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Poster #

Surface-water nitrate exposure to world populations has expanded and intensified since 1970

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Background

Water-related health risks are one of the major concerns worldwide. Today, more than two billion, or one-in-four people around the world do not have safe drinking water services[1].

Surface waters provide half of the current global drinking water supply[2]. The quality of surface waters may pose vital influences on human health as drinking water is one of the most important pathways of human exposure to potential adverse chemicals.

Excessive nitrate in surface waters deteriorates water quality and threatens human health. Various adverse health effects have been reported in relation to human exposure to high levels of nitrates in the water supply. Methemoglobinemia is an acute adverse health effect of high nitrate exposure, particularly for infants, pregnant women, and individuals with gastrointestinal or genetic diseases[3]. High nitrate ingestion may therefore increase the risks for various cancers, birth defects, and spontaneous abortions[4]. Documented adverse health risks range from thyroid hypertrophy[5], non-Hodgkin's lymphoma[6], insulin-dependent diabetes mellitus[7], central nervous system birth defects[8], intrauterine growth restriction[9], to cancers of the digestive tract (e.g., stomach, esophagus, colon and rectum)[10] and the genitourinary system (e.g., bladder, ovarian, prostate)[11].

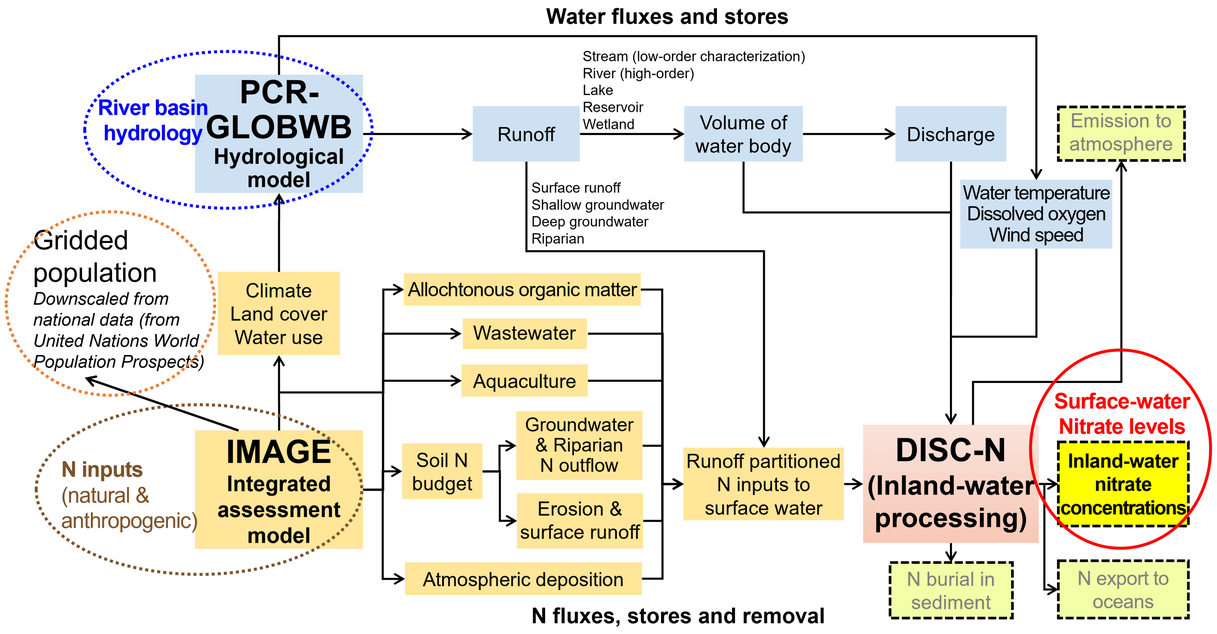
Human activities have caused increased nitrate concentrations in global surface waters over the past 50 years[12-14]. However, an assessment of the long-term trajectory of surface-water nitrate exposure to world populations and associated potential health risks is imperative but lacking.

Aim

To quantify the spatial and temporal changes in surface-water nitrate exposure to world populations and their implications for potential acute and chronic health risks. .

Multi-disciplinary approach

We used the spatially explicit surface-water nitrate concentrations simulated by IMAGE-DGNM (the Integrated Model to Assess the Global Environment - Dynamic Global Nutrient Model)[15-16] and gridded population density data from the same integrated model IMAGE[17] with a consistent resolution of 0.5°×0.5°.



In combination with thresholds for various health risks from epidemiological studies[3-11], we calculated world populations at potential acute and chronic health risks related to surface-water nitrate exposure at multiple spatial scales during 1970-2010. We leverage biogeochemical, socio-economic, and epidemiological knowledge from different disciplines, and evaluates the role of humans in driving environmental changes and environmental effects on humans in a consistent manner.

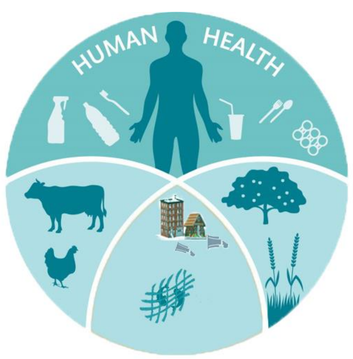


Figure 1. Multi-disciplinary approach used in this work to quantify spatially-explicit potential acute and chronic health risks associated with surface-water nitrate exposure and their influenced populations worldwide since 1970.

Results

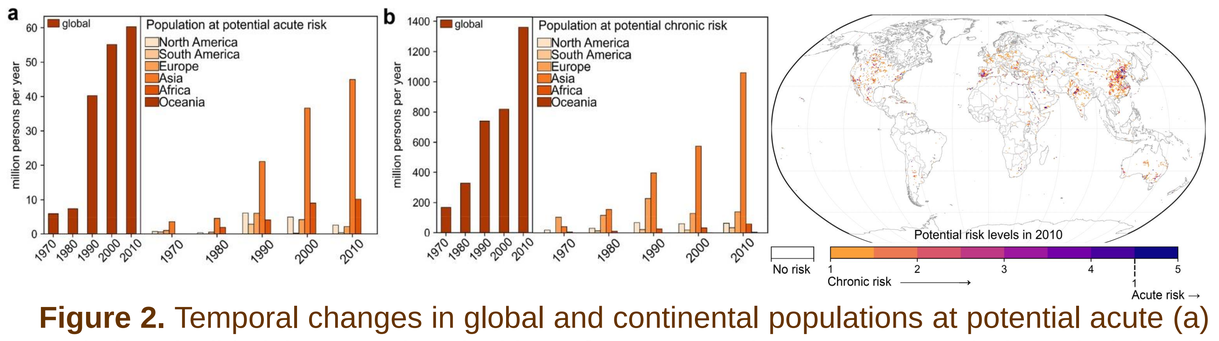
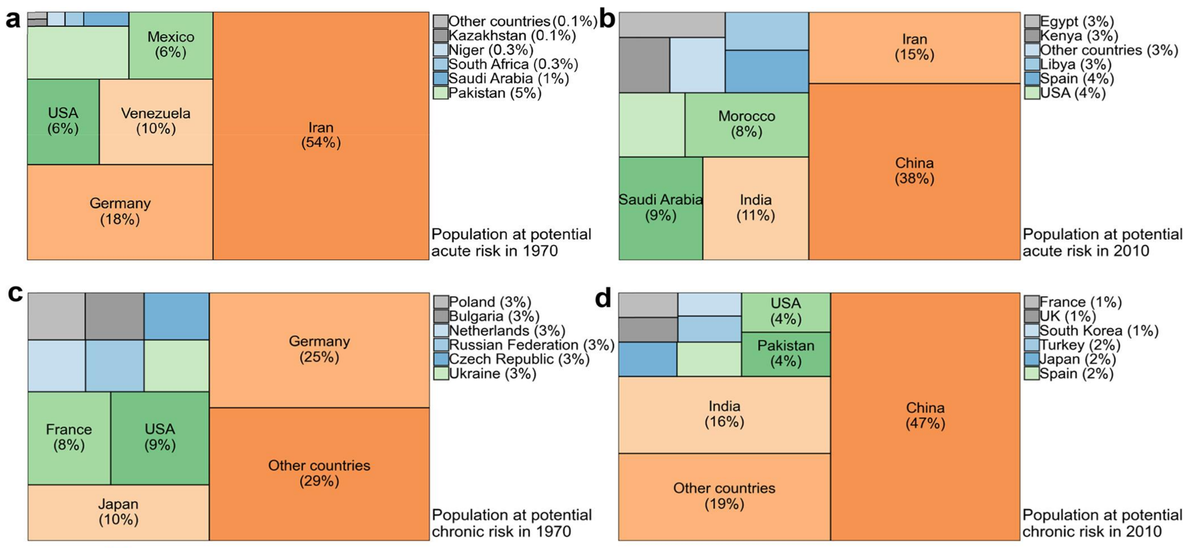


Figure 2. Temporal changes in global and continental populations at potential acute (a) and chronic (b) risks associated with surface-water nitrate exposure during 1970-2010.

- During 1970-2010, global populations potentially affected by acute health risks associated with surface-water nitrate exposure increased from 6 to 60 million persons per year.
- Asia dominated populations at potential acute risks during 1970-2010.
- Populations at potential chronic health risks increased from 169 to 1361 million persons per year.
- Dominance of chronic health risks shifted from Europe (1970) to Asia (2010).



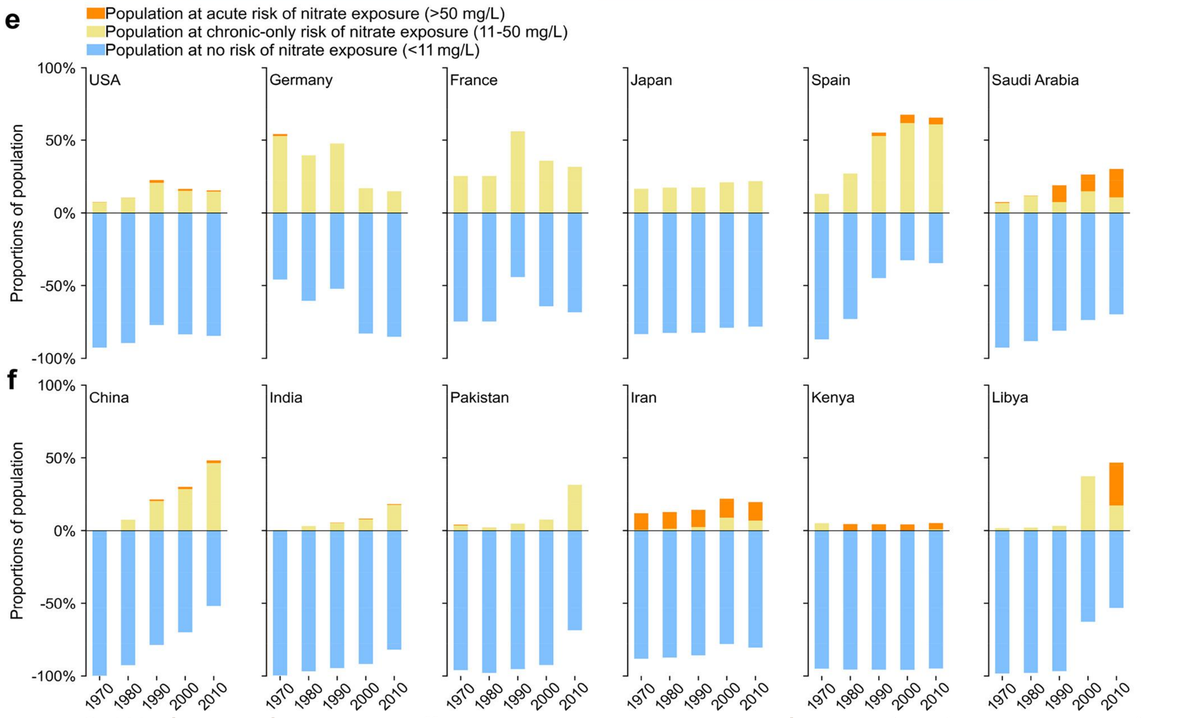


Figure 3. World populations in different countries at potential acute (a, b) and chronic (c, d) risks associated with surface-water nitrate exposure in 1970 (a, c) and 2010 (b, d), and temporal changes in the proportions of populations at potential no risk, chronic-only risk, and acute risk associated with surface-water nitrate exposure in high- (e) and middle-income countries (f).

- Potential acute risks increasingly affected Asian countries.
- Populations potentially affected by chronic risks shifted from dominance by high-income countries (in Europe and North America) to middle-income countries (in Asia and Africa).
- This shift is a result of disproportionate changes in national populations, decreased proportions of populations at chronic/acute risks in high-income countries, and increased proportions of populations at chronic/acute risks in middle- to low-income countries.

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