Agreement between NO_2 passive samplers and urban monitoring stations

Samantha Sartori[1], Cristian Pattaro[1], Marta Rava[1], Roberto Bono[2] and Roberto de Marco

[1]Division of Epidemiology & Medical Statistics, University of Verona
[2]Department of public health and microbiology, University of Turin

ABSTRACT
The interest of environmental epidemiology towards the effects of air pollution on health, requires reliable data on individual exposure to pollutants.
The measurements from one or more monitoring stations (MSs) may not represent the exposure of the whole population.
In the present work we considered the situation where a measure of global NO_2 exposure for an area of interest is needed and data from a number of monitoring stations placed in the area are available. The crucial question is whether the use of all the available information coming from the whole set of MSs (combined by some function, e.g. mean, median, max, etc.) is better than the use of the measurement coming from a single "representative" MS. Single and combined measurements are evaluated and compared.
In the frame of the European Community Respiratory Health Survey II (2001-03), 342 outdoor passive samplers (PSs) were used to measure the 14-day NO_2 exposure in the urban area of two Italian cities. Individual measurements were compared with the same-period NO_2 mean concentrations obtained from local (background and traffic) MSs. Correlation and Concordance Correlation Coefficients (CCC) were estimated to assess the agreement between MSs and PSs.
For this purpose, traffic MSs, background MSs, the best MS (the one with the best correlate with the PS or the one with the best concordance) and the MS average for all the MSs of each centre were compared to PS concentrations.
When data on NO_2 concentration coming from multiple MSs were available, the MS average appeared to be the statistic summary representing and correlating the exposure of the population.

AIMS OF THE STUDY

The need of proceeding through the most suitable way when assigning an exposure measure to the inhabitants of an urban area was reason of this study.
Our focus was onto two objectives:
- the first one was to verify the ability of the environmental MSs to give a reliable estimation of the amount of pollution to which a subject, living in that town, is truly exposed
- the second one was to evaluate the best summary statistics to be used, when multiple and different MSs are being used in the same city, for assessing individual exposure.

This information is of great interest for the ecological studies, where common values of pollution are usually assigned to each subject.

MATERIALS AND METHODS

The study is part of the survey ECRHS-II NO_2 indoor, which took place in the years 2001-2003, with the aim of evaluating the exposure to NO_2 in domestic environment.
The 227 participants to this study were part of random samples of the adult population of the two cities.
The protocol provided for the collocation of a passive NO_2 sampler outside the window of the kitchen of the house where the subject lived. Samplers collected NO_2 over a period of 14 days. The chemical mechanism of the sampler allowed the registration of the average exposure over the period.
To control for the seasonal effect, two measurements have been taken for each individual, usually six months far apart (we labelled the two measurement as Phase I and Phase II).
NO_2 time series from several MSs placed throughout the towns involved have been produced by the local Agency for the Protection of the Environment (ARPA).
For studying the ability of MSs to represent the individual exposure, values of individual NO_2 have been compared with the values registered at the MSs during the corresponding period of opening.
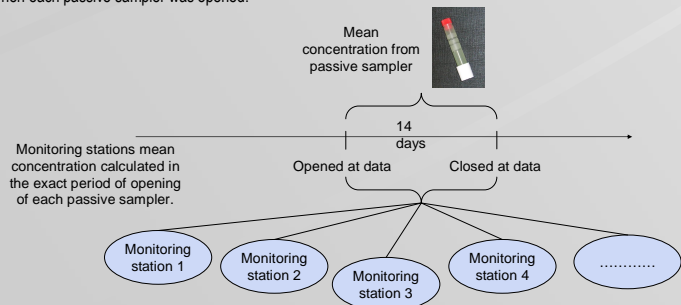
Missing Data:
- We did not taken into account those MSs for which we could not compare time-series longer than 7 days with the 15 days average of the individual sampler.
- For reasons of chemical reliability, we excluded individual samplers that stayed opened for more than 25 days.

Centre/MSs	Types of MSs	
	Type	Description
Verona		
Torricelle	BS	**Background** MS placed in a **Suburban** area
P.zza Bernardi	BU	**Background** MS placed in a **Urban** area
S. Giacomo	TU	**Traffic** MS placed in a **Urban** area
C. Milano	TU	**Traffic** MS placed in a **Urban** area
Cason	BR	**Background** MS placed in a **Rural** area
ZAI	TU	**Traffic** MS placed in a **Urban** area
Torino		
Rivoli	TU	**Traffic** MS placed in a **Urban** area
Rebaudengo	TU	**Traffic** MS placed in a **Urban** area
Lingotto	BU	**Background** MS placed in a **Urban** area
Gaidano	TS	**Traffic** MS placed in a **Suburban** area
Cristina	TU	**Traffic** MS placed in a **Urban** area

The comparison is between the mean concentration registered from each monitoring station in the same period when each passive sampler was opened.

Mean concentration from passive sampler

14 days

Monitoring stations mean concentration calculated in the exact period of opening of each passive sampler.

Opened at data — Closed at data

Monitoring station 1 · Monitoring station 2 · Monitoring station 3 · Monitoring station 4 · ....

The agreement between the concentration measured from the MSs and the concentration measured from the individual samplers was studied using graphical representations and assessed through the Pearson's coefficient of correlation and the coefficient of concordance (CCC; Lin 1989)

RESULTS

The correlation of the mean of concentrations of all the MSs with passive samplers is similar in the 2 areas and is not lower to the best correlated MS.
When considering the pollution levels registered from the individual samplers, Torino resulted with higher levels than Verona (respectively 69.0 vs 51.4, p<0.001); an opposite result has been observed when the values at the MSs were considered (38.9 vs 43.9, p<0.001).

Centre/MSs	Type of MSs	Oss.	NO_2 average	NO_2 sd	NO_2 range	Corr	CCC
Verona (Phase I e II)							
Torricelle	BS	222	20.6	10.8	6.5-49.5	.64	.18
P.zza Bernardi	BU	222	50.8	18.5	15.6-89.8	.58	.58
S. Giacomo	TU	222	46.6	10.7	26.5-73.9	.66	.53
C. Milano	TU	222	49.0	6.3	36.2-67.3	.41	.24
Cason	BR	222	37.7	11.2	18.5-68.4	.62	.39
ZAI	TU	220	58.5	14.0	36.8-131.5	.46	.40
Media Verona		222	43.9	10.2	26.1-71.0	.66	.49
Torino (Phase I)							
Rivoli	TU	103	49.3	13.4	27-82.2	.56	.31
Rebaudengo	TU	92	41.8	5.8	30-55.7	.48	.09
Lingotto	BU	105	27.9	15.2	8-55.3	.58	.15
Gaidano	TS	68	23.6	16.4	8-53.7	.54	.14
Cristina	TU	105	45.5	10.0	14.7-72.5	.38	.14
Media Torino		105	38.9	10.3	19.9-64.6	.64	.19

Note column headers: NO2 mean concentration measured from the MSs for each subject in the PSs opened period; Correlations and Concordance between PSs and MSs

The Figure shows the combined trend of the concentration measured by the samplers and the mean registered in the open period of each sampler by the MSs.

TORINO

VERONA
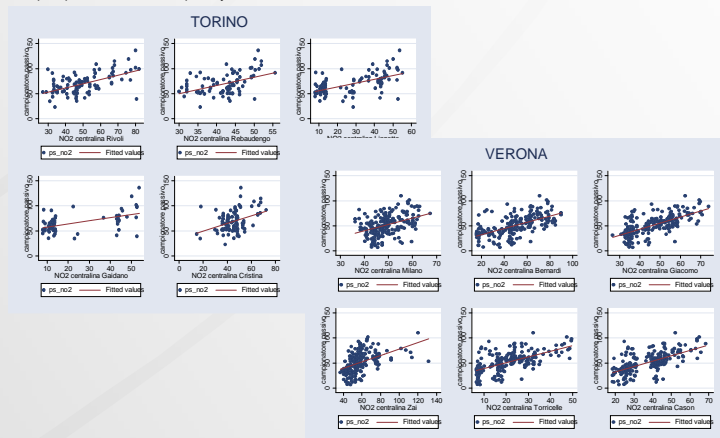
The correlation and the concordance between the MS's data and those measured by passive sampler are reported in the Table with reference to the type of MS and to the area. It can be noted how the concordance changes among the areas.

Centre	Traffic		Background		Best monitoring station*		MSs Average	
	Corr 95% C.I.	CCC 95% C.I.	Corr 95% C.I.	CCC 95% C.I.	Corr 95% C.I.	CCC 95% C.I.	Corr 95% C.I.	CCC 95% C.I.
Verona (nr.=222) 3 traffic 3 background	.61 [.52-.69]	.46 [.39-.53]	.64 [.56-.72]	.41 [.35-.49]	.66 [.58-.73] Urban-Traffic	0.58 [.50-.67] Urban-Background	.66 [.58-.73]	.49 [.42-.56]
Torino (nr.=104) 4 traffic 1 background	.63 [.49-.73]	.20 [.14-.26]	.58 [.43-.69]	.15 [.10-.21]	.58 [.43-.69] Urban-Background	.31 [.21-.41] Urban-Traffic	.64 [.51-.74]	.19 [.13-.25]

* We define the best MS, as the one with the best correlate with the PS (column Corr), or the one with the best concordance (column CCC).

DISCUSSION

In the present work we considered the situation where a measure of global NO_2 exposure for an area of interest is needed and data from a number of monitoring stations placed in the area are available.
The use of a "representative MS" is certainly an appealing way of dealing with the problem, but the notion of representativeness and the validity of the choice are rarely discussed and taken into account.
The assignment of an exposure level to an area implies the choice of what type of data to use. The choice can be easy if the monitoring net is based on a fine grid. Unfortunately this is not common, and MSs are often located in few special places.
This study takes its origin from the necessity of verifying the capacity of MSs of providing a global esteem of pollutant and the impact of different methodological paths that can be followed.
If the aim is not that of esteeming the pollution in determined areas of the town, but rather the one of assigning an exposure to the whole area along a given period of time, the use of the information provided by the whole set of MSs seems to be the right choice.

CONCLUSION

The study shows that the mean of all the MSs is correlated to the measurement of the passive sampler with the same strength of the best monitoring station of the centre. Therefore, if the aim is to assign an exposure level to the area without any information regarding the MSs or about the structure of the monitoring net of the centre, using the information coming from the entire set of MSs appears to be the best choice.

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