Air pollution from ships and its impact on health

Carla Ancona

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Italy is the first European market for cruise traffic, with 10.4 million passengers in 2017 and an average annual growth rate of 8% between 2005 and 2017.

The first seven ports (Civitavecchia, Venice, Naples, Savona, Genoa, Livorno and Bari) handle almost 80% of passengers,
Real-time monitoring of ships in the Adriatic (SHAPe project - IPA Adriatic). Naval routes 2-7 March 2018
Source: Marchesi Environmental Agency FVG
Air quality in Trieste (north east Italy)
Source: Marchesi Environmental Agency FVG
more than 500 cruises a year; half a dozen ferry lines carry passengers, cars, and freight to Sardinia, Sicily, and other points in the Mediterranean; economic effect of the cruise activities equal to 401.9 million euros
Background

Epidemiological studies carried out in the Civitavecchia district showed high mortality and morbidity risk for lung cancer, mesothelioma and respiratory diseases both among workers and general population.

- Harbor workers (Bonassi 1985)
- Electric power plant workers (Forastiere 1989)
- Seamen and ship workers (Rapiti 1992)
- Respiratory diseases in children (Forastiere 1992, 1994)
- Lung cancer case-control study (Fano, 2004)

data about individual exposure to pollutants from the different sources were not available
71,362 people
(18+ years)
What is (and which was) the individual level of exposure of residents?

Is there an association between ships emissions and long-term effect on the health of residents?
dispersion model

SPRAY

Meteorology

Emissions/hour

i.e. Plant

Orography

# particles

Exposure

Domain (50x50km)
resolution 500x500m
(consistent with meteo field)

3D hour concentration
500x500m

Annual average concentration
dispersion model
PM10 $\mu g/m^3$ concentrations
Biomonitoring the concentrations of metals in blood or in urine allows to assess the human contamination to environmental pollutants through all routes of exposure.

Disease or not disease
Human biomonitoring Study

A sample of 1200 residents (age 35-69) was randomly selected from the Municipal Register's data and their residence addresses were geocoded.

<table>
<thead>
<tr>
<th>Biomarcatore</th>
<th>NHANES® - USA</th>
<th>Revisione letteratura</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antimonio (Sb)</td>
<td>centrale a carbone</td>
<td>dieta; acqua</td>
</tr>
<tr>
<td>Arsenico (As)</td>
<td>centrale a carbone; porto; dieta; acqua</td>
<td></td>
</tr>
<tr>
<td>Berillio (Be)</td>
<td>combustione olio e carbone; fumo</td>
<td>fumo; dieta; acqua; rifiuti pericolosi</td>
</tr>
<tr>
<td>Cadmio (Cd)</td>
<td>combustione carbone e petrolio; fumo</td>
<td>centrale a carbone; porto; fumo</td>
</tr>
<tr>
<td>Cobalto (Co)</td>
<td>combustione carbone e petrolio; traffico</td>
<td>dieta (integratori)</td>
</tr>
<tr>
<td>Cromo (Cr)</td>
<td>centrali a carbone; porto; traffico; industria galvanica; fumo; dieta</td>
<td></td>
</tr>
<tr>
<td>Iridio (Ir)</td>
<td>traffico</td>
<td></td>
</tr>
<tr>
<td>Manganese (Mn)</td>
<td>porto; combustione; dieta</td>
<td></td>
</tr>
<tr>
<td>Mercurio (Hg)</td>
<td>combustione carbone; dieta</td>
<td>centrale a carbone; dieta</td>
</tr>
<tr>
<td>Molibdeno (Mo)</td>
<td>centrale a carbone; acqua; dieta</td>
<td></td>
</tr>
<tr>
<td>Nichel (Ni)</td>
<td>combustione carbone; porto; traffico; combustione; fumo; dieta; bigiottiera; detergenti</td>
<td></td>
</tr>
<tr>
<td>Palladio (Pd)</td>
<td>traffico</td>
<td>traffico</td>
</tr>
<tr>
<td>Piombo (Pb)</td>
<td>centrale a carbone</td>
<td>porto; dieta; acqua; bottiglie in pet ad alte temperature</td>
</tr>
<tr>
<td>Platino (Pt)</td>
<td>traffico</td>
<td></td>
</tr>
<tr>
<td>Rame (Cu)</td>
<td>centrale a carbone; porto; traffico</td>
<td></td>
</tr>
<tr>
<td>Radio (Rh)</td>
<td>Traffico</td>
<td></td>
</tr>
<tr>
<td>Stagno (Sn)</td>
<td>combustione carbone e petrolio; consumo di prodotti in scatola</td>
<td></td>
</tr>
<tr>
<td>Tallio (Tl)</td>
<td>combustione del carbone</td>
<td>combustione carbone</td>
</tr>
<tr>
<td>Tungsteno (W)</td>
<td>combustione; cementifico; acqua</td>
<td></td>
</tr>
<tr>
<td>Vanadio (V)</td>
<td>porto; carburanti di origine fossile; dieta</td>
<td></td>
</tr>
<tr>
<td>Zinco (Zn)</td>
<td>combustione; traffico; dieta</td>
<td></td>
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</tbody>
</table>
Association between PM$_{10}$ from the harbor and urinary concentration of heavy metals

PM$_{10}$ da Porto (stazionamento)

1.31 (0.98-1.76) 95% confidence interval

1.16 (0.98-1.38) 95% confidence interval

95% p-5% p = 0.065
Study design – Long term effect

- Study area definition
- Geocoding procedure
- Municipality data
- Pollution source
- Dispersion model (footprint)
- Distance from other industrial sites
- Socioeconomic level
- Meteorology
- Other pollution sources
- Orography
- Environmental monitoring
- Occupational history
- Population cohort
- Epidemiological evaluation
- Exposure-response relationship
- Follow-up
- t₀
- t₁
**Resident cohort approach**

Residents at 01-01-1996
follow-up 31-12-2013

71.362 people (18+ years)

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**OUTCOME**

Mortality (1996-2013)

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**EXPOSURE**

Distance from the harbour

≤ 500 m or >500 m
4664 residents < 500 meters
## Association between living <500 m from the harbour and mortality

<table>
<thead>
<tr>
<th>Condition</th>
<th>n</th>
<th>HR adj</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural mortality (001-799)</td>
<td>13,687</td>
<td>1.03</td>
<td>0.96 - 1.10</td>
</tr>
<tr>
<td>Malignant cancers (140-208)</td>
<td>4,427</td>
<td>1.11</td>
<td>0.99 - 1.25</td>
</tr>
<tr>
<td>Stomach (151)</td>
<td>294</td>
<td>1.39</td>
<td>0.89 - 2.17</td>
</tr>
<tr>
<td>Colon and rectum (153-154; 159)</td>
<td>585</td>
<td>1.09</td>
<td>0.79 - 1.50</td>
</tr>
<tr>
<td>Liver (155-156)</td>
<td>291</td>
<td>0.99</td>
<td>0.63 - 1.54</td>
</tr>
<tr>
<td>Pancreas (157)</td>
<td>240</td>
<td>1.05</td>
<td>0.65 - 1.68</td>
</tr>
<tr>
<td>Larynx (161)</td>
<td>38</td>
<td>0.34</td>
<td>0.04 - 2.59</td>
</tr>
<tr>
<td>Trachea, bronchus and lung (162)</td>
<td>1,046</td>
<td>1.31</td>
<td>1.04 - 1.66</td>
</tr>
<tr>
<td>Pleura (163)</td>
<td>29</td>
<td>0.61</td>
<td>0.14 - 2.63</td>
</tr>
<tr>
<td>Bladder (188)</td>
<td>181</td>
<td>1.11</td>
<td>0.62 - 1.98</td>
</tr>
<tr>
<td>Kidney (189)</td>
<td>103</td>
<td>0.29</td>
<td>0.09 - 0.95</td>
</tr>
<tr>
<td>Brain and other parts of CNS (191-192; 225)</td>
<td>92</td>
<td>0.84</td>
<td>0.35 - 2.02</td>
</tr>
<tr>
<td>Lymphatic and hematopoietic tissue (200-208)</td>
<td>368</td>
<td>1.08</td>
<td>0.73 - 1.61</td>
</tr>
<tr>
<td>Neurological diseases (330-349)</td>
<td>341</td>
<td>1.51</td>
<td>1.05 - 2.18</td>
</tr>
<tr>
<td>Cardiovascular diseases (390-459)</td>
<td>5,354</td>
<td>0.97</td>
<td>0.88 - 1.08</td>
</tr>
<tr>
<td>Respiratory diseases (460-519)</td>
<td>874</td>
<td>0.79</td>
<td>0.60 - 1.04</td>
</tr>
<tr>
<td>Digestive system diseases (520-579)</td>
<td>561</td>
<td>1.04</td>
<td>0.75 - 1.43</td>
</tr>
<tr>
<td>Renal diseases (580-599)</td>
<td>242</td>
<td>0.91</td>
<td>0.56 - 1.50</td>
</tr>
</tbody>
</table>
Discussion

- **Effect of diesel engine on lung cancer mortality**
  


- Traffic-related air pollution may negatively affect the **central nervous system** and contribute to central nervous system diseases
  


- Case-control study in Denmark found modeled NO$_2$ from traffic sources associated with **risk of Parkinson’s disease**
  
  Ritz B et al. Traffic-Related Air Pollution and Parkinson’s Disease in Denmark: A Case-Control Study. Environ Health Perspect 2015.
Prevention

- Ship emissions reduction (# of ships, speed, fuel)
- Verification of compliance with regulations in the use of fuels by all ships and boats
- Control of the fumes emitted by the chimneys of the ships and others polluting sources with LIDAR (Light Detection and Ranging),
- Replacement of trucks and cranes powered by diesel engines
- Environmental control
- Epidemiological surveillance
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No CoI
Let's breathe the Mediterranean

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Modello di dispersione

PM$_{10}$
Centrale a carbone

NO$_x$
 Traffico (cars+trucks)

PM$_{10}$
 Camini

Modello di dispersione degli inquinanti – Centrale Torrevaldaliga Nord – PM$_{10}$

Modello di dispersione degli inquinanti – Traffico stradale – NO$_x$ $\mu$g/m$^3$

Modello di dispersione degli inquinanti – Camini: – PM$_{10}$ $\mu$g/m$^3$