Global Health Impacts of International Shipping

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March 20, 2018

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- Shipping model: Jalkanen, J.-P., Johansson, L.
Estimates of Disease from Ship Emissions

1. **Ship activity-based emissions model**
   - Emissions associated with 0.5% global Sulphur rule

2. **High resolution atmospheric fate and transport model**
   - SOx concentrations at 10km x 10km resolution

3. **High resolution population health risk model**
   - Updated health equations – linear
   - Adult chronic exposure premature death
   - Childhood exposure asthma illness
Global Mortality due to PM exposure

Lung Cancer and Cardiovascular Mortality

- Cardiovascular
- Lung Cancer

BAU 2020

2020 Action
Regional Mortality due to PM exposure

<table>
<thead>
<tr>
<th>UNSD Region</th>
<th>BAU Mortality from Ships</th>
<th>Mortality from Ships with 2020 Action</th>
<th>Avoided Mortality with Cleaner Ship Fuels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asia</td>
<td>316,722</td>
<td>206,896</td>
<td>109,826</td>
</tr>
<tr>
<td>Europe</td>
<td>40,162</td>
<td>38,067</td>
<td>2,095</td>
</tr>
<tr>
<td>Africa</td>
<td>28,396</td>
<td>11,408</td>
<td>16,988</td>
</tr>
<tr>
<td>Latin America and Caribbean</td>
<td>10,862</td>
<td>5,923</td>
<td>7,079</td>
</tr>
<tr>
<td>Northern America</td>
<td>6,594</td>
<td>3,783</td>
<td>671</td>
</tr>
<tr>
<td>Oceania</td>
<td>488</td>
<td>184</td>
<td>304</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>403,224</strong></td>
<td><strong>266,261</strong></td>
<td><strong>136,963</strong></td>
</tr>
</tbody>
</table>

- Regional results highlight the importance of cleaner fuels in Asia, but also show that there’s work left to be done.

- Asthma results also important regionally, differ by population.
China

Mortality from ships: 206,000
Benefits of 0.5% rule: 45,700
China

Coastal Hotspots
China

Impacts extend far inland
Comparison with Liu et al. (2016)
Comparison with Liu et al. (2016)

Mortality in China (L): 206,000
Mortality in China (LL): 21,700

Liu modeling region

Figure 3 | Premature deaths per year attributable to East Asian shipping emissions in each 0.5° × 0.5° grid box. Positive values mean that shipping emissions damage human health.

Comparison with Liu et al. (2016)

Log-linear and linear health functions produce very different results.

Figure 3 | Premature deaths per year attributable to East Asian shipping emissions in each 0.5° x 0.5° grid box. Positive values mean that shipping emissions damage human health.  

Straits of Malacca

Mortality rate shows a clear gradient away from high shipping activity areas around Singapore and the strait.
Panama

Mortality per 100k

Panama Canal
Panama

Mortality

Premature mortality per cell

0
1
2
3
4
5
6
Mexico

Mortality

Mortality per 100k

Health-risk influence of coastwise shipping
The Mediterranean

Mortality
The Mediterranean

Mortality per 100k
Additional Results

• The global 0.5% Sulphur rule will result in per-year benefits
  137,000 avoided lung cancer and cardiovascular mortalities
  ~7 million avoided “cases” of childhood cancer

• Shipping offers additional health benefits where feasible
  • Additional special SOx control areas
    • The Mediterranean
    • China
  • Shore power
    • Macroeconomic benefits gained by switching from bunker fuel to electricity
Thank you

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## Global Mortality and Morbidity

<table>
<thead>
<tr>
<th>Scenario Results (Linear C-R Model)</th>
<th>Mortality Estimate (annual premature adult deaths*)</th>
<th>Childhood Asthma (million cases)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BAU 2020</strong> (No implementation of global 0.5% S fuel standard)</td>
<td>CV† Mortality (CI 95% 200,300; 501,800)</td>
<td>14.0 (CI 95% 7.5; 21.0)</td>
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<td>LC† Mortality (CI 95% 12,000; 93,600)</td>
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<tr>
<td></td>
<td>Combined Mortality (CI 95% 212,300; 595,400)</td>
<td></td>
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<tr>
<td><strong>2020 Action</strong> (Implementation of global 0.5% S fuel standard in 2020)</td>
<td>CV Mortality (CI 95% 129,800; 327,000)</td>
<td>6.4 (CI 95% 4.1; 11.5)</td>
</tr>
<tr>
<td></td>
<td>LC Mortality (CI 95% 8,700; 68,700)</td>
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</tr>
<tr>
<td></td>
<td>Combined Mortality (CI 95% 138,500; 395,700)</td>
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<tr>
<td><strong>Health benefit of 2020 Action</strong></td>
<td>Avoided Mortality† CV: 122,200 (CI 95% 70,500; 174,800)</td>
<td>Avoided Morbidity 7.6 (CI 95% 3.4; 9.6)</td>
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<td>LC: 14,800 (CI 95% 3,300; 24,900)</td>
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<td></td>
<td>Combined: 137,000 (CI 95% 73,800; 199,700)</td>
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