**Title:** A Theory of Public Health Necessity

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Keywords:

**Abstract**

Since the World Health Organization was founded in 1948 there has been little reduction in the rate of infectious disease emergence despite success stories in controlling specific diseases. This manuscript is motivated by a need for effective and comprehensive approaches to implementing mitigation strategies and policies. The hierarchy of basic public health needs described in this text is founded in experiments and empirical evidence derived from numerous public health studies that have examined the effects of various exposures (e.g., energy, vaccines, clean water, shelter, etc.) and their associated public health outcomes (e.g., morbidity, mortality, DALY, QALY, PYLL, GBD). For a global public health system to function most effectively, basic health needs must be fulfilled (i.e., potable water, food and nutrition, shelter, energy, sanitation, education, health care, medical technology). We view public health components as a hierarchy of needs and associated resources required to maintain human health starting from the most basic needs that would secure the health of billions of people and progressing vertically towards more complex systems and interventions to benefit thousands or millions. Each hierarchy level builds on previously established factors and thus incrementally improves and prolongs quality and duration of life.

**Introduction**

Public health strategy, policy, and investment is not adequately preventing global disease. There is insufficient access to potable water, nutritious food, shelter, energy, sanitation, and education globally. These needs have the most impact on global health, yet most global public health strategy, policy, and investment focuses on healthcare and medical technology and have had little impact on reducing the overall global burden of disease.

The World Health Organization’s International Health Regulations (IHRs) were a positive step towards improving global health by improving the ability to detect and respond to diseases, but are deficient in preventing infectious disease outbreaks from occurring in the first place.1 The IHRs focus on what this manuscript refers to as post-outbreak healthcare and medical technology, rather than more fundamental and impactful areas of public health which align more closely with the Sustainable Development Goals (need reference to SDG’s). If all countries globally were providing the underlying requirements for healthy societies, then the IHR’s would be the logical next step for improvement; however, each country and community has different needs requiring attention to prevent disease.

Given the variation in the levels of core public health requirements, a logical framework can help to determine which public health needs should be addressed first. This framework should focus on preventing disease from occurring, not responding to it. This manuscript proposes a general theory of public health needs similar to the “Theory of Human Motivation” proposed by Maslow.2 This manuscript is an attempt to formulate a theory of public health necessity that satisfies theoretical demands while conforming to global public health’s known facts, and experimental, clinical, and observational health research. With this logical framework, global public health strategy, policy, and investment should be guided. Exporting public health solutions for higher order problems to areas where more basic challenges predominate are often unsustainable at best. The purpose of this framework is to maximize the impact of resources to best improve global public health by viewing eight key areas as essential building blocks: potable water, food and nutrition, shelter, energy, sanitation, education, health care, and medical technology (Figure 1).

**Potable Water**

Access to potable water is the most important public health need and the cornerstone of improved sanitation and biosecurity. The combination of clean water, adequate sanitation, and sufficient hygiene has the potential to prevent at least 9.1% of global disease burden and 6.3% of all deaths worldwide.3 The World Health Organization (WHO) defines safely managed drinking water in a household as being located on the premises, available when needed, and complying with fecal and chemical standards.4 While access to potable water is considered a basic human right, in 2015 one in ten people still lacked access to safe water globally.3,4,5

Increased access to clean water is necessary to prevent diseases contracted from contaminated water, including fecal-oral route transmission diseases like diarrhea, and is required in the treatment of many diseases.3,4 Additionally, clean water for sanitary purposes is integral to preventing disease transmission because personal hygiene (predominantly handwashing) is the only absolute protective barrier for blocking fecal-oral routes of disease transmission.6 Studies show that washing hands with soap can decrease the incidence of diarrhea, severe intestinal infections, shigellosis, and pneumonia in children by approximately 50%.7,8 Universally improved drinking and washing water has the potential to reduce contraction of diarrhea by 45% and morbidity by 21% worldwide,9 indicating the gap in providing this basic public health need. Diarrhea alone is a significant health issue: diarrheal disease remains a leading cause of child morbidity and the second greatest cause of mortality in children under 5 years old in the world.10

Access to fresh drinking water is limited by the availability, management, and equitable distribution of freshwater sources, and sanitation infrastructure. Universal access to potable water has beneficial secondary effects to public health. For example, diarrhea and other waterborne illnesses are a principal reason for both school and workplace absenteeism.11 Increasing access to potable water therefore produces concomitant benefits for education and worker absenteeism. Additionally, improved water facilities enable more children, particularly girls, to attend school because of the reduced burden for time spent collecting water.11,12,13,14 These secondary effects further reduce disease burden and will be discussed in subsequent sections in order of their relative importance (Figure 1).

**Food and Nutrition**

Access to sufficient and nutritious food is imperative to human survival and disease prevention, yet a significant proportion of the human population is not food secure.15,16,17,18 Food insecurity is the inability to acquire nutritious food through socially acceptable means and significantly contributes to poor health.19 Adults in food insufficient households are more likely to have unhealthy, nutrient-deficient diets, and food insecurity is associated with an increased rate of chronic illnesses including diabetes, heart disease, and high blood pressure.20,21 When food insecurity develops into malnutrition, health risks increase.15,22

Malnutrition and extreme food deficiencies significantly impair the health and development of individuals. The cyclical relationship between malnutrition and immune response dysfunction makes malnourished individuals particularly susceptible to infection and disease.15 Even mild forms of malnutrition are correlated with stunted growth and higher mortality rates.15,22,23 Approximately one third of children in developing countries under the age of five years are malnourished or suffer from chronic malnutrition, and are subsequently burdened with health issues like stunted growth, physical wasting, and being underweight.15 The Dutch Famine of 1944-1945 highlights the lifelong impact of malnutrition on human health: the malnutrition of pregnant women during the famine led to a higher rate of severe chronic illnesses in their offspring several decades later.23 In the developed world, malnutrition can occur in individuals who do not eat proper quantities of nutritious food. Residents of low income neighborhoods often lack access to affordable, healthy food suppliers, and their resulting diets are unhealthy and nutrient-poor, leading to a high prevalence of obesity, diabetes, heart disease, and other chronic conditions.24

In particular, micronutrient malnutrition is responsible for a wide range of non-specific physiological impairments, leading to reduced resistance to infections, metabolic disorders, and impaired physical and psychomotor development.18,25,26 Specific nutrient deficiencies are also correlated with the increased risk of certain diseases, often through a reduction of the mucosal immune function.15,18 Cost efficient interventions could mitigate these health risks. For example, research suggests that vitamin A-fortified golden rice could halve the impact of vitamin A deficiency on the population of India while maintaining cost effectiveness.27 A barrier to growing nutritious food is access to energy and electrification. Crop yields in low-income countries are currently much lower than those of farmers in high-income countries, who are able to use modern agricultural techniques.28 Research on energy-sustainable agriculture that does not require intensive, industrial-level resources could alleviate food insecurity in developing countries.

**Shelter**

Access to adequate and healthy shelter is a basic health need. Despite this, nearly 40 percent of urban growth has occurred in slum housing.29 Inadequate housing is defined as housing with moderate or severe structural problems including deficient plumbing, or electricity.30 Adequate housing protects against communicable and chronic diseases, injuries, poisonings, and both psychological and social stress.31,32,33,34 Unhealthy housing is defined as exposure to toxins or detrimental environmental conditions within the house, and includes exposure risk to rodents, mold, and water leaks.30 Both inadequate and unhealthy housing can leave residents vulnerable to chronic and communicable health threats.30,32,333,34

Inadequate shelter conditions often exist in a context of poverty, warfare, and limited infrastructure.35,36,37 Studies on refugee camps and homelessness highlight the health effects of poor housing conditions. Refugee camps are often overcrowded and plagued by inadequate heating, dampness, molds, poor lighting, and poor ventilation and are associated with incidence of respiratory diseases and fever.38,39 Bonner *et al*. found that households in Liberian refugee camps in Sierra Leone with more rat burrows and poorer external hygiene had a higher incidence of Lassa fever cases compared to nearby houses that were in better condition.36 Furthermore, housing instability can lead to limited access to medications and health care, and increased rates of chronic diseases, hospitalizations and emergency department use.36,37 Clean household energy is a primary component of healthy housing. Nearly half of the world’s population lacks access to clean household energy and must burn unprocessed biomass fuels like wood, coal, dung, and crop residues to heat the household and cook, which can lead to unhealthy housing scenarios.30,31,38,39 When compounded with poor indoor ventilation, the use of unprocessed biomass fuels indoors creates indoor air pollution (IAP) that causes 2.7% of the global disease burden. Nearly half of the world’s population has IAP, with women and children at highest risk of exposure. IAP associated conditions include acute lower respiratory infections, chronic obstructive pulmonary disease, lung cancer, cardiovascular disease and other health conditions.38,40,41

Although the exact size and nature of health gains from housing improvements are unknown, studies suggest that provisioning housing to individuals living without adequate shelter improves their self-reported physical and mental health, decreases rates of substance abuse, and increases health service use.42,43 Because of the association between poor housing conditions and disease risk, providing stable housing may alleviate associated health issues.42,43 Providing adequate shelter should be a fundamental concern of building successful public health infrastructure on which other key policies can be built. Policy intervention must work at multiple levels to solve this fundamental public health need by addressing intersecting factors including the provisioning of clean energy.

**Energy**

Accessible, clean energy has the potential to improve and modernize public health systems at multiple levels. Studies have revealed direct positive correlations between energy consumption per person, life expectancy, and infant mortality.28,44,45 Clean energy can power water and sanitation infrastructure, and mitigate harmful exposure to indoor air pollution from lighting and cooking with biofuels.38,39,46 Unfortunately, access to clean energy is not equitably distributed. Between two and four billion people depend on biomass fuels and are vulnerable to their direct health consequences, while lacking access to the indirect benefits of clean energy (e.g., improved transportation, agriculture, and health care).28 Policy should stimulate communities to move up the energy ladder by transitioning from burning biofuels to modern electric grids that would reduce both energy costs and pollution.39

Energy reforms that help provide clean and accessible energy to more of the global population can significantly improve the health conditions of households and health care facilities. A major benefit of clean energy and electrification is reducing exposure to indoor air pollution created by burning biofuels.39 Additionally, all levels of the health care industry, from community clinics to regional hospitals, benefit from improved electric infrastructure. Access to electricity can facilitate the use of better laboratory and diagnostic technologies, provide light for medical services during nighttime, ensure better sterilization of equipment, and allow the management of thermosensitive treatments (e.g., vaccines).28,39,47,48

Electrification policies must be constructed within their cultural context to ensure their wide adaptation. Globally, many families prefer to cook on biofuels even when electricity is available, leaving low-hanging unrealized health benefits on the table.39 Two common methods to increase electrification are extending grid access to communities and setting up decentralized energy production facilities, primarily based on renewable energy.48 For example, in Liberia more primary care providers use solar power than fossil fuels, which has concomitant benefits for other basic global health necessities like clean air and potable water.47 Additionally, electrification of health care facilities and households allow for access to information communication technologies that can radically improve health information and data systems and disseminate important health care information through TV and radio.39,49 Access to information communication technologies can revolutionize education for both health care workers and the general public. In these ways, clean energy and electrification are building blocks for the development of health care technologies, improved access to health care, better educational tools, and sanitation system infrastructure.

**Sanitation**

Sanitation measures that adequately separate human and animal waste from human contact are a primary tool in achieving safe and clean water supplies.50 Proper management of solid waste, management of clean water, and promotion of hygiene practices are effective means to limit the spread of disease.50 The primary effects of poor sanitation, hygiene, and contaminated water are water-borne diseases like cholera, viral hepatitis, typhoid, and other diarrheal diseases. In total, 4.3% of the global disease burden is attributed to diarrheal diseases, with 88% estimated to be caused by unsafe water and inadequate sanitation and hygiene.51 Effective management of waste should be a top public health priority on which other systems can be built.

Urbanization has posed challenges to sanitation management throughout history, which continues into the modern developing world.52 The increased spread of infectious diseases like cholera during the urbanization and industrialization of 19th century London illustrates these challenges. Britain was a pioneer in passing legislation and setting up governing bodies to reform sanitary conditions in the overcrowded, newly industrial cities in response to outbreaks like the 1847 cholera epidemic.53,54 Edwin Chadwick’s research definitively linking environmental conditions to disease incited the Public Health Acts of 1848 and 1875 that outlined plans for improved drainage and sewer systems, and regulated waste disposal practices.54,55 These acts were important precedents to government involvement in urban waste management.

Despite the increasing role of government in waste management in many parts of the world, proper management of solid waste continues to be a global problem.55,56,57,58 The unprecedented 828 million people living in urban slums in the developing world are without access to proper sanitation, which poses a grave human health risk.55,59 In 2015, one third of the world’s population did not have access to improved sanitation, with one eighth of the population practicing open defecation.5,60,61 Improperly disposed solid waste is often thrown into open spaces where stagnant water from clogged drains, refuse, and leachate percolating into waterways drives potable water contamination and disease outbreaks.52,55,14,56,62,63,64,65,66  Additionally, home incineration and disposal of hazardous and biomedical wastes cause health problems by polluting groundwater and air.56,67,68 As rapid urbanization continues, sanitation and solid waste disposal will become a larger public health threat that calls for political solutions.57,69

Successful sanitation policy combines technological implementation with increased cultural awareness.12,56,57,70 The developing world’s priority is the physical separation of waste from human populations, and a commensurate 90% of their municipal solid waste budgets are spent on this task alone.55,56,57,58,71,72 The developed world, having to a large degree accomplished this goal, may focus on improving waste processing methods and thus use less than 10% of their budgets for solid waste collection.72 To avoid deleterious public health outcomes, the developing world must start allocating funds to processing solid waste and transitioning from open landfills without treatment to sanitary landfills.56,73

Additionally, proper waste management and sanitation can have positive secondary effects on other public health goals. Strong and effective waste management policy directly aids local employment, energy production, the environment, and food production systems.56,74 Sanitation reforms benefit women’s health by attenuating physical violence in shared latrines and increasing access to education in schools that can accommodate menstruating students.11,12,14 Sanitation reform can also effectively regulate the sustainable production of nutritional foods. Wastewater is often used in crop irrigation and can cause increased risk of viral, bacterial, and protozoan enteric infections if improperly managed.75,76,77 One policy solution is to provide strict guidelines on the maximum concentration of excreted pathogens (e.g., viruses, bacteria, helminth eggs, and fecal coliforms) in the wastewater used in agriculture to prevent transmission of communicable disease through this pathway.74 Because water and waste guidelines are interconnected foundations to population health, a systems approach should be taken in the formation of waste and water policy.55

**Education**

Public health education, including education on sexually transmitted diseases, smoking tobacco, and unsafe drug usage, is integral in disease prevention and outbreak responses to global health threats.78,79 Limited access to educational tools and services can impede knowledge and understanding of behavioral health hazards. For example, in 1996, two-thirds of adult Chinese smokers believed cigarettes did “little to no harm”.78 Education on nutrition, sanitation practices, vaccines, antimicrobial resistance, and communicable disease transmission gives individuals the opportunity to make informed decisions about both personal and community-level disease prevention.80

The foundation for education is general literacy. Rajan, Kennedy & King found that increased literacy is one of two major factors (the other being alleviation of poverty) needed to improve public health throughout disparate populations.79 Literate adults have the ability to understand official written public health information like medical pamphlets, outbreak signage, or warning labels on tobacco products. Even if the adult population is mostly illiterate, educating children indirectly teaches parents, so education policy may be best suited focusing on younger generations.11 This underscores the importance of other foundational health needs, like electricity, clean water, and sanitation that contribute to decreased absenteeism from school and expand the opportunity for females to receive an education.

**Health Care Systems**

Once the aforementioned public health needs have been met, and education and literacy systems are in place, policies should focus on training and building the human and technological capital necessary to increase health care access.82  Building a trained health care workforce is a first step in the development of a health care system. Necessary human capital in the health care sector is built through appropriate education programs and long-term retention of qualified health care professionals.83,84,85,86 The absence of strong accreditation and training programs are an obstacle policy-makers must address to ensure a baseline level of health care competency worldwide.83,87,88,89,90 Skilled worker retention can be a significant impediment to building a health care system, particularly in rural areas. Improving basic infrastructure (e.g., access to shelter, potable water electricity, and sanitation) improves the quality of life for health care professionals and encourages their retention.39,91

Supplying trained workforces with necessary tools and medicines to treat patients can be challenging when reliable medical supply chain infrastructures are not in place. Developing countries frequently experience local and national drug shortages in which patients cannot access lifesaving drugs.92 In some countries, routine and cheap equipment, like chest tubes for trauma victims or ultrasound gel, are not sufficiently stocked in medical supply reserves and frequently run out.86,93 Policy should aim at emboldening the private and public sectors to collaborate to create reliable supply chains for critical drugs and medical supplies.

**Medical Technology**

Government organizations can contribute to improving the overall health care system of their country through research, education, financing, and technology development. An educated and trained workforce within a sustainable healthcare system requires sustained funding to develop and thrive. Scientifically informed allocation of funds to treatment and vaccine research programs, and the development of medical devices and biosurveillance systems is necessary to advance public health systems.78,83,90,93,94,95

Lastly, government health care financing is a political opportunity to increase access and quality of health care for those least able to afford it. Exorbitant health care costs have forced 100 million people worldwide below the poverty line, while further impoverishing 1.2 billion of the world's poorest.83,96 Furthermore, limited geographic access to health care facilities (e.g., primary care facilities and emergency medical services) can be an additional access obstacle, particularly in dense or rural, isolated areas where there are transportation limitations and road infrastructure deficiencies.97,98

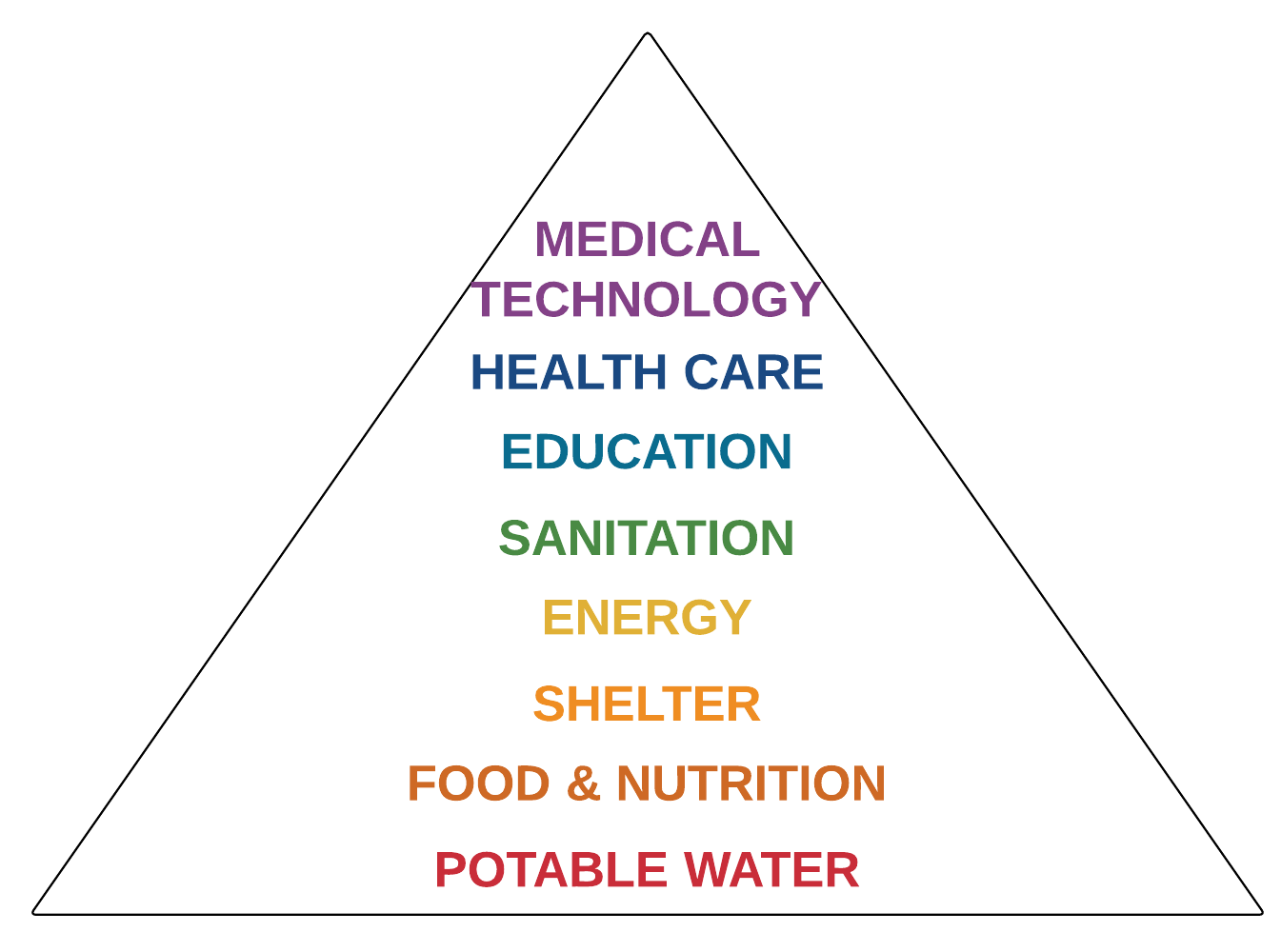
**Conclusion**

In recent decades, public health policy and investment has focused on medical technology and healthcare and has not reduced global infectious disease risk. Instead of focusing on health care and medical technology, global public health policy and investment should focus on adequate accessibility to (from most to least important): potable water, safe food, safe and secure shelter, clean and reliable energy, sanitation, and education. Public health encompasses a broad variety of scientific and political fields in which many players and moving parts must collaborate to achieve optimal health. Actions implemented in one area of public health necessity can have positive or negative effects on the capabilities of other sectors (Figure 1). Many factors outside the proposed framework may have impacts on the development of effective public health measures and these needs will likely vary based on location. At a minimum, a highly effective and functioning public health system needs these simple proposed factors to reduce a multitude of negative health outcomes. Culture, politics, geography, political instability, human rights, and many other factors outside the direct influence of the traditional health sphere and the theory proposed in this manuscript, can make or break a public health system.

An example of this is women’s rights, a factor that can have an enormous effect on the health of a population’s women and children.99 Severe injury and disfigurement, high rates of infection (in particular HIV transmission), and female/mother-infant mortality are not uncommon in cases of rape, female genital mutilation, acid-throwing, and other forms of abuse.99,99,101,102 Political representation, economic equality, and education are all necessary to improve the health of women around the globe.99

Country stability and peace are also important in overall public health. Areas with high levels of corruption and conflict suffer from the destruction of shelters, displacement of large groups of people, and deteriorating health-related infrastructure, including unstable water and food sources.60,103,104 Research indicates that countries with worse scores on the Corruption Perceptions Index (CPI) had higher rates of maternal mortality due to a lack of equitably accessible health services or transparent public health organizations.104 Chaotic, conflict-induced conditions leave populations susceptible to disease outbreaks, and unable to access health care when inflicted.34,105 Although these factors are not immediately vital to human health, public health organizations should consider the many overarching health implications involved in these issues and how they relate to the foundational needs outlined in this hierarchy.

Our proposed approach to sustainable public health is consistent with and underscores the importance of the Sustainable Development Goals. While the burden of effort required for implementation of the IHRs falls on the public health community, far more positive health outcomes will result from the multi-sectoral shared commitment to achieving the Sustainable Development Goals. As illustrated in our hierarchical model, public health is far more dependent on sound public services than it is on medical innovation.



**Figure 1.** Contributing factors to a successful public health infrastructure. Factors are ranked from most fundamental and basic (bottom), with subsequent levels of increasing sophistication building upwards.

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