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ORIGINAL ARTICLE

Foetal programming meets human capital: biological plasticity, development, and the limits to the economization of life

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Abstract

The disciplinary integration of biology and economy is taking new forms in the postgenomic era, transforming long-standing exchanges between human biology and economics. In this article, we first describe how an emerging area of research in development and health economics has embraced, stabilized, and expanded the emerging field of the Developmental Origins of Health and Disease (DOHaD). We map the global expansion of this literature particularly in the Global South. Via an analysis of shifting models of health in human capital, we argue that as economists draw on DOHaD theories, their increasing focus on marginalized groups in postcolonial settings produces a darker model of health deficit. Based on notions of accumulated shocks, this model questions the generalizable expansion of the economization of life and speaks to a wider and more sombre range of figures. Health models in economics reflect the double nature of biological and developmental plasticity caught between agency and passivity, change, and near-permanency.

Keywords DOHaD · Economization · Global South · Development economics · Human capital · Biological plasticity

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Introduction: Barker meets Becker at the World Bank

In 2018, then-World Bank President Jim Yong Kim spoke at the launch of an international program that sought to end famine. Most press reports at the time focused on the novel partnership between the World Bank and Red Cross with tech giants Microsoft, Google, and Amazon and the use of artificial intelligence to forecast drought and famine (States News Service 2018). Yet, at his speech to the UN General Assembly, Kim (2018) spoke about the long-term impacts of famines for children and future human capital:

> From a human capital standpoint, famines raise child mortality, increase stunting, and impair cognitive development for children *in utero* at the time of the famine and of the children who survive…. It's very likely that they won't ever catch up; they may in *fact be hardwired to fail* (our italics).

Kim further referenced the potential intergenerational impacts of famine, that they "cast a long shadow… creating a vicious cycle where economic losses span across generations".

Kim's allusions to stunting among children, the cognitive effects from famines endured while in utero, and the potential intergenerational impact of early-childhood deprivation reflect a growing body of research in public health and epidemiology held under the banner of the Developmental Origins of Health and Disease (DOHaD). While famine is among the most extreme examples, DOHaD research investigates the relation between environmental factors (nutrition being one, but also stress, violence, toxicity, among others) in pre-conception, pregnancy, and early childhood to later adult health outcomes, particularly non-communicable diseases (NCDs) such as cancers, cardiovascular diseases, and type 2 diabetes (Gluckman et al. 2016). The origins of DOHaD trace back to the work of British physician and epidemiologist David Barker (1938–2013) and colleagues at the University of Southampton, United Kingdom. By drawing on data from British public records, Barker and his group linked adult health outcomes—mostly in the forms of cardiovascular disease—to poor living conditions in utero and early childhood, as indexed by infant mortality (Barker and Osmond 1986). Other medical indices like low birth weight were viewed as markers of less-than-optimal health conditions in the prenatal environment, with significant implications later in life (Barker and Osmond 1986; Reyes and Manalich 2005). Systematized in his 1992 book *Fetal and Infant Origins of Adult Disease*, Barker's enthusiastic propagation gave a boost to what took the name of "Barker hypothesis", "foetal origins of adult disease" or "foetal programming" (Hales and Barker 1992; Fall et al. 1992; Barker 1995; Buklijas 2018, see also Lucas 1998). While not part of the original hypothesis, burgeoning developments in epigenetics after 2000s (Landecker and Panofsky 2013; Meloni and Testa 2014; Richardson 2015) offered a possible molecular mechanism to explain how pregnancy and post-natal environments affected health in adult life, with possible intergenerational effects (Roseboom et al. 2001). The growing emphasis on "critical windows" of human development reframes biology as differentially *plastic*, potentially sensitive to

changes in environments and experiences (Meloni 2019). Today, DOHaD covers a wide interdisciplinary area that includes epidemiologists, epigeneticists, public health specialists, and economists.

Since the founding meeting of the DOHaD Society in Mumbai, India in 2001, the field has gained traction in several Global South[1] countries facing a growing burden of NCDs that are attributed to the combined effects of maternal undernutrition and the adoption of a Westernized diet on metabolic disorders (Krishnaveni and Yajnik 2017; Solomon 2016; Pentecost 2018). Some of the growth in the field features research that exploits "shocks" as a form of natural experiment on a given population. This is an extension of early research that focused on examples like the Holocaust and Dutch Hunger Winter (see review of these studies in Lumey et al. 2011). Now, much scholarship looks to the Global South countries: the Biafran War (Akresh et al. 2017), rainfall shocks in Vietnam (Feeny et al. 2021), or the Rwandan Genocide (Bundervoet and Fransen 2018). Finally, the First Thousand Day campaign (indicating the period between a woman's pregnancy and her child's second birthday) has since 2008 received backing by international agencies such as the UN World Food Programme and UNICEF, private foundations such as the Gates Foundation, and a few governments (Cambodia, South Africa, India, Rwanda, in addition to the Netherlands, the US, and Ireland, among others), thus giving a further venue for policy application of DOHaD research (https://thousanddays.org/; Pentecost 2016; Pentecost and Ross 2019; Darling et al. 2020).

The increasingly Global South focus of DOHaD has paralleled and intersected with another avenue of growth: that of development and health economists linking foetal exposures to economic and human capital outcomes. As a physician and a medical anthropologist himself prior to becoming the World Bank president,[2] Kim's reference to the long-term effects of "critical windows" of human health for the economic futures of developing countries can be seen as the latest instantiation of a more than half century of ideas of human capital and health investment within the World Bank. Human capital refers to a micro-economic theory of "investments in man" (Sobel 1978) that is largely attributed to Chicago School economists Theodore Schultz (1902–1998) and, arguably more so, Gary Becker (1930–2014; Teixeira 2005, 2014; Flabbi and Gatti 2018). Becker, who in 1992 won the Nobel Prize for his work in human capital and rational-choice theory, described human capital in his Prize speech as a form of analysis that assumes individuals weigh the cost benefits

[1] The term "Global South" is an increasingly common shorthand in contemporary social sciences to include postcolonial areas outside the globally dominant regions of Europe and North America (Dados and Connell 2012). As with all shorthands, the term does not encompass the heterogeneities of the region, and we recognize the inconsistencies of its definition (Haug et al. 2021). In our citational analysis and for the purposes of coding, we used the definition of 'Global South' to refer to underdeveloped or economically disadvantaged countries as listed by the UN's Finance Center for South-South Cooperation (2015).

[2] As a medical anthropologist, Kim is most well-known for co-founding the international organization Partners in Health with fellow physician/anthropologist and Harvard colleague Paul Farmer (https://www.pih.org/jim-yong-kim).

of "education, training, medical care, and other additions to knowledge and health" (Becker 1993, p. 6), and that investments in self can have a profound effect not only for individuals and family, but on macro-economic conditions as well. In the last 50 years, the concept of human capital has gained widespread traction through mainstream economics, education policy, and, of course, institutions like the Bank. Since the 1970s the World Bank has paid increasing attention to issues of health and population control, leading to the 1993 "Investing in Health" World Development Report (Ruger 2005; Gaudilliere and Gasnier 2020; Kenny 2015). The Bank's changing emphasis on health for poverty alleviation is part of a shifting landscape of development economics, aid, and global health, marked by greater use of experimentation (Donovan 2018), micro-economic taxation policies to tackle global NCD epidemics (Reubi 2013, 2017), and new metrics and quantification to align with values of efficiency and evidence-based policy (Adams 2016; Reubi 2018; Walker 2019). Contemporary global health is shaped in complex ways by economic thinking, beyond simple narratives of structural adjustment policies or pro-market ideology (Reubi 2013). The framework of contemporary global health oscillates between global biosecurity, notions of mutual economic benefit, and "salvation" of saving lives (Lakoff 2010; Pentecost 2018).

It is in this context that a growing body of work among economists—a collection of health economists, micro-economists, and development economists—has taken seriously the lessons from the niche but increasingly significant field of DOHaD. The intersection of Barker with Becker leverages early life developmental plasticity for health and human capital gains, promulgating that investments during this sensitive period—often in the form of global health focus on maternal-child health and development interventions targeting pregnant women and very young children—can bring about greater economic returns in the future through improving later adult economic productivity.

Griffen (2023) recently examined the influential economist James Heckman's work in this arena and his advocacy toward investments in early-childhood programs in United States' policy. Besides the exclusive focus on US policy, Griffen reads the work of Heckman along two main axes: Developmental plasticity as a form of (nearly illimited) malleability through which it is possible to shape skill formation of the future workforce; and "economization of early life", that is expanding on Sunder Rajan ("capitalization of life" 2012) and Murphy ("economization of life" 2017), to how development interventions in early life are a key target "to unlock value at the more fundamental level of human biology" (2023, p. 10). Griffen's article captures important aspects of the marriage of developmental plasticity with microeconomics and emerges within a robust body of work on economization in contemporary life. In the last two decades, scholars have traced the process of assembling different areas of life into the purview of "the economic" what Çalışkan and Callon (2009) term "economization"; this has included the economization of education (Spring 2015), sexual desire (Dussauge 2015), and life itself (Murphy 2017). Laruffa (2022) situates economization as the key characteristic of neoliberalism itself. He articulates an expression of neoliberalism, one that is distinct from the era of Reagan, Thatcher, and structural adjustment policies, i.e. the retreat of social welfare and social spending. This distinct era—as 'social', 'feminist', or 'inclusive' neoliberalism, Laruffa

(2022, p. 13) suggests—operates on a different logic. It is a totalizing economization logic: "Social goals are promoted not only with a view to enhancing the legitimacy of neoliberalism and to remedying its dysfunctions but also because the 'social' itself is re-interpreted in economic terms" (ibid., p. 14). According to Laruffa, this is done through two ways, both of which apply to the DOHaD context. The uses social investment to bring new populations into the labour market through investments in human capital. The second garners returns through preventing the emergence of social problems, such as investments in maternal health to reduce adult NCDs.

Our analysis of the integration of developmental plasticity and development economics makes two interventions within the body of work on economization. In the first, while economization describes the hegemony of an "economic style of thought" (Hirschman and Berman 2014), our case also demonstrates that economics clearly absorbs a great deal from biology. Alongside economists expansion of DOHaD's findings from health-based outcomes to market-based outcomes, the field of DOHaD has in turn altered foundational economic models of health and human capital. This suggests more than a unidirectional flow of economization (see also Reubi 2013) and instead a much more complicated story of cross-pollination between the fields of economics and biology. Second, we suggest that any analysis in terms of 'economization' as presently theorized does not exhaust the full relationship between economic thinking, new modes or terrains of cultivating value, and slippage of plastic biology to damaged biology. A more granular assessment of the circulation of DOHaD findings in economics on a global scale shows how a "deficit accumulation" model (Dalgaard et al. 2021) is emerging that raises the question, in an economic logic, whether it is not just worthwhile but more importantly possible at all to harness value from everyone, every time, and everywhere. Especially when DOHaD findings are applied to marginalized populations in the Global South, with a historical legacy of differential valuations of life and tropes of damage and waste, plasticity as the infinite malleability of skills may turn into the "burden of plasticity" (Meloni 2018, 2019). This evidences an interesting conflict between the optimistic view of malleability in human capital (Becker 1964) and the more sombre understanding of inertial effects of early environment.

Therefore, this article is also in conversation with social science discussions on DOHaD, social epigenetics, and emerging postgenomic disciplines on whether the new biosocial sciences reify narratives of biological damage among certain marginalized populations, or can offer articulations of healing, health, community, and perhaps justice beyond a limited individualist and neoliberal cast (Warin et al. 2020, 2022; Meloni et al. 2022; Pitts-Taylor 2019; Gillies et al. 2016). We find our focus on economists significant given the increasing relevance that economics assumes as core mediator between medical science and policy initiatives (Fourcade et al. 2015; Griffen and Timmermans 2020; Hirschman and Berman 2014).

We proceed in three ways. First, we offer a brief contextualization of the co-production of DOHaD and economics and narrate the diffusion of biological theories of early life environments into development economics and policy. In so doing, as we shall argue, economics has done more than applying or legitimizing DOHaD but has also crucially expanded its role from claims about health to socioeconomic effects spanning childhood schooling and cognition, to adult economic productivity.

Secondly, through literature review and citational analysis among key papers in economics drawing on DOHaD, we evidence that much, if not the majority of, the growing research in this field is applied to populations living in the Global South. From there, we outline key models of health within human capital accounting, demonstrating the influence of biological findings on economic theories. The health models and the emphasis on marginalized populations leads to a receding figure of universal malleability and an emerging figure of deficit for which even small initial differences between individuals are irremediably amplified with the passing of time (Dalgaard et al. 2021). As we shall argue, this logic is not in contrast with contemporary research about biological plasticity. It simply exposes its second and often less visible face: the recognition that plasticity often overlaps with the apparently antithetic notion of robustness, which is the maintenance over time of biological traits regardless of environmental (or more broadly genetic) perturbation (Bateson and Gluckman 2011). This introduces figures of (dis)investment rendered as deficient, wasted potential, and irredeemable damage; these figures reflect the often overlooked sombre side to the economization of life.

On the convergence of DOHaD and microeconomics

While DOHaD scientists may have adopted an "economic style of thought" (Hirschman and Berman 2014), in this section we explore how economists have adopted a biological style of thought. In their embrace of DOHaD, they have contributed to stabilizing and expanding some of the field's core findings. In the first part of the section, we provide some historical context, for instance by exploring the rise of human capital theory from the Chicago School of Economics in the 1960s to the changing role of the World Bank in health funding. In the second, we situate why economists found DOHaD a compelling and useful theory. We suggest that DOHaD provided economists the epistemic heft of biological knowledge to contribute in key debates in health economics (for instance, the socio-economic and health "gradient"). DOHaD enabled development economists to leverage biological theories toward maximizing returns on health investments in early life. In doing so, economists expanded the range of outcomes that are linked to foetal and early life to include new areas such as educational achievements and labour market productivity.

Human capital theory, the World Bank, and investments in health and population

Gary Becker (1930–2014) has had incomparable influence in the economization of many areas of life previously viewed as beyond the market—marriage, family, parenting, fertility, health, and education. The Chicago School economist may have been one among many (along with Theodore Schultz and Jacob Mincer) that developed and inaugurated "human capital" as a theory from the late 1950s through the 1960s, but he is most closely associated with the term following the publication of his monograph *Human Capital* (1964; see Teixeira 2005). In sum, human capital theory reimagines education, on-the-job training, and health as "investments" in

human capacities that can bring later "returns" in the form of increased wages in the future, despite present-day deferrals to waged income (Becker 1975; Sweetland 1996; Teixeira 2005). This was in no doubt influenced, as Griffen and Panofsky (2021, p. 521) outline, by the US investment in the education of returning soldiers and the growing emphasis on the knowledge economy post-World War II. With the advent of human capital, a key shift in economic theory is a move away from the notion of the free labourer as established in classical economics, whereby the worker sold her labour time for wages (Feher 2009). In contrast, the notion of human capital collapses the labourer and her labour; it "re-imagines the laborer as capital…. whose value can be raised or lowered depending on the kinds of investments made therein" (Calkin 2018, p. 44). Some scholars see human capital as *the* form of subjectivity in contemporary neoliberalism, whereby all forms of activity are reframed as individualizing self-investments (Feher 2009; Brown 2016, 2017).

Human capital theory would make its way to the World Bank as the institution was undergoing major shifts in its development paradigm, in the late 1960s through the 1980s. Since its founding after World War II, the Bank's dominant framework for addressing its mandate of economic development and poverty alleviation was through post-conflict development, major infrastructure projects, and easing the globalization of trade and financial markets (Alacevich 2009a, b). During the McNamara presidency (1968–1981), the Bank expanded its view and underwent a major shift to meeting basic needs in health and nutrition, alongside educational investments for economic development (Teixeira 2017; Abbasi 1999; Ruger 2005). For instance, following human capital theories and the growing use of cost–benefit analysis (in contrast to manpower planning), by the 1970s the Bank began to adopt the perspective that education had a significant impact on economic development (Teixeira 2017; see also Reubi 2017 in global health). The interest in education paralleled a growing turn toward health investment. During this period, it was increasingly acknowledged that disease burdens, lack of access to healthcare, and malnourishment from extreme poverty were hindering development efforts (Ruger 2005). Today, the Bank is the world's largest health funder, outpacing the World Health Organization (Abbasi 1999).

Tellingly for our story, Ruger (2005) marks the start of the Bank's shift to health and social issues in its emphasis and increased lending for family planning programmes in the 1970s. Population and economics have been linked since the days of Malthus but had again been reinvigorated under post-World War II development logics (Murphy 2017). Institutions like the Bank pushed forward population polices through the framework of another of Gary Becker's theories; this was the quantity-quality tradeoff (Becker 1960; Becker and Lewis 1973), a belief that by reducing quantity of children among the poor, quality of those children would improve through shifts in parental investments and a greater resource pool in which to invest in the fewer children (Repo 2018). Contraception was initially the key technology to reducing fertility in developing countries (Pritchett 1994). But later interventions also leveraged education—particularly to young girls—toward the goal of reducing fertility (Bulatao 1984; Murphy 2017; Calkin 2018). As argued by historian and STS scholar Michelle Murphy, these population programmes wed together ideas of

reproduction, the suppressed fertility of certain (i.e. black and brown) women, and economic development.

Economists embrace, stabilize, and expand DOHaD

Even leaving aside the long and controversial marriage of economics and biology in the first decades of the twentieth century (see, for instance, Leonard 2005), economists are no stranger to biological theories to justify their interpretations of human behaviour. See for instance, contemporary work on neuroscience of economic decisions (Camerer et al. 2005) or the theories of Austrian-British Nobel Laureate (1974), political economist, and philosopher Friedrich Hayek, who drew on Darwinian natural selection (Spieker 2013). In this wider context, which we cannot cover in the limited space of this article, we suggest that for the specific economic area of development and health, David Barker's foetal origins theory came at an apt moment. For one, following the watershed moment of the 1993 *Investing in Health* report, the World Bank was increasingly focused on addressing the *burden* of disease, not just that which causes mortality, but disease that impacted the quality and productivity of life (Wahlberg and Rose 2015). From the Bank's perspective, a key concern was the emerging financial burden in developing economies facing the so-called epidemiological transition, where NCDs replaced infectious disease as the primary (and very costly) health burdens (Reubi 2013). With the influence of DOHaD, pregnancy and early childhood was situated as a key window for global health investment, thereby not only potentially improving health among mothers and young children, but having exponential affects toward ameliorating future ill health and its burdens (Pentecost 2018, p. 275). For economists, DOHaD was also useful to argue for increased returns on investment in programmes already in place—maternal health, population control, and early-childhood health and nutrition.

Several internal disciplinary discussions further laid the groundwork for the warm adoption of DOHaD among development economists. Persistent questions remained for sociologists and health economists: what some called "the health-wealth gradient", the association between those with better health markers and higher socio-economic status (Adler et al 1994). The foetal origins hypothesis[3] (so-called at the time) seemed a pertinent explanation (Otto 2007; Case et al 2005). Janet Currie was one such influential researcher to examine the role of health in labour market outcomes. Focusing also on *Head Start*, an early-childhood education program in the US, by the late 1990s and into the 2000s she began linking early-childhood development, foetal health, and adult labour market outcomes. But as Currie herself pointed out, the links between health and labour market outcomes had a bulky literature in development economics "because the link between health and work is more obvious in

[3] Much of the economics literature still uses the term "foetal programming" or "foetal origins", despite the medical and public health literature moving away from that term. We can surmise that this is largely because of the predominance of the subset of literature that, mimicking Barker's own work, correlates historical birth registry data with later health and human capital outcomes; as explained by Almond et al. (2018), pregnancy is a time-delineated period and thus it remains easier to use rather than the less distinct 'early childhood'.

societies in which many prime age adults are under-nourished and in poor health" (Currie and Madrian 1999, p. 3311). For many health economists in the late 2000s and early 2010s, Barker's theory provided a biological evidence base for the link between ill health, socio-economic status, and the persistence of poverty through generations.

This acceptance among economists is particularly salient if read against the background of scepticism that the Barker's hypothesis received early on among several epidemiologists and public health specialists, mostly due to its correlational nature (Paneth and Susser 1995; Rasmussen 2001). Even in the first economic uptake of foetal programming, mechanisms, correlational power between insults and effects, and interactions with confounders were still met with discussion (Adair and Prentice 2004) or considered "tentative" (Osmani and Sen 2003). This more "tentative" tone disappears with the first papers linking "shocks" in utero to human capital production: notably, Douglas Almond's (2006) study of the economic effects of the 1918 flu pandemic in the US. Almond, based at Columbia, calculated the wage differences from those exposed to the pandemic in utero in comparison with those before and after. "Shocks", such as Almond's use of the 1918 flu as a discrete and severe event, are a defining feature of this literature in its expansion of DOHaD findings. To offer a cursory overview, some works include: impact of rainfall shocks (Carillo 2020 [Colombia]; Feeny et al. 2021 [Vietnam]; Maccini and Yang 2009 [Indonesia]); historical famine (Almond et al. 2007 [China]; Dercon and Porter 2014 [Ethiopia]; and armed conflicts (Akresh et al. 2012 [Nigeria]; Leon 2012 [Peru]; Bundervoet and Fransen 2018 [Rwanda]); Ugaz and Zanolini 2011 [Philippines]; Sotomayor 2013 [Puerto Rico]). The wide range of studies listed here demonstrate the popularity not only of DOHaD as a working hypothesis in economics, but also the research model of using acute events as 'real-word experiments' to trace back to observational data.

It was Almond and Currie's (2011a) review paper "Killing Me Softly: The Fetal Origins Hypothesis", alongside the 2011 Distinguished Lecture Series by Currie at the American Economics Association (Currie 2011) that marked the popularity of the Barker hypothesis in economics. The embrace and stabilization of DOHaD within economist seems complete in a 2012 interview (Clement 2012), where Currie declared that:

> The links between early-life conditions and important markers of development and well-being throughout childhood, adulthood, and into old age *seem quite robust* (….) So economists *have taken that idea and run with it*. (….) I think there's pretty broad acceptance now of the idea that all kinds of things that happen when people are *in utero seem to have a long-term effect* (italics ours).

Alongside a *stabilization effect,* the circulation of DOHaD into development economics has expanded the foetal programming hypothesis. The Barker hypothesis had always very clearly remained within strictly medical parameters; outcomes focused on "coronary heart disease, type-2 diabetes, osteoporosis, asthma, lung disease and some forms of cancer" (Hanson et al. 2009). Even later expansions of the phenomenon are strictly within medical conditions, from diabetes, cancer, and osteoporosis (Calkins and Devaskar 2011) to relatively mild markers of aging like grip strength, skin thickness, and hearing impairment (Sayer et al. 1998). However, in its economic

uptake, the magnitude of effects has been expanded to cover not just measures of health, but *all measures of human capital* (since Currie and Hyson [1999]), including "labor market outcomes", IQ scores (Cook and Fletcher 2015), passing math and reading test scores at age 8 (Currie and Hyson 1999), years of school, illiteracy, and employment (Carillo 2020); likelihood of living in a wealthy neighbourhood (Currie and Moretti 2007), employability at age 33 (Prinz et al. 2018); years of schooling and socioeconomic success in adulthood (Adhvaryu et al. 2018). This body of research collectively draws together foetal experiences to later adult *economic output*. That is, insults during pregnancy could, via embedded effects in the foetal body, come to impact individual incomes and national economic production.

Perhaps most indicative of this successful stabilization and expansion between the two fields was the first Copenhagen Consensus conference. In 2004, Bjorn Lomborg, the Danish political scientist who was dubbed a future leader by the World Economic Forum, gathered some of the most esteemed economists (many Nobel Laureates) to assess 30 proposals to address the 10 most pressing world's problems—among them, climate change, education, global conflicts, communicable diseases, and malnourishment and hunger—down to rational cost–benefit analysis (Rehak 2005). In many ways, the logic of the Copenhagen Consensus—siphoning down issues of health, poverty, and environmental welfare to brutal measures of costs and the potential returns from their remediation—represented the quintessential example of the economization of global health (Reubi 2013), one among many areas of social and political life that are increasingly viewed as economic (Kenny 2015; Griffen and Timmermans 2020; Patchin 2021; Laruffa 2022).

In the paper on malnourishment and hunger, Jere Behrman (World Bank-affiliated economist at Penn), Harold Alderman (also World Bank-affiliated nutritionist and economist) and John Hoddinott (Professor of Food and Nutrition Economics and Policy at Cornell) acknowledge that addressing these problems are often framed on intrinsic and humanitarian grounds. They instead argue that "it is these potential gains in productivity and reductions in economic costs that provide the focus of our challenge paper" (Behrman et al. 2004). While laying out the breadth of the problem, the authors also focus on its long-term implications in the form of in utero and early-childhood exposure, "sensitive" periods where development is more receptive to influence and that during such periods, some shocks may be reversible *while others are not*" (2004, p. 4, italics ours). When the economic benefits of interventions are described, the authors frame "resource savings" (2004, pp. 6–7) in the form of reduced child deaths, reduced morbidity, and the savings from potential adult chronic disease; they find further returns on investment indirectly in the forms of increased worker productivity, schooling attendance, educational achievement, and better employment in the future (2004, pp. 8–10). Their argument proved convincing to the panellists evaluating proposals: Malnourishment and hunger was, after HIV/AIDS, listed as the problem that would offer the greatest economic returns for its amelioration (Rehak 2005).

Our narrative here has primarily focused on the wide uptake that DOHaD has enjoyed within economics, reflecting the dynamic cross-pollination between economics and biology. No doubt the story also takes a more traditionally economizing

trajectory, with DOHaD scholars similarly adopting the language of economic returns from maternal and early-life investments. Most notably, Victora et al's (2008) article in an agenda-setting series in the *The Lancet*, cites human capital as a framework for investments in maternal-child health programmes in developing countries. Victora et al (2008) reviews birth cohort studies from Brazil, Guatamala, South Africa, the Philipines, and India, and the series on maternal and child undernutrition is often credited with establishing the "first 1000 days" as a critical window for health intervention. Throughout the 2010s, the First 1000 Days became a rallying slogan for translating DOHaD findings into global health, international development, and national health policy, particularly in the Global South (Pentecost 2018).

The DOHaD-economics convergence is further creating a significant shift not only in the logics of intervention in maternal-child health, but radically shifting long-held models of health in human capital. However, we argue that the reshaping of economic models is emerging through research based in specific locations and histories. The economics literature adopting DOHaD is building a growing body of evidence from Global South populations and translating them into development interventions. Our final sections analyses these new models and explores their implications.

Accruing health capital in the Global South

Here, we argue that the growth of literature in the DOHaD-economics convergence, particularly at the policy level, is emerging from research and settings in the Global South. This is significant as it speaks to the enduring imaginaries of target populations in need of development and intervention (see also Lakoff 2010, 2015; Herrick and Reubi 2017). Further, it also has implications when placed in conversations with our findings related to shifting models of health in human capital, which is producing a deficit logic.

We selected four highly impactful and well-cited articles for our analysis, including three from David Barker et al. (Barker and Osmond 1986, 1990; Barker et al. 1995), as well as an article by Almond and Currie (2011a) that we mentioned above. To gather relevant references, we conducted a search on the Scopus database on 17 August 2022 to determine the citation count for each of the four articles. By utilizing Scopus Metrics, we identified the policy citations within the total number of citations. Subsequently, we selected the policy documents for screening and analysis, ensuring the removal of any duplicate policy citations. Each author categorized a portion of the policy references into three distinct categories: (1) Global South/developing context, (2) Global North/developed context, and (3) Other (a combination of North and South or global contexts). Figure 1 illustrates the process we used to quantify the number of policy citations for the four articles.

Our coding reflected and evidenced how these papers have enjoyed a widespread uptake in policy documents. Much of these policies have pertained to Global South contexts (see Fig. 1). Many citations come from the World Bank, the German-based Institute of Labor Economics, and the US-based National Bureau of Economic

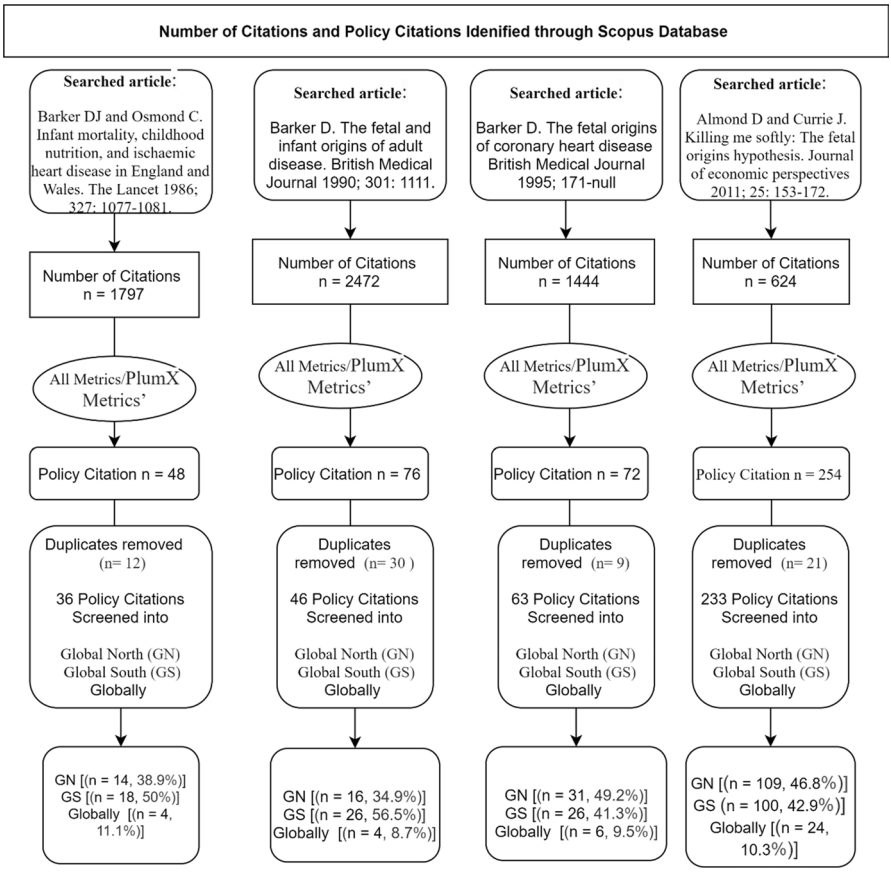

Fig. 1 Flowchart depicting the procedure for searching and selecting policy citations

Research. The Global South location of the policy documents was much greater among the earlier publications of Barker and colleagues. For instance, Barker and Osmond (1986) had 50% policy citations from the Global South and 39% from the Global North, while Barker (1990) had 56% from the Global South and 34% from the Global North. One limitation here is our geographic distinction of "Global South", as southern countries, and did not incorporate marginalized or poor communities within the geographic north. Thus, we potentially invisibilise the relative marginalization of such communities as refugees in Germany, food stamp recipients in the US, or the unemployed in England, populations that were subject of policy papers in our sample. Secondly, many of the studies from northern countries are historical (such as Bismarck's Germany and the 1981 Spanish military coupe), exploiting long histories of population health registries in more developed contexts, and which echo Almond's (2006) significant paper on the 1918 Spanish Flu.

Further analysis of these articles reveals that references from the Global South are increasing in recent years, as shown in Fig. 2 below. As an example, we considered

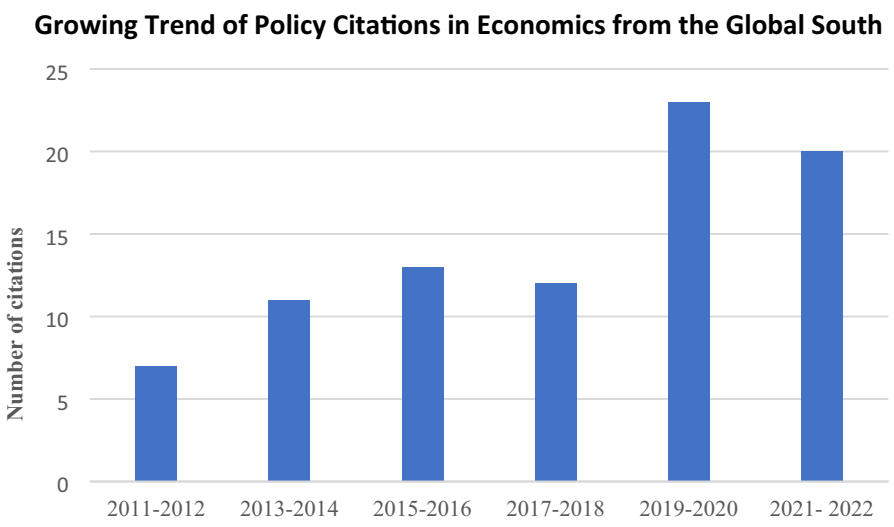

Fig. 2 Illustrates the policy citations of the Almond and Currie (2011a) paper in policy documents from the Global South, with a noticeable increasing trend in economics over time

the most recent paper among the four papers that were used for our analysis, which is the Almond and Currie (2011a) paper. This paper has 100 policy documents references from the Global South alone as shown in Fig. 1. Of these 86 policy documents revealed an increasing trend in economics referencing this Almond and Currie (2011a) paper.

While by no means overwhelming, we find it important to situate that this growing convergence of disciplines is finding traction in research on the Global South. Our point here is that at least half of the present policy documents and much of the recent growth of this field has been embraced by those working in or addressing so-called developing economies or low-income countries. Is there a difference to be made that this convergence is finding its greatest traction in spaces of economic development and international aid? And that policy is greatly focused on the Global South and developing contexts? We argue that it is indeed important to situate these economization processes within contexts, histories, and imaginaries. We note that the plasticity that is brought into analysis is less the malleability of skills and capabilities advocated by Becker and Heckman, and more the long-term effects of *scarring* that affect marginalized populations. As economics theorizing moves from abstract and disembodied adult, who might expand their skill capabilities through training, to embodied and situated vulnerable groups, this darker side of plasticity becomes more prominent. Without being exhaustive, it is palpable from these below examples (both taken from the policy literature on the Global South in Fig. 1, or the larger body of research citing these key texts) how during their epistemic voyage from the US to the Global South, Becker, Heckman, and the economization of life take a much more sombre aspect and tends toward a language of enduring damage or permanency.

For example, in their study on the Biafran war, Akresh et al. (2017) point out that "the available evidence suggests that human capital accumulation may be *more permanently scarred* following conflict, *particularly in developing countries*" (our emphasis). This characterization is commonly echoed: The developing world is experiencing a huge loss of human capital potential via debatably permanent effects from early life shocks, in part made worse through greater vulnerabilities from poverty, malfunctioning states and health services, and exposure to conflict and infectious disease. Can this be 'fixed'? Take for instance, a World Bank research paper on the effects of early life exposure to nitrogen pollution in waterways (Zaveri et al. 2019). In their analysis in India, Vietnam, and 33 African countries, researchers argue that "early-life exposure to nitrogen pollution has *enduring and irreversible* costs on human capital" (2019, p. 5 our emphasis). The authors use mapping of nitrogen-polluted waterways and population data to correlate early-life exposures to adult height, which they link as a proxy for adult economic productivity. They estimate that a loss of height of 2.81 cm results in a 7% loss of productivity (2009, p. 13).

In some contexts, the foreboding tone sets out, in the logic of global health more generally, that interventions can 'fix' this or at the least, mitigate losses. A quote here from Yale economist Orazio Attanasio is characteristic:

> The early years seem to be extremely important in the whole process, both because events during those years seem to have very long-run consequences and because very young children seem to be very malleable or, conversely, particularly vulnerable to negative environmental factors and different types of shocks. These considerations make the early years particularly salient for policy interventions. Not only might early years interventions be more effective in closing developmental gaps, but they could also make subsequent policies, aimed at, say, school-aged children, more effective (2015, p. 951).

Attanasio's article uses an intervention program in Colombia, whereby trained community members did home visits with caregivers and young children and provided an hour of developmentally appropriate play, to adapt models of human capital production in consideration of parental investment decisions.[4] In light of the programme's good results, Attanasio (2015, p. 981) asks, "Why parents were not investing 'enough' before the intervention?" and concluded that interventions can correct the views that "many poor parents do not think children need special inputs, and develop naturally, unless they are affected by severe shocks". In economics literature, this question emerges from the logics of the quantity-quality framework; that parents have differential investments in their children. Many economists examine how shocks intersect with parental investment patterns, asking whether parents attempt to ameliorate shocks or reinforce them (Almond and Mazumder 2013; Fan and Porter 2020).

[4] The question of human capital formation and investment when it comes to early life must contend that few, if any, early life decisions are made by the young person themselves. There is another story here regarding the way economists frame kin and kinship roles, the relationship of parents and child, and the larger social structure of responsibility for children.

The emphasis on the potential for global health interventions is also often coupled with more sombre or doomed analyses. In their discussion about claims to the positive effects of iodine supplementation in Tanzania, Araújo et al. (2021) also note that their paper is consistent with other findings that, "Inadequate supply of iodine during the in utero period can have *irreversible* consequences independently of subsequent supplementation" (2021, p. 6). They also ask, in the context of widespread unemployment in Tanzania, whether improvements to cognition will actually translate to improved human capital production, in the form of higher wages.

To be clear: tropes of scarring, being 'trapped' in poverty cycles or nearly irreversible effects do not appear in all papers, and are always used in a context where the overall message is that earlier intervention (financial, nutritional, among others) does work and is more cost effective than a later one. Nonetheless, it is palpable how, when moved to the Global South, developmental plasticity takes a much darker and enduring note that gets very close to ideas of permanency, from cradle to grave.[5] That is, when framed as a "window of opportunity", one is setting a temporal limit to plasticity and potential remediation; it invokes a threat that some may be irremediably damaged. While new figures of "investable life" (Murphy 2017) are made, others for which it may be too late to invest also take shape: Uninvestable or irremediable life. It is an narrative of 'lost' or 'wasted potential'. Moreover, this literature seems to sidestep the question of whether populations with greater negative shocks always react positively to investments, or at least *as positively* as their non-shocked counterparts. In one exception, researchers (Duque et al. 2018) examined the interactions between early life exposure to adverse weather in Colombia and a conditional cash transfer (CCT) program. Much of their paper is addressing the question of timing of interventions, finding that while those under age 6 were 12% more likely to remain in school, "those who received it later experienced a small and statistically insignificant increase" (2018, p. 5). The timing of interventions—adolescents or young children?—to provide the greatest returns on investment and thus represent an efficient use of resources remains a key debate in the literature. But in examining the interactions between adverse weather and CCT intervention, they found that the CCT program had a greater positive impact on non-shocked populations: "CCT has an additional return on children who started with a higher stock of skills due to no exposure". (2018, p. 26). That is, the returns were greater among the children already better off. This speaks to a greater assembly of figures than previously acknowledged in the economization literature. Not only emerging figures of "investable life" (Murphy 2017; Griffen 2023), but, what is much less discussed is the shadow figure of the uninvestable and neglected. A third figure is also here, one we elaborate on below, that can both provide a revenue stream (provides a rate of return greater than the initial investment) but that remains fundamentally 'scarred' from early life and which investment does not make up. Often understood in economics within a discussion on the "intergenerational cycle of poverty", it also speaks to the intergenerational reproduction of lives in need of investment, a logic of permanent deficit.

[5] This is not to claim that studies in the Global North from this literature are overlooking the long legacy on health and economic outcomes of sudden health shocks such as the 1918 pandemic, see Almond (2006) and Mazumder et al. (2009).

Models of health and human capital

It is our contention that by importing DOHaD and the foetal origins hypothesis in microeconomics, global health and development economists have found an epistemic ally that justify more and earlier investments and interventions. At the same time, the processes of economization that we trace here both produces new variations of investible life, and reifies global imaginaries of certain populations as needy, damaged, or wasted potential. This is reflected in the shifts in health modelling for human capital. Unlike early models that reflect depreciating impact of shocks over time, the marriage of developmental biology and microeconomics generates a specific model of temporality based on self-reproducing, latent, and delayed effects or "shock amplifications" (Dalgaard et al. 2021).

To appreciate this, it is important to understand the mainstream model of health capital alongside new and emerging models that have taken shape since the embrace of DOHaD. We suggest a brief tour through four models of health and human capital in economics.

Grossman's fade out model

Becker's formative theory of human capital framed a number of "activities" that "improve the physical and mental abilities of people" (Becker 1964, p. 9). While the majority of human capital investments were framed within education, Michael Grossman, a doctoral student of Becker's in the late 1960s (Grossman 2022), theorized the contribution of health as a component within human capital and set out a model of health as an economic factor. According to Grossman, health was "a durable capital stock that … consumers have incentives to invest in this stock in the present because it increases their earnings in the future" (Grossman 2022, p. 1808). Under the Grossman model, investments in health bolsters health stocks and determines the amount of time that the individual can spend labouring (i.e. reducing "non-productive time" or sick leave due to poor health) (Grossman 1972) or reduces savings through an outlay of health-related expenses (Smith 1999).

Using human capital as its base, Grossman (1972) assumed a stock of inherited health that slowly depreciated over time following a biological process of ageing. The model was monotonic: it always depreciated over time, never oscillating. "Investments" in health, such as medical care or nutrition (or "disinvestments" as the case with smoking), were accumulated to shape the rate of depreciation. Changes in behaviours may induce changes in investments or disinvestments, but never directly impact the health stock, and the impact of differential investments would also fade over time (Smith 1999). As such, the effect of any health endowment invested in early ages would be "gone by the mid-teen years", and economists would be hard-pressed to "detect any lingering effects of the shock after age 30" (Almond et al. 2014, p. 311). This was in contrast to later thinking in terms of delayed effects and the latent temporality of early events; Almond and colleagues summarize the Grossman's view:

> Health behaves like a physical stock and the impact of health shocks *fade away over time*. So, if health capital depreciates and is responsive to new health investments, then the effects of shocks to health capital tend to also depreciate over time, so that events further in the past will have less-important effects than more recent events (Almond et al. 2014, p. 310, italics in original).

While Grossman's model incorporates the idea that the value of the investment changes depending on when during the life cycle it is made (that is, investments in later life have less impact on health stock), it does not recognize the exponential value of early-life investments. As a result of the fade out paradigm, the Grossman model deferred attention from early effects and primarily focused instead on adult health investment decisions (Heckman 2007, p. 13250).

Heckman's "good start" and skill amplification

Commenting on the fade out model, yet with new research from Barker in hand, Smith (1999) asked, "How could short exposures matter if health is a stock?" In contrast to the prevalent attention to adult decisions in understanding the health-wealth relationship in adults, Smith suggested shifting focus to early childhood and even pregnancy. James Heckman and colleagues thereafter proposed an alternative model of health, later called "good start" by Almond and Currie (2011b, p. 159). Unlike Grossman's "fade out" model, Cunha and Heckman's (2007) model posited that capabilities (that is, cognitive abilities and health stocks) are not monotonic, but instead, "The capabilities produced at one stage augment the capabilities attained at later stages" (Heckman 2007, p 13252). This effect is termed ''self-productivity.'' It encompasses the ideas that capabilities are self-reinforcing and cross-fertilizing and that the effects of investment persist (Heckman 2007, p. 13252). For economists, the boon of such a model is that it can render interventions increasingly efficient (Almond et al. 2018) and targeted as it incorporates the timing of specific skill development. From Heckman's model, economists can then ask what intervention and at what time in the lifecourse would be most efficient to build certain skills, abilities, or health needs in order to have the greatest effect on human capital. It renders economic interventions timed with biological precision. Relatedly, it facilitates interventions across the lifespan as every age period has a corresponding developing ability, and therefor potential intervention.

Self-productivity, that each stage of development is reinforced by the previous and effects later stages, is one of several significant differences between the two health models. The second is the incorporation of "capabilities". This relates to Heckman's longstanding interest in non-cognitive skills (in contrast with cognitive skills as measured by IQ) that build human capital (Heckman 1999). The effect of this is to bring various "abilities"—examples are "perseverance, motivation, time preference, risk aversion, self-esteem, self-control, preference for leisure" (Heckman 2007, p. 13250)—within the scope for effecting wages and economic output. The third difference is what Heckman refers to as "dynamic complementarities", investments in these different periods bolster and are further supported by subsequent

investments. The effect of this is that "early investment should be followed up by later investment in order for the early investment to be productive" (p. 13253), creating the impetus for interventions across the lifecycle. These two differences reflect the scale and scope of the economizing dynamic within this field. Heckman's model brings not only health under the purview of the economic, but instead meets the full aspirations of human capital, as described by Feher: "More radically put, my human capital is me, as a set of skills and capabilities that is modified by all that affects me and all that I effect" (2009, p. 26). From personality, to psychology, to lifestyle, and preference for leisure activities: these may all become effectible elements for economic outcomes. Heckman's model incorporates the impressionability and relative plasticity of early life, as it simultaneously segments the entirety of lifespan into different skills formations, thereafter differing ripe moments for the most efficient interventions.

Failing to meet potential—the World Bank's Human Capital Index

Our third model reflects both the success story of human capital theory within the World Bank and the still growing success of DOHaD in health and human capital modelling. It also reflects how models of human capital and human potential can tip into sombre frames of damage and waste. In 2018 the World Bank launched its Human Capital Project, using the tagline #investinpeople and echoing the language of the "Investing in health" paradigm of the development bank's 1990s shift. The new project aims to develop a global "Human Capital Index" (HCI) to incentivize states to invest in human capital, particularly of children, where the gains would be greatest (World Bank Group 2018). The key project tool is the index itself, a new metric to measure the human capital of the next generation, defined as "the amount of human capital that a child born today can expect to achieve in view of the risks of poor health and poor education currently prevailing in the country where that child lives" (World Bank 2018, p. 3). In the methodology paper, three components of the index are explained: (1) Rates of survivorship (measured as under-5 mortality rates); (2) Education, measured as expected learning-adjusted years of school (which is adjusted based on the Bank's calculations of schooling quality); and (3) Health.

Aart Kraay, the economist heading the project to develop the HCI's methodology, based "health" as measured by rates of adult survival (from 15 to 60) and stunting rates. The latter is explained as "an indicator for the pre-natal, infant, and early-childhood health environment, summarizing the risks to good health that children born today are likely to experience in their early years—with important consequences for health and well-being in adulthood" (Kraay 2018, p. 3). Kraay set out that the HCI measured the *gaps* between the actual measures in a given country and an ideal standard of human capital. When it came to health, Kraay established that "full health" means 100% adult survival to 60 and no stunting. In the example of Morocco, Kraay explains that "a child born today will only be half as productive as she could have been relative to the benchmark of complete education and full health" (2018, p. 5). Here, the new HCI situates the developing world as unable to meet full potential, setting out an impetus for intervention (Taussig et al. 2013). This

practice of calculating human capital sets out benchmark comparison that reinforces and calculates *wasted* potential.

Health deficits in health capital—developmental plasticity and shock amplification

The most recent models not only incorporate DOHaD frameworks toward calculations of health and human capital, but take a step further to setting out a deficit logic. These models make explicit what is often a concealed question as certain forms of life become key figures of economization: what if some life is not fully remediable?

Dalgaard et al. (2021) discuss the applicability of a model of health ageing (Dalgaard and Strulik 2014) that allows for the amplification of initial shocks over the life time, again using foetal origins as a jumping off point. For this model, "health deficits accumulate exponentially over the life course…. Which means that small differences in initial conditions between individuals are amplified with the passing of time" (Dalgaard et al. 2021, p. 2). Their theory of health deficit accumulation originates from findings in gerontology (the frailty index and the reliability theory of ageing) and work on the relationship between human height, body size, the 'fertility transition', and economic development (Dalgaard and Strulik 2014, 2015, 2016). However, it is now expanded to account for accumulated health damage over the lifetime with roots in in utero or childhood shocks. In testing out its applicability, Dalgaard et al. theorize that an "initially unhealthier individuals accumulate health deficits faster" (2019, p. 7). They place a person with an in utero shock compared to a benchmark and reflect on the deviation over time: "the initial 25% deviation has reached 80% at the age of 30" (ibid.). Whereas the emphasis in Heckman (2007) is on the cost effective value of early life investment (that is, early life *should* have investments because they have greatest returns on investments), here the emphasis shifts toward a notion "persistent biological effect of the prenatal period" (Almond and Currie 2011a, p. 158, as quoted in Dalgaard et al. 2019, p. 5), which even in the best case of early investment may not be entirely remedied (Dalgaard et al. 2021). In the example of two individuals starting with a 10% difference in health (resulting from negative health shocks earlier in life or in utero), "the higher health expenditure is not powerful enough to equalize initial health differences. In fact, initial health differences get amplified over time: as individuals age, the vertical distance between the individuals' deficit trajectories becomes larger" (Dalgaard et al. 2021, p. 1279). Grossman himself considered this re-assessment of his model in a 50 year reflection on health capital, where he found the "lagged" effects models, such as those from Heckman (Cunha and Heckman 2007) and Dalgaard et al. (2021), to be "more realistic" (2022, p. 1811). He summarizes their objections as: "[In previous models], the deficit between those with relatively unfavorable endowments and those with more favorable endowments shrinks with age. Evidence from biology and gerontology supports the opposite: health deficits due to relatively low endowments rise with age" (Grossman 2022, p. 1810). Under the model proposed by Dalgaard et al. (2019, 2021), those initial deficits reduce the effectiveness and impact of health investments.

Here, the health deficit accumulation highlights the reproducing and lifelong effects of "shock amplifications" (Abeliansky and Strulik 2018, 2020). This renders the gaps, which are quantified by the models, as irremediable. Rather than a figure of investable life (or its corollary, neglected life), this is a third and more ambivalent figure that emerges in the current calculative practices of health capital: the shocked individual or human group that, even with investment, will never catch up with the benchmark individual or group.

Discussion: situating economization

The presentation of these four models of health is not to suggest a chronology or stages, as all are often simultaneously debated with various strengths and weakness (for example, Conti et al. 2019). Our major aim in laying out the various models of health is, firstly, to highlight on how the incorporation of foetal origins theories within economics is shaping new economic tools, forms of quantification, and metrics. While economic tools and logics have undoubtedly overtaken a wide range of social and political life, we demonstrate a multi-directional element of economization. As a second goal, we wished to reflect on how the growing emphasis on deficient and enduring lack in human capital potential intersects with the geography in which this knowledge is being put to use, thereby situating this increasingly stabilized area of research in a particular intersection of histories and imaginaries. These imaginaries, alongside enduring discourses within the field of 'scarring' and 'permanent damage', have significance when placed within discussions on economization of life and health.

What we have set out in this article is that global institutions such as the World Bank recognize interventions for 'poor people' as economically beneficial under a cost/benefit regime (Collin and Weil 2018). Within this framework, investments are likely to raise the human capital of poor people more than that of rich people, simply because the former group has a much larger deficiency to be addressed. Because there is the greatest gap, the greatest potential to make up, the most vulnerable and unhealthiest populations are those that "produce the most economic value" (Birch 2007, p. 94). However, there is the flip side to this story, one that reflects on the economic value of neglect. The emergence of the investable poor (Kish and Leroy 2015) or investible lives (Murphy 2017) produces a shadow figure: that not all lives may be equally productive and receptive to investment. In fact, crude cost/benefit analysis may suggest that it might be more economically beneficial to have differential investments, with only some populations gaining favour. This is logic of investment *and* disinvestment, with both rendered into potential areas for revenue. To put it in the words of Jaspir Puar, "Are all bodies available for rehabilitation?" (2009, p. 164). By this, Puar is asking about the biopolitical stratifications that render some populations as potentially capacitated alongside others "targeted for premature or slow death" (2017, p. 13). While debilitation is a form of massified disablement (xvii), it also situates *some, not all*, "that can be reinvigorated for neoliberalism, available and valuable enough for rehabilitation" (13). Puar's theory of debilitation-capacitation points out that economic rationalities may situate life,

death, *and debility* within cost–benefit rationalities for differential investments. To address Puar's question within the language of this article, some lives are seen as plastic enough for improvement, and others may not. Even those for whom intervention might return value may be framed as unable to 'close the gap'. Thus, to think through the implications of economization we have to register how racialized life has long been economized, reflected not only in slavery and eugenics and their legacies, but more broadly differentially valued labour power and biopolitical life for economic well-being of the nation (Kish and Leroy 2015; Patchin 2021; Murphy 2017).

Human capital in the age of DOHaD may be less malleable than what the classic human capital literature with its reference to a disembodied abstract adult individual would have imagined. From a health deficit viewpoint, differential ability does not just reflect "qualitative differences in types of education, on the job training, informal training" (Becker 1964, p. 136) but the quasi-exponential effect of early biological histories on present and future temporality. This is a new figure, the enduringly *not-nurtured-enough*, or damaged human group that has accumulated and thus embodies a deficit that may slow down growth and competitiveness of the nation. It is consistent with the double meaning of biological plasticity, as always caught between activity and passivity, change, and robustness (Bateson and Gluckman 2011; Malabou 2005), that is between individual optimization and the recognition of shocks that imprint individual or groups and may in the long term not be fully remediable. Our analysis leads us to ask if a new way to reproduce and even expand imaginaries of population differences via differential exposure to shocks or "burdens of plasticity" (Meloni 2019) is emerging in the Global South.

Conclusion

Health and development economists have enthusiastically drawn on DOHaD theories in the last two decades, producing a rich intersection of disciplinary perspectives, tools of quantification, and styles of thought that has gone largely overlooked within social science interest in postgenomics (an exception, Pentecost 2018). Here, we have placed this research nexus in context of the emergence of Becker's theories of human capital and the quantity-quality tradeoff, the shifting role of the World Bank toward basic needs, health, and nutrition, and how DOHaD theories were well-placed to address economists enduring questions around the wealth-health gradient and future burdens of NCDs in the Global South. While no doubt situated in a larger process of economization of global health, of early life, and life itself (Reubi 2013; Griffen 2023; Murphy 2017), our narrative points to a more complicated story of cross-pollination between two disciplines. Indeed, biological theories of the import of foetal and early life for adult health has had a significant impact on economic models of health and human capital. However, we find that the research nexus of foetal programming and human capital takes a more sombre and perhaps doomed tone. This suggests a series of shadow figures beyond just "investable life" (Murphy 2017), but also lives not worth investing in and lives beyond repair, even with investment. Thus, any analysis of economization in neoliberalism's contemporary

era (Laruffa 2022) needs to embrace this broader perspective which include, particularly in the Global South, tropes of damaged populations and differential valuations of human life.

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Declarations

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

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References

Abeliansky, A., and H. Strulik. 2018. Hungry children age faster. *Economics and Human Biology* 29: 211–222.

Abeliansky, A., and H. Strulik. 2020. Season of birth, health, and aging. *Economics and Human Biology* 36: 100812.

Adair, L.S., and A. Prentice. 2004. A critical evaluation of the fetal origins hypothesis and its implications for developing countries. *The Journal of Nutrition* 134 (1): 191–193. https://doi.org/10.1093/jn/134.1.191.

Adams, V. ed. 2016. Metrics: What counts in global health. Durham, NC: Duke University Press.

Adhvaryu, A., A. Nyshadham, T. Molina, and J. Tamayo. 2018. Helping children catch up: Early life shocks and the Progresa experiment (No. w24848). National Bureau of Economic Research.

Adler, N.E., T. Boyce, M.A. Chesney, S. Cohen, S. Folkman, R.L. Kahn, and S.L. Syme. 1994. Socioeconomic status and health: The challenge of the gradient. *American Psychologist* 49 (1): 15.

Alacevich, M. 2009a. The World Bank's early reflections on development: A development institution or a bank? *Review of Political Economy* 21 (2): 227–244.

Alacevich, M. 2009b. *The political economy of the World Bank: The early years*. Washington, DC: World Bank Publications.

Almond, D. 2006. Is the 1918 influenza pandemic over? Long-term effects of in utero influenza exposure in the post-1940 U.S. population. *Journal of Political Economy* 114 (4): 672–712. https://doi.org/10.1086/507154.

Almond, D., L. Edlund, H. Li, and J. Zhang. 2007. Long-term effects of the 1959–1961 China famine. Mainland China and Hong Kong.

Almond, D., and J. Currie. 2011a. Killing me softly: The fetal origins hypothesis. *Journal of Economic Perspectives* 25 (3): 153–172. https://doi.org/10.1257/jep.25.3.153.

Almond, D., and J. Currie. 2011b. Human capital development before age five. NBER Working Paper Series, December, 1–142.

Almond, D. and B. Mazumder. 2013. Fetal origins and parental responses. *Annual Review of Economics* 5 (1): 37–56.
Almond, D., et al. 2014. Fetal origins of lifetime health. In *Encyclopedia of health economics*, ed. A. Cuyler, 309–314. Amsterdam, NL: Elsevier.
Almond, D., J. Currie, and V. Duque. 2018. Childhood circumstances and adult outcomes: Act II. *Journal of Economic Literature* 56 (4): 1360–1446.
Akresh, R., S. Bhalotra, M. Leone, and U.O. Osili. 2012. War and stature: Growing up during the Nigerian Civil War. *American Economic Review* 102 (3): 273–277. https://doi.org/10.1257/aer.102.3.273.
Akresh, R., S. Bhalotra, M. Leone, and U.O. Osili. 2017. First and second generation impacts of the Biafran War. NBER Working Paper Series: 1–69.
Araújo, D., B. Carrillo, and B. Sampaio. 2021. The long-run economic consequences of iodine supplementation. *Journal of Health Economics* 79: 102490.
Attanasio, Orazio P. 2015. The determinants of human capital formation during the early years of life: Theory, measurement and policies. *Journal of the European Economic Association* 13 (6): 949–997. https://doi.org/10.1111/jeea.12159.
Barker, D.J. 1990. The fetal and infant origins of adult disease. *British Medical Journal* 301 (6761): 1111.
Barker, D.J. 1995. Foetal origins of coronary heart disease. *British Medical Journal* 311: 171–174.
Barker, D.J.P., and C. Osmond. 1986. Infant mortality, childhood nutrition, and ischaemic heart disease in England and Wales. *The Lancet* 327 (8489): 1077–1081. https://doi.org/10.1016/s0140-6736(86)91340-1.
Bateson, P., and P. Gluckman. 2011. *Plasticity, robustness, development and evolution*. Cambridge: Cambridge University Press.
Becker, G.S. 1990. An economic analysis of fertility. In Universities-National Bureau Committee for Economic Research (ed.) *Demographic and economic change in developed countries*, 209–240. New York: Colombia University Press.
Becker, G.S. 1964. *Human capital: A theoretical and empirical analysis, with special reference to education*. Chicago, IL: University of Chicago Press.
Becker, G.S. 1993. Nobel lecture: The economic way of looking at behavior. *Journal of Political Economy* 101 (3): 385–409.
Becker, G.S., and H.G. Lewis. 1973. On the interaction between the quantity and quality of children. *Journal of Political Economy* 81 (2): S279–S288.
Behrman, J.R. et al. 2004. Hunger and malnutrition. Copenhagen Consensus Challenge Paper, 29 April.
Birch, K. 2007. The virtual bioeconomy: The 'failure' of performativity and the implications for bioeconomics. *Distinktion: Scandinavian Journal of Social Theory* 14 (1): 83–99.
Buklijas, T. 2018. Histories and meanings of epigenetics. In *The Palgrave handbook of biology and society*, ed. M. Meloni, J. Cromby, D. Fitzgerald, and S. Lloyd, 167–187. London: Palgrave Macmillan.
Bulatao, R.A. 1984. Reducing fertility in developing countries: A review of determinants and policy levers. World Bank Staff Working Papers No. 680 and Population and Development Series, No. 5. Publications Sales Unit, Department T, The World Bank, 1818 H Street, NW, Washington, DC 20433.
Bundervoet, T., and S. Fransen. 2018. The educational impact of shocks in utero: Evidence from Rwanda. *Economics and Human Biology* 29: 88–101. https://doi.org/10.1016/j.ehb.2018.01.005.
Brown, W. 2016. Sacrificial citizenship: Neoliberalism, human capital, and austerity politics. *Constellations* 23 (1): 3–14. https://doi.org/10.1111/1467-8675.12166.
Brown, W. 2017. *Undoing the demos: Neoliberalism's stealth revolution*. Princeton, NJ: Princeton University Press.
Çalışkan, K., and M. Callon. 2009. Economization, part 1: Shifting attention from the economy towards processes of economization. *Economy and Society* 38 (3): 369–398.
Calkins, K., and S.U. Devaskar. 2011. Fetal origins of adult disease. *Current Problems in Pediatric and Adolescent Health Care* 41 (6): 158–176.
Calkin, S. 2018. *Human capital in gender and development*. New York: Routledge.
Camerer, C., G. Loewenstein, and D. Prelec. 2005. Neuroeconomics: How neuroscience can inform economics. *Journal of Economic Literature* 43 (1): 9–64.
Carillo, B. 2020. Early rainfall shocks and later-life outcomes: Evidence from Colombia. *The World Bank Economic Review*. https://doi.org/10.1093/wber/lhy014.

Case, A., et al. 2005. The lasting impact of childhood health and circumstance. *Journal of Health Economics* 24 (2): 365–389. https://doi.org/10.1016/j.jhealeco.2004.09.008.
Clement, D. 2012. Interview with Janet Currie. The Region. Federal Reserve Bank of Minneapolis. https://www.minneapolisfed.org/article/2012/interview-with-janet-currie. Accessed Oct 2020.
Collin, M., and D. Weil. 2018. The effect of increasing human capital investment on economic growth and poverty: A simulation exercise. Policy Research Working Paper; No. 8590. World Bank, Washington, DC. https://openknowledge.worldbank.org/handle/10986/30463
Conti, G., G. Mason, and S. Poupakis. 2019 Developmental origins of health inequality. IZA Discussion Paper No. 12448. https://doi.org/10.2139/ssrn.3478696
Cook, C.J., and J.M. Fletcher. 2015. Understanding heterogeneity in the effects of birth weight on adult cognition and wages. *Journal of Health Economics* 41: 107–116. https://doi.org/10.1016/j.jhealeco.2015.01.005.
Cunha, F., and J.J. Heckman. 2007. The technology of skill formation. *The American Economic Review* 97 (2): 31–47.
Currie, J. 2011. Inequality at birth: Some causes and consequences. *American Economic Review* 101 (3): 1–22. https://doi.org/10.1257/aer.101.3.1.
Currie, J., and R. Hyson. 1999. Is the impact of health shocks cushioned by socioeconomic status? The case of low birthweight. *American Economic Review* 89 (2): 245–250.
Currie, J., and E. Moretti. 2007. Biology as destiny? Short- and long-run determinants of intergenerational transmission of birth weight. *Journal of Labor Economics* 25 (2): 231–264.
Currie, J., and B.C. Madrian. 1999. Health, health insurance and the labor market. *Handbook of Labor Economics* 3: 3309–3416.
Dados, N., and Connell. R. 2012. The global south. *Contexts* 11 (1): 12–13.
Dalgaard, C.J., and H. Strulik. 2014. Optimal aging and death: Understanding the Preston Curve. *Journal of the European Economic Association* 12: 672–701.
Dalgaard, C.J., and H. Strulik. 2015. The physiological foundations of the wealth of nations. *Journal of Economic Growth* 20 (1): 37–73.
Dalgaard, C.J., and H. Strulik. 2016. Physiology and development: Why the West is taller than the rest. *Economic Journal* 126: 2292–2323.
Dalgaard, C.J., C.W. Hansen, and H. Strulik. 2019. Accounting for Fetal Origins: Health Capital vs. Health Deficits. Center for European, Governance, and Economic Development Research Discussion Paper No. 385. Göttingen, Germany: Georg August University of Göttingen. Available at http://doi.org/10.2139/ssrn.3472436.
Dalgaard, C.J., C.W. Hansen, and H. Strulik. 2021. Fetal origins—A life cycle model of health and aging from conception to death. *Health Economics* 30 (6): 1276–1290.
Darling, J.C., et al. 2020. The first thousand days: Early, integrated and evidence-based approaches to improving child health: Coming to a population near you? *Archives of Disease in Childhood* 105 (9): 837–841. https://doi.org/10.1136/archdischild-2019-316929.
Dercon, S., and C. Porter. 2014. Live aid revisited: Long-term impacts of the 1984 Ethiopian famine on children. *Journal of the European Economic Association* 12 (4): 927–948. https://doi.org/10.1111/jeea.12088.
Donovan, K.P. 2018. The rise of the randomistas: On the experimental turn in international aid. *Economy and Society* 47 (1): 27–58.
Duque, V., M. Rosales-Rueda, and F. Sanchez. 2018. How do early-life shocks interact with subsequent human-capital investments? Evidence from administrative data. In *IZA world of labor conference*.
Dussauge, I. 2015. Sex, cash and neuromodels of desire. *BioSocieties* 10 (4): 444–464.
Fall, C.H., D.J. Barker, C. Osmond, P.D. Winter, P.M. Clark, and C. Hales. 1992. Relation of infant feeding to adult serum cholesterol concentration and death from ischaemic heart disease. *British Medical Journal* 304 (6830): 801–805.
Fan, W., and C. Porter. 2020. Reinforcement or compensation? Parental responses to children's revealed human capital levels. *Journal of Population Economics* 33 (1): 233–270.
Feeny, S., et al. 2021. Early-Life exposure to rainfall shocks and gender gaps in employment: Findings from Vietnam. *Journal of Economic Behavior and Organization* 183: 533–554. https://doi.org/10.1016/j.jebo.2021.01.016.
Feher, M. 2009. Self-appreciation; or, the aspirations of human capital. *Public Culture* 21 (1): 21–41.
Flabbi, L., and R. Gatti. 2018. A primer on human capital. World Bank Policy Research Working Paper No. 8309. SSRN: https://ssrn.com/abstract=3105769

Fourcade, M., E. Ollion, and Y. Algan. 2015. The Superiority of economists. *Journal of Economic Perspectives* 29 (1): 89–114. https://doi.org/10.1257/jep.29.1.89.
Gaudilliere, J.P., and C. Gasnier. 2020. From Washington DC to Washington state: The global burden of diseases data basis and the political economy of Global Health. In *Data journeys in the sciences*, 351–369. Cham: Springer.
Gillies, V., R. Edwards, and N. Horsley. 2016. Brave new brains: Sociology, family and the politics of knowledge. *The Sociological Review* 64 (2): 219–237.
Gluckman, P.D., T. Buklijas, and M.A. Hanson. 2016. The Developmental Origins of Health and Disease (DOHaD) concept. In *The epigenome and developmental origins of health and disease*, ed. C. Rosenfeld, 1–15. London: Elsevier. https://doi.org/10.1016/b978-0-12-801383-0.00001-3.
Griffen, Z. 2023. The economization of early life. *Science Technology and Human Values*. https://doi.org/10.1177/01622439221147701.
Griffen, Z., and A. Panofsky. 2021. Ambivalent economizations: The case of value added modeling in teacher evaluation. *Theory and Society* 50 (3): 515–539. https://doi.org/10.1007/s11186-020-09417-x.
Griffen, Z., and S. Timmermans. 2020. The cost of saving babies: How economists justify policies. *Economy and Society* 49 (2): 1–22. https://doi.org/10.1080/03085147.2019.1690277.
Grossman, M. 1972. On the concept of health capital and the demand for health. *Journal of Political Economy*. https://doi.org/10.1086/259880.
Grossman, M. 2022. The demand for health turns 50: Reflections. *Health Economics* 31 (9): 1807–1822.
Hales, C.N., and D.J. Barker. 1992. Type 2 (non-insulin-dependent) diabetes mellitus: The thrifty phenotype hypothesis. *Diabetologia* 35 (7): 595–601.
Hanson, M., et al. 2009. *Early life nutrition and lifelong health*. London: British Medical Association.
Haug, S., J. Braveboy-Wagner, and G. Maihold. 2021. The 'Global South' in the study of world politics: Examining a meta category. *Third World Quarterly* 42 (9): 1923–1944.
Heckman, J.J. 1999. Policies to foster human capital. NBER Working Paper, (w7288).
Heckman, J. 2007. The economics, technology, and neuroscience of human capability formation. *PNAS* 104 (33): 13250–13255. https://doi.org/10.1073/pnas.0701362104.
Herrick, C., and D. Reubi, eds. 2017. *Global health and geographical imaginaries*. London: Taylor and Francis.
Hirschman, D., and E.P. Berman. 2014. Do economists make policies? On the political effects of economics. *Socio-Economic Review* 12 (4): 779–811. https://doi.org/10.1093/ser/mwu017.
Kenny, K.E. 2015. The biopolitics of global health: Life and death in neoliberal time. *Journal of Sociology* 51 (1): 9–27. https://doi.org/10.1177/1440783314562313.
Kim, J.Y. 2018. World Bank Group President Jim Yong Kim Opening Remarks at the event Partnering to Address Severe Food Insecurity. Speech at United Nations General Assembly. New York, 23 September.
Kish, Z., and J. Leroy. 2015. Bonded life. *Cultural Studies* 29 (5–6): 630–651. https://doi.org/10.1080/09502386.2015.1017137.
Kraay, A. 2018. Methodology for a World Bank Human Capital Index. Policy Research Working Paper; No. 8593. Washington, D.C.: World Bank, https://openknowledge.worldbank.org/handle/10986/30466
Krishnaveni, G., and C. Yajnik. 2017. Developmental origins of diabetes—An Indian perspective. *European Journal of Clinical Nutrition* 71 (7): 865–869.
Lakoff, A. 2010. Two regimes of global health. *Humanity: an International Journal of Human Rights, Humanitarianism, and Development* 1 (1): 59–79.
Lakoff, A. 2015. Global health security and the pathogenic imaginary. In *Dreamscapes of modernity*, 300–320. University of Chicago Press.
Landecker, H., and A. Panofsky. 2013. From social structure to gene regulation, and back: A critical introduction to environmental epigenetics for sociology. *Annual Review of Sociology* 39: 333–357.
Laruffa, F. 2022. Neoliberalism, economization and the paradox of the new welfare state. *European Journal of Sociology* 63 (1): 131–163.
Leon, G. 2012. Civil conflict and human capital accumulation the long-term effects of political violence in Perú. *Journal of Human Resources* 47 (4): 991–1022. https://doi.org/10.3368/jhr.47.4.991.
Leonard, T. 2005. Retrospectives: Eugenics and economics in the progressive era. *Journal of Economic Perspectives* 19 (4): 207–224.
Lucas, A. 1998. Programming by early nutrition: An experimental approach. *The Journal of Nutrition* 128 (2): 401S-406S.

Lumey, L.H., et al. 2011. Prenatal famine and adult health. *Annual Review of Public Health* 32: 237–262.
Maccini, S., and D. Yang. 2009. Under the weather: Health, schooling, and economic consequences of early-life rainfall. *American Economic Review* 99 (3): 1006–1026. https://doi.org/10.1257/aer.99.3.1006.
Malabou, C. 2005. *The future of Hegel: Plasticity, temporality, and dialectic*. London: Psychology Press.
Mazumder, B., et al. 2009. Lingering prenatal effects of the 1918 influenza pandemic on cardiovascular disease. *Journal of Developmental Origins of Health and Disease* 1 (1): 26–34. https://doi.org/10.1017/s2040174409990031.
Meloni, M. 2018. A postgenomic body: Histories, genealogy, politics. *Body and Society* 24 (3): 3–38.
Meloni, M. 2019. *Impressionable biologies: From the archaeology of plasticity to the sociology of epigenetics*. London: Routledge.
Meloni, M., and G. Testa. 2014. Scrutinizing the epigenetics revolution. *BioSocieties* 9 (4): 431–456.
Meloni, M., T. Moll, A. Issaka, and C.W. Kuzawa. 2022. A biosocial return to race? A cautionary view for the postgenomic era. *American Journal of Human Biology* 34 (7): e23742.
Murphy, M. 2017. *The economization of life*. Durham, NC: Duke University Press.
Osmani, S., and A. Sen. 2003. The hidden penalties of gender inequality: Fetal origins of ill-health. *Economics and Human Biology* 1: 105–121.
Otto, M. 2007. The health-wealth gradient: Examining the fetal origins hypothesis (Doctoral dissertation). Georgetown University, USA.
Paneth, N., and M. Susser. 1995. Early origin of coronary heart disease (the "Barker hypothesis"). *British Medical Journal* 310: 411–412. https://doi.org/10.1136/bmj.310.6977.411.
Patchin, P.M. 2021. For the sake of the child: The economisation of reproduction in the Zika Public Health Emergency. *Transactions of the Institute of British Geographers* 46 (1): 2–14. https://doi.org/10.1111/tran.12384.
Pentecost, M. 2016. Introduction: The first thousand days of life. Somatosphere, 11 April, http://somatosphere.net/2016/introduction-the-first-thousand-days-of-life.html/, Accessed on 13 Sept 2021.
Pentecost, M. 2018. The first thousand days: Epigenetics in the age of global health. In *The handbook of biology and society*, ed. M. Meloni, J. Cromby, D. Fitzgerald, and S. Lloyd. London: Palgrave Macmillan.
Pentecost, M., and F. Ross. 2019. The first thousand days: Motherhood, scientific knowledge, and local histories. *Medical Anthropology* 38 (8): 747–761. https://doi.org/10.1080/01459740.2019.1590825.
Pitts-Taylor, V. 2019. Neurobiologically poor? Brain phenotypes, inequality, and biosocial determinism. *Science, Technology, and Human Values* 44 (4): 660–685.
Prinz, D., et al. 2018. Health and economic activity over the lifecycle: Literature review. NBER Working Paper Series, Working Paper 24865. https://doi.org/10.3386/w24865
Pritchett, L.H. 1994. Desired fertility and the impact of population policies. *Population and Development Review* 20 (1): 1–55. https://doi.org/10.2307/2137629.
Puar, J.K. 2009. Prognosis time: Towards a geopolitics of affect, debility and capacity. *Women and Performance: A Journal of Feminist Theory* 19 (2): 161–172. https://doi.org/10.1080/07407700903034147.
Puar, J.K. 2017. *The right to maim*. Durham, NC: Duke University Press.
Rasmussen, K.M. 2001. The "fetal origins" hypothesis: Challenges and opportunities for maternal and child nutrition. *Annual Review of Nutrition* 21: 73–95. https://doi.org/10.1146/annurev.nutr.21.1.73.
Rehak, S.E. 2005. Climate change and the Copenhagen Consensus 2004: A critical review of economic prioritization. *Colorado Journal of International Environmental Law and Policy* 17: 41–58.
Repo, J. 2018. Gary Becker's economics of population: Reproduction and neoliberal biopolitics. *Economy and Society* 47 (2): 1–23. https://doi.org/10.1080/03085147.2018.1484052.
Reubi, D. 2013. Health economists, tobacco control and international development: On the economisation of global health beyond neoliberal structural adjustment policies. *BioSocieties* 8 (2): 205–228.
Reubi, D. 2017. Rational sin—How Chicago economics remade global public health. Limn. https://limn.it/articles/rational-sin/
Reubi, D. 2018. Epidemiological accountability: Philanthropists, global health and the audit of saving lives. *Economy and Society* 47 (1): 83–110. https://doi.org/10.1080/03085147.2018.1433359.

Reyes, L., and R. Manalich. 2005. Long-term consequences of low birth weight. *Kidney International* 68: S107–S111.
Richardson, S.S. 2015. Maternal bodies in the postgenomic order. In *Postgenomics: Perspectives on biology after the genome*, ed. S. Richardson and H. Stevens, 210–231. Durham, NC: Duke University Press.
Roseboom, T.J., et al. 2001. Effects of prenatal exposure to the Dutch famine on adult disease in later life: An overview. *Twin Research and Human Genetics* 4 (5): 293–298.
Ruger, J.P. 2005. The changing role of the World Bank in global health. *American Journal of Public Health* 95 (1): 60–70. https://doi.org/10.2105/ajph.2004.042002.
Sayer, A., C. Cooper, J.R. Evans, et al. 1998. Are rates of ageing determined *in utero*. *Age and Ageing* 27: 579–583.
Smith, J.P. 1999. Healthy bodies and thick wallets: The dual relation between health and economic status. *The Journal of Economic Perspectives* 13 (2): 144–166. https://doi.org/10.1257/jep.13.2.145.
Sobel, I. 1978. The human capital revolution in economic development: Its current history and status. *Comparative Education Review* 22 (2): 278–308.
Sotomayor, O. 2013. Fetal and infant origins of diabetes and ill health: Evidence from Puerto Rico's 1928 and 1932 hurricanes. *Economics and Human Biology* 11 (3): 281–293. https://doi.org/10.1016/j.ehb.2012.02.009.
Sunder Rajan, K. 2012. Introduction: The capitalization of life and the liveliness of capital. In *Lively capital*, 1–42. Durham, NC: Duke University Press.
States News Service. 2018. United Nations, World Bank, and humanitarian organizations launch innovative partnership to end famine, 23 September. Accessed 13 July 2020.
Spieker, J. 2013. Defending the open society: Foucault, Hayek, and the problem of biopolitical order. *Economy and Society* 42 (2): 304–321.
Spring, J. 2015. *Economization of education: Human capital, global corporations, skills-based schooling*. New York: Routledge.
Solomon, H. 2016. *Metabolic living: Food, fat, and the absorption of illness in India*. Durham: Duke University Press.
Sweetland, S.R. 1996. Human capital theory: Foundations of a field of inquiry. *Review of Educational Research* 66 (3): 341–359. https://doi.org/10.3102/00346543066003341.
Taussig, K.S., K. Hoeyer, and S. Helmreich. 2013. The anthropology of potentiality in biomedicine. *Current Anthropology* 54 (S7): S3-14. https://doi.org/10.1086/671401.
Teixeira, P.N. 2005. The human capital revolution in economics. *History of Economic Ideas* 13 (2): 129–148.
Teixeira, P.N. 2014. Gary Becker's early work on human capital–collaborations and distinctiveness. *IZA Journal of Labor Economics* 3 (1): 1–20.
Teixeira, P.N. 2017. Economic beliefs and institutional politics: Human capital theory and the changing views of the World Bank about education (1950–1985). *The European Journal of the History of Economic Thought* 24 (3): 465–492.
Ugaz, J., and A. Zanolini. 2011. Effects of extreme weather shocks during pregnancy and early life on later health outcomes: the case of Philippines' typhoons. University of Chicago Harris School of Public Policy. Unpublished.
UN Finance Center for South-South Cooperation. 2015. Global South Countries. Available at: http://www.fc-ssc.org/en/partnership_program/south_south_countries.
Victora, C.G., L. Adair, C. Fall, P.C. Hallal, et al. 2008. Maternal and child undernutrition: Consequences for adult health and human capital. *The Lancet* 371 (9609): 340–357.
Wahlberg, A., and N. Rose. 2015. The governmentalization of living: Calculating global health. *Economy and Society* 44 (1): 60–90.
Walker, A. 2019. Into the machine: Economic tools, sovereignty, and joy in a global health institution. *Medical Anthropology Quarterly* 33: 539–556. https://doi.org/10.1111/maq.12529.
Warin, M., J. Keaney, E. Kowal, and H. Byrne. 2022. Circuits of time: Enacting postgenomics in indigenous Australia. *Body and Society* 29: 20–48.
Warin, M., E. Kowal, and M. Meloni. 2020. Indigenous knowledge in a postgenomic landscape: The politics of epigenetic hope and reparation in Australia. *Science, Technology, and Human Values* 45 (1): 87–111.
World Bank. 2018. The human capital project. World Bank, Washington, DC. https://openknowledge.worldbank.org/handle/10986/30498.

Zaveri, E., J. Russ, S. Desbureaux, R. Damania, A.S. Rodella, and G. Ribeiro. 2019. The nitrogen legacy: The Long-term effects of water pollution on human capital. Washington, DC: World Bank. https://openknowledge.worldbank.org/handle/10986/33073.

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