Pediatrics as Health Prevention

Dr. Leslie Solomonian, ND

The holistic approach of naturopathic medicine prioritizes promoting optimal health, as opposed to simply managing or preventing disease. However, even with that lens, patient care can be myopic, failing to look further down the road than a few months or even years.

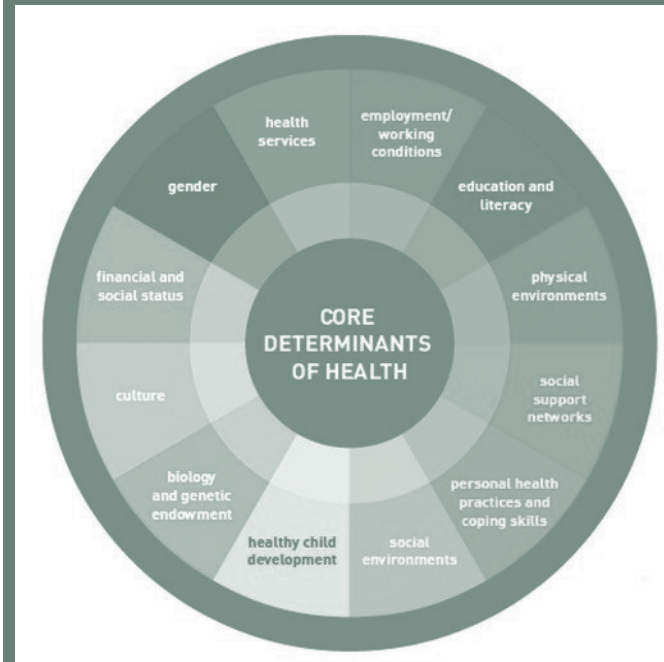
Pediatric practice is the epitome of long term health promotion and disease prevention. Beyond engaging in anticipatory guidance and surveillance regarding the most common causes of morbidity and mortality in childhood, naturopathic doctors have a tremendous opportunity to help families establish a strong foundation of anatomy, physiology and lifestyle behaviours that set children up for a lifetime of positive health,[1] which allows the next generation to self-actualize and contribute to a healthy society. It behooves clinicians and the public health system to optimize determinants of health early in life as a key strategy to reduce morbidity and early mortality in the entire population. This paper offers an overview of some of the most compelling links between childhood and adult health, and reminds readers of key lifestyle strategies key to optimal health from childhood onward.

Determinants of Health

In the past few generations, particularly in the developed world, pediatric medicine has undergone substantial shifts in priority and focus. Overall morbidity and mortality in childhood has been reduced, in large part due to discoveries and initiatives with respect to hygiene, nutrition, and medical innovation including antibiotics, and immunizations. The vast majority of infections in children are self-limiting, benign in nature, and easily addressed by a functional healthcare system. Conditions that in the past were considered terminal (e.g., polio, type 1 diabetes) are more effectively prevented and managed, extending lifespan and improving quality of life among children. However, there has been an increase in morbidity due to other conditions that are largely a consequence of non-communicable lifestyle and environmental factors (e.g., autism, ADHD, type 2 diabetes).[2,3,4,5] The rates of overweight and obesity among children are staggering;[6] stress-related conditions are increasing but often undiagnosed;[7,8,9] environmental toxin exposure continues to be an unauthorized experiment with extensive consequences.[10] Many children are overfed but undernourished.[11] Noise, light, and air pollution disproportionately affect immature neurological, endocrine, immunological, and metabolic systems.[12,13] Media and electronic devices, as well as parental misperceptions and hypervigilance about neighborhood safety can promote sedentary lifestyles and disengagement.[14,15,16] The emphasis in most North American communities has appropriately shifted from infection management and malnutrition to developmental screening, wellness promotion, and anticipatory guidance.[17] The heaviest burdens of adult disease are also predicted by epigenetically-mediated determinants, most of which have their roots in early life: developmental origins of health and disease.[18,19,20,21]

The World Health Organization, the Public Health Agency of Canada, and the Office of Disease Prevention and Health Promotion in the United States all emphasize the importance of determinants of health, all of which are interwoven with others, underscoring the importance of addressing health from a multifactorial perspective. The Public Health Agency of Canada's model identifies twelve core determinants, of which healthy childhood development is one (see figure 1).[22] The health and behaviors of parents even before a child is conceived have a huge impact on the health of children and the adults they become.

FIGURE 1: Core Determinants of Health



Source: Government of Canada[23]

Naturopathic doctors are well versed in the principles of prevention and education, key elements to effective promotion of health in the pediatric population, and are important allies with parents and caregivers. To promote optimal wellness, clinicians must be cognizant of the many determinants of health that impact the ability of a family to provide the best conditions for their child's growth and development. Given the tremendous potential to lifelong health when a healthy childhood is nurtured, working with children and families is the epitome of the principle of *praevenire*; prevention.

It is critical to note that not all of these determinants are fully within the control of individual families; the ability to engage in healthy lifestyle practices is affected by one's housing and neighborhood; family income; level of parents' education; access to nutritious foods; access to physical recreation; genetic makeup; and access to dental and medical care. Poverty and socioeconomic factors contribute to the social determinants of health, affecting nutrition, stress, toxic environmental exposure, access to the outdoors, and access to education.[24,25] Poverty increases the risk of adolescent substance use, earlier sexual debut, involvement in violence, and places a disproportionate burden on poor health.[26,27] Socioeconomic factors impact choice in healthcare, including the ability to access naturopathic services. Even families that make a living wage may struggle to prioritize out-of-pocket healthcare services such as necessary pharmaceutical medications (figure 2). Clinicians have a responsibility to seek means of universally increasing access and keeping costs manageable for families, in keeping with the principle of *Primum non nocere* and the spirit of the WHO's assertion that every human being has the fundamental right to "the highest attainable standard of health".[28]

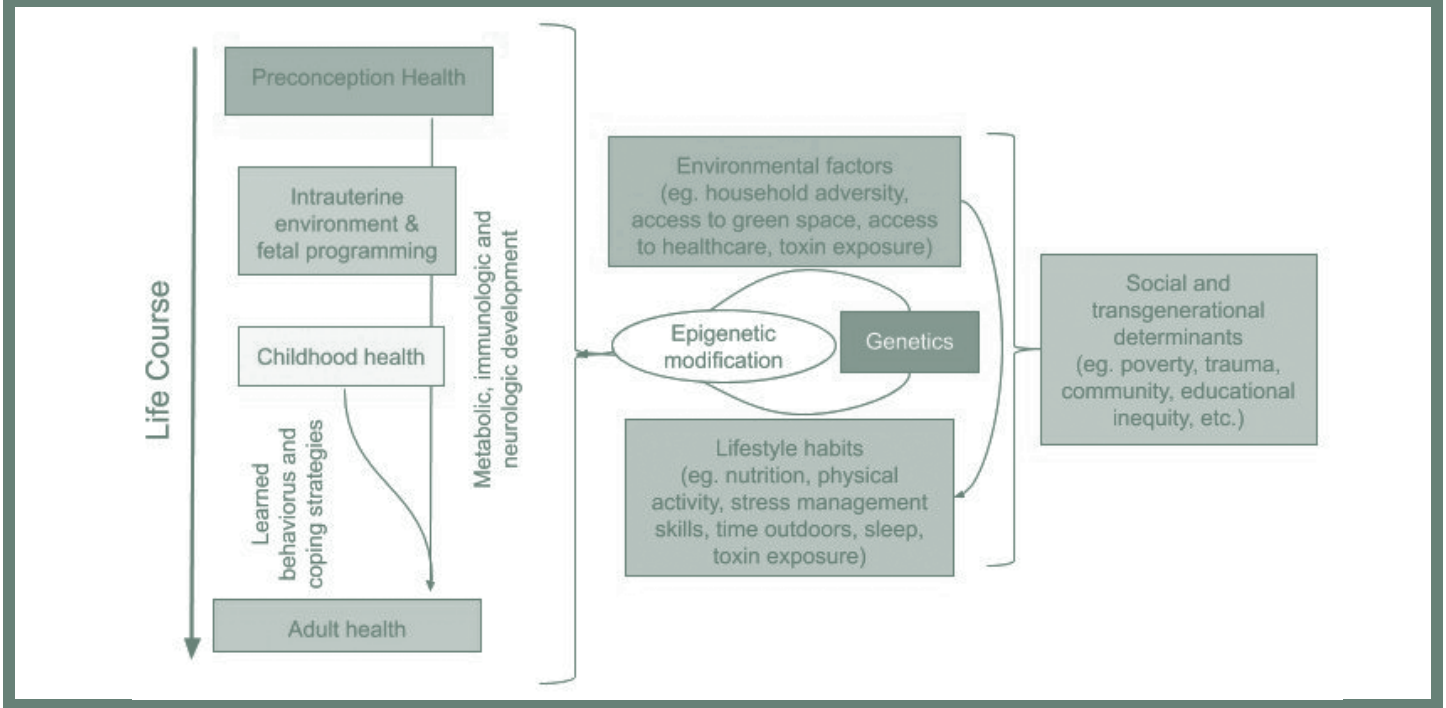
Selected Diseases of Adulthood and Evidence for their Origins in Childhood

Many diseases of adulthood are influenced by factors occurring during childhood, most by common pathways.[33] Not all are demonstrated through longitudinal studies or randomized control trials, both of which have significant issues of cost, feasibility and ethics. However, the totality of the evidence is highly compelling that promoting optimal conditions in childhood has broad-spanning benefits to adult morbidity and mortality via normalization of these pathways, with minimal adverse effects. Not only do environmental and lifestyle factors directly affect the developing anatomy and physiology of a growing body, but many behaviours are established in early life and tend to track into adulthood, affecting health outcomes across the life course (figure 2).[34,35]

Cardiometabolic Conditions

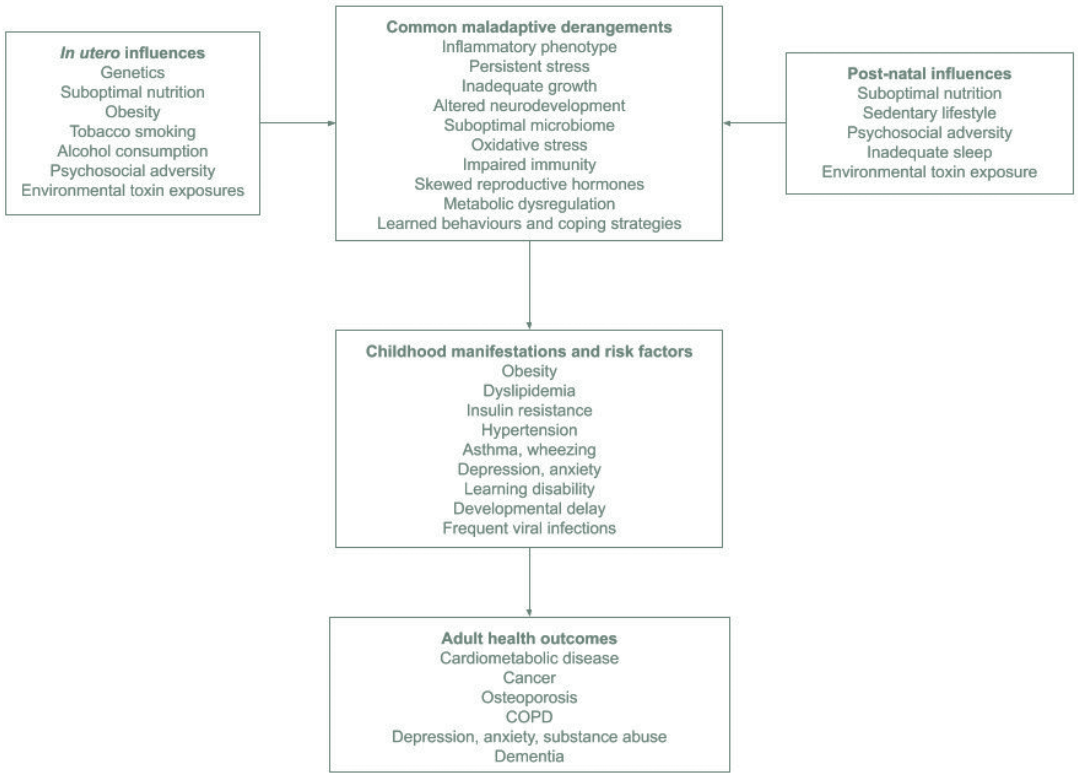
David J. Barker was the first to describe the developmental (originally "fetal") origins of adult disease with his observations of associations between birth weight and later cardiometabolic conditions.[36] Since then a great deal of exploration into epigenetic mechanisms has ensued (with 644 hits on a PubMed search for "Barker hypothesis"). It does appear very clear that lifestyle factors in early development is a strong predictor of the evolution of adult cardiometabolic conditions such as obesity, type II diabetes, and metabolic syndrome.[37,38,39] Childhood obesity seems to have received the greatest amount of attention in terms of demonstrated connections, as obesity tends to track into adulthood along with its cardiometabolic derangements.[40,41,42] These derangements (such as dyslipidemia, hypertension, dysbiosis, dysglycemia and a proinflammatory

FIGURE 2: An integrated model of the developmental origins of adult health and disease



Courtesy of the author; informed by references[29,30,31,32]

FIGURE 3: Common adverse childhood influences and mechanisms with significant effect on adult morbidity and mortality.



Courtesy of the author

phenotype) seem to be more harmful in younger individuals, and when they occur in childhood, increase the risk later in life.[43,44,45] The lifestyle predictors of obesity and poor cardiometabolic health in childhood are well-known (most notably physical activity, sleep, diet and smoke exposure), although these are notoriously difficult to modify.[46,47,48,49,50,51] The links between environmental toxicity and cardiovascular health are becoming more clear;[52,53,54] given the unique vulnerability of children to environmental toxicity, attention must be paid to these connections. Social and economic adversity in childhood also linearly associated with the risk of developing cardiometabolic disease in adulthood and should not be neglected as a key determinant, both because of elevated psychological stress, but also because of the greater risk of maladaptive health behaviours and environmental exposures.[55,56,57,58]

Chronic Respiratory Conditions

Not surprisingly, insults to respiratory and immune system development in early life predispose to chronic respiratory conditions, specifically chronic obstructive pulmonary disease (COPD), in later life.[59,60] Notably these include prematurity and low birth weight, exposure to tobacco *in utero* and as a child, environmental air pollution, and frequent viral infections. The development of asthma in childhood also predicts COPD;[61] asthma itself is predicted by poor pre- and postnatal nutrition,[62,63] lack of breastfeeding,[64,65] as well as low socioeconomic position. Childhood adversity is an independent predictor of adult COPD.[66] There is an association between obesity and asthma, as well as between obesity and COPD;[67,68] mechanisms and causation are uncertain, but links mediated via inflammatory pathways and the microbiome are plausible. Optimal diet appears to be protective against both asthma and COPD.[69,70,71]

Osteoporosis

Because bone mass peaks in the third decade of life, the emphasis on strong bones should be in the years of childhood, adolescence and young adulthood as opposed to in late life. The (American) National Osteoporosis Foundation recommends that bone strengthening activities be done at least three days a week. These are defined as "dynamic, moderate to high in load magnitude, short in load duration, odd or nonrepetitive in load direction, and applied quickly".[72] Rates of physical activity are abysmal for most children and adolescents due to a decline in active transportation, independent outdoor play, and increasing sedentary activity. Families should be encouraged to provide children with the space and opportunity to jump, climb, hop, run, bounce and skip; this tends to occur more readily among children who spend time outside, one excellent advantage of outdoor, unstructured play.[73] It is difficult for peak bone mass to be achieved in an environment of persistent inflammation or stress.[74] Dietary and psychosocial factors that elevate this environment may have a detrimental impact on the development of strong bones. Adequate nutrition is clearly essential, both key macro and micronutrients, including bioflavonoids that reduce inflammation and the need for calcium to act as a pH buffer in the bloodstream.[75]

Mental Health and Cognitive Function

Poor nutrition and early life adversity appear to be two of the strongest predictors of both childhood and adult mental illness.[76,77,78,79,80,81,8283,84,85,86] Nutrition and early life exposures have a tremendous influence on the health of the microbiota, which in turn has a bidirectional relationship with cognitive and mental health.[87,88] Physical activity, time in nature, and adequate sleep are also protective against mental illness, habits of which are established early in life.[89,90,91,92,93] Because mental health challenges tend to emerge during adolescence and young adulthood, and are chronically under identified, many go untreated and persist or deteriorate into adulthood.

Environmental exposures have been shown to increase the risk of neurodegenerative conditions such as Alzheimer disease.[94] Although the links are not all completely clear, lead and aluminum toxicity may be of particular concern.[95,96,97] Traumatic brain injury is also emerging as an important risk factor for neurodegeneration, including Alzheimer's, occurrences of which are common in childhood, particularly among some childhood athletes.[98] Although there is a dearth of studies that have longitudinally followed a cohort to look for an association between lifelong physical activity and the development of dementia, it does appear clear that physical activity in later life is protective against cognitive decline; again, habits of physical activity are established in early life.[99,100] Optimal body growth in childhood appears to be protective against dementia, likely as a proxy for optimal brain growth as a result of optimal nutrition and other conditions for health.[101,102] Optimal nutrition, including the Mediterranean diet, appears to be correlated with better cognitive function.[103] Greater educational and occupational attainment seem to reduce the risk of developing dementia.[104] Early life learning disabilities and delays can interfere with such attainment, and have also been associated with the development of dementia. Early identification of developmental and learning delays may prevent vulnerable students from being left behind, thus increasing their risk. Socioeconomic position is a potent predictor of cognitive development, and must be considered as an integral determinant of brain health and development.[105] In a very related way, early life adversity in general appears to increase the risk of developing dementia, likely through complex mechanisms.[106]

Cancer

A reduced risk of many types of cancer are associated with physical activity,[107,108] healthy diet,[109,110,111] and healthy body composition.[112,113] Through the establishment of healthy habits, the immunologic and metabolic phenotype established in early life, and epigenetic modification of the genome at vulnerable points in development[114] may contribute to this inverse association. Certainly there is ample evidence that exposure to environmental toxins increases the risk of various types of cancers,[115] some of which may have a long lead time after early life exposure.

Promoting Health and Preventing Disease

The encouraging news is that the most common noncommunicable chronic diseases in adulthood can be positively influenced by common lifestyle factors that can be fostered in childhood, notably physical activity.[116] sleep, diet, mitigation of psychosocial stress, reduction of environmental toxins, and time spent in a natural environment. By developing a therapeutic relationship with families, clinicians can identify vulnerabilities early on, and provide individualized education and preventative strategies. Regular well-child visits allow more thorough health promotion and sequential monitoring of healthy growth and development. However, every visit is an opportunity for surveillance, anticipatory guidance and health promotion.

Routinely inquiring about lifestyle and socio-environmental factors in a developmentally-appropriate way can help identify areas that may need support. It can be helpful to have families presenting for a well-check complete a standard "lifestyle log" for the week prior to the visit, including diet, sleep, physical activity, outdoor time and screen use.

Tools to assess for environmental exposures can reveal hazards that may affect development; resources can be found at **https://www.healthyenvironmentforkids.ca/content/resources-professionals**.

Having families complete an objective developmental screen for younger children helps clinicians to identify developmental vulnerabilities and provide early intervention (**https://firstwords.ca/nipissing-district-developmental-screening-tool/**). Most delays are preventable, and are greatly affected by social determinants of health.

Screening for depression, anxiety and substance misuse should be done routinely for all adolescents (**http://www.shared-care.ca/toolkits**); early identification intervention can reduce the risk of persistence and harmful outcomes of mental health struggles.

Addressing socioeconomic conditions can have widespread benefits for children's development.[117] By inquiring about a family's ability to make ends meet, to ensure food security and to provide a safe environment for growth, a naturopathic doctor has the capacity to help families address foundational factors for lifelong health.[118,119] Inquiring about adversity is critical, including screening caregivers for mental health problems, substance use, or conflict in the home.

Physical examinations and labs are used to monitor risk factors for chronic diseases, most notably cardiometabolic conditions such as hypertension and diabetes. Basic newborn screening can identify

Tools to screen for evidence of adversity and resilience factors in the home are available at **https://www.aap.org/en-us/advocacy-and-policy/aap-health-initiatives/resilience/Pages/Clinical-Assessment-Tools.aspx**.

conditions before they manifest, allowing early intervention to reduce the impact of genetic conditions such as sickle cell anemia or cystic fibrosis. Height/length, weight and blood pressure should be assessed at least annually after the age of one, with further investigations as indicated.[120,121] Assessing for iron status is worth considering (though not universally indicated) since iron-deficiency anemia is common in childhood and can have lifelong impacts.[122]

Healthy habits are fairly universal in their positive influence on optimizing lifelong health and wellbeing. (Please see Table 1 below for pediatric guidelines for the most common lifestyle factors affecting lifespan health.) Motivational interviewing strategies (and other collaborative approaches)[123] are helpful to support caregivers and older children in making behaviour changes, though require practitioner training to improve effectiveness.[124,125] Group visits can be useful to accessibly deliver comprehensive education; this approach can promote accountability, normalization, and empowerment.[126] Advocating for upstream changes is critical to affect change on the community/environmental level since not all determinants of health are within individual control;[127,128,129] please see the excellent commentary by Bem and Small for a primer on viewing pediatric health through an ecological lens.[130]

Conclusion

Habits, conditions and choices made in the early part of an individual's life have long lasting effects on health through the lifespan. A relatively small number of key determinants of health have a tremendous effect on the most significant causes of morbidity and mortality in Canada. Naturopathic doctors have the opportunity to substantially and positively impact the lifelong health of an individual by promoting optimal conditions through the pediatric years.

About the Author

Leslie Solomonian, ND uses naturopathic principles to help individuals, communities and the planet reach their full potential. Her work emphasizes the importance of social and ecological determinants of health, and she deeply values investing in pediatric health for the benefit of future generations. Leslie has been a faculty member at CCNM since 2005 and is pursuing a Masters of Public Health. She is also an active board member of the Pediatric Association of Naturopathic Physicians (PedANP), co-chair of Naturopathic Doctors for Environmental and Social Trust (NEST), author of the Textbook of Naturopathic and Integrative Pediatrics (CCNM Press)

Author reports no competing interests.

TABLE 1: Integrated guidelines for healthy lifestyle factors for children

PILLAR	GUIDELINES	ADDITIONAL RESOURCES
Nutrition	Plant based Fruit/vegetable rich Whole foods Mediterranean style	Castro-Quezada I, Román-Viñas B, Serra-Majem L. The Mediterranean diet and nutritional adequacy: a review. *Nutrients*. 2014;6(1):231–248.
Physical activity and sedentary time	0-5 year: At least 180 minutes of active play 5-17 years: 60 minutes per day of moderate to vigorous activity including 3 days/week of bone building activity	Solomonian L. Physical Activity in Children and Youth: Benefits, Barriers and Recommendations. *NDNR*. September 2014. http://csep.ca/CMFiles/Guidelines/CSEP_PAGuidelines_0-65plus_en.pdf
Sleep	4-12 months: 12 to 16 hours per 24 hours (including naps) 1-2 years: 11 to 14 hours per 24 hours (including naps) 3-5 years: 10 to 13 hours per 24 hours (including naps) 6-12 years: 9 to 12 hours per 24 hours Teenagers 13-18 years: 8 to 10 hours per 24 hours	https://aasm.org/resources/pdf/pediatricsleepdurationconsensus.pdf
Screen use	0-2 years: no screen use 2-5: less than one hour/day; "minimize, mitigate risks and be mindful" 5+: "manage screen use, encourage meaningful use, model healthy use, and monitor for signs of problematic use"	https://www.cps.ca/en/documents/position/screen-time-and-young-children https://www.cps.ca/en/documents/position/digital-media?utm_source=Media&utm_medium=News%20Release&utm_campaign=Digital%20Media
Time in nature	No clear guidelines; encourage at least 30 minutes of outdoor time daily	*Issues Ment Health Nurs*. 2014 Dec;35(12):975-8. Communing with nature. Flaskerud JH.
Reducing maladaptive stress	Screen for adversity and promote proactive stress management skills Advocate for families experiencing adversity	Meyer, C and Solomonian L. Pediatric Mental Health Update. *The Pulse.* Winter 2019. Bougea, A., Spantideas, N., & Chrousos, G. P. (2018). Stress management for headaches in children and adolescents: A review and practical recommendations for health promotion programs and well-being. *Journal of Child Health Care,* 22(1), 19–33.
Reducing toxic burden	Routine audits of household habits and practices to seek opportunities to reduce exposure to chemicals; encouraging lifestyle practices to promote detoxification	Children's Vulnerability to Environmental Toxins and Strategies to Minimize Exposure. *Vital Link*. Spring 2013.

References:

1. Seligman M. Positive Health. *Applied Psychology*. 2008;57(s1):3-18. doi:10.1111/j.1464-0597.2008.00351.x
2. Deavenport-saman A, Lu Y, Smith K, Yin L. Do Children with Autism Overutilize the Emergency Department? Examining Visit Urgency and Subsequent Hospital Admissions. *Matern Child Health J*. 2016;20(2):306-14.
3. Canada P. Autism Spectrum Disorder among Children and Youth in Canada 2018 - Canada.ca. https://www.canada.ca/en/public-health/services/publications/diseases-conditions/autism-spectrum-disorder-children-youth-canada-2018.html. Published 2018. Accessed May 26, 2020.
4. Brault MC, Lacourse É. Prevalence of prescribed attention-deficit hyperactivity disorder medications and diagnosis among Canadian preschoolers and school-age children: 1994-2007. *Can J Psychiatry*. 2012;57(2):93-101.
5. Panagiotopoulos C, Riddell MC, Sellers EA. Type 2 diabetes in children and adolescents. *Can J Diabetes*. 2013;37 Suppl 1:S163-7.
6. Childhood obesity. http://healthycanadians.gc.ca/healthy-living-vie-saine/obesity-obesite/risks-risques-eng.php. Accessed May 26,2020.
7. McRae L, O'Donnell S, Loukine L, Rancourt N, Pelletier C. Report summary - Mood and Anxiety Disorders in Canada, 2016. *Health Promotion and Chronic Disease Prevention in Canada : Research, Policy and Practice*. 2016;36(12):314-315.
8. Wiegner L, Hange D, Björkelund C, Ahlborg G. Prevalence of perceived stress and associations to symptoms of exhaustion, depression and anxiety in a working age population seeking primary care - an observational study. *BMC Family Practice*. 2015;16:38. doi:10.1186/s12875-015-0252-7.
9. Vermani M, Marcus M, Katzman MA. Rates of Detection of Mood and Anxiety Disorders in Primary Care: A Descriptive, Cross-Sectional Study. *The Primary Care Companion to CNS Disorders*. 2011;13(2):PCC.10m01013. doi:10.4088/PCC.10m01013.
10. Heindel J, Balbus J, Birnbaum L et al. Developmental Origins of Health and Disease: Integrating Environmental Influences. *Endocrinology*. 2015;156(10):3416-3421. doi:10.1210/en.2015-1394
11. Birch L, Savage JS, Ventura A. Influences on the Development of Children's Eating Behaviors: From Infancy to Adolescence. Canadian journal of dietetic practice and research: a publication of Dietitians of Canada = Revue canadienne de la pratique et de la recherche en dietetique : une publication des Dietetistes du Canada. 2007;68(1):s1-s56.
12. van Kamp I, Persson Waye K, Gidlof-Gunnarsson A. The effects of noise disturbed sleep in children on cognitive development and long term health. *Journal of Child and Adolescent Behavior*. 2015;3(1):1-8. doi:10.4172/2375-4494.1000179.
13. Ferguson KT, Cassells RC, MacAllister JW, Evans GW. The physical environment and child development: An international review. *International Journal of Psychology*. 2013;48(4):437–468. doi:10.1080/00207594.2013.804190.
14. Reid Chassiakos Y, Radesky J, Christakis D, Moreno M, Cross C. Children and Adolescents and Digital Media. *Pediatrics*. 2016;138(5):e20162593. doi:10.1542/peds.2016-2593
15. Vlaar J, Brussoni M, Janssen I, Mâsse L. Roaming the Neighbourhood: Influences of Independent Mobility Parenting Practices and Parental Perceived Environment on Children's Territorial Range. *Int J Environ Res Public Health*. 2019;16(17):3129. doi:10.3390/ijerph16173129
16. Riazi N, Blanchette S, Trudeau F, Larouche R, Tremblay M, Faulkner G. Correlates of Children's Independent Mobility in Canada: A Multi-Site Study. *Int J Environ Res Public Health*. 2019;16(16):2862. doi:10.3390/ijerph16162862
17. Schor EL. The future pediatrician: Promoting children's health and development. *The Journal of Pediatrics*. 2007;151(5):S11–S16. doi:10.1016/j.jpeds.2007.08.014.
18. Children are not little adults. Training modules and instructions for health care providers. World Health Organization. https://www.who.int/ceh/capacity/training_modules/en/. Published 2020. Accessed May 26, 2020.
19. Barker DJP. The developmental origins of chronic disease in later life. In: Nutritional Health. Springer Nature; 2012:59–83.
20. Johnson S, Riley A, Granger D, Riis J. The Science of Early Life Toxic Stress for Pediatric Practice and Advocacy. *Pediatrics*. 2013;131(2):319-327. doi:10.1542/peds.2012-0469
21. Halfon N, Verhoef PA, Kuo AA. Childhood antecedents to adult cardiovascular disease. *Pediatrics in Review*. 2012;33(2):51–61. doi:10.1542/pir.33-2-51.
22. Canada P. What Makes Canadians Healthy or Unhealthy? - Canada.ca. Phac-aspc.gc.ca. http://www.phac-aspc.gc.ca/ph-sp/determinants/determinants-eng.php#healthychild. Published 2020. Accessed May 26, 2020.
23. Canada P. What Makes Canadians Healthy or Unhealthy? - Canada.ca. Phac-aspc.gc.ca. http://www.phac-aspc.gc.ca/ph-sp/determinants/determinants-eng.php#healthychild. Published 2020. Accessed May 26, 2020.
24. Evans GW, Kim P. Childhood poverty and health: Cumulative risk exposure and stress Dysregulation. *Psychological Science*. 2007;18(11):953–957. doi:10.1111/j.1467-9280.2007.02008.x.
25. Evans GW, Kim P. Childhood poverty, chronic stress, self-regulation, and coping. *Child Development Perspectives*. 2013;7(1):43–48. doi:10.1111/cdep.12013.
26. Braveman P, Egerter S, Williams DR. The social determinants of health: Coming of age. *Annual Review of Public Health*. 2011;32(1):381–398. doi:10.1146/annurev-publhealth-031210-101218.
27. Human rights and health. Who.int. http://www.who.int/mediacentre/factsheets/fs323/en/. Published 2020. Accessed May 26, 2020.
28. Human rights and health. Who.int. http://www.who.int/mediacentre/factsheets/fs323/en/. Published 2020. Accessed May 26, 2020.
29. About the CDC-Kaiser ACE Study |Violence Prevention|Injury Center|CDC. Cdc.gov. https://www.cdc.gov/violenceprevention/childabuseandneglect/acestudy/about.html. Published 2020. Accessed May 26, 2020.
30. Dahlgren G, Whitehead M. Policies and strategies to promote social equity in health. Background document to WHO - Strategy paper for Europe. Ideas.repec.org. https://ideas.repec.org/p/hhs/ifswps/2007_014.html. Published 2020. Accessed May 26, 2020.
31. Forrest C, Halfon N. The Emerging Theoretical Framework of Life Course Health Development. In: Halfon N, Forrest C, Lerner R, Faustman E, ed. *Handbook Of Life Course Health Development*. Springer, Cham; 2018.
32. Power C, Kuh D, Morton S. From Developmental Origins of Adult Disease to Life Course Research on Adult Disease and Aging: Insights from Birth Cohort Studies. *Annu Rev Public Health*. 2013;34(1):7-28. doi:10.1146/annurev-publhealth-031912-114423
33. Hoffman DJ, Reynolds RM, Hardy DB. Developmental origins of health and disease: current knowledge and potential mechanisms. Nutr Rev. 2017;75(12):951- 970. doi:10.1093/nutrit/nux053
34. Kelder SH, Perry CL, Klepp KI, Lytle LL. Longitudinal tracking of adolescent smoking, physical activity, and food choice behaviors. *Am J Public Health*. 1994;84(7):1121–1126. doi:10.2105/ajph.84.7.1121
35. Rauner A, Jekauc D, Mess F, Schmidt S, Woll A. Tracking physical activity in different settings from late childhood to early adulthood in Germany: the MoMo longitudinal study [published correction appears in *BMC Public Health*. 2018 Feb 5;18(1):217]. BMC Public Health. 2015;15:391. Published 2015 Apr 17. doi:10.1186/s12889-015-1731-4
36. Edwards M. The Barker Hypothesis. In: *Handbook of Famine, Starvation, and Nutrient Deprivation*. Springer, Cham; 2017.
37. Huang R-C, Prescott SL, Godfrey KM, Davis EA. Assessment of cardiometabolic risk in children in population studies: underpinning developmental origins of health and disease mother–offspring cohort studies. *Journal of Nutritional Science*. 2015;4. doi:10.1017/jns.2014.69
38. Prabhakaran D, Anand S, Gaziano TA, Mbanya JC, Wu Y, Nugent R, eds. *Cardiovascular, Respiratory, and Related Disorders*. 3rd ed. Washington (DC): The International Bank for Reconstruction and Development / The World Bank; 2017.
39. Nadeau KJ, Maahs DM, Daniels SR, Eckel RH. Childhood obesity and cardiovascular disease: links and prevention strategies. *Nat Rev Cardiol*. 2011;8(9):513-525. Published 2011 Jun 14. doi:10.1038/nrcardio.2011.86
40. Nadeau KJ, Maahs DM, Daniels SR, Eckel RH. Childhood obesity and cardiovascular disease: links and prevention strategies. *Nat Rev Cardiol*. 2011;8(9):513-525. Published 2011 Jun 14. doi:10.1038/nrcardio.2011.86
41. Laitinen TT, Pahkala K, Venn A, et al. Childhood lifestyle and clinical determinants of adult ideal cardiovascular health: the Cardiovascular Risk in Young Finns Study, the Childhood Determinants of Adult Health Study, the Princeton Follow-Up Study. *Int J Cardiol*. 2013;169(2):126-132. doi:10.1016/j.ijcard.2013.08.090
42. Cote AT, Harris KC, Panagiotopoulos C, Sandor GG, Devlin AM. Childhood obesity and cardiovascular dysfunction. *J Am Coll Cardiol*. 2013;62(15):1309-1319. doi:10.1016/j.jacc.2013.07.042
43. Cote AT, Harris KC, Panagiotopoulos C, Sandor GG, Devlin AM. Childhood obesity and cardiovascular dysfunction. *J Am Coll Cardio*l. 2013;62(15):1309-1319. doi:10.1016/j.jacc.2013.07.042
44. Nadeau KJ, Maahs DM, Daniels SR, Eckel RH. Childhood obesity and cardiovascular disease: links and prevention strategies. *Nat Rev Cardiol*. 2011;8(9):513-525. Published 2011 Jun 14. doi:10.1038/nrcardio.2011.86
45. Nirmalkar K, Murugesan S, Pizano-Zárate ML, et al. Gut Microbiota and Endothelial Dysfunction Markers in Obese Mexican Children and Adolescents. *Nutrients*. 2018;10(12):2009. Published 2018 Dec 19. doi:10.3390/nu10122009
46. Perak AM, Benuck I. Preserving Optimal Cardiovascular Health in Children. *Pediatr Ann*. 2018;47(12):e479-e486. doi:10.3928/19382359-20181115-01
47. Van Buren DJ, Tibbs TL. Lifestyle interventions to reduce diabetes and cardiovascular disease risk among children. Curr Diab Rep. 2014;14(12):557. doi:10.1007/s11892-014-0557-2
48. Raghuveer G, White DA, Hayman LL, et al. Cardiovascular Consequences of Childhood Secondhand Tobacco Smoke Exposure: Prevailing Evidence, Burden, and Racial and Socioeconomic Disparities: A Scientific Statement From the American Heart Association [published correction appears in *Circulation*. 2016 Oct 18;134(16):e366]. Circulation. 2016;134(16):e336-e359. doi:10.1161/CIR.0000000000000443
49. Laitinen TT, Pahkala K, Venn A, et al. Childhood lifestyle and clinical determinants of adult ideal cardiovascular health: the Cardiovascular Risk in Young Finns Study, the Childhood Determinants of Adult Health Study, the Princeton Follow-Up Study. Int J Cardiol. 2013;169(2):126-132. doi:10.1016/j.ijcard.2013.08.090
50. Zhong H, Penders J, Shi Z, et al. Impact of early events and lifestyle on the gut microbiota and metabolic phenotypes in young school-age children. Microbiome. 2019;7(1):2. Published 2019 Jan 4. doi:10.1186/s40168-018-0608-z
51. Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents; National Heart, Lung, and Blood Institute. Expert panel on integrated guidelines for cardiovascular health and risk reduction in children and adolescents: summary report. Pediatrics. 2011;128 Suppl 5(Suppl 5):S213-S256. doi:10.1542/peds.2009-2107C
52. Münzel T. Up in the air: links between the environment and cardiovascular disease. Cardiovasc Res. 2019;115(13):e144-e146. doi:10.1093/cvr/cvz134
53. Bhatnagar A. Environmental cardiology: studying mechanistic links between pollution and heart disease. Circ Res. 2006;99(7):692-705. doi:10.1161/01.RES.0000243586.99701.cf
54. Cosselman KE, Navas-Acien A, Kaufman JD. Environmental factors in cardiovascular disease. Nat Rev Cardiol. 2015;12(11):627-642. doi:10.1038/nrcardio.2015.152
55. Friedman EM, Montez JK, Sheehan CM, Guenewald TL, Seeman TE. Childhood Adversities and Adult Cardiometabolic Health: Does the Quantity, Timing, and Type of Adversity Matter? *J Aging Health*. 2015;27(8):1311–1338. doi:10.1177/0898264315580122
56. Su S, Jimenez MP, Roberts CT, Loucks EB. The role of adverse childhood experiences in cardiovascular disease risk: a review with emphasis on plausible mechanisms. Curr Cardiol Rep. 2015;17(10):88. doi:10.1007/s11886-015-0645-1
57. Laitinen TT, Pahkala K, Venn A, et al. Childhood lifestyle and clinical determinants of adult ideal cardiovascular health: the Cardiovascular Risk in Young Finns Study, the Childhood Determinants of Adult Health Study, the Princeton Follow-Up Study. Int J Cardiol. 2013;169(2):126-132. doi:10.1016/j.ijcard.2013.08.090
58. Morelli V, Ziegler C, Fawibe O. Environmental Justice and Underserved Communities. Prim Care. 2017;44(1):155-170. doi:10.1016/j.pop.2016.09.016
59. Savran O, Ulrik CS. Early life insults as determinants of chronic obstructive pulmonary disease in adult life. *Int J Chron Obstruct Pulmon Dis*. 2018;13:683–693. Published 2018 Feb 26. doi:10.2147/COPD.S153555
60. Stocks J, Sonnappa S. Early life influences on the development of chronic obstructive pulmonary disease. *Ther Adv Respir Dis*. 2013;7(3):161–173. doi:10.1177/1753465813479428
61. Tai AS, Tran H, Roberts M, Clarke N, Wilson JW, Robertson CF. Pediatric Origins Of Adult Chronic Obstructive Pulmonary Disease(COPD): Childhood Asthma. *A95 Best Of Pediatrics 2010*. 2010. doi:10.1164/ajrccm-conference.2010.181.1_meetingabstracts.a2275
62. Lee-Sarwar K, Litonjua AA. As You Eat It: Effects of Prenatal Nutrition on Asthma. *J Allergy Clin Immunol Pract*. 2018;6(3):711–718. doi:10.1016/j.jaip.2018.01.026

63. Garcia-Larsen V, Giacco SRD, Moreira A, et al. Asthma and dietary intake: an overview of systematic reviews. *Allergy*. 2016;71(4):433-442. doi:10.1111/all.12800
64. Miliku K, Azad MB. Breastfeeding and the Developmental Origins of Asthma: Current Evidence, Possible Mechanisms, and Future Research Priorities. *Nutrient*s. 2018;10(8):995. Published 2018 Jul 30. doi:10.3390/nu10080995
65. Oddy WH. Breastfeeding, Childhood Asthma, and Allergic Disease. *Ann Nutr Metab*. 2017;70 Suppl 2:26-36. doi:10.1159/000457920
66. Svanes C, Sunyer J, Plana E, et al. Early life origins of chronic obstructive pulmonary disease. *Thorax*. 2010;65(1):14-20. doi:10.1136/thx.2008.112136
67. Hanson C, Rutten EP, Wouters EF, Rennard S. Influence of diet and obesity on COPD development and outcomes. *Int J Chron Obstruct Pulmon Dis*. 2014;9:723–733. Published 2014 Aug 5. doi:10.2147/COPD.S50111
68. Shore SA, Cho Y. Obesity and Asthma: Microbiome-Metabolome Interactions. *Am J Respir Cell Mol Biol*. 2016;54(5):609–617. doi:10.1165/rcmb.2016-0052PS
69. Tabak C, Smit HA, Heederik D, Ocke MC, Kromhout D. Diet and chronic obstructive pulmonary disease: independent beneficial effects of fruits, whole grains, and alcohol (the MORGEN study). *Clinical Experimental Allergy*. 2001;31(5):747-755. doi:10.1046/j.1365-2222.2001.01064.x
70. Scoditti E, Massaro M, Garbarino S, Toraldo DM. Role of Diet in Chronic Obstructive Pulmonary Disease Prevention and Treatment. *Nutrients*. 2019;11(6):1357. Published 2019 Jun 16. doi:10.3390/nu11061357
71. Lv N, Xiao L, Ma J. Dietary pattern and asthma: a systematic review and meta-analysis. *J Asthma Allergy*. 2014;7:105–121. Published 2014 Aug 12. doi:10.2147/JAA.S49960
72. Weaver CM, Gordon CM, Janz KF, et al. The National Osteoporosis Foundation's position statement on peak bone mass development and lifestyle factors: a systematic review and implementation recommendations. *Osteoporosis International*. 2016;27(4):1281-1386. doi:10.1007/s00198-015-3440-3
73. Herrington S, Brussoni M. Beyond Physical Activity: The Importance of Play and Nature-Based Play Spaces for Children's Health and Development. *Current Obesity Reports*. 2015;4(4):477-483. doi:10.1007/s13679-015-0179-2
74. Pietschmann P, Mechtcheriakova D, Meshcheryakova A, Föger-Samwald U, Ellinger I. Immunology of Osteoporosis: A Mini-Review. *Gerontology*. 2016;62(2):128–137. doi:10.1159/000431091
75. Movassagh EZ, Vatanparast H. Current Evidence on the Association of Dietary Patterns and Bone Health: A Scoping Review. *Adv Nutr*. 2017;8(1):1–16. Published 2017 Jan 17. doi:10.3945/an.116.013326
76. Merrick MT, Ports KA, Ford DC, Afifi TO, Gershoff ET, Grogan-Kaylor A. Unpacking the impact of adverse childhood experiences on adult mental health. *Child Abuse & Neglect*. 2017;69:10-19. doi:10.1016/j.chiabu.2017.03.016
77. Pechtel P, Pizzagalli DA. Effects of early life stress on cognitive and affective function: an integrated review of human literature. *Psychopharmacology (Berl)*. 2011;214(1):55–70. doi:10.1007/s00213-010-2009-2
78. Bea R H Van Den Bergh. Developmental programming of early brain and behaviour development and mental health: a conceptual framework. *Developmental Medicine & Child Neurology*. 2011;53:19-23. doi:10.1111/j.1469-8749.2011.04057.x
79. Cameron JL, Eagleson KL, Fox NA, Hensch TK, Levitt P. Social Origins of Developmental Risk for Mental and Physical Illness. J Neurosci. 2017;37(45):10783–10791. doi:10.1523/JNEUROSCI.1822-17.2017
80. Lim SY, Kim EJ, Kim A, Lee HJ, Choi HJ, Yang SJ. Nutritional Factors Affecting Mental Health. *Clin Nutr Res*. 2016;5(3):143–152. doi:10.7762/cnr.2016.5.3.143
81. O'Neil A, Quirk SE, Housden S, et al. Relationship between diet and mental health in children and adolescents: a systematic review. Am J Public Health. 2014;104(10):e31-42.
82. Pechtel P, Pizzagalli DA. Effects of early life stress on cognitive and affective function: an integrated review of human literature. *Psychopharmacology (Berl)*. 2011;214(1):55–70. doi:10.1007/s00213-010-2009-2
83. Bea R H Van Den Bergh. Developmental programming of early brain and behaviour development and mental health: a conceptual framework. *Developmental Medicine & Child Neurology*. 2011;53:19-23. doi:10.1111/j.1469-8749.2011.04057.x
84. Cameron JL, Eagleson KL, Fox NA, Hensch TK, Levitt P. Social Origins of Developmental Risk for Mental and Physical Illness. J Neurosci. 2017;37(45):10783–10791. doi:10.1523/JNEUROSCI.1822-17.2017
85. Lim SY, Kim EJ, Kim A, Lee HJ, Choi HJ, Yang SJ. Nutritional Factors Affecting Mental Health. *Clin Nutr Res*. 2016;5(3):143–152. doi:10.7762/cnr.2016.5.3.143
86. O'Neil A, Quirk SE, Housden S, et al. Relationship between diet and mental health in children and adolescents: a systematic review. Am J Public Health. 2014;104(10):e31-42.
87. Cenit MC, Sanz Y, Codoñer-Franch P. Influence of gut microbiota on neuropsychiatric disorders. *World J Gastroenterol*. 2017;23(30):5486–5498. doi:10.3748/wjg.v23.i30.5486
88. Goyal MS, Venkatesh S, Milbrandt J, Gordon JI, Raichle ME. Feeding the brain and nurturing the mind: Linking nutrition and the gut microbiota to brain development. *Proc Natl Acad Sci U S A*. 2015;112(46):14105–14112. doi:10.1073/pnas.1511465112
89. Hoare E, Milton K, Foster C, Allender S. The associations between sedentary behaviour and mental health among adolescents: a systematic review. Int J Behav Nutr Phys Act. 2016;13(1):108. Published 2016 Oct 8. doi:10.1186/s12966-016-0432-4
90. Lubans D, Richards J, Hillman C, et al. Physical Activity for Cognitive and Mental Health in Youth: A Systematic Review of Mechanisms. *Pediatrics*. 2016;138(3). doi:10.1542/peds.2016-1642
91. Ojio Y, Nishida A, Shimodera S, Togo F, Sasaki T. Sleep Duration Associated with the Lowest Risk of Depression/Anxiety in Adolescents. Sleep. 2016;39(8):1555-62. Published 2016 Aug 1. doi:10.5665/sleep.6020
92. McMakin DL, Alfano CA. Sleep and anxiety in late childhood and early adolescence. Curr Opin Psychiatry. 2015;28(6):483-9.
93. Piccininni C, Michaelson V, Janssen I, Pickett W.Outdoor play and nature connectedness as potential correlates of internalized mental health symptoms among Canadian adolescents. Prev Med. 2018 Jul;112:168-175. doi: 10.1016/j.ypmed.2018.04.020. Epub 2018 Apr 18.
94. Eiser AR. Why does Finland have the highest dementia mortality rate? Environmental factors may be generalizable. *Brain Research*. 2017;1671:14-17. doi:10.1016/j.brainres.2017.06.032
95. Reuben A. Childhood Lead Exposure and Adult Neurodegenerative Disease. *J Alzheimers Dis*. 2018;64(1):17–42. doi:10.3233/JAD-180267
96. Colomina MT, Peris-Sampedro F. Aluminum and Alzheimer's Disease. *Advances in Neurobiology Neurotoxicity of Metals*. 2017:183-197. doi:10.1007/978-3-319-60189-2_9
97. Klotz K, Weistenhöfer W, Neff F, Hartwig A, van Thriel C, Drexler H. The Health Effects of Aluminum Exposure. *Dtsch Arztebl Int*. 2017;114(39):653–659. doi:10.3238/arztebl.2017.0653
98. Perry DC, Sturm VE, Peterson MJ, et al. Association of traumatic brain injury with subsequent neurological and psychiatric disease: a meta-analysis. *J Neurosurg*. 2016;124(2):511–526. doi:10.3171/2015.2.JNS14503
99. Tan ZS, Spartano NL, Beiser AS, et al. Physical Activity, Brain Volume, and Dementia Risk: The Framingham Study. *J Gerontol A Biol Sci Med Sci*. 2017;72(6):789–795. doi:10.1093/gerona/glw130
100. Stephen R, Hongisto K, Solomon A, Lönnroos E. Physical Activity and Alzheimer's Disease: A Systematic Review. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*. March 2017. doi:10.1093/gerona/glw251
101. Huang TL, Carlson MC, Fitzpatrick AL, Kuller LH, Fried LP, Zandi PP. Knee height and arm span: A reflection of early life environment and risk of dementia. *Neurology*. 2008;70(Issue 19, Part 2):1818-1826. doi:10.1212/01.wnl.0000311444.20490.98
102. Goyal MS, Venkatesh S, Milbrandt J, Gordon JI, Raichle ME. Feeding the brain and nurturing the mind: Linking nutrition and the gut microbiota to brain development. *Proc Natl Acad Sci U S A*. 2015;112(46):14105–14112. doi:10.1073/pnas.1511465112
103. Petersson SD, Philippou E. Mediterranean Diet, Cognitive Function, and Dementia: A Systematic Review of the Evidence. *Adv Nutr*. 2016;7(5):889–904. Published 2016 Sep 15. doi:10.3945/an.116.012138
104. Meng X, D'Arcy C. Education and dementia in the context of the cognitive reserve hypothesis: a systematic review with meta-analyses and qualitative analyses. *PLoS One*. 2012;7(6):e38268. doi:10.1371/journal.pone.0038268
105. Everson-Rose SA. Early Life Conditions and Cognitive Functioning in Later Life. *American Journal of Epidemiology*. 2003;158(11):1083-1089. doi:10.1093/aje/kwg263
106. Pechtel P, Pizzagalli DA. Effects of early life stress on cognitive and affective function: an integrated review of human literature. *Psychopharmacology (Berl)*. 2011;214(1):55–70. doi:10.1007/s00213-010-2009-2
107. Brown JC, Winters-Stone K, Lee A, Schmitz KH. Cancer, physical activity, and exercise. *Compr Physiol*. 2012;2(4):2775–2809. doi:10.1002/cphy.c120005
108. Kyu HH, Bachman VF, Alexander LT, et al. Physical activity and risk of breast cancer, colon cancer, diabetes, ischemic heart disease, and ischemic stroke events: systematic review and dose-response meta-analysis for the Global Burden of Disease Study 2013. *BMJ*. 2016;354:i3857. Published 2016 Aug 9. doi:10.1136/bmj.i3857
109. Saha SK, Lee SB, Won J, et al. Correlation between Oxidative Stress, Nutrition, and Cancer Initiation. *Int J Mol Sci*. 2017;18(7):1544. Published 2017 Jul 17. doi:10.3390/ijms18071544
110. Schwingshackl L, Schwedhelm C, Galbete C, Hoffmann G. Adherence to Mediterranean Diet and Risk of Cancer: An Updated Systematic Review and Meta-Analysis. *Nutrients*. 2017;9(10):1063. Published 2017 Sep 26. doi:10.3390/nu9101063
111. Bishop KS, Ferguson LR. The interaction between epigenetics, nutrition and the development of cancer. *Nutrients*. 2015;7(2):922–947. Published 2015 Jan 30. doi:10.3390/nu7020922
112. Uzunlulu M, Telci Caklili O, Oguz A: Association between Metabolic Syndrome and Cancer. Ann Nutr Metab 2016;68:173-179. doi: 10.1159/000443
113. Esposito K, Chiodini P, Colao A, Lenzi A, Giugliano D. Metabolic syndrome and risk of cancer: a systematic review and meta-analysis. *Diabetes Care*. 2012;35(11):2402–2411. doi:10.2337/dc12-0336
114. Bishop KS, Ferguson LR. The interaction between epigenetics, nutrition and the development of cancer. *Nutrients*. 2015;7(2):922–947. Published 2015 Jan 30. doi:10.3390/nu7020922
115. Thompson PA, Khatami M, Baglole CJ, et al. Environmental immune disruptors, inflammation and cancer risk. *Carcinogenesis*. 2015;36 Suppl 1(Suppl 1):S232–S253. doi:10.1093/carcin/bgv038
116. Booth FW, Roberts CK, Laye MJ. Lack of Exercise Is a Major Cause of Chronic Diseases. *Comprehensive Physiology*. 2012. doi:10.1002/cphy.c110025
117. Cohen S, Janicki-Deverts D, Chen E, Matthews KA. Childhood socioeconomic status and adult health. *Annals of the New York Academy of Sciences*. 2010;1186(1):37-55. doi:10.1111/j.1749-6632.2009.05334.x
118. Morone J. An Integrative Review of Social Determinants of Health Assessment and Screening Tools Used in Pediatrics. J Pediatr Nurs. 2017;37:22-28. doi:10.1016/j.pedn.2017.08.022
119. Morelli V, Ziegler C, Fawibe O. Environmental Justice and Underserved Communities. *Prim Care*. 2017;44(1):155-170. doi:10.1016/j.pop.2016.09.016
120. Flynn JT, Kaelber DC, Baker-Smith CM, et al. Clinical Practice Guideline for Screening and Management of High Blood Pressure in Children and Adolescents [published correction appears in Pediatrics. 2017 Nov 30;:] [published correction appears in Pediatrics. 2018 Sep;142(3):]. *Pediatrics*. 2017;140(3):e20171904. doi:10.1542/peds.2017-1904
121. Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents; National Heart, Lung, and Blood Institute. Expert panel on integrated guidelines for cardiovascular health and risk reduction in children and adolescents: summary report. *Pediatrics*. 2011;128 Suppl 5(Suppl 5):S213-S256. doi:10.1542/peds.2009-2107C
122. Wang M. Iron Deficiency and Other Types of Anemia in Infants and Children. *Am Fam Physician*. 2016;93(4):270-278.
123. Tyler DO, Horner SD. Family-centered collaborative negotiation: a model for facilitating behavior change in primary care. *J Am Acad Nurse Pract*. 2008;20(4):194-203. doi:10.1111/j.1745-7599.2007.00298.x
124. Gayes LA, Steele RG. A meta-analysis of motivational interviewing interventions for pediatric health behavior change. *J Consult Clin Psychol*. 2014;82(3):521-535. doi:10.1037/a0035917
125. Christison AL, Daley BM, Asche CV, et al. Pairing motivational interviewing with a nutrition and physical activity assessment and counseling tool in pediatric clinical practice: a pilot study. *Child Obes*. 2014;10(5):432-441. doi:10.1089/chi.2014.0057
126. Smith JD, St George SM, Prado G. Family-Centered Positive Behavior Support Interventions in Early Childhood To Prevent Obesity. *Child Dev*. 2017;88(2):427-435. doi:10.1111/cdev.12738
127. Morelli V, Ziegler C, Fawibe O. Environmental Justice and Underserved Communities. *Prim Care*. 2017;44(1):155-170. doi:10.1016/j.pop.2016.09.016
128. Landrigan PJ, Rauh VA, Galvez MP. Environmental justice and the health of children. *Mt Sinai J Med*. 2010;77(2):178-187. doi:10.1002/msj.20173
129. Benfer EA. Health Justice: A Framework (and Call to Action) for the Elimination of Health Inequity and Social Injustice. *Am Univ Law Rev*. 2015;65(2):275-351.
130. Bem C, Small N. An ecological framework for improving child and adolescent health. *Arch Dis Child*. 2020;105(3):299-301. doi:10.1136/archdischild-2019-317518