Endocrine (2018) 59:495–498
DOI 10.1007/s12020-017-1326-1

VIEWPOINT

Particulate matter air pollution: individual choices for improving cardiometabolic well-being

Katherine Esposito[1] · Giuseppe Bellastella[1] · Maria Ida Maiorino[1] · Dario Giugliano[1]

Received: 30 March 2017 / Accepted: 9 May 2017 / Published online: 3 June 2017

Abstract Exposure to small particulate matter ($PM_{2.5}$) has become the 5th highest ranking risk factor for death, responsible for 4.2 million deaths worldwide. PM pollution is also associated with cardiovascular disease and type 2 diabetes, and may contribute to deteriorate the already poor cardiometabolic outlook of the diabetic patient. Although most sources of outdoor air pollution are well beyond the control of individuals, there is still room for personal action. Health behaviors (smoking cessation, avoiding obesity, and increasing physical activity) may increase the poor life expectancy of individuals in the lowest income quartile of the Western population; moreover, a favorable lifestyle, (no current smoking, no obesity, physical activity at least once weekly, and a healthy diet pattern), may cut by nearly 50% the risk of coronary heart disease among people at high genetic risk. Things seem not immutable, as individual healthy choices do matter.

Keywords Particulate matter · Type 2 diabetes · Cardiovascular disease · Health choices · Cardiometabolic well-being

World Health Organization recognizes air pollution as an important global risk factor for disease (http://www.who.int/mediacentre/news/releases/2014/air-pollution/en/). Exposure to small particulate matter (PM) of 10 microns (PM_{10}) or less ($PM_{2.5}$) in diameter has become the world's largest single environmental risk for health and life. PM pollutants consist of a mixture of particles (solid and liquid, organic and inorganic) suspended in the air, for the most derived from fossil–fuel combustion by motor vehicles. Their major components of PM are sulfate, ammonia, nitrates, black carbon, sodium chloride, mineral dust, and water.

Longevity and healthy life expectancy

Life expectancy is the average number of years that a newborn is expected to live if current mortality rates continue to apply [1]. In the first 15 years of this century, there has been a 5 years increase in life expectancy worldwide [2], which has counterbalanced the declines observed during the 1990s, when the AIDS epidemic in Africa and the collapse of the Soviet Union in Eastern Europe caused the fall in life expectancy. However, major inequalities still persist within and among countries (Table 1): women in Japan can expect to live the longest (average lifespan of 86.8 years), men in Switzerland enjoys the longest average survival (81.3 years), while people in Sierra Leone have the world's lowest life-expectancy (50.8 years for women and 49.3 years for men). On average, women live longer than men in every country of the world, with a difference of 4.6 years in 2015 (73.8 vs. 69.1 years).

Declining rates in the overall death rate

Starting from the 70s', there has been a decreasing trend in age-standardized death rate, including cardiovascular (CV) diseases and diabetes, in the USA and in other developed countries [3]. The progress against CV diseases has been attributed to improvements in control of risk factors

✉ Dario Giugliano
dario.giugliano@unicampania.it

1 Department of Medical, Surgical, Neurological and Metabolic Sciences, and Ageing, University L. Vanvitelli, Naples, Italy

Table 1 Life expectancy, healthy life expectancy and healthy years of life lost among the top ten countries in the world

Country	Life expectancy (years)		Healthy life expectancy (years)		Healthy years of life lost (years)	
	Men	Women	Men	Women	Men	Women
Japan	80.5	86.8	72.5	77.2	8.0	9.6
Switzerland	81.3	85.3	71.7	74.3	9.6	11.0
Singapore	80.0	86.1	71.8	75.9	8.2	10.2
Spain	80.1	85.5	70.6	74.1	9.5	11.4
Australia	80.9	84.8	70.8	72.9	10.1	11.9
Italy	80.5	84.8	71.8	73.7	8.7	11.1
Iceland	81.2	84.1	71.8	73.6	9.4	10.5
Israel	80.6	84.3	71.6	73.9	9.0	10.4
Sweden	80.7	84.0	71.1	73.0	9.6	10.0
France	79.4	85.4	70.7	74.4	8.7	11.0

(hypertension, hyperlipidemia, smoking cessation) and medical treatment [4]. On the other hand, years lost due to diabetes, diagnosed at 40 years of age, were reduced by 2 years from 1985 to 2011 [5], leading to more years spent with diabetes (increased by 156% for men and 70% for women). Despite these successes, a large burden of disease persists because of the continued increase in the prevalence of diabetes; moreover, mortality associated with a history of diabetes, stroke or myocardial infarction remains similar for each condition [6].

The raising numbers of old persons, as a consequence of declining mortality rates, especially in Westernized countries, will be associated with a huge challenge for health care delivery in the next decades. The lag between healthy life expectancy (HLE) and life expectancy is one of these challenges [7]. HLE provides an indication of overall health for a population and is a measure of the number of years of good health that a newborn in 2015 can expect to live. It is on average 11.7% shorter than life expectancy (range 9.3 to 14.7% between countries). The gap between life expectancy and HLE can also be described as the equivalent healthy years lost through morbidity and disability (Table 1). The main contributors to the loss of healthy years include CV diseases and diabetes. As their prevalence rises with age, their age-standardized rates are not declining: thus, HLE increases more slowly than life expectancy and the gap is predicted to wide as global life expectancy increases.

$PM_{2.5}$ predicts mortality

In 2015, over 90% of the world's population lived in areas that exceeded the WHO 10 μg/m^3 guideline. Exposure to $PM_{2.5}$ is the 5th highest ranking risk factor for death (Table 2), responsible for 4.2 million deaths worldwide [8].

Table 2 Global ranking of risk factors for total deaths

Factor	Ranking	Deaths (million)
High blood pressure	1	10.7
Smoking	2	6.4
High blood glucose	3	5.3
High total cholesterol	4	4.4
Ambient $PM_{2.5}$	5	4.2
High sodium	6	4.1
High body mass index	7	4.0
Low whole grain	8	3.2
Low fruit	9	2.9
Household air pollution	10	2.8
Low glomerular filtration	11	2.45
Alcohol use	12	2.4
Low nuts and seeds	13	2.1
Low vegetables	14	2.0
Low physical activity	15	1.6

Source: State of Global Air 2017. [8]

This recent estimation has surpassed by approximately a half million deaths the 3.7 million deaths per year attributable to outdoor air pollution by WHO in 2012 (http://www.who.int/mediacentre/news/releases/2014/air-pollution/en/). Indoor air pollution due to the use of solid fuels (wood, coal, etc.) for cooking and heating also has an important impact on health, ranking 10th overall; it also contributes to outdoor air pollution. Worldwide, it has been estimated that long-term exposure to ambient $PM_{2.5}$ is responsible for mortality from ischemic heart disease (17.1%), stroke (14.2%), lung cancer (16.5%), lower respiratory infections (24.7%), and chronic obstructive pulmonary disease (27.1%) [8].

$PM_{2.5}$, CV disease and diabetes

A number of other diseases, including diabetes, are also associated with acute or chronic exposure to air pollution [8]. The air connection with diabetes is intriguing for two main reasons: first, high blood glucose ranks third as a risk factor for global deaths, being responsible for 5.3 million deaths (Table 2); second, the diabetic tide is on the rise, with an estimated 642 million people being affected by 2040 [9].

So far, the results of the meta-analyses published support to a positive association between exposure to PM pollutants and incidence of diabetes [10]. The risk of future diabetes associated with exposure to 10 μg/m^3 increase of $PM_{2.5}$ is in the range of 10 to 27%. There are a number of possible biological pathways linking PM pollutants to diabetes, including, although not limited to endothelial dysfunction, vascular inflammation, hepatic insulin resistance, elevated blood pressure, and alterations in autonomic tone [11]. Interestingly, these same biological pathways link PM exposure to increased CV risk, an issue already recognized by international organizations (American Heart Association and European Society of Cardiology) [12, 13].

As diabetes and CV diseases are strictly linked, both epidemiologically and mechanistically, the possibility remains that chronic PM exposure may deteriorate the already poor cardiometabolic outlook of the diabetic patient. It may be by chance, but countries with high average annual population-weighted $PM_{2.5}$ concentrations, like China (58 µg/m^3) and India (74 µg/m^3) (www.stateofglobalair.com), are those with the highest numbers of diabetic patients (110, and 69 million, respectively). The highest concentrations of population-weighted average $PM_{2.5}$ in 2015 were in North Africa and the Middle East, due mainly to high levels of windblown mineral dust: in this world region, age-adjusted comparative diabetes prevalence ranks second in the world diabetes prevalence [9]. However, the ecological and plausible connection between PM and diabetes is not evident in other part of the world: in the USA, for example, the average annual population-weighted $PM_{2.5}$ concentrations were 8 µg/m^3 in 2015, below the upper limit to identify a good quality of the air. In the same year, the number of diabetic people in the USA averaged 29.3 million [9], with the highest (11.5%) world diabetes prevalence (adults, 20 to 79 years) in that world region (North America and Caribbean). Apart from PM pollution, other risk factors are obviously operative, either synergistically, additively, or antagonistically, to explain the long and apparently unrestrainable wave of type 2 diabetes in the world.

Individual choices do matter

Most sources of outdoor air pollution are well beyond the control of individuals. That air pollution is strictly linked to anthropic activities has become clear in Beijing, when Chinese Premier closed thousands of factories and banned half of five million registered cars to ensure an azure landscape. After that, Beijing has resumed its foggy landscape. (http://edition.cnn.com/2015/09/04/asia/china-beijing-blue-sky-disappears-after-military-parade/). Individuals should be informed that there is still room for personal action. In order to maximize HLE in people with or at risk for type 2 diabetes or CV diseases, for example, a look at the leading risk factors for total deaths may help (Table 2). At least 5 of 15 top risk factors are linked to diet, including high sodium, low whole grain, low fruit, low nuts and seeds, and low vegetables. In theory, this means that equilibrating all the dietary risks for health (consume less sodium and more whole grain, fruit, nuts and seeds, and vegetables) would counterbalance other non-dietary risks. There is evidence from randomized controlled trials that healthy diets, like Mediterranean diet is thought to be, can improve the cardiometabolic outlook of high risk patients, by preventing type 2 diabetes, ameliorating glucose control and cutting by 30% CV outcomes [14, 15].

Higher incomes are associated with longer life expectancy [16] and a recent study from the US population [17] concluded that life expectancy increases continuously with income, without threshold: life expectancy differs by 15 years for men and 10 years for women between the richest 1% and poorest 1% of individuals. Moreover the differences in life expectancy for individuals in the lowest income quartile are not significantly correlated with access to medical care, physical environmental factors, income inequality, or labor market conditions, but are related to differences in health behaviors, including smoking, obesity, and exercise. Interestingly enough, low physical activity is the 15th highest ranking risk factor for death. Finally, and perhaps more importantly, a favorable lifestyle, as defined as at least three of the four healthy lifestyle factors (no current smoking, no obesity, physical activity at least once weekly, and a healthy diet pattern), may cut by nearly 50% the risk of coronary heart disease among people at high genetic risk [18]. Thankfully, things seem not immutable. Individual healthy choices do matter, especially after presidential U.S. plan to weaken fuel standards, to rise coal industry again, and to reduce the agency's work on air quality (http://www.huffingtonpost.com/entry/american-lung-association-state-of-the-air-1017-us_us_58f4f5a0e4b0bb9638e566e6). If so, information on air pollution for a specific geographical area could be used in the stratification of the individual cardio-metabolic risk in the future.

Compliance with ethical standards

Conflict of interest The authors declare that they have no competing interests.

References

1. WHO, http://www.who.int/whosis/whostat2006DefinitionsAndMetadata.pdf. Accessed 17 Mar 2017
2. World Health Statistics 2016: Monitoring health for the SDGs http://www.who.int/gho/publications/world_health_statistics/2016/en/. Accessed 28 Mar 2017
3. R. Lozano, M. Naghavi, K. Foreman et al., Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of disease study 2010. Lancet **380**, 2095–2128 (2012)
4. J. Ma, E.M. Ward, R.L. Siegel, A. Jemal, Temporal trends in mortality in the United States, 1969-2013. JAMA **314**, 1731–1739 (2015)
5. E.W. Gregg, X. Zhuo, Y.J. Cheng, A.L. Albright, K.M. Narayan, T.J. Thompson, Trends in lifetime risk and years of life lost due to

diabetes in the USA, 1985-2011: a modelling study. Lancet Diabetes Endocrinol. **2**, 867–874 (2014)
6. Emerging Risk Factors Collaboration, Association of cardiometabolic multimorbidity with mortality. JAMA **314**(1), 52–60 (2015)
7. C.J. Murray, C. Atkinson, K. Bhalla et al., US Burden of Disease Collaborators, The state of US health, 1990-2010: burden of diseases, injuries and risk factors. JAMA **310**, 591–608 (2013)
8. Health Effects Institute. *State of Global Air 2017. Special Report*. (Health Effects Institute, Boston, MA, 2017)
9. International Diabetes Federation Diabetes Atlas 7th Edition, 2015. www.diabetesatlas.org. Accessed 28 Mar 2017
10. K. Esposito, M. Petrizzo, M.I. Maiorino, G. Bellastella, D. Giugliano, Particulate matter pollutants and risk of type 2 diabetes: a time for concern? Endocrine **51**, 32–37 (2016)
11. C.A. Pope 3rd, A. Bhatnagar, J.P. McCracken, W. Abplanalp, D.J. Conklin, T. O'Toole, Exposure to fine particulate air pollution is associated with endothelial injury and systemic inflammation. Circ. Res. **119**, 1204–1214 (2016)
12. R.D. Brook, S. RajagopalaS, C.A. Pope 3rd et al., American Heart Association Council on Epidemiology and Prevention, Council on the Kidney in Cardiovascular Disease, and Council on Nutrition, Physical Activity and Metabolism, Particulate matter air pollution and cardiovascular disease: an update to the scientific statement from the American heart association. Circulation **121**, 2331–2338 (2010)
13. D.E. Newby, P.M. Mannucci, G.S. Tell et al., ESC Working Group on Thrombosis, European Association for Cardiovascular Prevention and Rehabilitation; ESC Heart Failure Association. Expert position paper on air pollution and cardiovascular disease. Eur. Heart. J. **36**, 83–93b (2015)
14. K. Esposito, M.I. Maiorino, G. Bellastella, P. Chiodini, D. Panagiotakos, D. Giugliano, A journey into a Mediterranean diet and type 2 diabetes: a systematic review with meta-analyses. BMJ Open **5**, e008222 (2015)
15. K. Esposito, M.I. Maiorino, G. Bellastella, D.B. Panagiotakos, D. Giugliano, Mediterranean diet for type 2 diabetes: cardiometabolic benefits. Endocrine **56**, 27–32 (2017)
16. M. Marmot, Social determinants of health inequalities. Lancet **365**, 1099–1104 (2005)
17. R. Chetty, M. Stepner, S. Abraham, S. Lin, B. Scuderi, N. Turner, A. Bergeron, D. Cutler, The association between income and life expectancy in the United States, 2001-2014. JAMA **315**, 1750–1766 (2016)
18. A.V. Khera, C.A. Emdin, I. Drake et al. Genetic risk, adherence to a healthy lifestyle, and coronary disease. N. Engl. J. Med. **375**, 2349–2358 (2016)