Transport is associated with high air pollution peak exposures

Evidence from over 2000 days of personal monitoring

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Highlights

- Exposure profiles revealed 2.8 black carbon peaks per person per day using our peak detection algorithm
- Peaks contributed to 21% of total daily exposure to black carbon
- Participants most likely to encounter peaks while being in transport, and specifically bicycling
- Peak frequency and average exposure were only moderately correlated in a 24-h period

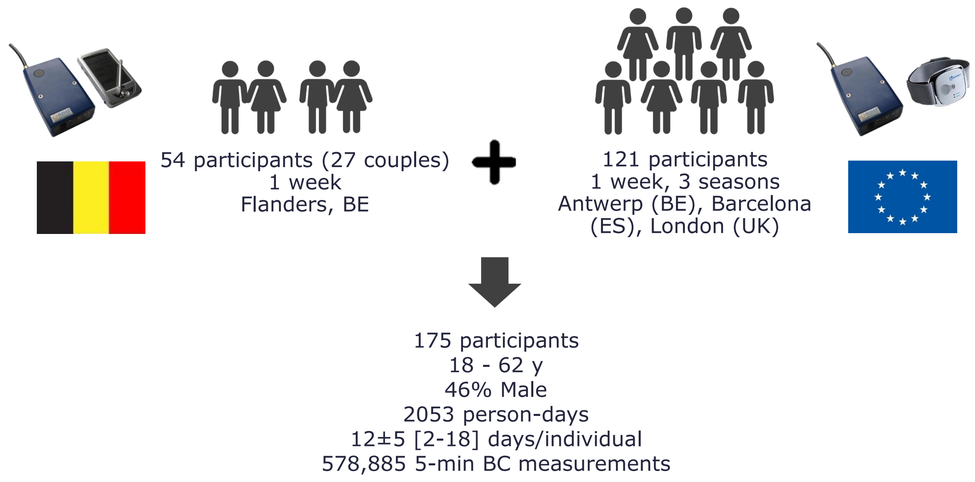
Introduction

There is a lot of evidence for health effects of long term exposure to air pollution. We also know that acute exposure to air pollution leads to acute changes in the body. However, what's the role of peak exposure events on long-term health?

Aims: To tackle this question, we first need to define an 'exposure peak'. It's is a widely used term but there is no fixed definition. Secondly, we study the role of personal characteristics, including time-activity and travel patterns, in daily exposure to peaks. And thirdly, we associate average exposure to the frequency of peaks.

We do this for **black carbon** (BC), a pollutant coming mainly from traffic in urban areas, with a proven short and long term health impact, and easily measurable with a portable monitor.

Dataset



Association between daily exposure and number of peaks

Pearson's r correlation coefficient between daily average BC exposure and the number of peaks during that same day was **0.44** (Fig. 3). The association between cumulative daily exposure and cumulative peak exposure during that same day was 0.69.

There was an increase in the correlation between average BC exposure and the number of peaks with an increasing number of measurement days per individual, i.e. not considering one person-day (24 h), but up to 18 person-days. From 10 days onward, the correlation coefficient increased to values above 0.60.

We could identify four **exposure profiles** according to low or high average daily exposure, and a low or high number of peaks on the same day (Fig. 4).

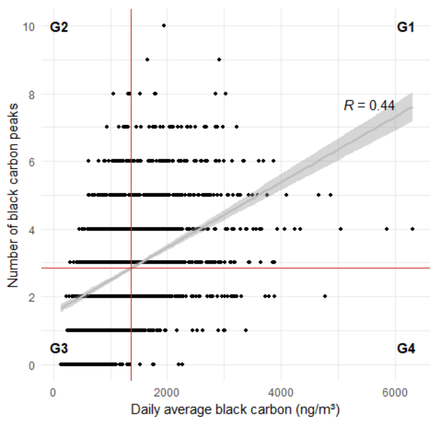


Fig. 3: Correlation plot of daily average BC exposure and the number of peaks. The red lines represent the average values that split the groups (G1-G4).

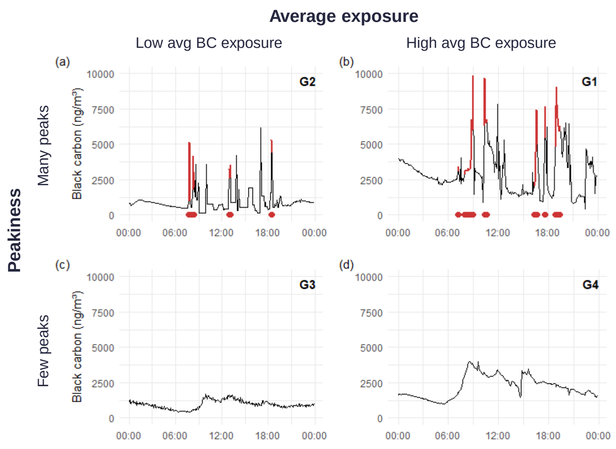


Fig. 4: Exposure profiles: Four daily timeseries as examples for each group defined in Fig. 3 (G1-G4). The red lines and dots indicate the peaks.

Peak detection algorithm

The algorithm calculates a moving mean for BC beginning at midnight. If the next observation is 3.5 SD away from the moving mean, the algorithm sets a peak. A peak can be given a weight below 1 in the moving window to limit the impact of peak events on the mean. The algorithm was programmed in R and can be used to detect peaks in real-time.

Fig. 1: Illustration of the peak detection algorithm in one 24-hour timeseries (time window = 2 hours; threshold = 3.5*SD; weight = 0.1). The timeseries presents personal monitoring of BC on May 21, 2015 in Barcelona, Spain. In this 24-hour timeseries the algorithm detected two peaks (in red in the graph). The average BC concentration was 944 ± 1437 ng/m³.

Results

General results

- Time-activity pattern: 30% sleeping, 62% daily activities, 8% in transport. Differences in activity reporting between the two studies may have led to some misclassification errors.

- Black carbon measurements were lognormally distributed (Fig. 2) (mean 1364 ng/m³; median 854 ng/m³) → Peaks!

- 2.8±1.6 (avg±SD) peaks per person per day.

- An average peak lasted 27.5±19.3 minutes.

- Although peaks were generally short in duration, they contributed to 21% of total daily exposure to black carbon.

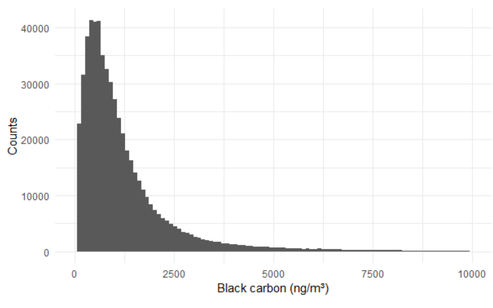
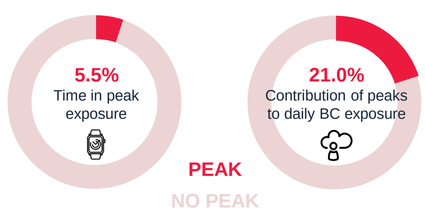
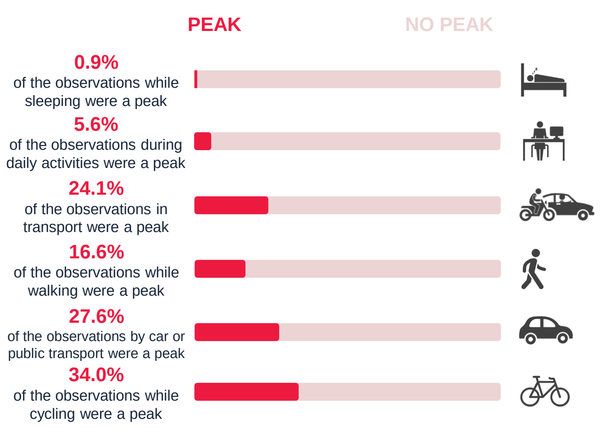


Fig. 2: All 5-min BC measurements in the pooled sample (N=578,885).



Factors associated to peaks



!! Findings from mixed effects logistic regression models that controlled for confounding variables (person, dataset) were comparable to the results from the descriptive analysis.

Gender and age were unrelated to the occurrence of peaks

More peaks during traffic rush hour
More peaks on Monday through Friday
More peaks in cold seasons

Sensitivity of the peak definition

Using a **fixed threshold** of for example 2500 ng/m³ is problematic on days with high background concentrations with a single peak lasting multiple hours, and at the same time excursions above this background are not explicitly marked.

Changing the parameter values of the algorithm impacted the results in the expected direction, for example lowering the threshold to 1.5 SD increased the frequency (3.7 ± 2.3 peaks per day) and the duration (44.9 minutes) of peaks. Independent of the definition of a peak or the parameters used in the algorithm, the Pearson's r between daily average BC exposure and daily number of peaks always ranged between 0.4 and 0.6.

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Dons, E., Laeremans, M., Orjuela, J.P., Avila-Palencia, I., de Nazelle, A., Nieuwenhuijsen, M., Van Poppel, M., Carrasco-Turigas, G., Standaert, A., De Boever, P., Nawrot, T., Int Panis, L., 2019. Transport most likely to cause air pollution peak exposures in everyday life: Evidence from over 2000 days of personal monitoring. Atmos. Environ. 213, 424-432. https://doi.org/10.1016/j.atmosenv.2019.06.035