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STUDY

Positive impact of the introduction of low emission zones in Antwerp and Brussels on air quality, socio-economic disparities and health: a quasi-experimental study.

Scientific summary

A publication from the Mutualités Libres/Onafhankelijke Ziekenfondsen
Route de Lennik 788A - 1070 Brussels
T 02 778 92 11
commu@mloz.be

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Authors > Luk Bruyneel[a,b], Bianca Cox[c], Anne Stauffer[d], Ludo Vandenthoren[a], Frans Fierens[e], Tim S. Nawrot[f,g], Christian Horemans[a]

[a] Independent Health Insurance Funds, Brussels, Belgium
[b] Leuven Institute for Healthcare Policy, KU Leuven, Leuven, Belgium
[c] VITO Health, Flemish Institute for Technological Research (VITO), Mol, Belgium
[d] Health and Environment Alliance, Brussels, Belgium
[e] Belgian Interregional Environment Agency, Brussels, Belgium
[f] Centre for Environmental Sciences, Hasselt University, Diepenbeek, Belgium
[g] Centre for Environment and Health, KU Leuven, Leuven, Belgium

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Air pollution has detrimental effects on both physical and mental health . To improve air quality within cities and assure that individuals can enjoy cities more, city authorities have been implementing a wide range of urban air pollution control policies and strategies. Low emission zones (LEZ) manage traffic entering cities by granting access only to vehicles that meet certain emission standards. In 2022, 320 LEZs were in force across Europe.

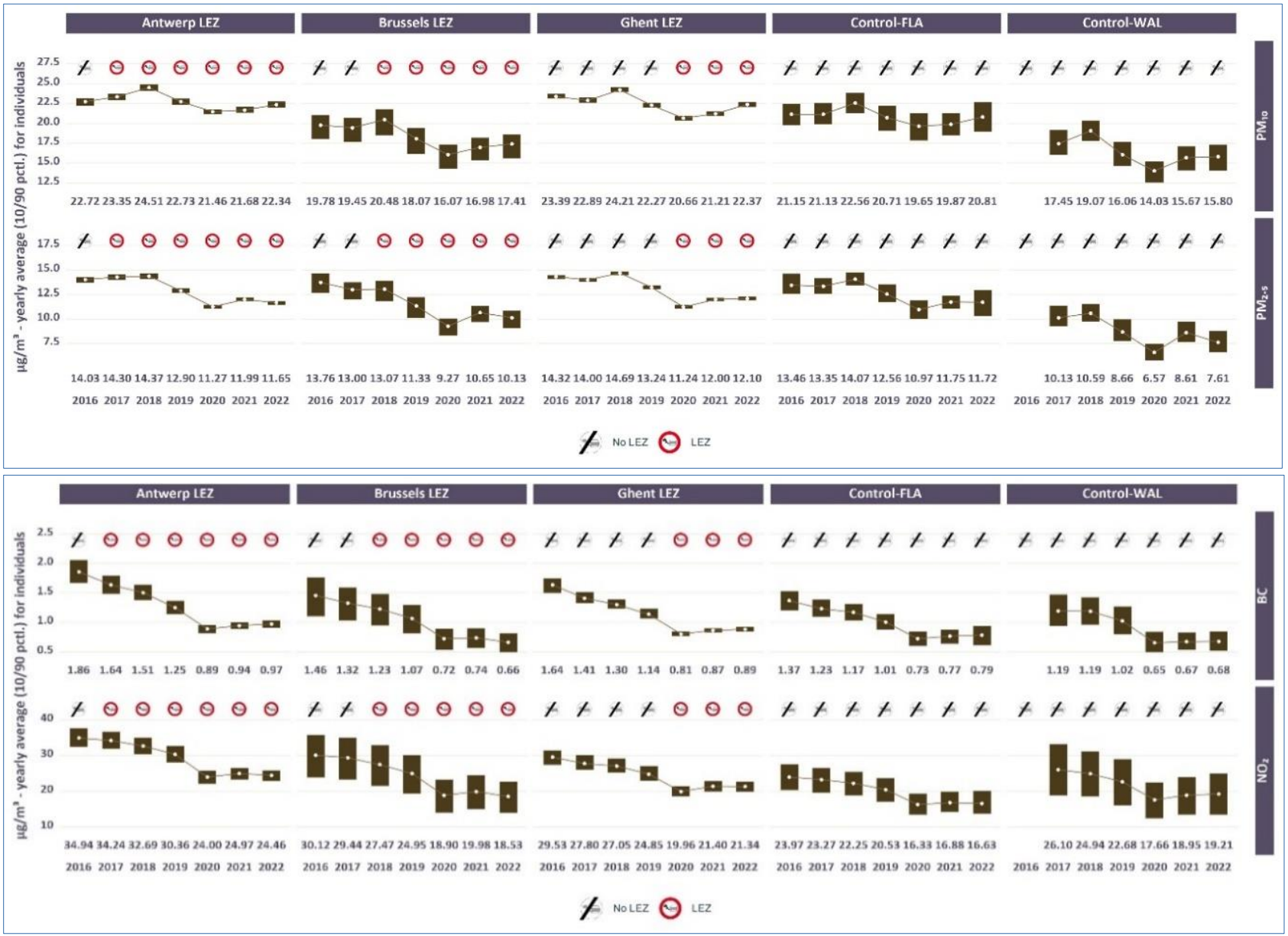
In this study, the Independent Health Funds (Mutualités Libres/Onafhankelijke Ziekenfondsen), in collaboration with Health and Environment Alliance (HEAL), KU Leuven, VITO, UHasselt, the Belgian Interregional Environment Agency, provide new insights into the impact of LEZs. This study evaluated if implementation of LEZs in Antwerp (2017), Brussels (2018) and Ghent (2020) improved air pollution within the boundaries of the defined zones, if spatial spillover effects occurred, if socioeconomic inequality in air pollution exposure changed over time, and if these developments were beneficial for health.

The study population comprised 420,007 individuals living within the LEZs, within seventeen control cities or within adjacent areas of these cities up to 5 kilometers. Annual residential air pollution (particulate matter - $PM_{2.5}$ and PM_{10}; nitrogen dioxide - NO_2; black carbon - BC) was calculated for 2016-2022. Individual-level health outcomes (diabetes, cardiovascular disease, obstructive airway diseases, antidepressants, antithrombotic agents) were available for 2014-2023. Random effect models were constructed to assess the impact of LEZs on air pollution and socioeconomic disparities, and a comparative interrupted time series analysis was conducted to evaluate the health impact. For the Ghent LEZ, a limited number of descriptive statistics are provided since it is too soon to assess its effects.

This population-wide research calculated residential exposure to BC, NO_2, PM_{10} and $PM_{2.5}$ and showed that the LEZs in Antwerp and Brussels have improved **air quality** statistically significantly more rapidly compared to other Belgian cities on average. Figure 1 displays average annual air pollution concentrations. Compared to control cities, individuals living within Antwerp and Brussels were confronted with higher concentrations of air pollutants in the years before LEZ implementation. They then saw a greater improvement in air quality with the LEZ compared to air quality improvements in control cities. In Brussels, NO2 concentrations reduced from 29.44 µg/m³ in 2017, the year before the introduction of the LEZ, to 18.53 µg/m³ in 2022. Compared to Brussels, the NO2 concentration in Walloon control cities was thus higher in 2022 (19.21 µg/m³) while it was lower in 2017 (26.10 µg/m³). Similarly, the average BC concentration in Brussels in 2017 was 1.32 µg/m³. In control cities in Flanders and Wallonia, this was 1.23 µg/m³ and 1.19 µg/m³, respectively. In 2022, the BC concentration was lower in Brussels (0.66 µg/m³) compared to that in control cities in Flanders (0.79 µg/m³) and Wallonia (0.68 µg/m³). In 2016, the year before the introduction of the LEZ in Antwerp, the average PM2.5 concentration was 14.03 µg/m³. In control cities in Flanders, this was 13.46 µg/m³. In 2022, the PM2.5 concentration was lower in Antwerp (11.65 µg/m³) compared to that in control cities in Flanders (11.72 µg/m³).

It is interesting to observe that the improvement of air quality is not limited to the LEZ. Our findings suggest strong positive spatial spillover effects of up to 5 km from the implementation of both the Antwerp and Brussels LEZ.

Figure 1 - Average annual residential exposure to PM_{10}, $PM_{2.5}$, BC, and NO_2 for individuals living within the Antwerp, Brussels, and Ghent Low emission Zones or within control cities: evolution 2016-2022

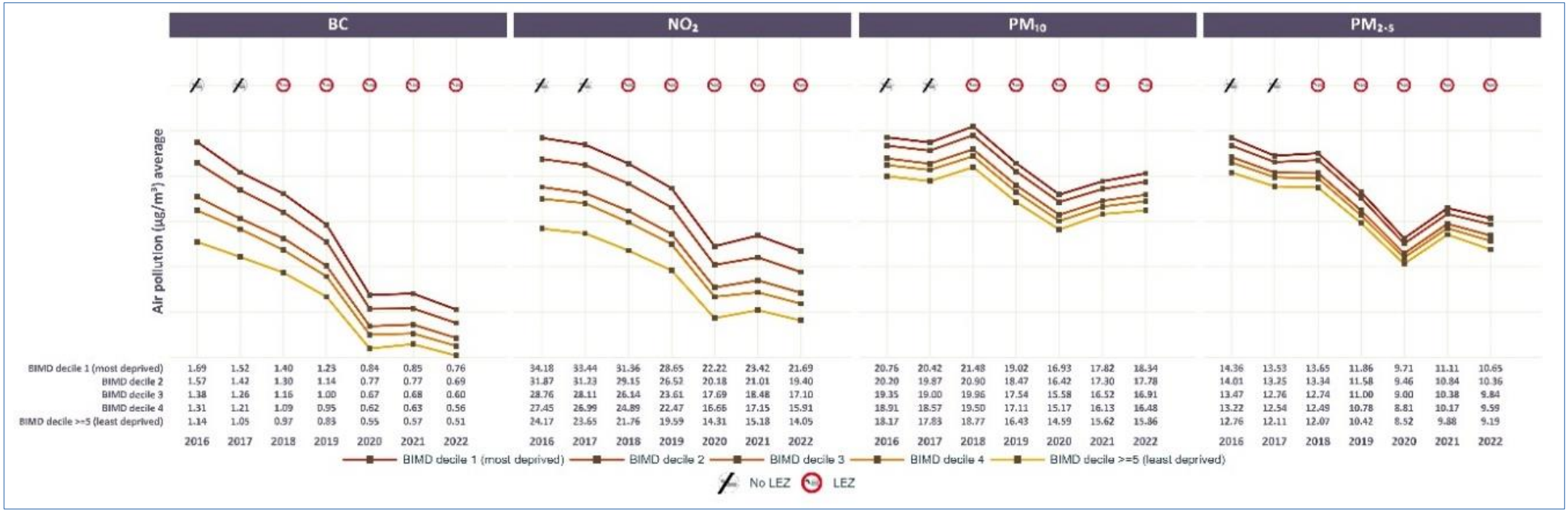


This study also aimed to evaluate if **socioeconomic inequality** in air pollution exposure changed over time. Information on socioeconomic position at the level of census tracts was available via the recently developed Belgian Indices of Multiple Deprivation (BIMD). Census tracts are a nationwide geographic subdivision of municipalities based on urban development, socioeconomic characteristics, and morphological properties. Census tracts are referred to as neighbourhoods in this text.

Socioeconomic disparities in air pollution (BC and NO_2) decreased, bolstering the environmental justice case for the low emission zone's establishment. The study shows that the most deprived neighbourhoods in the Brussels-Capital Region bear the heaviest burden of air pollution – but also that for some pollutants (BC and NO_2), the LEZ resulted in a faster decrease of air pollution in those neighbourhoods.

Figure 2 presents a visual depiction of the evolution (2016-2022) in air quality across socioeconomic position in Brussels. Several observations can be made. First, air quality is consistently worse with each increase in deprivation. Both before and after the introduction of the LEZ, more deprived neighbourhoods systematically bear the heaviest burden of air pollution. For example, in 2022, most deprived neighbourhoods had an average concentration of NO_2 of 21.69 µg/m³, while the least deprived neighbourhoods had an average concentration of 14.05 µg/m³. Second, everyone has enjoyed reductions in air pollution, irrespective of socioeconomic position. For BC and NO_2, the LEZ resulted in a statistically significantly faster decline in concentrations for the most deprived groups. For BC, there is a consistently stronger decline with each increase in socioeconomic deprivation. For NO_2, the least deprived neighbourhoods declined less rapidly compared to other neighbourhoods.

Figure 2 - Average annual residential exposure to BC, NO_2, $PM_{2.5}$, and PM_{10} for individuals living within the Brussels Low Emission Zone: evolution 2016-2022 across socioeconomic position measured using the Belgian Indices of Multiple Deprivation



Note: BIMD= Belgian Indices of Multiple Deprivation.

This study did not detect statistically significant differences in the evolution of **health outcomes** among persons living in the LEZs compared to control cities, although air quality had improved significantly faster in the LEZ over the same period. The only exception is the use of antidiabetics, for which there was a less steep pre-post LEZ increase among the cohort living in the Brussels LEZ versus the cohort living in control cities. The European Environment Agency (2023) estimates that for NO_2, the highest impact on health is due to diabetes mellitus, with 314,574 disability-adjusted life years (DALYs), which is much higher compared to stroke (204,723 DALYs) and asthma (115,425 DALYs). NO_2 showed great reductions in the Antwerp (from 34.94 µg/m³ in 2016 to 24.46 µg/m³ in 2022) and Brussels (from 30.12 µg/m³ to 18.53 µg/m³) LEZs, strongly outperforming other cities. Further research may confirm whether the effects we observe here for diabetes are a precursor to possible expected effects on other disease conditions. While there is a large evidence base for both short and long-term effects from air pollution exposure, the larger share of the health burden is from chronic exposure. For the majority of LEZs to have the intended effects on the environment and human health, they must be implemented for several years or have consistently effective vehicle standards. It is thus recommended to reevaluate the health impact in the near future.

General conclusions: Findings of this study suggest that with the introduction of the LEZ, all pollutant concentrations declined significantly more rapidly in both Antwerp and Brussels and adjacent areas compared to other Belgian cities and adjacent areas. Socioeconomic disparities in BC and NO_2 concentrations decreased over time. Findings for the evolution of diabetes suggested a positive impact of the LEZ for this particular outcome. This study suggests that LEZ implementation holds strong advantages that may extend beyond the boundaries of the defined zones. As air pollution concentrations in European cities are still high, policies such as LEZs are required to attain the World Health Organisation Global Air Quality Guidelines.

Selection of relevant studies:

Andersen, Z.J., Raaschou-Nielsen, O., Ketzel, M., Jensen, S.S., Hvidberg, M., Loft, S., Tjønneland, A., Overvad, K., Sørensen, M., 2012. Diabetes incidence and long-term exposure to air pollution: a cohort study. Diabetes Care 35, 92–98. https://doi.org/10.2337/DC11-1155

Azdad, Z., Stoll, B., Müller, J., 2022. The development trends of low- and zero-emission zones in Europe - Clean Cities Campaign [WWW Document]. URL https://cleancitiescampaign.org/research-list/the-development-trends-of-low-and-zero-emission-zones-in-europe/ (accessed 10.20.24).

Chamberlain, R.C., Fecht, D., Davies, B., Laverty, A.A., 2022. Effects of low emission zones and congestion charging zones on physical health outcomes: a systematic review. The Lancet 400, S30. https://doi.org/10.1016/s0140-6736(22)02240-1

European Environment Agency, 2023. Harm to human health from air pollution in Europe: burden of disease 2023 [WWW Document]. URL https://www.eea.europa.eu/publications/harm-to-human-health-from-air-pollution (accessed 12.2.24).

Hegelund, E.R., Mehta, A.J., Andersen, Z.J., Lim, Y.H., Loft, S., Brunekreef, B., Hoek, G., De Hoogh, K., Mortensen, L.H., 2024. Air pollution and human health: a phenome-wide association study. BMJ Open 14. https://doi.org/10.1136/BMJOPEN-2023-081351

Leefmilieu Brussel, 2023. Evaluatie van de Lage-emissiezone - Rapport 2022.

Mudway, I.S., Dundas, I., Wood, H.E., Marlin, N., Jamaludin, J.B., Bremner, S.A., Cross, L., Grieve, A., Nanzer, A., Barratt, B.M., Beevers, S., Dajnak, D., Fuller, G.W., Font, A., Colligan, G., Sheikh, A., Walton, R., Grigg, J., Kelly, F.J., Lee, T.H., Griffiths, C.J., 2019. Impact of London's low emission zone on air quality and children's respiratory health: a sequential annual cross-sectional study. Lancet Public Health 4, e28–e40. https://doi.org/10.1016/S2468-2667(18)30202-0/ATTACHMENT/31005C8F-23B9-47FB-B891-C887A35B592B/MMC2.XLSX

OECD, 2024. OECD Territorial Reviews: Brussels-Capital Region, Belgium, OECD Territorial Reviews. OECD, Paris. https://doi.org/10.1787/0552847B-EN

Otavova, M., Masquelier, B., Faes, C., Van den Borre, L., Bouland, C., De Clercq, E., Vandeninden, B., De Bleser, A., Devleesschauwer, B., 2023. Measuring small-area level deprivation in Belgium: The Belgian Index of Multiple Deprivation. Spat Spatiotemporal Epidemiol 45, 100587. https://doi.org/10.1016/J.SSTE.2023.100587

Saez, M., López-Casasnovas, G., 2019. Assessing the Effects on Health Inequalities of Differential Exposure and Differential Susceptibility of Air Pollution and Environmental Noise in Barcelona, 2007-2014. Int J Environ Res Public Health 16. https://doi.org/10.3390/IJERPH16183470

Sarmiento, L., Wägner, N., Zaklan, A., 2023. The air quality and well-being effects of low emission zones. J Public Econ 227, 105014. https://doi.org/10.1016/J.JPUBECO.2023.105014

Verbeek, T., Hincks, S., 2022. The 'just' management of urban air pollution? A geospatial analysis of low emission zones in Brussels and London. Applied Geography 140. https://doi.org/10.1016/j.apgeog.2022.102642

Vlaamse Milieumaatschappij, 2024b. Luchtkwaliteit in de Antwerpse agglomeratie - 2023 [WWW Document]. URL https://vmm.vlaanderen.be/publicaties/luchtkwaliteit-in-de-antwerpse-agglomeratie-2023 (accessed 12.1.24).

Wood, H.E., Marlin, N., Mudway, I.S., Bremner, S.A., Cross, L., Dundas, I., Grieve, A., Grigg, J., Jamaludin, J.B., Kelly, F.J., Lee, T., Sheikh, A., Walton, R., Griffiths, C.J., 2015. Effects of Air Pollution and the Introduction of the London Low Emission Zone on the Prevalence of Respiratory and Allergic Symptoms in Schoolchildren in East London: A Sequential Cross-Sectional Study. PLoS One 10. https://doi.org/10.1371/JOURNAL.PONE.0109121

Young, K., Zhang, H., Thornton, A., 2023. Inequalities in air pollution exposure, Part 2: Comparison with other cities.

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Route de Lennik 788 A - 1070 Brussels
T 02 778 92 11
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