

Contribution of smokers, ambient air pollution and establishment characteristics to fine particulate matter concentrations inside bars, restaurants and cafes

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Background / Objectives

Background

About a third of the Swiss population smokes, which is still allowed in many public places such as restaurants and bars. Consequently, many employees and non-smokers are involuntarily exposed to Environmental Tobacco Smoke (ETS) in such establishments.

Objectives

- To investigate the ETS-concentrations in bars, cafés and restaurants in central Zurich during the months of August and September 2008, when no smoking ban existed
- To analyse the impact of potential sources and establishment characteristics on the ETS-concentrations.

Method / Strategy

Study design

A sample of 102 hospitality establishments was randomly selected among the 700 restaurants of central Zurich. The places were visited at random time points on all weekdays from morning until midnight during 14 days in August-September 2008. Each visit lasted 30 minutes.

Exposure measurement

ETS-exposure was determined by measuring fine particle (PM_{2.5}) concentrations with a nephelometer positioned on top of a table that was away from open windows and particle source such as a flame grills, candles etc. If available, seating was chosen in a non-smoking area.

Other parameters

Numbers of smokers, other sources, seats, open windows, and open doors were recorded. Ambient air pollution data was obtained from public authorities.

Statistical analysis

Grouping variables were compared by Kruskal-Wallis rank sum test and Two-Sample Kolmogorov-Smirnov Test. Robust MM regression was used to investigate the influence of number of smokers and size of the establishment.

Results

Investigated establishments

Measurements were conducted in a total of 102 establishments over 14 days between August 14 and September 1, 2008 (Table 1).

Table 1: Summary statistics of the 102 visited establishments.

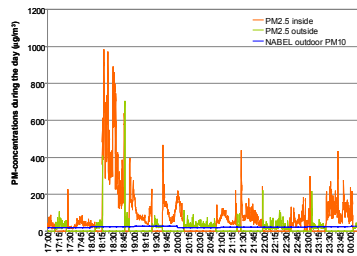
	Minimum	Average	Maximum
Number of Seats	20	65	200
Number of Guests ¹	0	12	80
Number of Smokers	0	3	15
Number of Staff	1	3	20

¹ Number of guests without the experimenter.

Forty of the 102 establishments had one or more window open allowing draft, whilst 85 had one or more open doorway. 33 establishments displayed evidence of alternative particle sources, such as open kitchens, candles, pizza ovens and the like.

Concentrations inside and outside

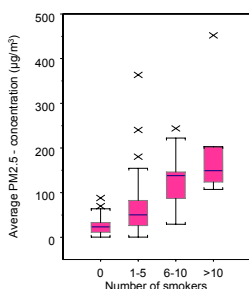
Time courses were analysed (Graph 3) and average concentrations inside and outside calculated. **The average PM_{2.5} inside establishments was 64.7 µg/m³** (StDev 73.2 µg/m³, 30-min maximum 452.2 µg/m³). Concentrations inside the establishments were significantly higher than outdoors (p<0.001, Kolmogorov-Smirnov).



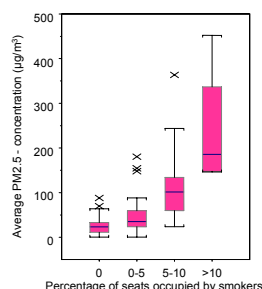
Graph 1: Example of a PM_{2.5}-concentration time-course during one of the measurement days. NABEL is a fixed site measurement in central Zurich.

Regression model

PM_{2.5} inside the establishments was significantly associated with number of smokers (Graph 1), percentage of seats occupied by smokers (Graph 2), and outdoor PM. **Each smoker increased PM_{2.5} on average by 15 µg/m³.**



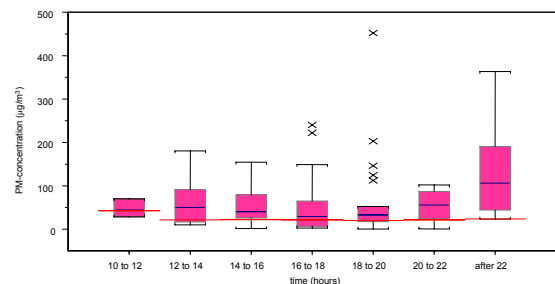
Graph 1: Influence of number of smokers on the PM_{2.5}-concentrations inside an establishment



Graph 2: Influence of the percentage of seats occupied by smokers.

Other factors: In a final step, the bimodal variables open door and open window were added to the model. PM_{2.5} inside the establishment showed a tendency towards increased values in dependence of closed doors, closed windows and other sources. However, none of these factors was significant in a simple pair-wise comparison (Two-Sample Kolmogorov-Smirnov Test). No associations were found with other sources, open doors and open windows.

Bars showed significantly higher (mean 81.1 µg/m³) concentrations than restaurants and cafes. Bars also had more smoking guests. Concentrations were highest in the late evening.



Graph 4: Average daytime variation of PM_{2.5} and NABEL PM₁₀ (red line).

Discussion and Conclusion

What do the results represent

This is a representative assessment of PM_{2.5} in bars, cafés and restaurants of central Zurich in late summer of 2008. Due to the pleasant summer weather most guests chose to sit outside, in terraces and beer gardens rather than inside. Many doors and windows were open during the measurements. Such patterns, in tandem with positive meteorological summer conditions paint a **„best case scenario“** picture whereby results are likely to reflect the **lowest concentration levels of the year**. The concentrations in the examined establishments were nevertheless **high** by reaching maximal 30-minute-average concentrations of up to 450 µg/m³. Ambient air pollution levels were in the same time period much lower with an average of 24 µg/m³ for PM₁₀.

Health relevance

Step 1: Estimate the contribution to the overall PM_{2.5} exposure.

- Employees will receive an annual average of about 20 µg/m³ if working in a bar with 100 µg/m³ tobacco smoke during 235 working days of 8 hours.
- Guests of a one a smoky bar with 450 µg/m³, will see from a one-hour visit an increase of the average PM_{2.5} exposure by about 20 µg/m³.

Step 2: Comparison with epidemiological data on ambient PM_{2.5}-mortality.

Rough estimation of risk:

- > Risk of bar employees for long-term all-cause, cardiopulmonary, and lung cancer mortality is increased by 8%, 12%, and 16%.
- > Daily mortality risk of a guest in a smoky bar increases by 3% on the day of the visit.

Conclusions

This study demonstrates that **already few smokers strongly affect air quality** by bringing particle to levels that imply serious health consequences for both employees and clients.

Acknowledgements

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