**DOHaD in Science and Society: Emergent Opportunities and Novel Responsibilities**

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**ABSTRACT**

The field of Developmental Origins of Health and Disease (DOHaD) has grown considerably in the past decades and is receiving increasing recognition from health policy makers. Today, DOHaD research aims to offer a comprehensive perspective on health and disease that traces how different life experiences shape health and disease risks over the entire life course.This integrative perspective opens up distinct possibilities for improving health. At the same time, it raises questions regarding specific social responsibilities of DOHaD as a field, and about possible pathways to a socially just and scientifically robust implementation of DOHaD knowledge in society.In this article, we review the history and key characteristics of DOHaD as a field of scientific knowledge production. We argue that based on its key assumptions – i.e. that life circumstances, health and disease are closely linked on a molecular scale – DOHaD is an inherently political research field. When tracing how life environments affect health and disease, it is of the utmost social and political importance to specify how DOHaD understands and frames these life environments, which aspects of life worlds are included and which excluded, and how research results are interpreted and translated into health recommendations at individual, societal and policy levels. We suggest a number of ways by which the DOHaD community can constructively and responsibly meet the demands that these inherent characteristics place on knowledge production and dissemination in the field.

**Key words:** developmental origins of health and disease; responsible research; life course; social complexity; health massages; co-creation; social and political aspects

**Introduction**

Since its formal establishment in 2003 as the International DOHaD Society, the field of Developmental Origins of Health and Disease (DOHaD) has grown considerably – both in terms of the size of its research community as well as the scientific and social recognition it receives. Historically, DOHaD arose from a merging of epidemiological studies linking constrained fetal development, measured by the proxy of low birthweight, with cardiometabolic disease in the elderly, and basic animal research in developmental physiology.1 At its inception, DOHaD mainly focused on the importance of development – from the early embryo through infancy and childhood – for individual and population health and disease development. Today however, DOHaD research aims to offer a comprehensive perspective on health and disease that traces how different life experiences shape health and disease risks over the entire life course, ranging from the preconception period to advanced age. Research is undertaken in a variety of settings, linking variations in patterns of development to a wide range of non-communicable diseases (NCDs). As NCDs today account for about 72% of deaths globally,2 the life course approach fundamental to DOHaD is increasingly receiving attention by health policy makers globally.3,4

The integrative perspective on the development of health and disease across the life course is a particular strength of the DOHaD approach.5 It opens up distinct possibilities for improving health by recognizing and improving understandings of how different life environments shape trajectories of health and disease across the life course. At the same time, these innovative characteristics raise questions regarding specific social responsibilities of DOHaD as a field, and about possible pathways to a socially just and scientifically robust implementation of DOHaD knowledge in society, particularly as research from the field is receiving increasing recognition from health policy makers.

In this article, we review the history and key characteristics of DOHaD as a field of scientific knowledge production. We argue that based on its key assumptions – i.e. that life circumstances, health and disease are closely linked on a molecular scale – DOHaD is an inherently political research field. When tracing how life environments affect health and disease, it is of the utmost social and political importance to specify how DOHaD understands and frames these life environments, which aspects of life worlds are included and which excluded, and how research results are interpreted and translated into health recommendations at individual, societal and policy levels. We suggest a number of ways by which the DOHaD community can constructively and responsibly meet the demands that these inherent characteristics place on knowledge production and dissemination in the field.

**Origins**

The history of DOHaD as a research field reached a milestone with the work of David Barker on the fetal origins of disease. The early observations of Barker and colleagues concerned cohorts of individuals born in the UK in the first half of the 20th C, and linked low birthweight to death from cardiovascular disease, and to hypertension, type 2 diabetes and the metabolic syndrome in adult life.6 Barker realized that the geographical distribution of cardiovascular disease in the UK was more closely related to early childhood mortality than to the standard of living of individuals experienced as adults, and that individuals carried with them a risk of such disease characteristic of their birthplace even if they moved subsequently. These observations followed those of Forsdahl and others1 in showing that poor childhood conditions cast a long shadow in health terms across life, and focused attention firmly on the prenatal period of development. There followed a considerable amount of animal research, conducted on a range of species, which not only confirmed the principle that aspects of fetal life affected cardiometabolic function in adulthood, but elucidated some important underlying mechanisms, such as epigenetic processes.7,8

Around 2003 the field of fetal origins of adult disease morphed into DOHaD. There were two reasons for this transformation. The first was the recognition that the phenomenon clearly concerned not only fetal life, but development extending back into the early embryonic period and forward into infancy and early childhood.9 The second reason for the change to DOHaD was the realization that development affected the later life *health* of individuals, not just their risk of disease, because health and disease are not simply opposite sides of the same coin. This insight made it clear that DOHaD processes affect all members of the population, in many different ways, and that they are a part of fundamental human biology, not just of disease aetiology, which linked DOHaD to basic research in developmental biology.10

Understanding DOHaD as offering insights into fundamental processes of human biology also helped to clarify one common misunderstanding: it is often assumed that DOHaD proposes that NCDs actually *start* in utero and thus that the developmental shifts that are observed in response to environmental experiences and exposures constitute inherently pathological processes. Yet, it is more appropriate to understand DOHaD as proposing that certain developmental pathways can influence individual responses to later life health challenges in terms of susceptibility and resilience – not that they inevitably lead to disease. This perspective aligns DOHaD with research perspectives from fields such as life course epidemiology.11

Today, DOHaD seems to increasingly fit with the current ‘post-genomic’ Zeitgeist of biological thinking that is characterized by a growing recognition of the complexities involved in gene regulation and biological function.12 Yet, during the last few decades developmental perspectives on health and illness were often overshadowed by approaches from genetics and genomics that primarily focused on genetic variants and mutations as main heritable causes of disease development. However, when the sequencing of the human genome did not result in the leap in understanding NCD aetiology both researchers and patients had hoped for, perspectives that de-centered the gene and instead focused on deciphering the complex interactions between genes and their multiple environments within and outside the body gained attention and momentum.13,14 This shift might constitute the inversion of a trend that has profoundly characterized much of biomedicine in the second half of the 20th century: to locate the causes of health and illness mainly within individual bodies and their molecular composition. Conrad Waddington, the developmental biologist who coined the term ‘epigenetics’ in the 1940s,15 noted that even by the 1960s the invention of novel techniques in molecular biology had mostly directed research away from the study of gene-environment interactions towards the study of genes in isolation. For DOHaD this shift towards postgenomic perspectives on health and illness constitutes an important window of opportunity. At the same time, the longstanding mismatch between DOHaD and dominant perspectives in biomedicine means that DOHaD is today not yet institutionally well-established in terms of dedicated research centres or departments. This issue is complicated by the fact that DOHaD research often moves across a range of different academic disciplines, organ systems and medical specialties. Its institutionalization thus requires specific attention to and accommodation of this inherently interdisciplinary character of the field.

**Current Opportunities**

In recent years, the number of diseases that have been linked to developmental origins has expanded enormously. They now include a wide range of NCDs such as cardiovascular disease, diabetes, chronic lung disease and some forms of cancer;16 most ageing-related diseases, for example osteoporosis, sarcopenia and cognitive decline;17 and more recently a number of mental illnesses.18 This makes DOHaD an increasingly important field for public health policy. The growing recognition of DOHaD perspectives in health policy in the past years was heightened by an increased focus on NCDs within the international health policy community. In 2011, the General Assembly of the United Nations held its first high level political meeting on the Prevention and Control of NCDs.19 The discussion at this meeting was informed by the perception that, despite the achievement of the Human Genome Project, a substantial proportion of NCD risk at the population level was not attributable to fixed genetic factors. At the same time, lifestyle interventions to reduce incidence of NCDs in adults were also achieving disappointing results. Although only referred to specifically in one clause (No. 26) in the UN Political Declaration in 2011, the General Assembly addressed the importance of developmental factors for NCD risks for the first time in this meeting.

It was also acknowledged that NCDs are no longer primarily a burden for high income countries. In fact, 80% of deaths from NCDs occur in low to middle income countries, and the WHO predicts that the increasing burden of NCDs that is predicted for the future would fall disproportionately on such countries, potentially negating the economic and humanitarian benefits of communicable disease prevention.20 Consequently, global perspectives have become increasingly important in DOHaD research and studies investigate how specific local life contexts and histories affect health and disease risk. Interestingly, such studies receive most attention from governmental and non-governmental health policy actors who operate on a global scale, for example, as part of the Sustainable Development Goals (SDGs; especially Goals 2, 3 and 5), the UN Global Strategy for Women’s, Children’s and Adolescents’ Health (2015) and the WHO Nurturing Care Framework (launched May 2018). Yet, national and local health policy actors are often less involved with DOHaD research. There is to some extent also a growing interest in DOHaD knowledge by private sector actors, and by organisations which represent or aim to engage the sector more positively and responsibly (e.g. UN Global Compact; ILSI). Notably, clinical groups which formerly did not see the relevance of DOHaD to practice are now more engaged: for example, The International Federation of Gynecology and Obstetrics (FIGO) has established a committee to address NCD issues, with a focus on pregnancy and women’s health.

DOHaD thus appears to move increasingly into a position where insights from the field could influence clinical practice and public health policy to a certain extent. This is an important moment for the field that should encourage the community to pause and reflect on how to best address these novel opportunities. Markedly, this should include a reflection on the scope, scale and character of the interventions to improve health currently conceived and promoted by researchers in the DOHaD field. To date, and perhaps following the field’s history of research on the fetal origins of disease, interventions proposed by DOHaD often largely focus on behavioural aspects and lifestyle changes (in particular on parental behaviour).21 Suggestions for interventions on the level of social structure often remain sparse despite a growing recognition of the significant influence of the wider social and material environment on developmental processes, including factors such as environmental toxins or social stressors that can hardly be contained or managed by individual parents alone. Pharmacological interventions during pregnancy and infancy have been largely eschewed, and the concept that DOHaD processes operate in a graded manner across the entire population lends support for such caution. It is also clear that no single ‘golden bullet’ intervention is likely to be effective, even in those situations where the risk trajectory is high. Moreover, the question arises of whether interventions should be targeted at parents or their children, and when. Most comprehensive reviews of these questions, e.g. in relation to prevention of childhood obesity,22 have concluded that a multifaceted approach is necessary, starting before conception in both the men and women, and continuing through pregnancy, infancy and childhood and into adolescence and the reproductive years of the next generation. This makes evident that, while DOHaD has its roots in epidemiological studies and related basic scientific investigations of underlying mechanisms, it has today evolved into a research field that is increasingly involved with questions of public health policy-making, social responsibility and public outreach.

**Novel Responsibilities**

This emergent social and political role of DOHaD research raises the stakes for addressing questions of social responsibility in the field. In the remainder of this article, we will thus lay out three important perspectives that we consider crucial for the field in order to actively create pathways for implementing DOHaD knowledge in society and policy in socially just and scientifically robust ways.

***Maintaining the Complexity of the Social Determinants of Health and Illness***

What makes DOHaD unique is that it attends to how a range of environmental factors can affect health by inducing changes in the organism during particular periods of life. These factors include the availability of certain nutrients, toxic exposures, social stress or infectious disease agents. Yet, while research focuses on studying these factors at the level of their molecular and clinical effects, in the social world the distribution of potentially negative exposures and experiences is significantly shaped by patterns of social stratification and inequality. Access to high-quality foods, clean air, clean water or regular healthcare, for example, often depends on income, social status and location. This inherent connection between DOHaD and questions of social and environmental disparities and justice is a vital aspect of its political potential.

Considerations of the social determinants of health and illness were present in DOHaD from the outset. For example, Barker and Osmond argued in their comparative study of mortality patterns in three English towns that the differences they found were the result of living conditions during early life, in particular infant breast feeding, housing and overcrowding.23 Crucially, for example, Barker and Osmond discussed the differences in the duration of breast feeding not simply as a question of different maternal behaviour but in terms of how this behaviour was linked to social and economic factors: the economic need to work in mills caused women in one of the towns to wean their infants earlier than in the other places. Barker and Osmond’s early work thus already pointed to what is a crucial insight: while the developmental origins of adult health and disease can be mediated by parental behaviour, the available options for change are often shaped and limited by social and economic conditions.

In the subsequent decades, however, discussions of the social determinants of health and disease often played a minor role within DOHaD research.21 Complex social contexts disappeared behind more simplistic variables such as ‘duration of breastfeeding’ or ‘high-fat diet’. The environment of the developing organism often became reduced to the maternal body and maternal behaviours that were discussed in a socially decontextualized manner.24,25 This had at least two problematic consequences. On the one hand a focus on the mother without adequate discussion of social context increases historically entrenched sexist tendencies to “blame the mother,” i.e. to hold mothers disproportionately responsible for the health and well-being of their children. 26 Other potent actors, ranging from fathers to employers, food producers or policy-makers, fade out of sight. This leads, secondly, to a tendency to frame and discuss problems and potential solutions at the level of the individual rather than at more collective levels, such as the family, the community or the state.27 Yet, as DOHaD knowledge becomes more relevant for health policy-making, it is vital to bring the more complex social dimensions back in,28 to avoid over-simplistic attributions of responsibility.29, 30, 31 For example, appeals to mothers to adopt healthier diets for themselves and their children will inevitably fail if the mothers lack access to affordable healthy foods, are overworked due to unequal distribution of care duties between the genders, remain the target of predatory food marketing and cannot rely on public food infrastructures to support healthy eating (e.g. work place or school cafeterias).

Bringing such dimensions back into DOHaD research means considering them as important aspects of the social fabric that need to be considered at all stages of DOHaD research, from the design, through implementation and to interpretation of studies. This might require expanding the range of professionals who work together on DOHaD studies to include experts from different fields of the social sciences. This is equally relevant for research on human cohorts and studies in animal models as both require the translation of social worlds into aspects of the study design. By broadening its understanding of relevant determinants of health, DOHaD can provide knowledge that paints a more accurate picture of the multiple interactions between social life and biology that shape long-term chances of health and disease risks.

***Considering the Social Contexts of Health Messages***

Acknowledging that health behaviours are always tied to wider life circumstances also provides insights that are highly relevant for the communication of health messages by researchers and others engaged in DOHaD research. On the one hand, while health is unquestionably an important value and a basic human right, it is also important to acknowledge that it is only one social value among others. For example, the beneficial developmental effects of breastfeeding are well documented in DOHaD.31 However, a public health focus on promoting breastfeeding runs the danger of quickly coming into conflict with other social and political values – such as a focus on gender equality in society, a woman’s right to make her own decisions about her own body and equal work-force participation of women at all levels of employment. Researchers and others who engage in health messaging should consider these broader social contexts and scrutinize the effects their messages might have in a larger social context.

For this purpose, it can be rewarding to draw on research from other fields to better understand how people engage with and are affected by different types of health messages in the context of their specific life worlds. For example, social science research has shown that if health messages centre excessively on bodyweight as a proxy for health, they can easily contribute to the stigmatization of fatness, fat shaming, and the promotion of body image issues.32, 33, 34 This is especially the case if losing weight is depicted mainly as a question of personal choice and behaviour. Many people who are classified as overweight or obese have already undergone numerous, unsuccessful, attempts to lose weight, which is in line with recent scientific evidence against the long-term efficacy of diets.35 Yet, they are still often held responsible, blamed and shamed for being overweight as individuals, for example by relatives, friends, colleagues, and even by health professionals.34 The latter aspect is particularly problematic: it is a shared experience of many overweight and obese people that doctors tend to explain most of their health issues as a result of their excess weight, which can increase the risk of overlooking other underlying problems in obese patients.33 Health messages that frame differences in bodyweight primarily as the result of individual choices thus run against current scientific evidence and can aggravate the cultural stigma surrounding overweight and contribute to an increase in body anxiety and eating disorders among overweight individuals and wider society.32

Such issues surrounding body weight are one example of how health messages that focus predominantly on behaviour can easily complicate the lives of those they aim to assist.36A first step towards more context-sensitive health messaging should thus be to scrutinize the vocabulary used and remove potentially harmful simplifications (such as using body weight as a proxy for discussions about health). A second step should be to recontextualize health-messaging in terms of the structural factors that affect human health beyond individual choices, a process that requires detailed understanding of the life worlds of the respective publics that researchers aim to reach.

***Engaging Communities***

One way of achieving greater cultural and social sensitivity in the design of studies and the dissemination of results is to engage actively with the relevant public and communities that research seeks to address throughout the research process. The idiom of co-creation37 aims to introduce the idea that by considering study participants or stakeholders in the use of science and technology as partners in the knowledge creation process, research stands to benefit from the expert knowledge they hold about their specific life worlds. This requires rethinking the classical ‘expert’ model that is often prevalent in biomedicine, in which only researchers and health professionals hold knowledge that is relevant for addressing health risks and disease aetiology. This knowledge is then transmitted in a unidirectional manner to the public who are supposed to act on the information they receive. If they fail to act accordingly, this is often framed as irrational and irresponsible behaviour. Yet a rich corpus of studies about the public uptake of scientific information shows that the reasons why members of the public might not act on new scientific knowledge are much more complex and varied.38, 39 In many cases, the information provided fails to take into account relevant aspects of their lives and hence it remains largely non-actionable. This may concern economic limitations, competing social norms, values and life goals, or the lack of necessary infrastructures. Each of these factors might make it impossible or undesirable to put the information provided to good use. At the same time, a study design that is not based on a detailed understanding of the life worlds of the study participants might be unware of many contributing variables in the first place. For example, a study of premature epigenetic ageing among African American women, who were the sources of income for their families, showed that chronic financial stress is the most significant predictor of faster aging, and is much more significant than nutrition, smoking or exercise habits.40 Similarly, studies show a significant correlation between experiences of racism and pre-term labour that overrides, for example, socio-economic status.41

These are complex social factors that are important parts of the study participants’ worlds that are however often overlooked in study designs that do not sufficiently engage with these life worlds but primarily focus on variables that are already on the researchers’ radar. A co-creation approach works to involve these publics right at the outset of the study and to include study participants in designing and conducting studies. While co-creation approaches have been applied by a number of DOHaD studies already,42,43 this perspective could be highly relevant for the field on a larger scale as it can assist in maintaining complexity and context-sensitivity with regard to study parameters and health messaging.

Historically, involving affected communities has often improved research protocols and clinical applications significantly. An iconic example was the ACT UP movement in the 1980s, a collective of HIV patients and allies that influenced the course of HIV research in important ways by pressing for more patient-centred perspectives.44 DOHaD research finds itself in the peculiar position that its respective public could be considered to be the entire population, while at the same time some groups in society, who might be most at risk, might not consider themselves ‘affected’. Actively engaging different sections of the public is hence of utmost importance, as could be partnerships with social movements that e.g. work for the improvement of living conditions of underprivileged groups. Ultimately, DOHaD perspectives are inextricably entangled with questions of social justice. Finding ways to ally with such struggles on local and national levels could be an important way for DOHaD to create a positive social impact.

**Conclusions**

DOHaD research can provide powerful insights into how life exposures and experiences can affect health and illness across the life course and across generations. In this article, we have argued that the distinct perspective on health and illness that DOHaD proposes lends an inherently political character to the field: as its insights become increasingly important for health policy-making and clinical practices, it is crucially important to consider how the field frames the social and environmental factors that relate to health outcomes and how it communicates its findings to the wide range of stakeholders implicated. We have argued for the importance of maintaining complexity when studying social determinants of health and illness and of seeking out interdisciplinary collaboration to succeed in this endeavour. We have outlined the importance of considering social context when constructing health messages in order to avoid negative effects in terms of aggravating social stigma or discrimination, e.g. against women or people with excess weight. We discussed the importance of co-creation of research in order to involve relevant sections of the public in the design and conduct of research and the interpretation of results as a possible pathway to maintaining the necessary complexity and context-sensitivity when engaging in DOHaD research or communicating its results and implications.

We are aware that in many countries worldwide, health policy-making, just like policy-making in general, shows tendencies towards delegating the responsibility for health and illness to the individual, framed as a consumer-patient who is required to make ‘healthy choices’ based on the health messages transmitted.34, 36 However, many studies have shown that this framing is flawed and that much more attention needs to be paid to structural factors that crucially influence health behaviour beyond individual choice28 and that often reflect social inequality. DOHaD as a field offers an opportunity to make visible how complex and stratified life worlds influence chances for health and risk of disease. At this important moment in time, when the challenge of preventing NCDs is widely recognized and DOHaD research is receiving increasing attention in the policy field, we urge DOHaD researchers to resist the temptation to generate simplified causal narratives and individual-level solutions, but rather to work to make the complex social contexts of developing health and illness visible to policy-makers, health care professionals, patients and wider society.

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