated by excluding data from monitoring stations located in hot spots, as stated above.

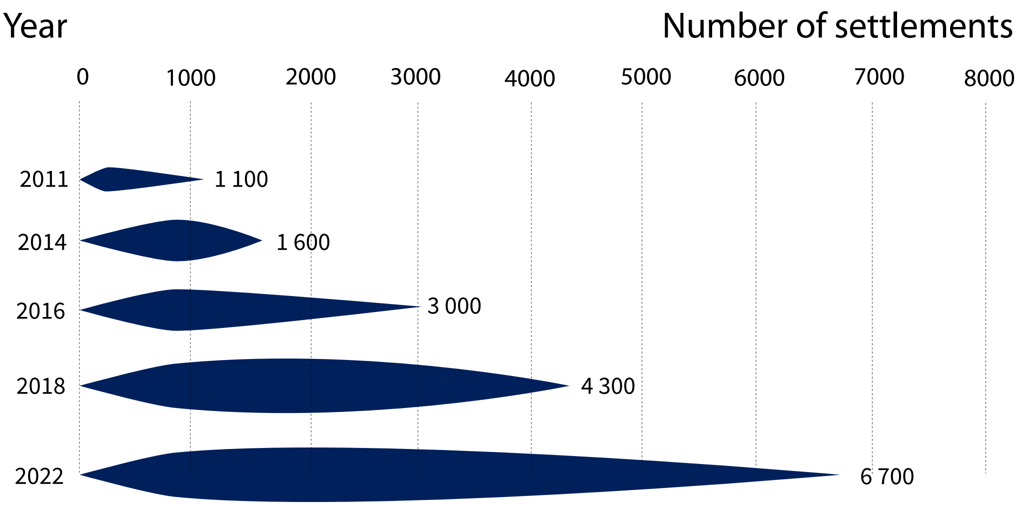
The population data used for weighting exposures and for estimating the number of inhabitants in human settlements were derived from United Nations Population Statistics (*23*) (when available) for all the human settlements covered or census data from national statistics offi es (*24*).

The temporal coverage represents the number of days per year that measurements were collected and any other range provided in the original sources. When data from several monitoring stations in one city or town were available, the average temporal coverage was used as the overall average. Although information on temporal coverage was not always available, the reporting agencies often set a threshold for the number of days covered before reporting the measurements from a station or using it to estimate the city mean.

6. Discussion

Since 2011, when WHO released the fi st database, the availability of data has increased dramatically. Fig. 8 shows the numbers of settlements for which PM measurements were available up to 2022. Within a decade, the number of cities and towns in which air quality is measured increased by approximatively 600 %. This is a signifi ant achievement as ground monitors, especially in settlements with elevated concentrations of PM_{10} and $PM_{2.5}$, will be pivotal for monitoring the progress of national policies and interventions.

Fig. 8. Number of human settlements included in the WHO database, by year of release



The database is the result of collaborations among WHO, countries and academic institutions, and has contributed considerably to improving estimates of exposure to particulate matter (*1, 2*).

The addition of NO_2 measurements will contribute to (*i*) increasing awareness about this pollutant, which is often used as an effective proxy for anthropogenic fuel combustion, specifi ally from traffic and especially in ur an settings; (*ii*) monitoring progress in policies to reduce exposure to air pollution; and (*iii*) improving work to derive estimates of global exposure to NO_2 (*12, 18, 25–27*).

6.1. Limitations of the database

The aim of the database is to compile ground measurements of annual mean concentrations of $PM_{2.5}$, PM_{10} and NO_2. The database has several limitations, the main one being that comparison of data from different countries is limited because of :

- different locations of measurement stations ;
- different measurement methods ;
- different temporal coverage of certain measurements (If only part of a year is covered, the measurement may deviate signifi antly from the annual mean because of seasonal variations) ;
- data from different countries were available for different years ;
- possible inclusion of data that were not eligible for the database because of insufficient in ormation for ensuring compliance ;
- differences in the size of urban areas covered (For certain countries, only measurements for larger cities were found, whereas for others, data for cities with only a few thousand inhabitants were available.) ;
- heterogeneity in the quality of measurements ; and
- omission of data that could not yet be accessed because they were not in one of the four languages selected or were difficult o access.

Some of these limitations were discussed in a recent article, based on the 2016 version of the database (*28*).

6.2. Prospects

Our past and current databases contain data from reference-grade monitors (or provided by country officials) in an at empt to rely on official da a used for regulatory purposes. Countries have, however, shown growing interest in measuring and using data from alternative methods (i.e., other than standard reference-grade monitors), such as those obtained with low-cost sensors (LCS), or estimates based on satellite data (or a combination thereof), particularly in regions in which there are no high-quality data. A common yet difficult question to answer is the reliability of these sensors.

In a recent report, the World Meteorological Organization (29) assessed several studies on the use of LCS and concluded that they are not yet suitable for replacing reference-grade monitors but could complement them.
In countries with at least some reference-grade monitors, LCS could be added to the monitoring network to improve spatial coverage of air-quality monitoring. The importance of quality assurance and quality control of data from LCS should, however, be emphasized in order to reduce the uncertainty of the measurements.

Data from LCS can be affected adversely by changes in humidity, temperature and the presence of other pollutants. In addition, LCS are susceptible to drifting aselines.

A meta-analysis of the scientific and g ey literature also indicated that, while LCS could supplement air monitoring networks, more work is necessary before they could be used independently for monitoring source compliance (*30*).

An example of the use of LCS data to supplement data from reference-grade monitors is that of the Meteorological Institute in The Netherlands; Mijling et al. (*31*) showed signifi antly better modelled concentrations of NO_2 on a fine spatial scale, although it was reported that the improvement was observed only when the LCS data were calibrated and validated with a reference monitor. Standard protocols for calibrating and validating LCS are available from the European Union (*32*) and the USA (*33*). Environmental regulators and policy-makers who plan to include LCS in their monitoring networks should develop robust protocols for LCS calibration and validation to ensure that the data closely reflect those f om a reference-grade monitor. LCS are nevertheless being increasingly used, including to obtain real-time information and related indices of air quality (*34*).

On the other end, satellite remote sensing has also dramatically improved in its ability to measure air quality (*35*). The primary advantage of satellite data compared to ground measurements is their spatial coverage. Satellite data is available for the entire globe and can provide invaluable information on the level, composition and transportation of pollution but also on the changes over time. Health and air quality communities have increasingly been using satellite data, and this trend is expected to continue (*36, 37*). Satellite data has been used to assess global air pollution exposure for the last three decades (*2, 38*) and it is an integral part of the modelling for SDG 11.6.2, Air quality in urban areas (*15, 39*). The reliability of the satellite-based estimates of air pollutants concentration depends, to a large extent, on the availability of the ground monitoring data, which allows calibration of the estimates.

An expert group was set up recently to advise WHO on continuing assessment of exposure to air pollution (*40*), and its recommendations will be used in future versions of this database.

6.3. Feedback, updating and improvement of the database

Countries, municipalities and their agencies that have relevant measurements are welcome to provide more recent or complete data in order to update or improve the database. Please contact us by writing to *aqh_who@who.int*.

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Annex 1. WHO regional groupings

Table A1. WHO region and World Bank income classification for each country

Country	WHO regions	World Bank income, (2019)[a]
Afghanistan	Eastern Mediterranean Region	Low income
Albania	European Region	Upper middle income
Algeria	African Region	Lower middle income
Andorra	European Region	High income
Angola	African Region	Lower middle income
Antigua and Barbuda	Region of the Americas	High income
Argentina	Region of the Americas	Upper middle income
Armenia	European Region	Upper middle income
Australia	Western Pacific egion	High income
Austria	European Region	High income
Azerbaijan	European Region	Upper middle income
Bahamas	Region of the Americas	High income
Bahrain	Eastern Mediterranean Region	High income
Bangladesh	South East Asia Region	Lower middle income
Barbados	Region of the Americas	High income
Belarus	European Region	Upper middle income
Belgium	European Region	High income
Belize	Region of the Americas	Upper middle income
Benin	African Region	Lower middle income
Bhutan	South East Asia Region	Lower middle income
Bolivia (Plurinational State of)	Region of the Americas	Lower middle income
Bosnia and Herzegovina	European Region	Upper middle income
Botswana	African Region	Upper middle income
Brazil	Region of the Americas	Upper middle income
Brunei Darussalam	Western Pacific egion	High income
Bulgaria	European Region	Upper middle income
Burkina Faso	African Region	Low income
Burundi	African Region	Low income
Cabo Verde	African Region	Lower middle income
Cambodia	Western Pacific egion	Lower middle income

Country	WHO regions	World Bank income, (2019)[a]
Cameroon	African Region	Lower middle income
Canada	Region of the Americas	High income
Central African Republic	African Region	Low income
Chad	African region	Low income
Chile	Region of the Americas	High income
China	Western Pacific egion	Upper middle income
Colombia	Region of the Americas	Upper middle income
Comoros	African Region	Lower middle income
Congo	African Region	Lower middle income
Cook Islands	Western Pacific egion	Not applicable income
Costa Rica	Region of the Americas	Upper middle income
Côte d'Ivoire	African Region	Lower middle income
Croatia	European Region	High income
Cuba	Region of the Americas	Upper middle income
Cyprus	European Region	High income
Czechia	European Region	High income
Democratic People's Republic of Korea	South East Asia Region	Low income
Democratic Republic of the Congo	African Region	Low income
Denmark	European Region	High income
Djibouti	Eastern Mediterranean Region	Lower middle income
Dominica	Region of the Americas	Upper middle income
Dominican Republic	Region of the Americas	Upper middle income
Ecuador	Region of the Americas	Upper middle income
Egypt	Eastern Mediterranean Region	Lower middle income
El Salvador	Region of the Americas	Lower middle income
Equatorial Guinea	African Region	Upper middle income
Eritrea	African Region	Low income
Estonia	European Region	High income
Eswatini	African Region	Lower middle income
Ethiopia	African Region	Low income
Fiji	Western Pacific egion	Upper middle income
Finland	European Region	High income
France	European Region	High income
Gabon	African Region	Upper middle income
Gambia	African Region	Low income
Georgia	European Region	Upper middle income
Germany	European Region	High income
Ghana	African Region	Lower middle income

Country	WHO regions	World Bank income, (2019)[a]
Greece	European Region	High income
Grenada	Region of the Americas	Upper middle income
Guatemala	Region of the Americas	Upper middle income
Guinea	African Region	Low income
Guinea-Bissau	African Region	Low income
Guyana	Region of the Americas	Upper middle income
Haiti	Region of the Americas	Low income
Honduras	Region of the Americas	Lower middle income
Hungary	European Region	High income
Iceland	European Region	High income
India	South East Asia Region	Lower middle income
Indonesia	South East Asia Region	Upper middle income
Iran (Islamic Republic of)	Eastern Mediterranean Region	Upper middle income
Iraq	Eastern Mediterranean Region	Upper middle income
Ireland	European Region	High income
Israel	European Region	High income
Italy	European Region	High income
Jamaica	Region of the Americas	Upper middle income
Japan	Western Pacific egion	High income
Jordan	Eastern Mediterranean Region	Upper middle income
Kazakhstan	European Region	Upper middle income
Kenya	African Region	Lower middle income
Kiribati	Western Pacific egion	Lower middle income
Kuwait	Eastern Mediterranean Region	High income
Kyrgyzstan	European Region	Lower middle income
Lao People's Democratic Republic	Western Pacific Region	Lower middle income
Latvia	European Region	High income
Lebanon	Eastern Mediterranean Region	Upper middle income
Lesotho	African Region	Lower middle income
Liberia	African Region	Low income
Libya	Eastern Mediterranean Region	Upper middle income
Lithuania	European Region	High income
Luxembourg	European Region	High income
Madagascar	African Region	Low income
Malawi	African Region	Low income
Malaysia	Western Pacific egion	Upper middle income
Maldives	South East Asia Region	Upper middle income
Mali	African Region	Low income
Malta	European Region	High income

Country	WHO regions	World Bank income, (2019)[a]
Marshall Islands	Western Pacific egion	Upper middle income
Mauritania	African Region	Lower middle income
Mauritius	African Region	High income
Mexico	Region of the Americas	Upper middle income
Micronesia (Federated States of)	Western Pacific Region	Lower middle income
Monaco	European Region	High income
Mongolia	Western Pacific egion	Lower middle income
Montenegro	European Region	Upper middle income
Morocco	Eastern Mediterranean Region	Lower middle income
Mozambique	African Region	Low income
Myanmar	South East Asia Region	Lower middle income
Namibia	African Region	Upper middle income
Nauru	Western Pacific egion	High income
Nepal	South East Asia Region	Lower middle income
Netherlands (Kingdom of)	European Region	High income
New Zealand	Western Pacific egion	High income
Nicaragua	Region of the Americas	Lower middle income
Niger	African Region	Low income
Nigeria	African Region	Lower middle income
Niue	Western Pacific egion	Not applicable income
North Macedonia	European Region	Upper middle income
Norway	European Region	High income
Oman	Eastern Mediterranean Region	High income
Pakistan	Eastern Mediterranean Region	Lower middle income
Palau	Western Pacific egion	High income
Panama	Region of the Americas	High income
Papua New Guinea	Western Pacific egion	Lower middle income
Paraguay	Region of the Americas	Upper middle income
Peru	Region of the Americas	Upper middle income
Philippines	Western Pacific egion	Lower middle income
Poland	European Region	High income
Portugal	European Region	High income
Qatar	Eastern Mediterranean Region	High income
Republic of Korea	Western Pacific egion	High income
Republic of Moldova	European Region	Lower middle income
Romania	European Region	High income
Russian Federation	European Region	Upper middle income
Rwanda	African Region	Low income

Country	WHO regions	World Bank income, (2019)[a]
Saint Kitts and Nevis	Region of the Americas	High income
Saint Lucia	Region of the Americas	Upper middle income
Saint Vincent and the Grenadines	Region of the Americas	Upper middle income
Samoa	Western Pacific Region	Upper middle income
San Marino	European Region	High income
São Tome and Principe	African Region	Lower middle income
Saudi Arabia	Eastern Mediterranean Region	High income
Senegal	African Region	Lower middle income
Serbia	European Region	Upper middle income
Seychelles	African Region	High income
Sierra Leone	African Region	Low income
Singapore	Western Pacific Region	High income
Slovakia	European Region	High income
Slovenia	European Region	High income
Solomon Islands	Western Pacific Region	Lower middle income
Somalia	Eastern Mediterranean Region	Low income
South Africa	African Region	Upper middle income
South Sudan	African Region	Low income
Spain	European Region	High income
Sri Lanka	South East Asia Region	Lower middle income
Sudan	Eastern Mediterranean Region	Low income
Suriname	Region of the Americas	Upper middle income
Sweden	European Region	High income
Switzerland	European Region	High income
Syrian Arab Republic	Eastern Mediterranean Region	Low income
Tajikistan	European Region	Low income
Thailand	South East Asia Region	Upper middle income
Timor-Leste	South East Asia Region	Lower middle income
Togo	African Region	Low income
Tonga	Western Pacific Region	Upper middle income
Trinidad and Tobago	Region of the Americas	High income
Tunisia	Eastern Mediterranean Region	Lower middle income
Türkiye	European Region	Upper middle income
Turkmenistan	European Region	Upper middle income
Tuvalu	Western Pacific Region	Upper middle income
Uganda	African Region	Low income
Ukraine	European Region	Lower middle income
United Arab Emirates	Eastern Mediterranean Region	High income

Country	WHO regions	World Bank income, (2019)[a]
United Kingdom of Great Britain and Northern Ireland	European Region	High income
United Republic of Tanzania	African Region	Lower middle income
United States of America	Region of the Americas	High income
Uruguay	Region of the Americas	High income
Uzbekistan	European Region	Lower middle income
Vanuatu	Western Pacific egion	Lower middle income
Venezuela (Bolivarian Republic of)	Region of the Americas	Upper middle income
Viet Nam	Western Pacific egion	Lower middle income
Yemen	Eastern Mediterranean Region	Low income
Zambia	African Region	Lower middle income
Zimbabwe	African Region	Lower middle income

[a]World Bank country and lending groups (US$). Low : ≤ US$ 1035 ; lower middle income : US$ 1036-4045 ; upper middle income : US$ 4046–12 535 ; High : > US$ 12 535 (*http://databank.worldbank.org/data/download/site-content/OGHIST.xlsx*).

Annex 2. PM and NO_2 annual means by region, income and settlement size

Table A2. PM_{10}, $PM_{2.5}$ and NO_2 annual means by WHO region, income level and settlement size for which data were available in the latest year between 2010 and 2019 (in µg/m³)

WHO regions and classification by income	Settlement size (no. of inhabitants)	PM_{10}	$PM_{2.5}$	NO_2
WHO regions				
African Region	< 100 000	50.0	32.1	NA
	100 000 —< 500 000	49.3	38.9	14.9
	500 000 —< 1 000 000	42.2	21.8	NA
	1 000 000 —< 3 000 000	73.6	33.0	NA
	> 3 000 000	61.0	25.4	16.8
	all cities	56.3	31.1	15.9
Regions of the Americas	< 100 000	24.2	9.1	10.1
	100 000 —< 500 000	31.5	12.5	15.7
	500 000 —< 1 000 000	27.7	12.3	23.0
	1 000 000 —< 3 000 000	42.2	15.7	22.1
	> 3 000 000	35.2	12.9	25.0
	all cities	29.8	11.2	15.5
South-East Asia Region	< 100 000	90.2	32.3	13.9
	100 000 —< 500 000	86.4	46.9	23.1
	500 000 —< 1 000 000	96.3	62.0	29.6
	1 000 000 —< 3 000 000	101.5	62.9	28.3
	> 3 000 000	112.7	86.3	38.1
	all cities	92.9	59.0	27.3
European Region	< 100 000	21.0	12.3	16.8
	100 000 —< 500 000	24.9	13.4	24.4
	500 000 —< 1 000 000	27.3	15.4	30.6
	1 000 000 —< 3 000 000	27.0	14.6	31.3
	> 3 000 000	30.1	15.7	39.3
	all cities	22.0	12.8	18.5
Eastern Mediterranean Region	< 100 000	120.5	35.4	54.0
	100 000 —< 500 000	114.3	36.7	46.1
	500 000 —< 1 000 000	97.1	35.5	53.9
	1 000 000 —< 3 000 000	145.3	43.0	37.3
	> 3 000 000	143.9	57.4	53.1
	all cities	120.2	38.9	47.5

WHO regions and classification by income	Settlement size	PM_{10}	$PM_{2.5}$	NO_2
Western Pacific Region	< 100 000	17.3	28.5	11.6
	100 000 —< 500 000	32.4	36.3	19.9
	500 000 —< 1 000 000	46.5	39.7	31.3
	1 000 000 —< 3 000 000	41.9	37.3	30.6
	> 3 000 000	42.4	38.3	35.7
	all cities	26.0	36.3	28.5
Income level				
High income	< 100 000	20.7	11.4	16.3
	100 000 —< 500 000	26.1	12.9	22.3
	500 000 —< 1 000 000	29.9	13.5	24.6
	1 000 000 —< 3 000 000	27.2	13.0	24.0
	> 3 000 000	27.3	12.4	23.5
	all cities	22.0	11.9	17.7
Low-and middle income	< 100 000	59.4	32.9	19.9
	< 100 000	62.8	36.2	25.8
	500 000 —< 1 000 000	72.5	40.1	37.1
	1 000 000 —< 3 000 000	88.4	39.6	32.4
	> 3 000 000	80.7	43.3	38.7
	all cities	68.0	37.9	29.4
World	< 100 000	24.7	15.0	16.5
	100 000 —< 500 000	39.8	26.7	23.1
	500 000 —< 1 000 000	52.2	35.4	30.2
	1 000 000 —< 3 000 000	69.3	33.9	28.9
	> 3 000 000	65.6	37.9	33.5
	all cities	32.5	24.5	19.4

NA: not applicable.

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