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ORIGINAL ARTICLE

The Developmental Origins of Health and Disease and Sustainable Development Goals: mapping the way forward

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In this paper, meant to stimulate debate, we argue that there is considerable benefit in approaching together the implementation of two seemingly separate recent developments. First, on the global development agenda, we have the United Nations General Assembly's 2015 finalized list of 17 Sustainable Development Goals (SDGs). Several of the SDGs are related to health. Second, the field of Developmental Origins of Health and Disease (DOHaD) has garnered enough compelling evidence demonstrating that early exposures in life affect not only future health, but that the effects of that exposure can be transmitted across generations – necessitating that we begin to focus on prevention. We argue that implementing the SDGs and DOHaD together will be beneficial in several ways; and will require attending to multiple, complex and multidisciplinary approaches as we reach the point of translating science to policy to impact. Here, we begin by providing the context for our work and making the case for a mutually reinforcing, synergistic approach to implementing SDGs and DOHaD, particularly in Africa. To do this, we initiate discussion via an early mapping of some of the overlapping considerations between SDGs and DOHaD.

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Introduction

The linkage between health and development is demonstrated by the evidence that investing in health is beneficial to socio-economic development[1] and, conversely, that socio-economic development results in better health and human capital. The United Nations (UN) Sustainable Development Goals (SDGs) were announced in a document entitled: 'Transforming our world: the 2030 Agenda for Sustainable Development'. They incorporate 17 overarching global goals that supersede the Millennium Development Goals. They aim to comprehensively address four dimensions as part of a global vision for sustainable development: Inclusive Social Development, Environmental Sustainability, Inclusive Economic Development as well as Peace and Security.[2,3] The 17 goals and 169 targets represent a call to action in terms of developing people and the planet, thereby creating prosperity, fostering peace and creating a lasting partnership with international stakeholders.[2] (Table 1).

Many of the interlinked SDG goals relate, directly or indirectly, to human growth, survival and thriving, which are also the concerns of the DOHaD agenda. The DOHaD concept was originally developed from epidemiological studies of mortality across infant and adult groups.[4] The accumulating evidence from DOHaD studies convincingly shows how early-life exposures during conception, pregnancy, infancy and childhood can have a significant impact on health and disease risk in later life.[5]

The 2015, the Cape Town DOHaD Manifesto[5] summarized the major early-life exposures that might impact later health. These include environmental factors (e.g. maternal, fetal and infant malnutrition), external toxins (e.g. from cigarette smoke, alcohol), age of pregnancy (teenage or advanced maternal age) and psychological and physiological stress. Scientific evidence shows the impact that these stressors may have in terms of increasing the risk for both short- and long-term illness and mortality, from both infectious diseases and chronic non-communicable diseases such as cardiovascular disease, type II diabetes, certain cancers, chronic lung diseases and mental illness. In particular, non-communicable conditions are on the increase in Africa.[6]

Along with our colleagues who are interested in DOHaD-related work, we have recently begun a 4-year initiative at the Stellenbosch Institute for Advanced Study (STIAS) entitled *DOHaD and SDGs: Moving Towards Early Implementation in Africa*.[7,8] Part of the impetus for this work came from a DOHaD summit held in Cape Town in 2015, captured in the Cape Town DOHaD Manifesto.[5] Our collaborative thinking during several meetings at STIAS in South Africa during the spring of 2016 convinced us that we must approach implementation of SDGs and DOHaD simultaneously. We argue that future investments in both will more effectively lead to greater positive societal impact, as will the dialogue and the

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Table 1. *Sustainable Development Goals (SDGs)*[2]

Goal 1: End poverty in all its forms everywhere[a]
Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture[a]
Goal 3: Ensure healthy lives and promote well-being for all at all ages[a]
Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all[a]
Goal 5: Achieve gender equality and empower all women and girls[a]
Goal 6: Ensure availability and sustainable management of water and sanitation for all[a]
Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all
Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
Goal 10: Reduce inequality within and among countries[a]
Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable[a]
Goal 12: Ensure sustainable consumption and production patterns
Goal 13: Take urgent action to combat climate change and its impacts[a]
Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development
Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification and halt and reverse land degradation and halt biodiversity loss
Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
Goal 17: Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development

[a]United Nations SDGs directly relatable to Developmental Origins of Health and Disease.

advocacy efforts that will be needed to inform the public and compel governments to develop policies that link health to broader socio-economic development. We believe it will be easier to mobilize financial and human resources when SDGs and the DOHaD agenda are presented together. Further, it should be possible to jointly monitor and evaluate implementation. It has been argued by Chatora[9] that, for the health agenda, an SDG-linked approach can help by providing clarity of goals and targets by 2030; by providing a 'comprehensive and holistic approach' to the entire environment of, for example, a child; and by optimizing the linkages of the SDGs in dealing with structural issues.[9] It will also be easier to design interventions that serve both SDGs and DOHaD. In terms of SDGs there is strong potential for DOHAD to support countries in prioritizing areas of concern, including closure of the policy-implementation gap, setting interim targets to enhance political accountability, transforming interim targets into specific 3–5 year action plans, strengthening monitoring frameworks that reflect the interconnectedness of SDGs in an integrated manner and costing of action plans to inform national budgets.[9]

The examples illustrated in Table 2 reflect just a few of the many that link DOHaD and the SDGs. It displays how these developmental insights can be made to support each other. In applying these principles, the expected enhancement of human capital may lead to lasting positive change for people and the planet.

An example in which DOHaD evidence intersects with SDGs is the use of a community-based model for the delivery of Kangaroo Mother Care for improving child survival and brain development in low-birth-weight new-borns. The evidence in resource-poor settings is that this method reduces infant mortality and increases maternal–neonatal bonding.[14] This in turn increases human potential including in parameters such as performance at school and long-term employment income.[12]

Walker *et al.*[13] estimated that ~ 200 million children residing in developing countries fail to realize their inherent developmental potential. Further, a meta-analysis published in 2016 concluded that: 'Breastfeeding is potentially one of the top interventions for reducing under-5 mortality'.[21] Yet, much still needs to be done to encourage exclusive breast-feeding programmes, and to educate mothers of the benefits of breast milk for their infant.[21,22]

The SDG targets for 2030 are undoubtedly ambitious,[2] and it will take vision, political commitment and well-planned and well-articulated measures to address these challenges[8,9]; however, although the challenges are great, some optimism can be generated by adopting an SDG–DOHaD-linked strategy that lends itself to joint problem identification and problem solving. In this effort, advancing ideas that tackle root causes and result in high-impact positive changes will be essential.[4,8,9]

Examples of strategies to advance a joint SDG and DOHaD agenda

Joint action to advance the DOHaD message of health promotion and the challenge of meeting specific SDGs requires the engagement of multiple agencies and groups in society to address core issues of both DOHaD and the SDGs and assess where interests overlap. Similarly, parallel dialogue can explore strategies required to advance the agendas, and identify the processes for effective engagement of all contributing agencies – many of which may well not have worked together previously.

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Table 2. *Mapping the Sustainable Development Goals (SDGs) that directly relate to the Developmental Origins of Health and Disease (DOHaD) concept*

SDG[1]	Potential DOHaD interventions	Advantages	Examples
Eliminate poverty	Early reproductive education Early-childhood development Promote school attendance and health literacy	Child spacing, planned parenthood, mothers able to balance work Enhanced employment opportunities	Micro-clinics in Nairobi slums[10] mHealth information for migrants: a pilot project to increase health information accessibility for migrants in Vietnam[11]
Eliminate hunger	Promote Breast-feeding programmes Encourage nutritionally balanced complementary feeding Improve community environment for food growth	Access to highly nutritious and immune-supportive food for new-borns Decrease financial burden of bottle-feed cost on poor families Low-cost fresh produce from community	Saving Brain initiatives[12] Perinatal vitamin supplementation[13]
Good health	Maternal-child bonding Focus on first 1000 days of life Promote good antenatal care Teach young mothers and fathers about alcohol and smoking effects	Increased mental and physical capacity of the youth Decreased burden of disease due to poor antenatal, perinatal and postnatal care Limiting incidence of fetal alcohol syndrome/respiratory disease	A community-based model of delivery of Kangaroo Mother Care for improving child survival and brain development in low-birth-weight new-borns[14]
Quality education	Early access to mental stimulation and eye-contact (first 1000 days) Promote access to books and toys to increase brain development Inform and educate parents on pro-social behaviour	Improved mental capacity and social development Achievement of fine and gross motor development On-going supportive environment to learn life skills	Health Promoting Schools[15,16]
Gender equity	Reproductive Health Education Increased employment opportunities for women Supportive work environment for female employees Equal gender schooling access	More equitable society Improved gender relations Enhanced social cohesion	ZanaAfrica – safe, quality and affordable sanitary pads for women and girls in East Africa[17]
Clean water and sanitation	Encourage good-hygiene practices, hand-washing and appropriate waste disposal Increase recycling of waste	Decreased environmental toxins Prevention of spread of diarrhoeal disease Decrease child mortality	Peepoo: a biodegradable toilet turning human waste into valuable fertilizer[18]
Reduced inequalities and social protection	Assess and support disabled individuals Support policies which encourage reporting of social injustices Strict anti-abuse legislation	More actively involved community members Decreased burden of mental illness and psychological disorders	Mobile App for accurate and simple Disability Assessment and Support[19]
Make cities and human settlements inclusive, safe, resilient and sustainable	Increase access to basic services through micro-clinics Mental health support Microfinance structures	Sustainable economic growth Equal access to resources Equal participation and decision-making Gender equality	Working with microfinance clients to increase access to affordable and reliable healthcare[20]

Governments and their ministries

Governments often respond best when presented with compelling economic arguments. The costs and the benefits of prevention via DOHaD-informed early-life intervention *v.* the reality of spiralling costs of care for managing the same preventable diseases in later life is one such compelling argument. Such arguments can be strengthened further by referring to benefits of scale and reduction of duplication that can be obtained by combining the DOHaD and SDG agendas.

Ministries tend to work in silos in many situations, often asking for budgets without considering potential cost-savings achievable through the development of national level cross-cutting programmes. An example of such a national level cross-cutting programme could easily be based on the use of a joint SDG-DOHaD strategy. Doing this proactively would result in

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a bigger 'bang for the buck' for national ministries of planning, health and education. City and human settlement planning could then also draw upon joint SDG and DOHaD considerations so that cities may be safer and healthier (see Table 2).

Agencies and NGOs

Bilateral and multilateral aid and development partners, agencies and philanthropic foundations active in Africa all have roles to play in advancing the joint SDG/DOHaD agenda; however, DOHaD experts need to explain the issues and the benefits of a joint approach, whereas NGOs should consider rethinking their priorities. It is not easy to change the dominant paradigms of the kind of help these actors provide in poor resource settings. NGOs need to engage more and engage early with those they seek to benefit, and to learn to listen more.

In the end it will be evidence of the effectiveness of the joint DOHaD–SDG approach that will matter most in changing the minds of NGOs and other development partners; hence, this evidence must be sought early by DOHaD experts and it must be presented early. Another early-advocacy approach may be to point to 'Calls for Action' that make the argument for the DOHaD approach based on a number of different types of evidence.[8]

Academies of science and universities

An attempt should be made to include SDG/DOHaD concepts in the curricula of a broad range of disciplines so the leaders of tomorrow can have an opportunity to discuss the issues; however, there is still a need for more research, including on the most promising methods of communication and advocacy, especially in the African context. With this in mind, the STIAS[7,9] and the African Academy of Sciences are jointly helping to build a network of young research scholars to advance DOHaD science in Africa.

Scientists

Continued research is required, especially on DOHaD issues focussed on Africa. In doing this, it is important to appreciate the enormous variation in physical, economic and health realities among different African countries and the impact these may have on DOHaD–SDG research and implementation.

Some early-life exposures are still more prominent in Africa than elsewhere and may be on the rise; these will require more thorough investigation. For example, with extensive prevention of malaria during pregnancy, and drug interventions to reduce mother-to-child transmission of human immunodeficiency virus, the role of *in utero* exposure to antimalarial drugs and antiretroviral therapy require investigation of their effects in offspring at different stages of development.

Healthcare professionals and the media

The current healthcare focus on lifestyle change, particularly in adult life, to address known chronic non-communicable disease risk factors such as diet, physical activity, tobacco smoking and abuse of alcohol is relatively unsuccessful; on the whole, conditions such as type II diabetes, cardiovascular disease, chronic lung diseases and certain cancers are on the rise in many parts of the world. It makes more sense to also focus on early-life exposures that seem to programme people from an early age to suffer from these conditions later in life; however, many medical practitioners have not yet heard of the evidence supporting the DOHaD paradigm. There is work to be done here, for this constituency could play a crucial role in implementing and disseminating the message through contact with their patients, by acting as champions linking DOHaD to SDGs and through their interactions with the media; indeed, they might play a crucial role in educating the media that reports on science and health.

Educators

SDGs No. 1–6 directly address factors that contribute to health, disease and well-being in children (e.g. poverty, malnutrition, health, education, empowering women and girls, and water). Educators should be made aware of their potential to impact the lives of children by providing knowledge relevant to these SDGs and their relationship to DOHaD. An innovative approach to doing this in Africa could be to use the World Health Organization's Health Promoting School (HPS) model to effect change.[15,16] We have early evidence that the HPS's approach that we have used previously in other contexts can be used to engage youth in DOHaD-related issues.

Discussion

Of the 17 SDGs, at least eight (indicated with 'a' in Table 1) can be mapped directly to the DOHaD approach.

DOHaD mapping to the relevant SDGs (Table 2) demonstrates a potential unifying, reinforcing and synergistic approach to implementation. We would expect that employing this unified approach will have greater benefits than employing either approach alone.

We have recently argued for consideration of early DOHaD interventions in Africa.[7–9] Numerous strategies to improve population outcomes have been, and are currently being, studied. Table 2 presents a targeted mapping of the applicable SDGs to the DOHaD framework, with illustrative examples.

It is time to focus on early-childhood development in Africa, energized by DOHaD thinking and implemented with the SDG goals in mind. Barros and Ewerling[23] have urged policymakers, governance bodies and researchers to prioritize equitable early-childhood development. These researchers, and others, have highlighted the need to focus on implementation strategies of the SDGs to ensure that all children and adolescents have an equal opportunity 'to thrive and not simply survive'.[22,23] This has paved the way for the 'first 1000 days of life' focus, in which the period from conception to a child's second birthday is prioritized in terms of nutrition, social development and environmental exposures. It is now being realized that the window of opportunity can be extended beyond the 1000 days.

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Former Secretary-General of the UN, Ban Ki-moon implored policymakers[24] to consider that 'sustainable development is the pathway to the future we want for all. It offers a framework to generate economic growth, achieve social justice, exercise environmental stewardship and strengthen governance'.

DOHaD convincingly offers such a pathway, by providing the upstream answers necessary to achieve the UN SDGs. As we embark on energizing our approach to realizing the SDGs, DOHaD holds great potential in mapping the way forward.

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Authors' Contributors

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Conflicts of Interest

None.

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