A Systems Thinking Approach to Reduce Health Disparities

Abstract

The social determinants of health play a major role in the health of children and adolescents and risk of morbidity in the future. Research shows that a greater surrounding of greenness is associated with slower epigenetic aging. A study suggests that the expansion of greenness may be more important to populations with limited resources. Furthermore, malnutrition and exposure to toxicants such as pollution during critical stages of development can lead to an increased risk of health problems such as elevated blood pressure and cardiovascular disease later in life. Oftentimes, those that have a low socioeconomic status are subjected to increased exposure to pollution and lack of safe green spaces. Additionally, those that experienced early life stress tend to have accelerated biological aging. This paper examines indicators and studies used to evaluate the health and opportunities of individuals and neighborhoods and the impacts that the natural and built environment that we inhabit have on our future health. The Health in All Policies framework is analyzed through a case study of Israel's Efsharibari program.

Introduction:

The Social Determinants of Health (SDH) defines the social contexts that affect health and how social conditions translate into health effects (Currie, Candace, et al., 2012). It can include income and social protection, education, unemployment, working conditions, food insecurity, housing, basic amenities and the environment, early childhood development, and access to adequate and affordable health services (Social Determinants of Health). There are two types of determinants: structural and proximal. The structural determinants are the social, economic, and political mechanisms that shape the quality of life in communities and neighborhoods. Examples of these determinants include economic, political, social welfare, and education systems. Proximal determinants occur due to structural determinants and can also be impacted by cultural, religious, and community factors. Examples of proximal determinants include family, friends, neighborhoods, and access to education (Currie, Candace et al., 2012).

While life expectancy has seen an overall increase, the disparity remains stark. There is an 18-year gap in life expectancy between high and low-income countries (Social Determinants of Health). Neighborhood deprivation in high-income countries has also been associated with poor educational attainment, teenage pregnancy, poor mental health, and youth violence (Currie, Candace et al., 2012). This underscores the urgent need to address health disparities.

Key Indicators or Studies used to evaluate the health and opportunities of a neighborhood or community

The Global Action for Measurement of Adolescent (GAMA) indicators are 47 indicators identified by the World Health Organization (WHO) as measurements of adolescent health in a country. These indicators, which cover various health and social factors, are divided into six sections: policies, systems, determinants, behaviors, well-being, and outcomes. The core indicators in the policies, programs, and laws section include having a national adolescent health program with regular budget allocation and national standards for delivering adolescent health services. In the systems performance and interventions section, health services used amongst adolescents and Human Papillomavirus (HPV) vaccine coverage are core indicators. The social, cultural, economic, educational, and environmental health determinants section covers the proportion of adolescents who have completed school, are in poverty, food insecurity, and are not in education, as well as the proportion of older female adolescents who understand sexual and reproductive health decision making. Regarding health behaviors and risks, being overweight, obesity, thinness, vegetable and fruit consumption, heavy episodic drinking, and physical education are core indicators. The subjective well-being section sees having someone to talk to as a core indicator. Lastly, the health outcomes and conditions section includes adolescent mortality, birth rates, and Human Immunodeficiency (HIV) prevalence as core indicators (World Health Organization, 2024).

These indicators have been used in 12 countries across WHO's six regions: Armenia, Colombia, Cote d'Ivoire, Guatemala, Guinea, India, Lesotho, Malaysia, Pakistan, Timor-Leste, Togo, and the United Republic of Tanzania. However, these countries have faced challenges with the feasibility of implementing these indicators and the acceptability of collecting data to assess these indicators. A key finding from a study of the implementation of GAMA indicators in these countries is the crucial role of multi-sectoral collaboration. Strengthening this collaboration will aid countries in data collection and improving adolescents' health (Kågesten et al., 2024).

The Healthy People 2030 plan created by the Office of Disease Prevention and Health Promotion includes 358 core, developmental, and research objectives and 23 leading health indicators. These objectives help to measure the nation's progress in crucial areas of public health. The Healthy People 2030 aims to address the Social Determinants of Health in five areas: economic stability, education access and quality, health care access and quality, neighborhood and built environment, and social and community context (Healthy People, 2030).

The Neighborhood Deprivation Index (NDI) measures communities' obstacles to achieving good health. The index looks at wealth and income (median household income; percent of households receiving dividends, interest, or rental income; percent of households receiving public assistance; median home value; percent of families with incomes below the poverty level), education (percent with a high school diploma or higher; percent with a college degree or higher), occupation (percent in management, business, science, or arts occupation; percent unemployed), and housing conditions (percent of households that females head; percent of housing units that are owner occupied; percent of households with a telephone; percent of households without complete plumbing facilities). NDI values range from -3.6 to +2.8, with

higher values indicating more neighborhood deprivation. This index has been used to analyze health disparities and policy development (*Methods - Neighborhood Deprivation Index Data* 2022).

The Child Opportunity Index (COI) is a tool used to evaluate risk factors at the neighborhood level based on data collected from 72,000 census tracts in the 100 largest metropolitan areas. The index considers education, health and environment, and social and economic factors in the neighborhood. This index highlights the disparity in opportunities for children in different neighborhoods. The average Child Opportunity Score for White children is 73, 72 for Asian children, 33 for Hispanic children, and 24 for Black children. Black and Hispanic children are also seven and five times more likely, respectively, to live in a neighborhood that is considered very low opportunity compared to white children (Acevedo-Garcia et al., 2020).

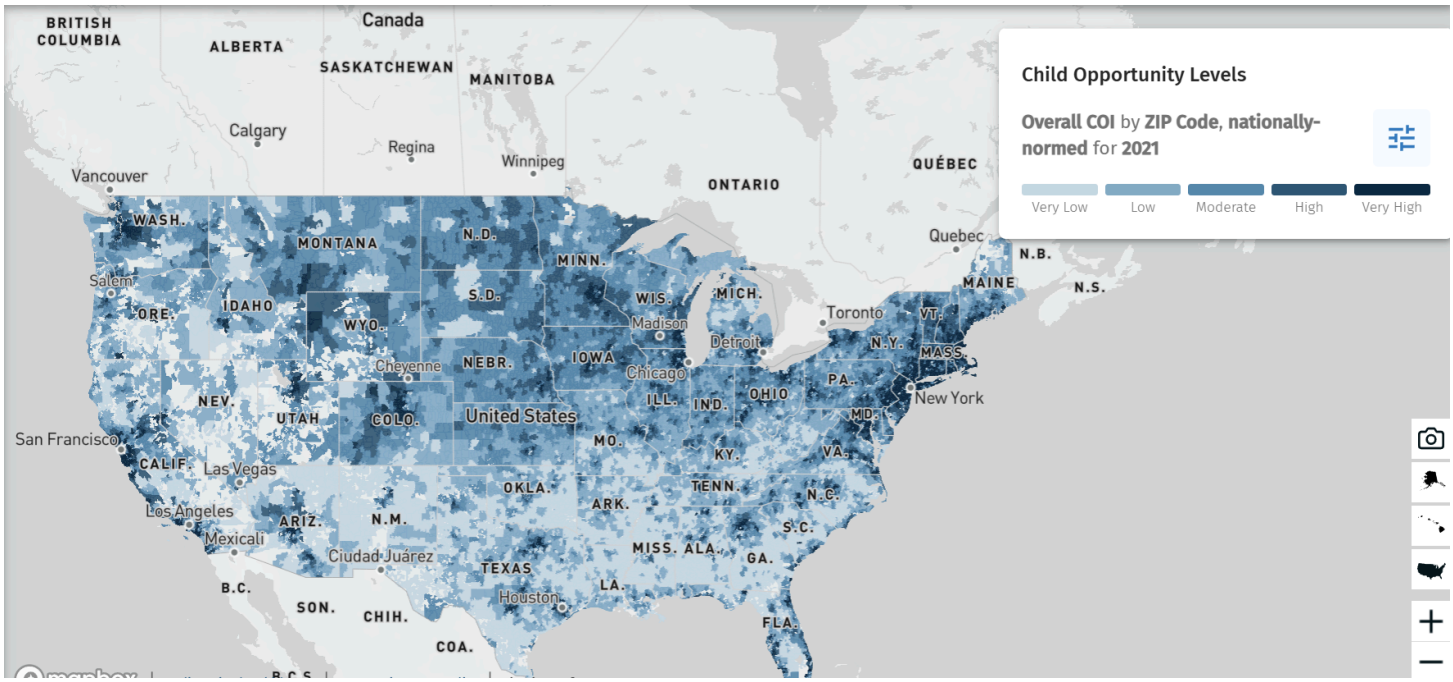

Figure 1: Map of COI scores by neighborhood in the U.S (diversitydatakids.org, 2024).

Epigenetic Ageing

Epigenetic aging measures a person's biological age based on their DNA. Epigenetic clocks provide a way to estimate biological age (Harvanek et al., 2024). Researchers use epigenetic clocks to quantify biological age using biological markers. Epigenetic age acceleration occurs when an estimate of a person's predicted biological age is higher than their chronological one (Faul JD et al., 2023). Epigenetic age acceleration has been associated with cancer incidence and mortality, cardiovascular health factors, and incident cardiovascular disease (Li et al., 2022).

Higher socioeconomic status (SES) in early and later life and upward social mobility are related to slower epigenetic aging. While early-life SES-related adversities can cause individuals to be more likely to have faster epigenetic aging, some of these effects can be mitigated by

improving SES later in life (Crimmins et al., 2024).

Grim Age Acceleration (GrimAA) and Pheno Age Acceleration (PhenAA) are second-generation clocks. They were trained on mortality and health indicators and were used to predict the length of one's life and health (Crimmins et al., 2024). GrimAA has been known to predict time to death and other mortality outcomes. Faster GrimAA has also been associated with cardiovascular health from a young age (Allen, 2021). PhenoAA tracks aging using Creatinine Serum glucose, white blood cell count, and C-reactive protein (Jiang, 2022). DunedinPACE is a third-generation clock that estimates the rate of change in epigenetic age rather than the current age (Crimmins et al., 2024).

Impact of the Natural Environment

A longitudinal study looking at the impact of greenness on epigenetic aging reveals that having a greater surrounding of greenness is associated with slower epigenetic aging. The study also showed that greater exposure to greenness had a more significant impact on those with higher neighborhood deprivation scores. Exposure to dense green vegetation (high normalized difference vegetation index scores) was associated with slower GrimAA and reduced stress among participants with higher neighborhood deprivation scores. This indicates that greenness exposure is more important to populations with limited resources. Long-term exposure to greenness was associated with two components of GrimAA: DNA surrogate cystatin-C (useful measurement for poor kidney functions) and smoking pack-years (Kyeezu Kim et al., 2023)

Malnutrition and exposure to toxicants and pollution are associated with poor health outcomes. Malnutrition during fetal development can cause changes to metabolic and endocrine regulation that can increase the likelihood of obesity and cardiovascular disease later in life. Furthermore, prenatal exposure to air pollution is associated with lower lung volume and decreased lung function in early childhood, premature birth, and low birth weight. Exposure to air pollution in early childhood can lead to an increased risk of developing leukemia, elevated blood pressure, and asthma in adolescence and early adulthood. However, families struggling with intergenerational poverty and those in rural areas are more likely to be exposed to toxic substances (National Scientific Council on the Developing Child, 2023).

Impact of the Built Environment

There are three types of stress: positive, tolerable, and toxic. Positive stress relates to moderate, short-term stress responses and is a normal part of learning and an essential part of the developmental process. Tolerable stress refers to stress responses that can negatively impact the brain but occur only for a short period, allowing the brain to recover and reverse the harmful effects that may occur. However, these responses can become toxic in the absence of supportive relationships. Toxic stress refers to the prolonged activation of the body's stress response system. This can be due to stressful events that are chronic and uncontrolled. High exposure to toxic stress can cause the stress response system to respond at lower thresholds

than others. This causes the stress response system to be activated more frequently and for more extended periods than it should be.

Studies examining the impact of maternal deprivation on rats showed that young rodents who did not receive attentive maternal care had impaired production of neural growth factors important for brain development and repair. Pregnant female rodents that experienced very high levels of stress tend to have offspring that are more fearful and reactive to stress. Both of these groups were also found to have impaired memory and learning abilities and experienced more memory loss and cognitive impairments in adulthood. However, positive experiences after infancy (from birth to one year old) in young rats, such as being exposed to environments that have opportunities for exploration and play, were shown to compensate for some of the negative consequences that resulted from prenatal stress and postnatal neglect (National Scientific Council on the Developing Child, 2005/2014).

The Lifestyle Influences of Family Environment (LIFE) study cohort and the Yale Stress Center Cohort looked at early life stress's impact on GrimAge Acceleration. In both cohorts, those who had experienced early life stress/childhood adversity had higher GrimAge Acceleration than those who did not. In both cohorts, lower GrimAge Acceleration was associated with lower insulin resistance in those overweight or obese. Childhood adversity was also associated with higher Body Mass Index (BMI) and insulin resistance, a higher chance of developing metabolic syndrome, increased obesity, and accelerated epigenetic aging (Harvanek, Zachary M et al., 2024).

Health in All Policies Approach

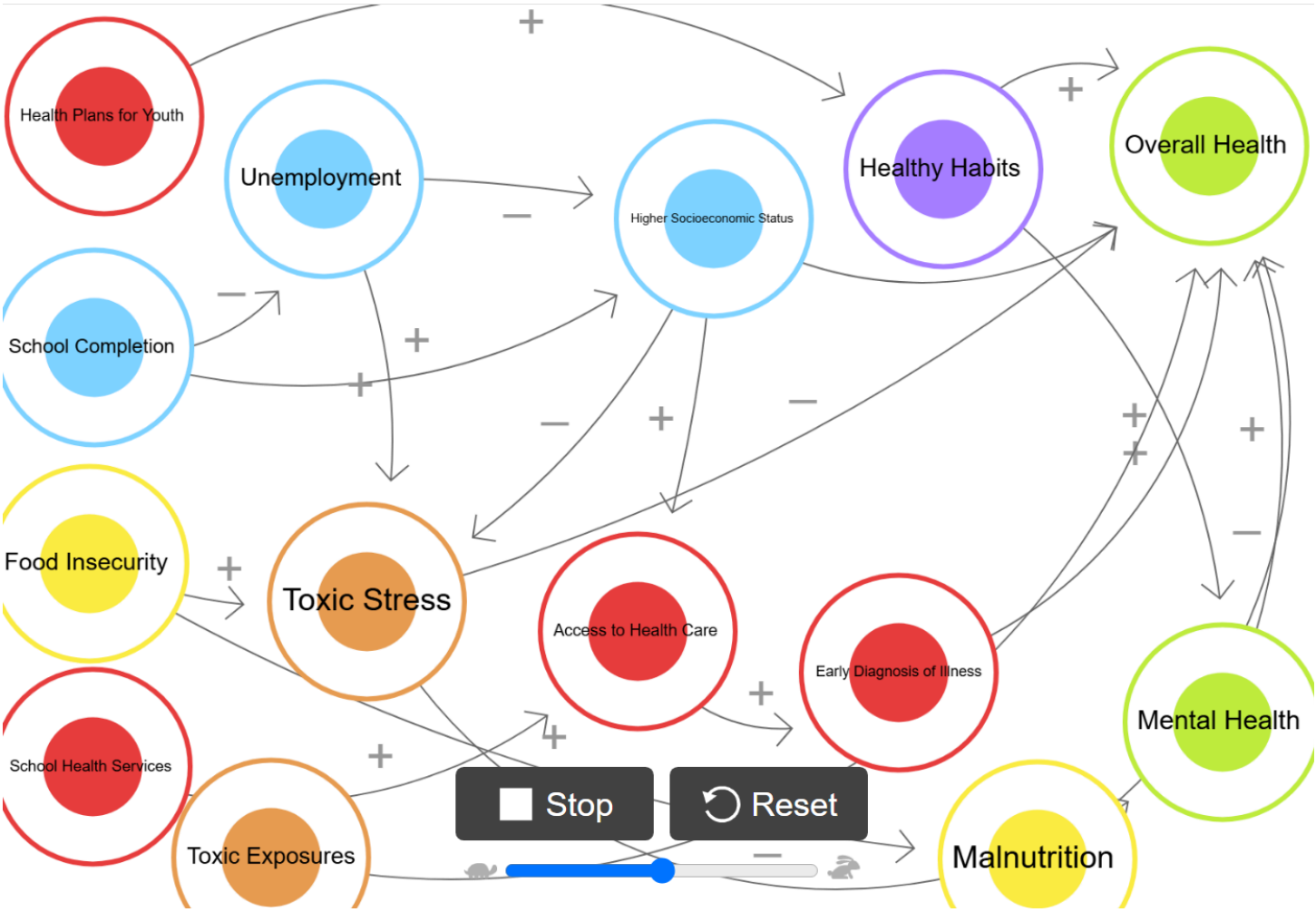

Figure 2: Loopy model of the impact of different social determinants of health (Youngquist, 2025)

This research highlights the impact of the natural and built environment on health. Therefore, it is important to look at health holistically and that policies consider the impact of the social determinants of health. The following paragraphs look at the Health in All Policies (HiAP) Approach and how it has been applied to reduce health disparities.

Health in All Policies (HiAP) is "the policy practice of including, integrating, or internalizing health in other policies that shape or influence the Social Determinants of Health" (McQueen D et al., 2012). According to the Adelaide Statement on Health in All Policies, the HiAP approach works when there is engagement with stakeholders outside the government; accountability, transparency, and participatory processes are present; there are systematic processes that take into account intersectoral interactions; and there are cross-sector initiatives that build partnerships and trust. Health departments will need to understand the political agendas and administrative goals of other sectors, create regular platforms for discussion and problem-solving with other sectors, evaluate the effectiveness of intersectoral work and policy-making; and build capacity through better mechanisms, resources, support, and staff

(Adelaide Statement on Health in All Policies, 2010). However, the HiAP approach can cause an increased burden on the already stretched healthcare professionals.

Case Study of Israel's Efsharibari (Healthy is Possible) Program - a program that incorporates Health in All Policies (HiAP)

Israel's Efsharibari (Healthy is Possible) program is a comprehensive initiative that began in 2011 and aims to address obesity and related chronic diseases. The program's main objectives are to reduce obesity rates, improve public health, and implement policies that promote physical activity, healthy nutrition, and lifestyle changes. The program is designed to curb health challenges by looking at the root cause of the problem and aims to address health inequities at the causal level. The program involves the health, education, culture, and sports sectors working together to promote health. It also uses the HiAP Framework, which aims to integrate health considerations in different policymaking sectors.

The program's main components were forming an intersectoral committee working together to integrate health promotion and passing a legislative agenda to improve healthy food accessibility, education, and incentives for health providers. The Healthy Ministry's General leads the intersectoral committee and includes representation from the Ministries of Finance, Agriculture, Interior, Trade, Labor and Industry and Communications, Health Maintenance Organizations (HMOs), and the Israeli Defense Force. Additionally, Israel's legislative agenda has focused on removing unhealthy food from schools and banning the marketing of unhealthy food in schools. Furthermore, the Ministry of Education and Health also trained teachers to turn schools into health-promoting schools. Health providers have also been rewarded for providing diabetes programs and guidance for overweight children and their parents (Kranzler Y., Davidoich N., Fleishman Y., et al., 2013).

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