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STATE-OF-THE-ART REVIEW

A Review of Medication Use as an Indicator of Human Health Impact in Environmentally Stressed Areas

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Abstract

We reviewed from literature the feasibility of medication use as an indicator of health outcomes in environmentally stressed areas, especially where a paucity of typical epidemiological and other risk-based data are encountered. The majority of studies reported were about medication use as an indicator of adverse respiratory effects from air pollution in developed countries. Studies to a lesser extent pointed to medication use as indicator of health outcomes associated with other environmental health stressors such as water, noise pollution, and habitat conditions. The relationship between environmental stressors and medication use strongly suggests that medication use could be used to measure the impact of environmental stressors that otherwise could not be measured by epidemiological or other impact assessment studies, typically in settings where morbidity and mortality data might not be not accessible.

KEY WORDS adverse health outcomes, environmental health indicators, environmentally stressed areas, environmental stressors, medication use

INTRODUCTION

The environment plays a significant role in shaping the health of a person and can cause significant burden of disease. The World Health Organization estimated that 24% of global disease burden and 23% of all deaths are caused by environmental stressors.[1] It is therefore important to know the key drivers of environmentally attributed disease to inform policy on reducing environmental risk factors to health.[2]

Environmentally stressed areas are geographical areas under any severe ecological influence or change[3] that causes an apparent and dramatic change in the biophysical (natural) environment. In the context of this review, this means environmental change directly or indirectly driven by natural phenomena or human activities—to the extent that environmental stressors result from this change and cause health effects in humans.[1]

Environmental stressors can be specific, such as traffic- and industry-related air pollution and noise,[4] outdoor smoke from vegetation fires,[5] indoor smoke from solid fuel combustion,[6] and naturally occurring chemical compounds (eg, arsenic and lead) found in contaminated drinking water, food, and soil.[7,8] These stressors can also be described in nonspecific terms, such as those often more broadly associated with environmental settings within urban environments,[9] or changes caused by resource development activities (eg, mining and natural gas extraction).[10]

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Health effects commonly associated with living in environmentally stressed areas are often reported and, depending on the stressor, include effects on respiration (asthma), the central nervous system (headache, depression, and anxiety), and the gastrointestinal system (gastric reflux, stomach cramps, and diarrhea).[11,12] Epidemiological studies have found associations between a wide array of environmental stressors and specific health effects. For instance, long-term exposure to traffic-related particulate matter is associated with heart rate variability[13] and increased blood pressure.[14]

We can manage adverse health effects by prevention and or reduction of environmental stressors through suitable interventions and policies,[8] but this requires reliable information. Epidemiological as well as predictive environmental health risk and impact studies use indicators of morbidity and mortality that rely on data drawn from primary sources—a clear example being hospital admissions. These indicators are therefore more likely to reflect only the most critical cases leading to hospital admissions or deaths[15] and are often limited by a paucity of available or accessible data.[16] Hospital admission data would, for instance, exclude those who did not require hospitalization but who received other medical treatment from medical practitioners—usually including prescribed medications.[15] It would likely also exclude those who did not seek or require a medical treatment but "self-treated" using over-the-counter medications.

We argue that medication use is a source of data that can be used to indicate underlying health effects of environmental stressors. It could detect affected people who were issued prescription medication after receiving medical care from either a hospital or general medical practice and could detect those using over-the-counter medications. The types of medication dispensed could indicate specific health effects in a population, including those whose health might be affected by environmental stressors in particular geographical areas.

The aim of this review was to explore whether medication use (in the absence or paucity of other relevant health data) could be a feasible indicator of adverse environmental health stressors.

REVIEW STRATEGY

We conducted a narrative review of science and gray literature following a similar structure to Morrell et al.[17] We searched PubMed and Scopus databases for studies of medication use related to environmental health impact published between January 1993 and August 2013. The literature included science papers as well as gray literature such as reports in news media, conference papers, editorials, government publications, and lectures. Typical search terms were "medication use," "medication sales," "environmental hazard," "urban environment," "pollution," "chemical," "water," "air," and "noise."

The initial titles and abstracts of the retrieved reports (791) were scrutinized and allocated a relevance rank. This ranking—based on our own classification—refers to their relevance in terms of the aim of this review as well as the strength of evidence presented in the particular report. The 4 relevance categories were as follows:

Highly relevant reports had a very specific focus on medication use data in the absence of other health data of a population. The population in question was exposed to clearly definable environmental stressors or lived in specific environmentally stressed areas. The evidence we looked for in the report was whether a change in medication use reflected any health effect caused by the environmental stressors in the study population.

Relevant reports considered medication use but did not have it as a primary data source or specific focus and were more general in nature—that is, using broader sources of data about medication use as well as health outcome to explore adverse environment and health impact on populations. These reports were nevertheless relevant to this review because they contained information on medication use as part of outcome indicators such as symptoms, clinical diagnosis, and hospital admissions.

Low relevance reports referred, in some way, to medication use but did not report on whether environmental heath impact could be deduced from the medication use. For instance, some studies in this category collected medication use details to (i) adjust for potential confounders of health outcome attributed to medication use; (ii) alluded to a failure of medication adherence among population affected by potential environmental stressors; or (iii) recorded general and daily medication use without any further analysis of the data. The reports were included because they offered insight into how medication use could be used to indicate environmental stress in a population

Irrelevant reports were excluded from the review when they did not meet the requirements of the review aim. These included investigations about outcomes of medication use on the health of environment and people. For instance, the impact of medical waste on the environment, antibiotic drug resistance, and where medication would lead to increased but unrelated incidents (eg, falls among the elderly). Other examples were papers that (i) focused on nonenvironmental stressors (eg, persons living

with physical disabilities or genetic diseases) and their relationships with medication use; (ii) were conducted on animals or in vitro studies (experiments conducted using biological organisms, eg, human cells in laboratories) to specifically identify medication use behavior, patterns, or habits among people; (iii) focused on medication treatment, prevention, and or intervention management of a particular disease; (iv) had title and abstract translated in English but the content written in foreign language; or (v) did not provide access to full text.

REVIEW FINDINGS

The search identified 791 articles of which 639 were excluded as irrelevant; 152 study reports were reviewed. Of these, we included 32 studies in the 3 relevance categories.

The reports were assessed on 3 aspects. The first aspect was the global distribution of studies and sources of medication use data. It was important to know the source and methods of medicine use data to elucidate the strengths and constraints of obtaining and using the data. The second aspect was whether medication use was a feasible indicator of health outcomes associated with environmental stressors, including environmental carriers (such as air, water, food, etc.), conditions (noise and heat), and habitats (environmental settings such as "built" environments as well as people's environmental susceptibility—generally stress related). The third aspect was the type of medications used and whether environmental stressors caused specific health effects.

Distribution of Reports and Data Sources. Of the 152 reviewed reports, 14 (9%) were highly relevant, 86 (57%) relevant, and 52 (34%) less relevant (Table 1).

Most studies came from North America (50%) and Europe (36%), and most of these were highly relevant or relevant. Oceania (mainly Australia and New Zealand), Asia, Africa, and South America accounted for less than 10% of studies. Most studies obtained medication use data directly from individuals (76%), and these were mainly of some relevance. Although there were fewer studies from government agencies, hospitals (11%), and pharmacies (3%), they were mostly highly relevant. One in 10 studies could not be classified (11% under the Review column in Table 1).

Environmental Stressors and Medicines Use. Five environmental stressor clusters were identified and are classified by relevancy: polluted air, polluted water, excessive noise, multiple stressors, and habitat (Table 2).

Polluted air. Studies of medication use associated with airborne stressors were the most commonly reported (65%). Excessive airborne gaseous and particulate substances were measured at specific (eg, indoor air, mostly domestic) and nonspecific sources (eg, in ambient outdoor air). Some studies examined both ambient and indoor air stressors. In terms of health effects, the studies reported effects on the respiratory, cardiovascular, dermatologic, and sensory systems (Fig. 1).

One highly relevant study (Carlsen et al[18]) reported that increased hydrogen sulfide and airborne particles in the atmosphere of Iceland's capital were associated with increased asthma medication use. From the relevant studies, Gillespie-Bennett et al[19] found that increased indoor NO_2 concentrations were associated with increased use of asthma medication, increased respiratory tract and asthma

Table 1. Relevancy, Global Distribution, and Sources of Studies of Medication Use Data and Environmental Stressors

Global region	Government			Hospital			Individual			Pharmacy			Review			No. (%)
	H	R	L	H	R	L	H	R	L	H	R	L	H	R	L	
Africa	—	1	—	—	—	—	—	—	1	—	—	—	—	—	—	2 (1.3)
Asia	—	—	—	—	—	—	—	4	5	—	—	—	—	—	—	9 (5.9)
Europe	7	4	—	—	—	—	1	25	6	3	—	—	1	5	2	54 (35.5)
North America		2	—	—	—	2	1	37	26	—	—	—	—	3	5	76 (50)
Oceania	—	—	—	—	—	—	—	5	3	1	—	—	—	1	—	10 (6.6)
South America	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	1 (0.7)
No. of studies (%)	7	7	—	—	—	2	3	71	41	4	—	—	1	9	7	152 (100)
	14 (9.2)			2 (1.3)			115 (75.7)			4 (2.6)			17 (11.2)			

H, highly relevant; R, relevant; L, low relevance.
Government reports indicate that data were obtained from medicinal registries of national health agencies. *Hospital* refers to medical history, including past and current medication use obtained from hospital admittance data. *Individuals* were phoned or interviewed face to face with questionnaire-based and survey data obtained from the individuals who participated in the particular study. *Pharmacy* indicates medication sales records. *Review* indicated studies of general investigations into the health impact of people living in environmentally stressed areas.

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Table 2. Environmental Stressors in Terms of Carriers, Conditions, and Habitats Relevant to Medication Use

Environmental Stressor	Descriptions	Highly Relevant	Relevant	Less Relevant	Total (%)
Air	Mostly chemical and particulate pollutants	7	63	32	102 (67)
Noise	Mostly traffic related	2	11	1	14 (9)
Water	Containing microbial or chemical pollutants	2	1	1	4 (3)
Multiple carriers	Chemical and microbial pollutants naturally or accidentally released into air, water, food and soil	2	5	4	11 (7)
Habitat	Generally related to urban or built environments and people's environmental susceptibility	1	8	12	21 (14)
No. of studies		14 (9)	88 (58)	50 (33)	152 (100)

symptoms, and reduced lung function. From the less relevant studies, de Hartog et al[20] found no correlation between particle matter concentration in air and lung function perturbation (as measured by use of respiratory medication).

Excessive noise. Noise can cause hypertension, anxiety, and insomnia from nonspecific exposures such as excessive noise from road and air traffic in ambient conditions (outside air and or road traffic) and specific points in occupational settings (eg, a factory).

One highly relevant study by Floud et al[21] found that aircraft noise in urban areas was associated with increased antihypertensive and anxiolytic medication use. One relevant study (Stokholm et al[22]) reported that white collar female workers exposed to noise greater than 90 dB(A) had increased diagnoses of hypertension and subsequent medication use. One of the less relevant studies (Talbott et al[23]) found that excessive noise exposure predicted hypertension and antihypertensive medication use.

Polluted water. Exposure to polluted water can result in a several disorders ranging from gastroenteritis to endocrine disruption. Waterborne stressors included chemical pollutants (eg, arsenic) and pathogenic waterborne bacteria. Stressors were reported for specific points in potable water supplies

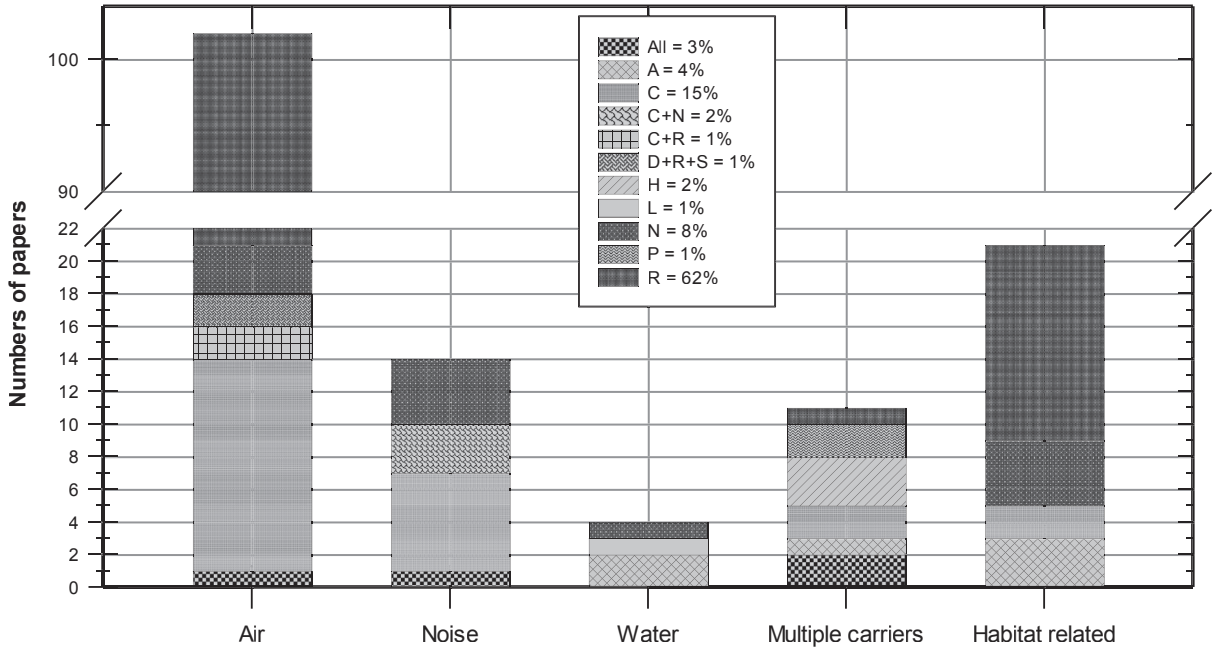

Figure 1. Numbers of papers reporting medication use (based on Anatomical Therapeutic Chemical [ATC] classification system) indicating health effects from environmental stressors. Abbreviations: All, all ATC codes; A, alimentary tract and metabolism; C, cardiovascular system; C+N, cardiovascular system and nervous system; C+R, cardiovascular system and respiratory system; D+R+S, dermatologic system, respiratory system, and sensory organs; H, systemic hormonal preparations; L, antineoplastic and immune-modulating agents; N, nervous system; P, antiparasitic products; R, respiratory system.

(tap water and borehole water) and nonspecific exposure points such as in ambient waters (natural waters such as rivers, lakes, and oceans).

A highly relevant study from Beaudeau et al[24] found an association between poor tap water quality and sales of medications to treat gastroenteritis. A relevant study from Stein and Savitz[25] reported increased medication use in young children diagnosed with attention-deficit hyperactivity disorder. These children had increased serum levels of perfluorinated compounds associated with their drinking water. One less relevant study (Basu et al[26]) found that people exposed to arsenic in drinking water in India had increased frequencies of micronuclei reflecting DNA damage in cells. They used medication data to distinguish between healthy and unhealthy participants.

Multiple environmental stressors and carriers. Some studies considered multiple environmental stressors but in a broader context—for instance, the accidental release of stressors into the ambient environment from anthropogenic sources. These may be chemical stressors (eg, hydrofluoric acid) or microbiological stressors (eg, enteric bacterial pathogens). The stressors induced gastrointestinal, respiratory, cardiovascular, and hormonal disturbances.

Dayal et al[27] was a highly relevant study that found exposure to hydrofluoric acid in an urban community led to increased medication use for respiratory, cardiovascular, and hormonal diseases and symptoms. A relevant study from Zock et al[28] found that participants who cleaned up an oil spill had increased medication use for respiratory symptoms. Of less relevance, Mbuh et al[29] concluded a high prevalence of soil-transmitted helminth and protozoan infections was reduced with the appropriate medications.

Habitat. *Habitat stressors* refer to broader environmental settings (eg, built environments and people densities) that induce negative human health outcomes in particular geographic places. An individual's environmental susceptibility refers to issues that are not linked to a specific environmental stressor but more broadly to the environment in which they were studied. These issues include people's access to health care and individual factors such as ethnicity, gender, age, and behavior.

A highly relevant study from Mckenzie et al[30] reported that people living in urban environments, compared with those living in rural areas, had more prescriptions for psychotropic medications to treat anxiety, depression, and psychosis. Mujahid et al[31] (a relevant study) concluded that people living in safer environments and with access to healthy food were less likely to be taking antihypertensive medication. One low relevance study from Zagozdzon et al[32] reported that rural Polish women, compared with those living in urban settings, had physical health that was worse than their mental health.

One relevant study of environmental susceptibility (Greaves et al[33]) identified considerable ethnic and racial differences in asthma prevalence and medication use. A less relevant study, Hill et al,[34] concluded that racial disparities in pediatric asthma were associated with health beliefs, health care setting, gene–environmental interactions, and an increased asthma incidence caused by poor medication adherence.

Medicine Use as Indicator of Health Effects Associated with Environmental Stress. The medications in the studies were classified according to the Anatomical Therapeutic Chemical (ATC) classification system of the World Health Organization.[35] They were then allocated to a health outcome and associated environmental stressor (Fig. 1).

Some studies explored medication use across all ATC classes, whereas others focused on medication use for treating more than 1 body system—for instance, the cardiovascular system and respiratory system. Most studies focused on one major class of medication. Three in 5 studies (62%) focused on the use of respiratory medicines. Although this is consistent with the studies of airborne pollutants (67% of reports, Table 2), it points to a dominant interest in research, monitoring, and surveillance of the health effects of airborne pollutants. Fewer studies reported the use of cardiovascular and combinations medications and medications for treating conditions of the nervous system. Few papers (3%) involved all ATC codes, 2% for systemic hormonal preparations, and 1% each for antineoplastic and immune-modulating agents and a combination of dermatologic, respiratory, and sensory organs, respectively.

Summary of the Findings. The relationship between environmental stressors and medication use suggests that medication use—by indicating health detriment—could be used to measure the impact of environmental stressors that otherwise could not be measured by epidemiological or other impact assessment studies in settings where typical morbidity and mortality data might not be not accessible.

The highly relevant as well as relevant papers mainly reported medication use that indicated the disease or symptom associated with the environmental stressor, whereas the less relevant papers were more concerned with the environmental cause

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of the disease where medication use was a variable in the association.

Medication use has strong potential as an indicator of health impact from environmental stressors.

DISCUSSION

The idea of medication use as a health indicator was proposed some decades ago. In 1994, Dayal et al[27] suggested that medication use might be a more objective and reliable measure of health compared with health outcome measures based only on symptomology. This argument was supported by Bowler et al[36] almost a decade later who stated that, although medication use is consistent with symptoms, it could also be used to track negative effects over a longer term than would solely symptom-based studies. Pitard et al[37] reasoned that medication use could provide information in situations that did not involve medical care, hospital admission, or severe cases such as deaths. It can provide high-resolution data for detailed daily variation in symptomology and disease conditions that do not require medical examination or hospitalization.[15,37]

In the context of indicating the linkages between environment and health, medication use might indicate nonsalient health outcomes in a wide demographic range of people affected by environmental stressors. It is also a more realistic local level health outcome indicator compared with other health indicators (morbidity, etc.), and also in smaller geographical and less populated areas. An example was the increased use of anxiety-related medications after the 2011 Queensland (Australia) flood.[38] In this study medication use was an indicator of health effects in a small number of people in affected areas that quite possibly might have been underreported by conventional health services (eg, hospitalizations).

Where available, population health data can be accessed at national or regional levels but are generally difficult to obtain for small or selected populations in small geographical areas such as those in localized stressed environments (eg, resource development sites).[39] Medication use could be a reliable and measurable health outcome indicator in areas where such data might not be readily accessible or available in formal regional or national health data repositories. Medication use data could also be sourced at other points where people seek medical assistance such local pharmacies, general practitioners (GPs), and hospitals. Another source of data is that obtained directly from participants in communities. One constraint could be a lack of support from individuals and pharmacies to participate in studies,[40] with a distinct possibility of recollection bias in individuals.[41]

Nearly all the studies (>90%) were conducted in developed country settings. Access to medication use data is more readily obtained than in developing countries, likely reflecting the higher resource capabilities of developed economies.[16]

From an environmental health research and monitoring perspective in developed countries, there appears to be greater concern about the health effects of air pollution than the risks in other environmental settings (eg, water). This also suggests that data are more available in countries that can afford to collect it. Nevertheless, the application of medication use in health-related air pollution settings strongly implies medication use is an effect indicator across all of the environmental health settings, conditions, and carrier media.

Medication use as an environmental health indicator has limitations, but no more so than other health indicators. An individual person is subject to multiple environmental stressors at any point in time; thus the strength of the correlation between medication use and a single or few environmental stressors should be treated with caution.[42]

The larger number of studies that obtained medication use from individuals suggests difficulties in accessing medication use data from official sources. Some European countries have accessible national medical registry systems that contain medication use data,[15,18,30] thus allowing public access to these data. Although several European studies sourced their data from government agencies, most European studies still sourced medication use data from individuals.

Medication use based on prescribing data may simply reflect prescribing patterns and so the use of medications, as well as the influence of alternative interventions such as psychological interventions, might not therefore entirely measure the full health impact of environmental stressors.[43] Medication use is also influenced by the health system of a country in terms of co-payments made by patients, and these could potentially exclude people who cannot afford to buy medicines.[44]

The few studies in the Oceania countries of Australia and New Zealand, unlike other developed countries, did not use medication use data from government or hospital sources to study environmental stress in populations. This could indicate the difficulty of obtaining medication use data from these sources because of limited public access or inadequate national medication use recording systems.

CONCLUSIONS

Medicine use provides a sound basis for developing indicators to measure health effects in people living in environmentally stressed areas. Medication use can, within a broad spectrum of effects-based data or without it, reflect health outcomes ranging from people who are critically ill requiring hospital admission to those with minor health complaints (eg, headache) and who are generally not captured in institutional health databases.

Only a few relevant studies used medication use as a primary health outcome indicator to assess environmental health impacts over the last 2 decades. This may reflect a general lack of recognition of medication use as a feasible indicator in this context. We further suggest that it is also because reliable medication use data are not readily available or are difficult to access.

We therefore recommend that, in jurisdictions where comprehensive and official medication use data are recorded and accessible, medication use should be considered as a feasible (and perhaps preferred) environmental health indicator. Medication use data collected from individuals can also be an option for a further tier of data, it being available in small geographical areas where institutional health records are likely not available. It is recognized that such medication use could be subject to reporting bias, but it can nevertheless be credible if sound data collection protocols are developed and implemented. Although there are constraints to be negotiated, this review finds that medication use is applicable as a mainstream health indicator in environmentally stressed areas.

REFERENCES

1. Prüss-Üstün A, Corvalán C. Preventing Disease Through Healthy Environments: Towards an Estimate of the Environmental Burden of Disease. Geneva, Switzerland: World Health Organization; 2006.
2. Lim SS, Vos T, Flaxman AD, et al. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet 2013;380:2224–60.
3. Freedman B. Environmental Stress. In: Bortman M, Brimblecombe P, Cunningham MA, eds. Environmental Encyclopedia. 3rd ed. Detroit, MI: Gale; 2003:514–5.
4. Allen RW, Criqui MH, Roux AVD, et al. Fine particulate matter air pollution, proximity to traffic, and aortic atherosclerosis. Epidemiology (Cambridge, Mass) 2009;20:254.
5. Johnston FH, Webby RJ, Pilotto LS, Bailie RS, Parry DL, Halpin SJ. Vegetation fires, particulate air pollution and asthma: a panel study in the Australian monsoon tropics. Int J Environ Health Res 2006;16:391–404.
6. Uzun K, Özbay B, Ceylan E, Gencer M, Zehir I. Prevalence of chronic bronchitis-asthma symptoms in biomass fuel exposed females. Environ Health Prev Med 2003;8:13–7.
7. Ötleş S, Çağindi O. Health importance of arsenic in drinking water and food. Environ Geochem Health 2010;32:367–71.
8. Braun JM, Kahn RS, Froehlich T, Auinger P, Lanphear BP. Exposures to environmental toxicants and attention deficit hyperactivity disorder in U.S. children. Environ Health Perspect 2006;114:1904–9.
9. Henderson-Wilson C, Townsend M. How residential environments impact on health. Health Issues 2007;93:25–9.
10. Moore M. The Independent Review of Coal Seam Gas Activities in NSW (Human Health and Environment Effects). Deakin, ACT, Australia: Public Health Association Australia; 2013.
11. Thomson RM, Armstrong JG, Looke DF. Gastroesophageal reflux disease, acid suppression, and Mycobacterium avium complex pulmonary disease. Chest 2007;131:1166–72.
12. Caruso CC, Lusk SL, Gillespie BW. Relationship of work schedules to gastrointestinal diagnoses, symptoms, and medication use in auto factory workers. Am J Ind Med 2004;46:586–98.
13. Adam M, Felber Dietrich D, Schaffner E, et al. Long-term exposure to traffic-related PM10 and decreased heart rate variability: is the association restricted to subjects taking ACE inhibitors? Environ Int 2012;48:9–16.
14. Schwartz J, Alexeeff SE, Mordukhovich I, et al. Association between long-term exposure to traffic particles and blood pressure in the Veterans Administration Normative Aging Study. Occup Environ Med 2012;69:422–7.
15. Finnbjornsdottir RG, Zoëga H, Olafsson O, Thorsteinsson T, Rafnsson V. Association of air pollution and use of glyceryl trinitrate against angina pectoris: a population-based case-crossover study. Environ Health 2013;12:38.
16. Byass P. The unequal world of health data. PLoS Med 2009;6:e1000155.
17. Morrell S, Taylor R, Lyle D. A review of health effects of aircraft noise. Aust N Z J Public Health 1997;21:221–36.
18. Carlsen HK, Zoëga H, Valdimarsdóttir U, Gíslason T, Hrafnkelsson B. Hydrogen sulfide and particle matter levels associated with increased dispensing of anti-asthma drugs in Iceland's capital. Environ Res 2012;113:33–9.
19. Gillespie-Bennett J, Pierse N, Wickens K, et al. The respiratory health effects of nitrogen dioxide in children with asthma. Eur Respir J 2011;38:303–9.
20. De Hartog J, Ayres J, Karakatsani A, et al. Lung function and indicators of exposure to indoor and outdoor particulate matter among asthma and COPD patients. Occup Environ Med 2010;67:2–10.
21. Floud S, Vigna-Taglianti F, Hansell A, et al. Medication use in relation to noise from aircraft and road traffic in six European countries: results of the HYENA study. Occup Environ Med 2011;68:518–24.
22. Stokholm ZA, Bonde JP, Christensen KL, Hansen ÅM, Kolstad HA. Occupational noise exposure and the risk of hypertension. Epidemiology 2013;24:135–42.

23. Talbott EO, Gibson LB, Burks A, Engberg R, McHugh KP. Evidence for a dose-response relationship between occupational noise and blood pressure. Arch Environ Health 1999;54:71–8.
24. Beaudeau P, Le Tertre A, Zeghnoun A, Zanobetti A, Schwartz J. A time series study of drug sales and turbidity of tap water in Le Havre, France. J Water Health 2012;10:221–35.
25. Stein CR, Savitz DA. Serum perfluorinated compound concentration and attention deficit/hyperactivity disorder in children 5-18 years of age. Environ Health Perspect 2011;119:1466–71.
26. Basu A, Mahata J, Roy AK, et al. Enhanced frequency of micronuclei in individuals exposed to arsenic through drinking water in West Bengal, India. Mutat Res 2002;516:29–40.
27. Dayal HH, Li YH, Dayal V, Mittal CK, Snodgrass W. Use of medication data to validate an association in community-based symptom prevalence studies. Arch Environ Health 1994;49:93–7.
28. Zock J-P, Rodriguez-Trigo G, Rodriguez-Rodriguez E, et al. Persistent respiratory symptoms in clean-up workers 5 years after the Prestige oil spill. Occup Environ Med 2012;69:508–13.
29. Mbuh JV, Ntonifor NH, Ojong J. The epidemiology of soil-transmitted helminth and protozoan infections in south-west Cameroon. J Helminthol 2012;86:30–7.
30. McKenzie K, Murray A, Booth T. Do urban environments increase the risk of anxiety, depression and psychosis? An epidemiological study. J Affect Disord 2013;150:1019–24.
31. Mujahid MS, Diez Roux AV, Morenoff JD, et al. Neighborhood characteristics and hypertension. Epidemiology 2008;19:590–8.
32. Zagozdzon P, Kolarzyk E, Marcinkowski JT. Quality of life and rural place of residence in Polish women—population based study. Ann Agric Environ Med 2011;18:429–32.
33. Greaves IA, Sexton K, Blumenthal MN, et al. Asthma, atopy, and lung function among racially diverse, poor inner-urban Minneapolis schoolchildren. Environ Res 2007;103:257–66.
34. Hill TD, Graham LM, Divgi V. Racial disparities in pediatric asthma: a review of the literature. Curr Allergy Asthma Rep 2011;11:85–90.
35. Chen L, Zeng WM, Cai YD, Feng KY, Chou KC. Predicting anatomical therapeutic chemical (ATC) classification of drugs by integrating chemical-chemical interactions and similarities. PLoS One 2012;7:e35254.
36. Bowler RM, Gysens S, Hartney C, Ngo L, Rauch SS, Midtling J. Increased medication use in a community environmentally exposed to chemicals. In Health 2002;40:335–44.
37. Pitard A, Zeghnoun A, Courseaux A, et al. Short-term associations between air pollution and respiratory drug sales. Environ Res 2004;95:43–52.
38. Turner LR, Alderman K, Huang C, Tong S. Impact of the 2011 Queensland floods on the use of tobacco, alcohol and medication. Aust N Z J Public Health 2013;37:396.
39. McCarron G. Symptomatology of a gas field: an independent health survey in the Tara rural residential estates and environs. Available at: http://www.catskillcitizens.org/learnmore/2013-04-symptomatology_of_a_gas_field_Geralyn_McCarron.pdf; 2013. Accessed November 1, 2013.
40. Johnston FH, Hanigan IC, Bowman DM. Pollen loads and allergic rhinitis in darwin, australia: a potential health outcome of the grass-fire cycle. EcoHealth 2009;6:99–108.
41. Greiser E, Greiser C, Janhsen K. Night-time aircraft noise increases prevalence of prescriptions of antihypertensive and cardiovascular drugs irrespective of social class—the Cologne-Bonn Airport study. J Public Health 2007;15:327–37.
42. Richardson EA, Mitchell RJ, Shortt NK, Pearce J, Dawson TP. Evidence-based selection of environmental factors and datasets for measuring multiple environmental deprivation in epidemiological research. Environ Health 2009;1(8 Suppl):S18.
43. Mok PL, Leyland AH, Kapur N, et al. Why does Scotland have a higher suicide rate than England? An area-level investigation of health and social factors. J Epidemiol Community Health 2013;67:63.
44. Grosse-Tebbe S, Figueras J. Snapshots of Health Systems: WHO on Behalf of the European Observatory on Health Systems and Policies. Denmark: World Health Organisation; 2005.