Public Health: Introduction

Public health is more than the sum of the health of individuals. Public health is concerned with the health of the public and with health issues in the public realm. Discussions on public health partake, by necessity, in the same complex discussions as those of the public realm. They grapple with similar issues of public versus private needs. For instance: It has become abundantly clear that information technologies create new opportunities to invigorate the public realm[1], and equally clear that many of them are mere smoke and mirrors. The overconfidence in the ability of technical systems to do good is of particular poignancy in matters of the public realm where everyone's interests are at risk. Biosensing for public health must face similar challenges, which are amplified by the high stakes of this territory and potential life and death consequences.

The papers discussed here are only one vector into this very challenging topic. They do not deal with the 'big questions', in an abstract way, but in applied settings through discussions of case studies and methods developed to understand the problems at hand. The papers in this section are chosen for the variety of methodologies proposed to address core issues in public health on local and global scales.

One of the most frequent and important public health issues is that of exposure of the public to contaminants from industrial processes, including everything from fabrication of tools to disposal of consumer goods. The hazardous waste site is a bad solution to the intractable problem generated by a lack of market control over the complete life-cycle of industrial products. New research has found yet more health problems emanating from hazardous waste and coined them *contaminants of emerging concern* (CECs). Interest in CECs parallels advances in analytical chemistry through liquid chromatography and mass spectrometry. Because of their widespread use and environmental persistence, some CECs are ubiquitous and transported far from their sources of first use, where they eventually bioaccumulate. For example, polybrominated biphenyl ethers (PBDE), used in flame retardants of furniture and electronics, are known to accumulate in household dust and undergo long-range atmospheric transport. They have been detected in polar bears and gulls in the arctic[2].

There is an acknowledged need for new criteria by which to classify CECs. Included in the list of criteria (that already includes toxicity) are: bioconcentration, atmospheric oxidation, and persistence. Because quantities and concentrations are so crucial to fabrication processes on a global scale, production volume is now also considered a main criterion. Unfortunately, many problems are yet untouched. Commonly used models for predicting environmental fate and transport are not adequately developed to address the properties of nanoparticles that may exhibit properties midway between particulate and dissolved contaminants, for example. Also, there is an urgent need to address risks posed by compounds that do not exhibit a monotonic dose–response curve or affect different physiological end points differently in various concentration ranges[3].

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[1] Marc Böhlen, Hans Frei, MicroPublicPlaces, Architectural League, NY, 2010.

[2] Ela, WP, Sedlak DL, Barlaz MA, Henry HF, Muir DCG, Swackhamer DL, Weber EJ, Arnold RG, Ferguson LP, Field JA, Furlong ET, Giesy JP, Halden RU, Henry T, Hites RA, Hornbuckle KC, Howard PH, Luthy RG, Meyer AK, Sáez EA, vom Saal FS, Vulpe CD, Wiesner MR, Toward Identifying the Next Generation of Superfund and Hazardous Waste Site Contaminants, Journal Environmental Health Perspectives, Vol 119, Issue 1, 2010.

[3] Dito.

Particulate matter, on the other hand, is a well-studied domain. Studies in particulate matter distribution have produced quantitative results with actionable suggestions. Recent research has looked at the issue of individual- and population-level characteristics resulting in increased risk of PM-related health effects. Common methods include three types of epidemiological studies: 1) stratified results (e.g., males vs. females), which allow one to compare populations exposed to similar PM concentrations within the same study design, 2) controlled human exposure studies that examined individuals with a preexisting disease, and 3) toxicological studies that used animal models of disease[4]. Some studies add socioeconomic status as a criterion. This is an important addition to the standard list as it acknowledges the significance of affluence and lack thereof as an important factor in the risk of exposure to particulate matter. This dependency shows itself in many different contamination contexts. For example, increased exposure to manganese through drinking water has been shown to be related to impaired manual dexterity and speed, short-term memory, and visual identification as well as lower intelligence quotients[5]. Because manganese causes aesthetic problems (it generates stains and black sediment), families who have the means might treat water domestically to remove manganese while those who cannot afford the treatment suffer from the continued exposure.

One challenge that public health research faces is the need for local measurements in order to understand local conditions and the sheer impossibility of generating sufficient data to represent such local conditions. Small area measurement methods can deliver more precise and accurate local-level information than direct estimates from surveys or administrative records, where sample sizes are often too small to yield acceptable standard errors. Some recent research has been devoted to finding ways of estimating local conditions from sparse data, given certain correlations between related data. Small area measurement requires careful validation using approaches other than conventional statistical methods such as in-sample or cross-validation methods because they cannot solve the problem of validating estimates in data-sparse domains[6]. In addition, the inclusion of relevant domain-specific covariates generally improves predictive validity, especially at small sample sizes, and their leverage can be equivalent to a five- to tenfold increase in sample size.

On the other end of the spectrum are studies investigating public health conditions across the planet. Climate change studies are a prominent example of this category. One recent study surveyed the impact of climate change on human health, with focus on the relationship between heat waves and mortality and morbidity[7]. The study attempted to quantify the excess mortality associated with heat waves in Chicago, Illinois, for the years 2081–2100 under several global climate change scenarios. The researchers made their estimates with the help of a weather-mortality model based on historical data. In a second step they estimated future heat waves and applied these results to the heat wave mortality model. The results varied widely based mostly on the climate model chosen, but predicted very strong increases in

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[4] Sacks, JD; Stanek, LW; Luben, TJ; Johns, DO; Buckley, BJ; Brown, JS; Ross, M., Particulate matter induced health effects: Who's susceptible? Environmental Health Perspectives, Volume 119, Issue 4, 446-454, 2011

[5] Bouchard, M., Sauvé, S., Barbeau, B., Legrand, M., Brodeur, M., Bouffard, T., Limoges, E., Bellinger, D., Mergler, D.,Intellectual Impairment in School-Age Children Exposed to Manganese from Drinking Water. Environ Health Perspect 119:138-143, 2010.

[6] Srebotnjak, T; Murray, C., Mokdad, A., A novel framework for validating and applying standardized small area measurement strategies. Population Health Metrics, Vol. 8, issue 26, 2010.

[7] Peng, R., et al., Toward a Quantitative Estimate of Future Heat Wave Mortality under Global Climate Change, Environ Health Perspect. 119(5): 701–706, 2011.

mortality rates throughout (in excess of 2000 additional deaths). What is interesting (alarmingly) in this paper is the quantitative coupling of global climate change with a local scale experience.

Another public health issue of global proportions is E-waste[8] (waste derived from electronic gadgets). E-waste is a critical global environmental health issue because of massive production volume (20-50 million tons/year) and insufficient management policies. E-waste elements (lead, cadmium, chromium and others) are well studied, but toxicant mixtures and their effects on living systems have not been examined in detail yet. Although the Basel Convention regulates transboundary movement of hazardous waste, significant amounts of e-waste have been exported to developing countries and recycled in local towns and villages, using primitive technologies. Because of a lack of stringent environmental regulation and worker protection, toxicants in e-waste cause serious contaminations of local air, dust, soil, and water. This is dangerous particularly for developing fetus and children due to (suspected) developmental neurotoxicants in e-waste.

Corporations, particularly in the area of Big Data, are also active in global scale investigations of public health issues. Google's *Flu trends*[9], for example, models the spread of colds and flus by tracking people's searches of flu-related topics. The work is based on close relationships between how many people search for flu-related topics and how many people actually have flu symptoms. Because the relative frequency of certain queries is highly correlated with the percentage of physician visits in which a patient presents influenza-like symptoms, one can accurately estimate the current level of weekly influenza activity. This has been demonstrated for each region of the United States (and several countries across the globe) with a reporting lag of about one day[10]. By counting how often the software system detects these search queries, it can estimate how much flu activity is circulating in different countries and regions around the world.

In addition to statistics and machine-learning-based data crunching methods, graphic representations of complex systems are used to describe problems pertinent to public health. *Causal diagrams*, for example, are tools for controlling complex representations[11]. They can be used to describe complex causal systems, which is for example the case in communicable disease epidemiology. Causal diagrams can also be used as a basis for building computational models. They make assumptions explicit, provide a framework for analysis, generate testable predictions, explore the effects of interventions, and identify data gaps. Furthermore, causal diagrams can be used to integrate different types of information and to facilitate communication amongst public health experts and between public health experts and experts in other fields.

A variation of the graphic modeling approach has been employed in a report on traffic design in Helsinki[12]. Here, researchers describe traffic design through trip aggregation models that

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[8] Chen A, Dietrich KN, Huo X, Ho SM, Developmental neurotoxicants in e-waste: an emerging health concern. Environ Health Perspect., 119(4):431-8, 2011.

[9] http://www.google.org/flutrends/us/#US

[10] Ginsberg, J., Mohebbi1, Rajan, M., Patel,S., Brammer, L.,Smolinski1, M.,Larry Brilliant, L., Detecting influenza epidemics using search engine query data, Nature 457, 1012-1014, 19 February 2009.

[11] Joffe, M., Mindell, J., Complex Causal Process Diagrams for Analyzing the Health Impacts of Policy Interventions, J Public Health. 96(3): 473–479, 2006.

[12] Tuomisto, J., Tainio, M., An economic way of reducing health, environmental, and other pressures of urban traffic: a decision analysis on trip aggregation, J BMC Public Health, pp. 1471-2458, 2005.

take individual and public needs into account. The authors call this system *composite traffic* (similar to car-pooling, but with dedicated drivers and larger vehicles), as it represents a composite of the flexibility of the taxi and the efficient trip aggregation of the bus. The authors studied 1) how effectively trips could be aggregated; 2) various costs and pressures of car and composite traffic; 3) perceived costs for different passengers; 4) incentives needed to reach particular composite traffic volumes or areal coverage; and 5) how variation, uncertainty, and multiple decision- makers would affect the decision situation. The authors used a diagramming technique called *pyrikilo* that describes an environmental health risk situation in a formal manner utilizing system diagrams with causal connections of actions, outcomes, and interconnected variables.

A further contribution to the significance of a socioeconomic perspective in public health debates has been provided by Jason Corburn in *Street Science*[13]. This text engages with several issues that remain largely unaddressed in the environmental policy and public-health literatures. The text emphasizes how *local knowledge* (as expressed in the knowledge and practical insights of those directly affected by a particular health hazard, for example) has contributed positively to the formulation of more sustainable resource-management practices and development decisions. The author also elaborates on the structural incompatibility of insights from local knowledge that are often contextual, while policymaking in the public health arena tends operate through generalized rule sets. Corburn offers a differentiated view of the role of local knowledge and discusses, amongst other issues, the romanticization of local knowledge as a fashionable way to 'reconnect with the earth' while freeing the public realm and policy makers of their responsibility to ensure safe living conditions for all.

Further readings

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[13] Corburn, J., Street Science, MIT Press, 2005.