AIR QUALITY LIFE INDEX® | UPDATE MARCH 2018

Is China Winning its War on Pollution?

By Michael Greenstone and Patrick Schwarz

SUMMARY

Four years after Chinese Premier Li Keqiang declared a "war against pollution," has the government delivered on its promises to improve air quality? Using daily data from more than 200 monitors across the country from 2013 to 2017[1], we find that China's most populated areas have experienced remarkable improvements in air quality, ranging from 21 to 42 percent, with most meeting or exceeding the goals outlined in their National Air Quality Action Plan. If these reductions in pollution are sustained, the average Chinese citizen would see their life expectancy increase by 2.3 years relative to 2013. Although China faces a long road ahead to reach national and international air quality standards, these results suggest the country is winning its war on pollution.

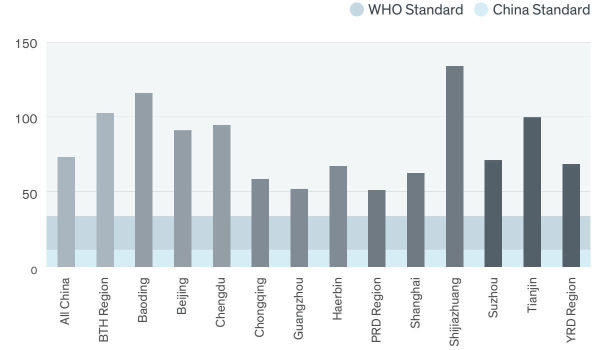
1 To have data that is the latest available and the most accurate on high-pollution winter days, this report uses pollution data fromground-level monitors. These measurements are generally higher than the satellite-derived pollution data used in the AQLI map tool.

INTRODUCTION

A New Age of Environmental Protection?

Leading up to the declaration, China had been experiencing some of its highest concentrations of fine particulate matter pollution (PM2.5) on record with little reason to believe conditions would ever improve. In the country's capital city of Beijing, for example, average PM2.5 concentrations in 2013 were 91 micrograms per cubic meter ($\mu g/m^3$), or nine times the amount the World Health Organization (WHO) considers safe and well above the county's own class-two national standard of 35 $\mu g/m^3$ (see Figure 1). In January of 2014, pollution reached 30 to 45 times recommended daily levels, and city officials warned residents to stay indoors. Similarly, in Shanghai, concentrations were 63 $\mu g/m^3$, or 6 times the WHO standard of 10 $\mu g/m^3$. In the 204 prefectures where we estimated PM2.5 in 2013, which represents nearly 70 percent of the total population, PM2.5 concentrations averaged 73 $\mu g/m^3$, which if sustained corresponds to a 6.2-year decline in life expectancy for the average resident.[2]

Figure 1 · $PM_{2.5}$ Concentrations Across China in 2013 ($\mu g/m^3$)



Notes and Sources: Data are from the China National Environmental Monitoring Center. "All China" refers to the 204 prefectures for which our balanced sample of monitors has available data. "BTH" refers to Beijing-Tianjin-Hebei; "PRD" refers to the Pearl River Delta; "YRD" refers to the Yangtze River Delta. The cities shown in this figure are the ten most populated prefectures in our sample.

> "The data is in—China is winning its war against pollution and is due to see dramatic improvements in the overall health of its people."
>
> **Michael Greenstone,** The Milton Friedman Professor in Economics Director, EPIC

With these record levels of air pollution came increased public scrutiny, which had been gradually rising for nearly a decade. In 2007, Ma Jun, director of China's path breaking environmental NGO, the Institute of Public & Environmental Affairs, released the China Air Pollution Map, a tool that allowed users to view air quality data from around the country. Beginning in 2008, the U.S. embassy in Beijing began publicly posting readings from its own air quality monitor on Twitter and the State Department website, which residents quickly pointed out conflicted with the level of air quality reported by the city government. By 2012, the U.S. embassy in Guangzhou and Shanghai also had set up their own pollution monitors and began reporting data.

Then, in the summer of 2013, EPIC Director Michael Greenstone and three co-authors published a study in the Proceedings of the National Academy of Sciences that found high air pollution had cut the lifespans of people living in northern China short by about five years compared to those living in the south. The study was covered by nearly every major international news outlet, several outlets in China, and went 'viral' on social media and through popular Chinese blogs. The clear demonstration of the health impacts further galvanized public scrutiny and drew the attention of the environment ministry. Soon after, reports began to circulate of foreigners leaving the country due to health concerns. By 2014, news reports from Beijing (which was singled out by the National Action Plan to reduce its concentrations of PM2.5 to below 60 $\mu g/m^3$) described daily conversations about air quality as a "national pastime amongst ex-pats and Chinese locals alike," with blogs and parenting forums being monopolized by discussions about taking vacations in "clean air destinations" and which air filter to purchase.[3]

With the Chinese public growing increasingly concerned about the pollution problem and demanding action, China matched its shift in rhetoric with concrete policy initiatives. The country released its National Air Quality Action Plan in 2013, laying out specific targets to improve air quality by the end of 2017. Included in the mammoth \$270 billion initiative were plans to reduce annual average PM2.5 concentrations in the densely populated Beijing-Tianjin-Hebei area by 25 percent and by 15 percent and 20 percent in the Pearl and Yangtze River Delta regions, respectively. Beijing, which had additionally set aside \$120 billion to fight pollution, would need to reduce PM2.5 levels to below 60 $\mu g/m^3$, or a 34 percent decline from its 2013 average of 91 $\mu g/m^3$. Across all urban areas, concentrations of PM10 would need to fall by at least 10 percent relative to 2012 levels.

The plan pledged to meet these goals by reducing dependency on coal, controlling vehicle emissions, increasing renewable energy generation, and increasing enforcement of emissions standards. The government also increased transparency in reporting air quality statistics by widening its air quality monitoring network and releasing the data to the public. In short, the stage was set for China to finally begin addressing its decades-long struggle to control air pollution.

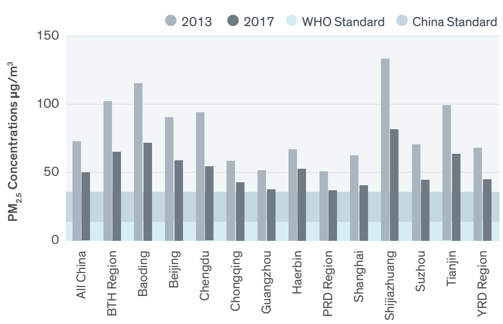
Between 2013 and 2017, the government took concrete steps to follow through on plans outlined in the Action Plan. New coal-fired power plants were prohibited in the Beijing-Tianjin-Hebei, Pearl River Delta and Yangtze River Delta regions, while existing plants were required to reduce their emissions. Those that didn't were replaced with natural gas. Large cities, including Beijing, Shanghai and Guangzhou, reduced emissions from automobiles by restricting the number of cars on the road. In the industrial sector, iron- and steel-making capacity was

2 The 6.2-year decline in life expectancy is based on a pair of studies coa-authored by Michael Greenstone that provides credible estimates of the impact of air pollution on life expectancy. For more information, see Figure 4 and the AQLI webpage, available at aqli.epic.uchicago.edu.

3 Wainwright, Oliver, "Inside Beijing's airpocalypse — a city made 'almost uninhabitable' by pollution", The Guardian, December 16, 2014.

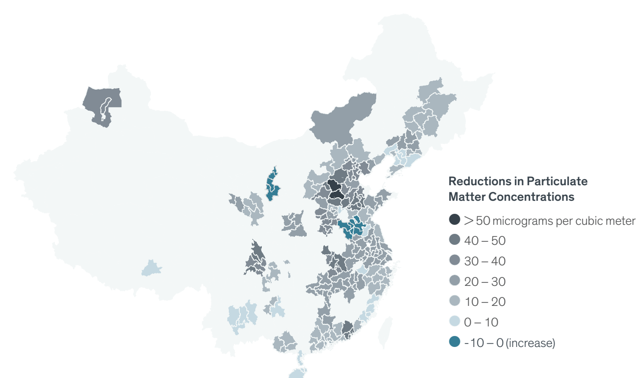
Table 1: China National Action Plan on Air Pollution Prevention and Control	
Goal 1	Lower urban concentrations of PM10 by 10 percent relative to 2012 levels; gradually increase the number of days with fairly good air quality.
Goal 2	Reduce concentrations of PM2.5 In the Beijing-Tianjin-Hebei, Pearl River Delta, and Yangtze River Delta by 25 percent, 20 percent, and 15 percent, respectively.
Goal 3	Reduce the annual PM2.5 concentrations in Beijing to below 60 μg/m³.

Figure 2 · $PM_{2.5}$ Concentrations Across China in 2013 and 2017 (μg/m³)



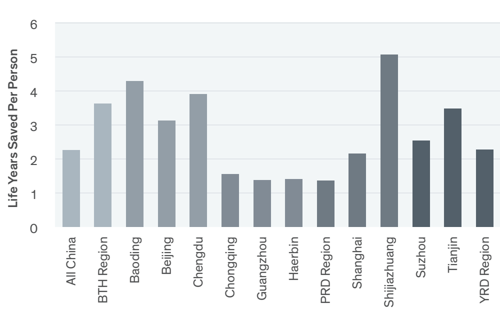
Notes and Sources: Data are from the China National Environmental Monitoring Center. "All China" refers to the 204 prefectures for which the balanced sample of monitors has available data. "BTH" refers to Beijing-Tianjin-Hebei; "PRD" refers to the Pearl River Delta; "YRD" refers to the Yangtze River Delta. The cities shown in this figure are the ten most populated prefectures in our sample.

Figure 3 · Change in PM2.5 Concentrations, 2013 and 2017



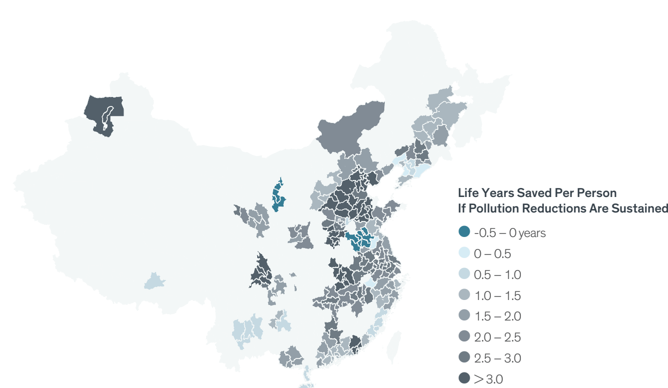
Notes and Sources: Data are from the China National Environmental Monitoring Center, using a balanced set of monitors with non-missing data in 2013 and 2017. Areas marked in white are not within range of any monitoring station.

Figure 4 · Change in PM2.5 Concentrations, 2013 and 2017



Notes and Sources: The estimated gains in life expectancy are based on a pair of studies published in the Proceedings of the National Academy of Sciences (Chen et al. 2013; Ebenstein et al. 2017) which estimate the impact of long-term exposure to fine particulate matter on life expectancy. The studies, which are based on Chinese data, suggest that a 10 μg/m³ decrease in sustained exposure to PM2.5 increases life expectancy by 0.98 years. For more information about the AQLI and the underlying studies, visit the AQLI website, available at: aqli.epic.uchicago.edu.

Figure 5 · Life Years Saved if Pollution Reductions Are Sustained



Notes and Sources: Pollution data are from the China National Environmental Monitoring Center, using a balanced set of monitors with non-missing data in 2013 and 2017. The calculation of life years saved uses the same methodology as the AQLI, which is described in detail in the notes of Figure 4.

reduced. In one of its more aggressive actions, government officials in the Beijing-Tianjin-Hebei area physically removed coal boilers from homes and replaced them with gas or electric heaters when the region was failing to meet its pollution targets.

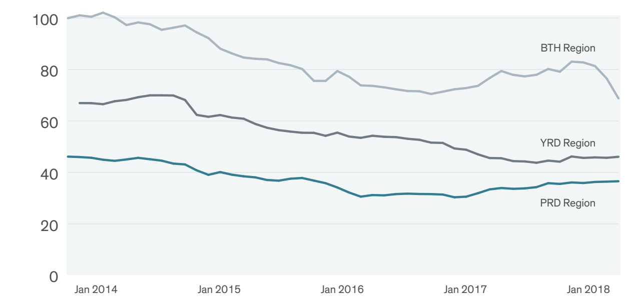
RESULTS

The Battle is Won, But the War is Not Over

After analyzing government PM2.5 data from more than 200 monitors throughout the country,[4] we find that the National Action Plan and subsequent aggressive measures to reduce pollution were strikingly successful. Since 2013, air quality has improved dramatically across the county, particularly in China's most populated cities. As seen in Figures 2 and 3, pollution fell nearly across the board and outpaced the targets outlined by the National Action Plan. In the Beijing-Tianjin-Hebei region, for example, concentrations fell by 37 μg/m³, or 36 percent from 2013 levels. The Pearl River Delta and Yangtze River Delta regions saw similar declines in pollution of 27 percent and 34 percent, respectively. For the 70 percent of the population with data available in 2013 and 2017, concentrations of PM2.5 fell by an average of 23 μg/m³, or 32 percent. Although concentrations are still above China's own standard and well above WHO guidelines, these data indicate that the country has achieved remarkably cleaner air in the very short period of four years.

Figures 4 and 5 translate these gains in air quality into the number of additional years a person could live if these improvements in air quality are sustained, using the Air Quality Life Index, or AQLI™, method.[5] In the 204 prefectures for which we have data, which cover nearly 70 percent of the total population, residents can expect to live on average 2.3 years longer relative to 2013 if the recent reductions in pollution are sustained. The roughly 20 million residents in Beijing could expect to live 3.1 years longer. Appendix Table 1 at the end of this document lists the specific gains for the 50 most populated prefectures for which data is available.

Figure 6 · Average PM2.5 in Beijing-Tianjin-Hebei, Yangtze River Delta and Pearl River Delta Regions, 2013–2017 (μg/m³)



Notes and Sources: Pollution data are from the China National Environmental Monitoring Center. Each line plots lagged twelve-month rolling average concentrations of PM2.5 for the Beijing-Tianjin-Hebei, Yangtze River Delta, or Pearl River Delta region.

Achieving the targets set out by the National Air Quality Action Plan wasn't without its challenges. As late as summer 2017, just months before the policy's deadline, the Beijing-Tianjin-Hebei area wasn't on track to meet its target. As illustrated in Figure 6, which plots rolling 12-month averages of pollution in the three key regions targeted by the National Action Plan, PM2.5 concentrations actually rose between January and July of 2017 in the Beijing-Tianjin-Hebei region and leveled off in the Pearl River Delta and Yangtze River Delta regions. The response from the Ministry of Environmental Protection was an aggressive 143-page "battle plan" that called for major reductions in industrial and residential coal consumption in the Beijing-Tianjin-Hebei area through March of the following year. The ensuing campaign, which included the physical removal of coal-fired boilers used for home heating throughout large northern cities, left some without winter heat while they waited for natural gas or electric replacements. Although the plan was a huge success in decreasing PM2.5 concentrations through the end of the year, as seen in the sharp declines at the end of 2017 in Figure 6, it also makes clear that longer-term solutions are still needed to make these reductions permanent.

4 While the Chinese National Air Quality Monitoring Network includes over 1,500 monitors in 2017 and 750 monitors in 2013, our analysis focuses on the set of monitors with available data throughout the year in both 2013 and 2017. The results of our analysis are robust to a variety of different monitor selection criteria.

5 The AQLI is based on a pair of studies (Chen et al. 2013; Ebenstein et al. 2017) published in the Proceedings of the National Academy of Sciences (PNAS) whose results suggest that a 10 μg/m³ reduction in sustained exposure to PM2.5 increases life expectancy by 0.98 years. See the AQLI website for more details about the study and methodology, available at: aqli.epic.uchicago.edu

CONCLUSION

The National Action Plan of 2013 aimed for a future of clean air and blue skies. While much of the country still has average PM2.5 concentrations above both China's own standard and WHO guidelines, data from China's national monitoring network indicate that the country has made significant gains in achieving its air quality goals. Existing gains have already made a significant impact on public welfare—if these new pollution levels are sustained, residents of China can expect to live on average 2.3 years longer. These improvements in air quality in just four years are truly remarkable by any measure. By comparison, it took the United States a dozen years and the vicious 1981-82 recession to achieve similar reductions in air pollution after the enactment of the Clean Air Act in 1970.

Looking forward, it is apparent that longer-term solutions are still needed. Indeed, the Ministry of Environmental Protection plans to formulate a new three-year air quality plan to win what the central government considers one of "the three tough battles" China faces in the next three years (poverty alleviation also being one). With economic growth remaining a priority in China, there are great opportunities to embrace market approaches—like taxes and cap-and-trade markets for pollution. These approaches would better facilitate growth than the engineering-style fiat tactics used frequently thus far in China's "war against pollution."

NOTE

The AQLI's methodology for calculating loss in life expectancy has been updated since the release of an earlier version of this report. The methodology is based on the results of Chen et al. (2013) and Ebenstein et al. (2017), which estimate the effect of PM10 on life expectancy. To more accurately calculate the effect of PM2.5 on life expectancy, we now use a PM2.5-to-PM10 ratio that is more consistent with the studies' setting. As a result of these changes, some of the values cited in the report are slightly smaller than in the previous version. For more details on the AQLI's methodology, visit: LINK.org

ACKNOWLEDGEMENTS

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Appendix Table | Pollution and Life Expectancy Gains in China's Most Populated Prefectures

		$PM_{2.5}$ Concentrations (µg/m3)			
Prefecture	Population	2013	2017	Difference	Life Expectancy Gain
Shanghai (Districts)	22,810,750	62.5	40.5	-21.9	2.2
Beijing (Districts)	19,323,943	90.6	58.8	-31.8	3.1
Chongqing (Districts)	16,078,945	58.6	42.7	-15.9	1.6
Chengdu	14,418,717	94.2	54.3	-39.8	3.9
Guangzhou	13,052,193	51.7	37.7	-14.0	1.4
Tianjin	11,297,312	99.1	63.6	-35.6	3.5
Baoding	11,210,792	115.5	71.7	-43.8	4.3
Haerbin	10,901,443	67.1	52.8	-14.3	1.4
Suzhou	10,707,893	70.6	44.7	-25.9	2.5
Shijiazhuang	10,454,812	133.4	81.7	-51.7	5.1
Linyi	10,286,295	61.9	49.6	-12.3	1.2
Shenzhen	10,276,070	47.0	33.8	-13.2	1.3
Wuhan	10,052,242	101.9	60.2	-41.7	4.1
Handan	9,420,317	121.4	74.2	-47.2	4.6
Weifang	9,308,278	54.6	29.7	-24.9	2.4
Wenzhou	9,307,296	52.5	35.3	-17.2	1.7
Hangzhou	8,899,881	65.6	45.7	-19.8	1.9
Zhengzhou	8,833,352	101.2	68.8	-32.4	3.2
Xuzhou	8,811,221	70.5	70.9	0.4	0.0
Xian	8,683,317	89.6	69.4	-20.2	2.0
Qingdao	8,567,147	54.6	29.7	-24.9	2.4
Dongguan	8,384,385	50.0	36.6	-13.3	1.3
Shenyang	8,318,117	71.1	50.4	-20.6	2.0
Quanzhou	8,303,943	34.6	26.1	-8.5	0.8
Jining	8,279,669	87.4	67.9	-19.5	1.9
Changchun	7,926,384	62.9	47.9	-15.0	1.5
Tangshan	7,781,505	96.7	63.5	-33.2	3.2
Ningbo	7,674,403	55.3	40.1	-15.2	1.5
Shangqiu	7,554,970	70.3	71.0	0.7	-0.1
Nanjing	7,503,510	75.9	47.7	-28.2	2.8
Yancheng	7,413,151	67.0	47.3	-19.7	1.9
Nantong	7,401,301	70.4	42.3	-28.0	2.7
Foshan	7,360,496	55.5	40.6	-14.8	1.5
Xingtai	7,310,084	129.6	77.4	-52.2	5.1
Cangzhou	7,292,225	93.9	66.1	-27.8	2.7
Changsha	7,240,351	80.7	54.1	-26.6	2.6
Fuzhou	7,231,472	35.1	25.9	-9.2	0.9
Yantai	7,056,225	54.6	29.7	-24.9	2.4
Jinan	6,981,460	105.6	62.8	-42.8	4.2
Zhanjiang	6,937,755	27.3	21.1	-6.2	0.6
Nanning	6,832,173	56.7	36.8	-19.9	2.0
Dalian	6,777,162	51.0	36.2	-14.8	1.4
Shangrao	6,752,626	75.1	47.2	-27.9	2.7
Kunming	6,605,984	32.9	24.4	-8.5	0.8
Wuxi	6,547,877	72.3	46.4	-25.9	2.5
Huanggang	6,315,869	96.8	56.8	-40.0	3.9
Taizhou	6,094,948	53.8	37.4	-16.4	1.6
Jieyang	6,015,329	73.9	30.5	-43.4	4.3
Qujing	5,990,068	32.9	24.4	-8.5	0.8
Wuzhishan	5,944,605	27.3	21.1	-6.2	0.6

Notes: Pollution data is from China's National Air Quality Monitoring Network. Population counts are calculated by aggregating LandScan 2015 gridded datasets to prefecture administrative boundaries.

ABOUT THE AIR QUALITY LIFE INDEX®

The Air Quality Life Index, or AQLI™, translates particulate pollution concentrations into the impact on lifespans. Specifically, it provides a reliable measure of the potential gain in life expectancy communities could see if their pollution concentrations are brought into compliance with World Health Organization, national, or some other standard.

Unlike much of the research linking air pollution and human health consequences, the AQLI is based on the consequences of sustained exposure to air pollution and plausibly isolates the impact from other factors that could affect health. It serves as an important complement to the frequently used Air Quality Index (AQI), which is a complicated function of air pollution concentrations and does not map directly to health.

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