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## Cycling: Health Benefits and Risks

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de Hartog et al. (2010) quantified the balance between physical activity and air pollution and accident risks of cycling and concluded that the benefits outweigh the risks by an order of magnitude. This is the most comprehensive and quantitative comparison to date, based on the published data available at the time. In the weeks after publication of the article, two new relevant studies were published; this illustrates that a scientific answer to this question is urgent from the societal perspective. In many places cyclists are perceived to have a higher exposure to air pollution and a higher accident risk. Do the new data tilt the balance between the risks and benefits of cycling?

de Hartog et al. (2010) used a ventilation rate that is twice as high for cyclists as for car drivers. In a recent study in Belgium (Int Panis et al. 2010), we found that both the ventilation rate and the tidal volume were increased and that minute ventilation was 4.3 times higher in cyclists compared with car passengers (similar to the ratio of metabolic rates). The difference can further be explained by differences in cycling speeds and lung deposition resulting in a dose that is up to 9 times higher in cyclists.

The life expectancy (LE) loss estimated from substituting this ratio into the calculation by de Hartog et al. (2010) may thus offset most of the expected LE gain. However, this is unlikely because some studies have observed an LE gain in the presence of air pollution (Andersen et al. 2000). To resolve this conflict, it is important to consider the implicit assumptions in the comparison.

First, the higher dose ratios apply only to situations without route choice, although cyclists prefer to avoid motorized traffic, which exposes them to lower concentrations (Zuurbier et al. 2009). Second, an LE loss calculation based on long-term studies assumes a linear relationship between the risk and the daily dose. Exposure to short, high bursts of traffic exhaust may be different from an exposure to the same dose over a longer period. Assuming a linear exposure response function leads to overestimation of the impact of peak exposures. Third, cyclists are not a random sample from the general population. Air pollution mortality is often associated with the elderly and individuals with cardiovascular problems, but most cyclists are neither old nor very likely to suffer from bad health. Also, LE loss calculations cannot distinguish between situations in which a few people suffer a high LE loss or those in which many people have a small loss (Rabl 2003). Cyclists are generally young and in excellent health and therefore less vulnerable, implying that the relative risk used by de Hartog et al. (2010) is too high for application to this specific population.

In addition, accidents remain an important cause for concern. Aertsens et al. (2010) recently estimated the cost of minor bicycle accidents at an astonishing 0.12€/km cycled. Including the more serious accidents in the equation would yield a cost that could easily offset the value of the LE benefit calculated by de Hartog et al. (2010).

If the higher LE observed in present day cyclists can be transferred to people now taking up cycling, the benefits will probably be higher than the risks. However, it will be crucial to demonstrate that cycling increases physical activity. Without increased physical activity there are only risks, but reducing those risks may yield larger benefits than anticipated.

*The views and opinions expressed in this article are those of the author and not necessarily those of his employer.*

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## Cycling: de Hartog et al. Respond

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We thank Int Panis for his thoughtful comments on our article (de Hartog et al. 2010), and we broadly agree with his comments. In fact, we discussed most of the issues—including the limitation to impact on mortality, sensitive subgroups, route choice, and activity substitution—in our paper.

The first issue discussed by Int Panis is whether we underestimated the difference in minute ventilation between cyclists and car drivers; however, his comment was based on a recent Belgian study (Int Panis et al. 2010) that was not published at the time of our study. In our analysis we used a ratio of 2.2 [the average of two Dutch studies that closely agreed (van Wijnen et al. 1995; Zuurbier et al. 2009)], whereas the Belgian study (Int Panis et al. 2010) found a ratio of 4.3. The difference is probably explained in part by differences in cycling speed: 12 km/hr in the recent Dutch study (Zuurbier et al. 2009) and > 19 km/hr in the Belgian study (Int Panis et al. 2010). In urban areas, the average cycling speed is about 15 km/hr, including stop time. Rather than replacing the previous estimates by with the newer Belgian estimate, we believe that the best current estimate would be the average of the ratios of the three available studies. This would lead to a ratio of 2.9. Use of this ratio based on more studies clearly would not tip the balance between cycling and car driving as Int Panis suggests. We think it is stretching the data too much to use deposited particle mass (actually 5.9–8.99 higher in the Belgian study) for the analysis, because the long-term epidemiological studies we used are based on concentrations measured in outdoor air. In the most likely estimate we provided for air pollution [based on black smoke, which better represents traffic exposures than $PM_{2.5}$ (particulate matter < 2.5 μm in aerodynamic diameter)], even including these estimates would not make a difference.

As we noted in the "Discussion" of our article (de Hartog et al. 2010), cyclists have more opportunity in urban areas to choose low-exposure routes. This would indeed result in smaller differences in inhaled doses between cyclists and car drivers than we used. We agree that we may have overestimated the air pollution risks related to cycling because, in general, subjects who cycle are healthier than those who respond in long-term epidemiological studies. However, with increasing evidence that air pollution—through oxidative stress and inflammation—may also increase preclinical cardiovascular disease, including

atherosclerosis (Brook et al. 2010), long-term effects of air pollution are not limited to mortality in the most sensitive subjects.

Another issue deals with the large number of nonfatal bicycle accidents reported in a recent assessment in Belgium (Aertsens et al. 2010). We do not want to downplay the importance of these accidents; however, because Aertsens et al. (2010) exclusively reported accidents in cyclists, the study cannot be used in a comparative assessment of the risks of cyclists and car drivers, the topic of our paper. There is therefore no basis for Int Panis's statement that inclusion of this information could easily have tipped the balance between risks and benefits. As we discussed in our article (de Hartog et al. 2010), we also did not take into account the benefits of physical activity on quality of life and other nonfatal health effects. We welcome an attempt to systematically make this assessment. In an assessment of traffic accident risks and benefits from air pollution and physical activity in the general population using disability-adjusted life years (DALYs), Woodcock et al. (2009) found that about about 80% of the calculated DALYs of all stressors were due to loss in life years, so we do not expect our conclusion to be much affected when morbidity is assessed. Finally, we fully agree with the statements about the importance of reducing risks from accidents and air pollution for commuters. Our paper should not be interpreted as a plea for ignoring these important risks.

*The authors declare they have no actual or potential competing financial interests.*

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