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

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**Introduction**

There is a general hierarchy of basic health needs that need to be fulfilled to increase the public’s health. Basic health needs are founded in experiments and known facts derived from numerous public health studies that have examined their effect on various exposures and their associated public health outcomes (e.g., morbidity, mortality, DALY, QALY, PYLL, GBD). These hierarchy of public health needs are illustrated in Figure 1. For a public health system to function most effectively, each basic health need must be fulfilled and are ranked ordered from most to least critical to achieve the best functioning public health system. In Figure 1, depicts the basic resources necessary to maintain human life and vertically progressed towards systems and interventions that been demonstrated to improve and prolong quality of life.

**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, sanitation, and hygiene have the potential to prevent at least 9.1% of global disease and 6.3% of all deaths worldwide (Prüss-Üstün *et al*., 2008). The 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 (WHO & UNICEF JMP, 2015). While access to potable water is considered a basic human right, and has increased globally annually, 1 in 10 people in the world lacked access to safe water in 2015 (WHO, 2015a; Cooley *et al*., 2013; WHO & UNICEF JMP, 2014).

Clean water is necessary for the prevention of diseases contracted from contaminated water, including fecal-oral route transmission diseases like diarrhea, and is required in the treatment of many diseases (Prüss-Üstün *et al*., 2008; WHO, 2015a). Access to clean water for sanitary purposes is integral in the prevention of disease transmission because personal hygiene (predominantly handwashing) is the only absolute protective barrier for blocking fecal-oral routes of transmission (Gine *et al.*, 2015). Studies show that handwashing behavior can decrease the incidence of diarrhea, severe intestinal infections, shigellosis, and pneumonia in children by approximately 50% (Curtis, 2003; Luby, 2005). Universally improved drinking and washing water has the potential to reduce contraction of diarrhea by 45% and morbidity by 21% worldwide (Lenton, 2005). Diarrhea alone is a significant health issue; diarrheal disease remains a leading cause child morbidity and second most cause of mortality in children under 5 years old in the world (WHO Media Center, 2014b).

Fresh drinking water access is limited by availability and management of freshwater sources, and equitable distribution of these sources. Access to potable water has many beneficial secondary effects to public health. For example, there are concomitant benefits for education and worker absenteeism. Diarrhea and other waterborne illnesses are a principal reason for both school and workplace absenteeism (Tobin & van Koppen, 2005). Additionally, improved water facilities enable more children, particularly girls, to attend school because of the reduced burden for time spent collecting water (Lofrano & Brown, 2010; HDR, 2006; Tobin & van Koppen, 2005; Tacoli, 2012). Also, availability of clean water is often dependent on adequate waste sanitation. These secondary effects further reduce disease burden and will be discussed in subsequent sections in order in relation to 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 does not have food security (Rodriguez *et al*., 2011; Sorsdahl *et al*., 2011; USDA, 2015; Allen *et al.*, 2006). Food insecurity is the ability to acquire nutritious food through socially acceptable means and significantly contributes to poor health (Scott & Wehler, 1998). 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 (Dixon *et al*., 2001; Vozoris & Tarasuk, 2003). When food insecurity propagates into malnutrition, the health risks can be even greater (de Onis *et al*., 2000; Rodriguez *et al*., 2001).

Malnutrition and extreme food deficiencies significantly influence the health and development of individuals. The cyclical relationship between malnutrition and immune response dysfunction makes malnourished individuals particularly susceptible to infection and disease (Rodriguez *et al*., 2011). Even mild forms of malnutrition are correlated with stunted growth and higher mortality rates (de Onis *et al*., 2000; Rodriguez *et al.*, 2011; Roseboom *et al*., 2001). Approximately one third of children in developing countries under the age of five years are malnourished or suffer from chronic malnutrition, and subsequently deal with health issues like stunted growth, physical wasting, and being underweight (Rodriguez *et al*., 2011). The Dutch Famine of 1944-1945 highlights the lifelong impact of malnutrition on human health: the undernutrition of pregnant women during the famine led to a higher rate of severe chronic illnesses in their offspring several decades later (Roseboom *et al.*, 2001). In the developed world, malnutrition presents itself in individuals that are not eating proper quantities of nutritious food. Low income residents often lack access to affordable healthy food stores and their resulting diets are unhealthy and nutrient-poor, leading to high prevalence of obesity, diabetes, heart disease, and other chronic conditions (Walker *et al.*, 2015; USDA Food Deserts).

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 (Kirkpatrick & Tarasuk, 2008; Lee & Frongillo, 2001; Allen *et al*., 2006). Specific nutrient deficiencies are also correlated with the increased risk of certain diseases, often through a reduction of the mucosal immune function (Rodriguez *et al*., 2011; Allen *et al*., 2006). Research suggests that vitamin A-fortified golden rice could halve the impact of vitamin A deficiency on the Indian population while being cost-efficient (Stein *et al*., 2008). Crop yields in low-income countries are currently much lower than those of farmers in high-income countries, who are able to use energy-intensive agricultural techniques (Wilkinson *et al.*, 2007). Research into energy-sustainable agriculture that does not require intensive, industrial-level resources could also 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 occurred in slum housing (WHO, 2010). Inadequate housing is defined as having moderate or severe structural problems, plumbing, or electricity (CDC; Raymond *et al*., 2011). Adequate housing protects against communicable and chronic diseases, injuries, poisonings, and both psychological and social stress (WHO 1989; Habib *et al*., 2009; Kushel *et al*., 2006; Roberts *et al.*, 2009). 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 (Raymond *et al*., 2011). Both inadequate and unhealthy housing can leave residents vulnerable to chronic and communicable health threats (Raymond *et al*., 2011; WHO 1989; Habib *et al*., 2009; Kushel *et al*., 2006; Roberts *et al.*, 2009).

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 of unprocessed biomass fuels like wood, coal, dung, and crop residues, which can lead to unhealthy housing scenarios (Bruce, 2007; World Bank, 2008; Raymond *et al*., 2011). 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 are 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 (Bruce, 2007; Bruce *et al*., 2002; WHO, n.d.).

Inadequate shelter conditions often exist in a context of poverty, warfare, and limited infrastructure (Al-Katib *et al*., 2010; Bonner *et al*., 2007; Kelly *et al*., 2013). Studies on refugee camps and homelessness highlight the health effects of 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 (Al-Katib *et al*., 2010; Roberts *et al*., 2009). In 2007 Bonner *et al*. found that households in Liberian refugee camps in Sierra Leone with more rat burrows and poorer external hygiene had higher incidence of Lassa fever cases compared to nearby houses that were in better condition. Furthermore, housing instability can lead to limited access to medications and health care, and increased rates of chronic diseases, hospitalizations and emergency department use (Habib *et al*., 2009; Kushel *et al*., 2006). 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 utilization (Fitzpatrick-Lewis *et al*., 2011; Thomson *et al*., 2001).

Because of the association between poor housing conditions and disease risk, providing stable housing may alleviate associated health issues (Fitzpatrick-Lewis *et al*., 2011; Thomson *et al*., 2001). Providing adequate shelter should be the fundamental concern of building successful public health infrastructure on which other key policies can be built.

**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 (Wilkinson *et al*., 2007; UN Development Program, 2006; World Resources Institute, 2007). Clean energy can power water and sanitation infrastructure, and mitigate harmful exposure to indoor air pollution from lighting and cooking with biofuels (Gohlke *et al*., 2011; Bruce, 2007; World Bank, 2008). Unfortunately, access to clean energy is not equitably distributed. Between two and four billion people depend on biomass fuels and are vulnerable to their health consequences, while lacking access to the indirect benefits of clean energy (e.g., improved transportation, agriculture, and health care) (Wilkinson *et al*., 2007). 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 (World Bank, 2008).

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 (World Bank, 2008). 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 management of thermosensitive treatments (e.g., vaccines) (World Bank, 2008; Adair-Rohani *et al*., 2013; USAID, n.d; Wilkinson *et al*., 2007.).

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 (Word Bank, 2008). Two common methods to increase electrification are extending grid access to communities and setting up decentralized energy production facilities, primarily based on renewable energy (USAID, n.d.). For example, in Liberia more primary care providers use solar power than fossil fuels (Adair-Rohani *et al*., 2013); this has concomitant benefits for other basic global health necessities like clean air and potable water. Additionally, electrification of health care facilities and households allows 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 (Simba, 2004; World Bank, 2008). Access to information communication technologies can revolutionize education for both health care workers and the general public.

**Sanitation**

Sanitation measures that can adequately separate human waste from human contact are a primary tool in achieving safe and clean water supplies (WHO, 2008- poor sanitation). Proper management of solid waste, management of clean water, and promotion of hygiene practices are effective means to limit the spread of disease (WHO- poor sanitation). 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 (World Bank, 2003). 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, continuing into the modern developing world (Konteh, 2009). The urbanization and industrialization of London contributed to 19th century infectious disease outbreaks including the 1847 cholera epidemic. As a response, Britain was a pioneer in passing legislation and setting up governing bodies to reform sanitary conditions in the overcrowded, newly industrial cities (Fee and Brown, 2005; Hamlin and Sheard, 1998). 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 (Marshall & Farahbakhsh, 2013; Hamlin & Sheard, 1998). 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 (Srivastava *et al*., 2015; Guerrero *et al*., 2013; Singh *et al*., 2014; Marshall and Farahbakhsh, 2013). 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 (Marshall and Farahbakhsh, 2013; UNFPA, 2011). 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 (WHO, 2015b; Cooley *et al*., 2013; WHO & UNICEF, 2014). 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 (Marshall and Farahbakhsh, 2013, Coffey & Coad, 2010; Konteh, 2009; Tacoli, 2012; Srivastava *et al*., 2015; Castro *et al.*, 2010; Nagarajan *et al*., 2012; Mor *et al*., 2006; Vasanthi *et al*., 2008). Home incineration and disposal of hazardous and biomedical wastes cause health problems by polluting groundwater and air (Srivastava *et al*., 2015; Kathiravale & Muhd Yunus, 2008; Kansal *et al*., 1998). As rapid urbanization continues, sanitation and solid waste disposal will become a larger public health threat that calls for political solutions (Minghua *et al*., 2009; Guerrero *et al*., 2013).

Successful sanitation policy combines technological implementation with increased cultural awareness (Guerrero *et al*., 2013; Lofrano & Brown, 2010; HDR 2006; Srivastava *et al*., 2015). 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 (Guerrero *et al.*, 2013; Srivastava *et al*. 2015; Hoornweg & Bhada-Tata, 2012; Marshall & Farahbakhsh, 2013; Memon, 2010; Singh *et al.*, 2014). 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 (Memon, 2010). 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 (Srivastava *et al*., 2015, Wilson, 2007).

Additionally, proper waste management and sanitation can have positive secondary effects on other public health goals too. Strong and effective waste management policy directly aids local employment, energy production, the environment, and food production systems (Srivastava *et al*., 2015; Hussain *et al*., 2002). Sanitation reform benefits women’s health by attenuating physical violence in shared latrines and increasing access to education in schools that can accommodate menstruating students. (Lofrano & Brown, 2010; HDR, 2006; Tobin & van Koppen, 2005; Tacoli, 2012). 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 (Mara & Bos, 2010; Katzenelson *et al*., 1976; Fattal *et al.*, 1986). One policy solution is to provide strict guidelines on maximum concentration of excreted pathogens (e.g., viruses, bacteria, helminths eggs, and fecal coliforms) in wastewater used in agriculture to prevent transmission of communicable disease through this pathway (Hussain *et al*., 2002). Because water and waste guidelines are interconnected foundations to population health, a systems approach should be taken to the formation of waste and water policy (Marshall & Farahbakhsh, 2013).

**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 (Abdullah & Husten, 2004; DiClemente *et al*., 1986). 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” (Abdullah & Husten, 2004). Education on sanitation practices, vaccines, antimicrobial resistance, and communicable disease transmission gives individuals the opportunity to make informed decisions in both personal and community-level disease prevention (WHO Health Education, 2012).

The foundation for education is general literacy. Rajan, Kennedy & King (2013) found that increased literacy rate is one of two major factors (the other being alleviation of poverty) in improving public health throughout disparate populations. 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 (Tobin & van Koppen, 2005). 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 girls to receive an education.

**Health Care Systems**

Once the previously mentioned health needs have been met, policies should focus on building the human and technological capital necessary to increase access to health care (Kim *et al.*, 2013). 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 (WHO MDG to SDG; WHO Health Workforce, 2015; LaGrone *et al.*, 2012; Shah *et al.*, 2015). 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 (WHO MDG to SDG; O’Bierne *et al*., 2013; Travis *et al*., 2004; Mbanjumucyo *et al*., 2015; Razzak *et al*., 2002). 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 aids in their retention (World Bank, 2008; Chaudhury & Hammer, 2003).

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 (Médecins Sans Frontières, 2015). 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 (Mock *et al*., 2005; Shah *et al.*, 2015). 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. Informed allocation of funds to treatment and vaccine research programs, medical device, and biosurveillance system development is necessary to advance public health systems (Mock *et al*., 2005; Pedrique *et al*., 2013; Chekijian *et al*., 2013; Abdullah & Husten, 2004; WHO MDG to SDG; Razzak, 2002;). 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 (WHO MDG to SDG; WHO Health System Financing, 2010). 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 and is hindered by transportation limitations and road infrastructure deficiencies (Perry & Gesler, 2000; Arcury *et al*., 2005).

**Conclusion**

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 least, 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 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 fetuses/infants (Heise, 1994). 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 (Heise, 1994; WHO, 2013; WHO, 2014c; WHO, 2015a). Political representation, economic equality, and education are all necessary to improve the health of women around the globe (Heise, 1994).

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 (Macrae *et al*., 1996; Pinzón-Flórez *et al*., 2015; WHO, 2015b). 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 (Pinzón-Flórez *et al*., 2015). Chaotic, conflict-induced conditions leave populations susceptible to disease outbreaks, and unable to access health care when inflicted (Ford, 2007; Roberts et al., 2009). 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.

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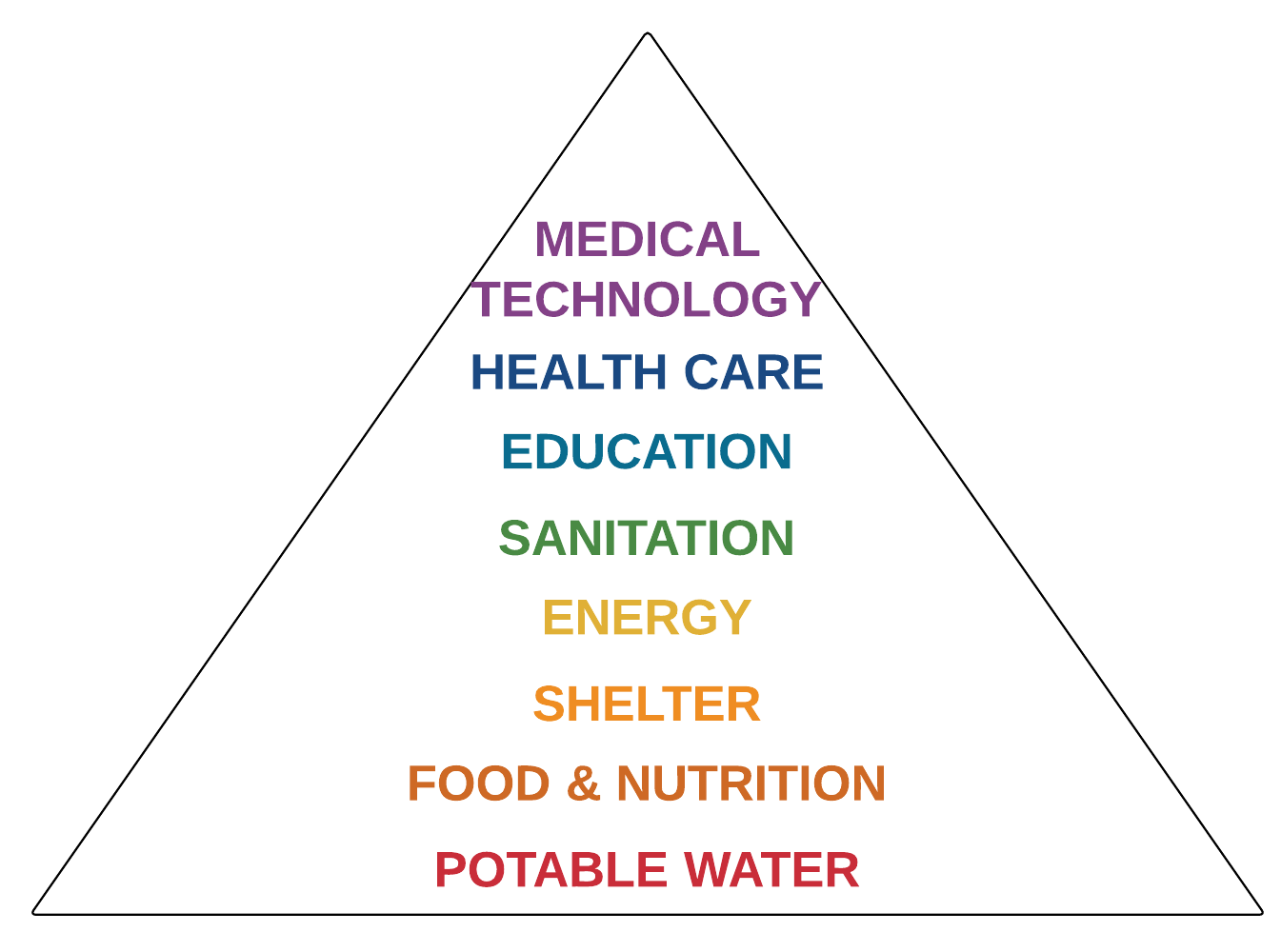
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**Figure 1.** BLABLA