The air we breathe: differentials in global air quality monitoring

Air pollution is a severe problem worldwide, causing more than 7 million deaths every year. On May 12, 2016, WHO released its most recent report on urban air pollution. Compared with the last report released in 2014, the number of cities with air quality monitoring data available almost doubled, reaching 3000 cities in 103 countries. According to this new report, low-income and middle-income countries have the highest particulate matter (PM) levels: Onitsha, Nigeria, is the most polluted city in the world, followed by other cities in Nigeria, Pakistan, Iran, Afghanistan, and India in the top ten. The annual mean levels of PM$_{10}$ (ie, PM with a diameter of less than 10 μm) in the ten most polluted cities range from 329 μg/m$^3$ to 594 μg/m$^3$, 16-30 times higher than WHO-recommended limits (annual mean 20 μg/m$^3$). Many of the 100 most polluted cities, all of which have annual mean PM$_{10}$ levels above 130 μg/m$^3$, are in India, China, and other countries in Africa, southeast Asia, and the Middle East. 98% of cities with a population larger than 100 000 in low-income and middle-income countries have PM$_{10}$ levels above WHO-recommended annual limits, compared with 56% of such cities in high-income countries.

The WHO report covers thousands of cities that have air quality monitoring; however, many cities still do not monitor air quality. Here, we analyse data from the WHO Report and other sources to compare air quality monitoring coverage in 2012–14, adjusting for population sizes and land area, in different countries and regions of the world (table). In general, high-income countries have the best air quality monitoring in terms of the number of monitoring stations relative to population size or land area. Despite many efforts by the governments of several countries, most low-income and middle-income countries still have insufficient air quality monitoring.

![Table: Air quality monitoring coverage in 2012–14, by country and world region](http://dx.doi.org/10.1016/j.clinepi.2016.02.027)
China, one of the countries with many cities among the 100 most polluted, has been making efforts to monitor air quality and decrease air pollution levels by greatly reducing coal use, investing in renewable energy, and enforcing stricter rules for car ownership. As a result, PM$_{2.5}$ levels had been reduced by an average of 11.92% in major Chinese cities from 2013 to 2014.\textsuperscript{2} Air pollution monitoring has been improving rapidly in China: the number of monitored cities increased by 4.5 times and the number of monitoring stations increased by three times between 2012 and 2014.\textsuperscript{2} However, the coverage is still lower than that in high-income countries such as the USA, Japan, and many European countries.\textsuperscript{3-5}

In India, the predominance of highly polluting diesel vehicles and industrial coal burning still contributes to high PM levels. However, subsidies for diesel fuel have finally been halted in 2014, and India’s air quality monitoring system, despite being much smaller than that in China, has been expanded to more cities.\textsuperscript{6} Other low-income and middle-income countries, such as Pakistan and Indonesia, still have inadequate or no air pollution monitoring.\textsuperscript{7,8} In Russia, only two cities are reported to have air monitoring despite its extensive territory.\textsuperscript{1,8}

Despite the size of the African continent, only a few countries in Africa (eg, Nigeria and Egypt) have air quality monitoring stations, and South Africa has the largest monitoring system.\textsuperscript{1,9} By contrast, Australia, a high-income country with a vast area, has monitoring stations distributed according to population density.\textsuperscript{1,0} In South America, Chile has one of the largest monitoring systems, covering most regions in the country.\textsuperscript{1,1} Brazil, despite having more air monitoring stations than Chile, has a poor coverage and a highly unequal distribution of these stations; most stations are located in the southeast, the north is not monitored, and several large metropolitan areas in the northeast are also unmonitored.\textsuperscript{1,2}

The USA and Europe have recommendations for the number of monitoring stations relative to population size. Europe establishes a minimum of one PM$_{10}$ monitoring station for cities with up to 249 000 people, two stations for cities with 250 000–999 000 people, and 3–4 stations for cities with 1 000 000–2 749 000 people, and the numbers are doubled in highly polluted cities. In the USA, cities with more than 500 000 people are required to have one PM$_{10}$ monitoring station, cities with more than 1 000 000 people are required to have two stations, and highly polluted cities should have 3–4 times these required numbers. These recommendations could guide other countries in establishing and improving air quality monitoring.

The USA, Europe, and Japan have the best air quality monitoring coverage (table); in particular, Japan has the highest number of air monitoring stations per 10 000 km$^2$, in part because of its small territory. Outside these regions, Chile is the only country with a comparable air monitoring coverage relative to population size. Australia and South Africa have moderate air quality monitoring coverage relative to population size. Brazil, South America overall, Egypt, and China have similar numbers of stations per 1 000 000 population, but the number of stations per 10 000 km$^2$ in Brazil and in South America in general is five times lower than that in China, showing that a lot remains to be done to improve air quality monitoring in these regions. India and Russia have four times fewer stations per 1 000 000 population than China, despite the fact that India and China have comparable population sizes. In the case of Russia, the low number probably reflects insufficient information on air quality monitoring. Finally, Nigeria and Pakistan, in which five of the ten most polluted cities in the world are located, as well as Indonesia, have the worst monitoring coverage.

Thus, despite efforts of WHO in reporting global air pollution and other initiatives like the World Air Quality Index Project,\textsuperscript{7} which shows real-time air pollution levels in many cities worldwide, numerous cities in low-income and middle-income countries are not monitored for air quality. There is an urgent need to extend air quality monitoring to these regions and to make the information available so that governments can take measures to reduce air pollution, improving human health where health care is historically less accessible.

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Newborn screening for cystic fibrosis, an autosomal recessive genetic disorder, has been practised for over 40 years. Usually, newborn babies are defined as screen-positive for cystic fibrosis when immunoreactive trypsinogen levels are elevated on two consecutive samples, or on a single sample along with identification of one or two CFTR mutations. Programmes rely on sweat chloride testing in the first few months of life to distinguish true cases of cystic fibrosis from falsely screen-positive non-affected individuals (who are mostly cystic fibrosis carriers). Current guidelines emphasise the need for standardisation, referral only to proficient sweat chloride testing laboratories, and adequate sample volumes. Here, we raise additional concerns about whether a negative sweat chloride test result (<40 mmol/L), when conducted correctly, is sufficient to rule out cystic fibrosis.

Cystic fibrosis is caused by defects in the CFTR anion channel. Mutations in CFTR cause CFTR function that varies from zero to near normal levels. Cystic fibrosis with pancreatic insufficiency occurs when CFTR function is zero or close to zero, whereas CFTR function greater than 10% of normal levels permits enough pancreatic function to avoid pancreatic destruction and allow near-normal digestion. Physiological consequences of mild CFTR defects can be influenced by other genetic and environmental factors to produce a spectrum of CFTR-related disorders (eg, congenital absence of the vas deferens and recurrent respiratory infections). However, sweat chloride concentration varies inversely and logarithmically with CFTR function (figure), dropping steeply as function increases and declining much more slowly as CFTR function increases from 10%, making discrimination among CFTR function greater than 10% of normal levels difficult.

Unsurprisingly, the range of reported sweat chloride concentrations among registries of patients with cystic fibrosis includes so-called normal values (ie, <40 mmol/L in children ≥6 months old and ≥40 mmol/L in children >5 years old). The C-sweat to M-sweat ratio in the sweat gland

Figure: Two measures of CFTR function in the sweat gland

Sweat chloride is most sensitive at lower levels of CFTR function. The C-sweat to M-sweat ratio provides a direct readout of CFTR function and is linear over most of the range, but must be corrected as zero CFTR function is approached. C-sweat = β-adrenergically induced CFTR-dependent sweat. M-sweat = methacholine-induced sweat. Adapted from Char and colleagues.1