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WORKING PAPER

THE GLOBAL BRAIN CAPITAL DASHBOARD

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Harris A. Eyre is a contractor with Meadows Mental Health Policy Institute. The author did not receive financial support from any firm or person for this article or, other than the aforementioned, from any firm or person with a financial or political interest in this article. The author is not currently an officer, director, or board member of any organization with a financial or political interest in this article.

The Brookings Institution is financed through the support of a diverse array of foundations, corporations, governments, individuals, as well as an endowment. A list of donors can be found in our annual reports published online. The findings, interpretations, and conclusions in this report are solely those of its author(s) and are not influenced by any donation.

The Global Brain Capital Dashboard

Rym Ayadi, Harris A. Eyre, Carol Graham, Sara Ronco, Elena Stotts-Lee[1]

Introduction

The 'global brain' is under tremendous pressure from issues across the lifespan (Winter et al., 2022). Impaired social and emotional development in early childhood, education loss due to COVID-induced school disruptions, the negative effects of social media on youth, long COVID brain effects, and rising rates of dementia are placing strain on the health of the 'global brain.'

Brain health is a critical aspect of human well-being, affecting cognitive abilities, socioemotional stability, and overall quality of life (World Health Organization, 2022). However, the growing prevalence of brain disorders is taking a steep economic toll. Mental health disorders alone are estimated to cost the global economy $5 trillion per year, and this is projected to rise to $16 trillion by 2030 (Arias et al., 2022; Bloom et al., 2011). Similarly, every year, dementia costs the global economy more than $1.3 trillion, a value that is set to increase to $2.8 trillion by 2030 (World Health Organization, 2023b).

Brain health plays an increasingly critical role in an economy predicated on "Brain Capital" (which encompasses an individual's social, emotional, and cognitive resources) (Smith et al., 2021; World Health Organization, 2023a). Global economies are becoming increasingly dependent on Brain Capital, whereby a premium is placed on brain skills (both cognitive and non-cognitive) and brain health (Lundbeck, 2023). This is particularly true in the context of accelerating AI advances which are disrupting and replacing lower-skilled tasks (Eyre et al., 2023).

We are living in a poly-crisis i.e., at the confluence of major societal challenges - spanning climate change, political instability, geopolitical and geoeconomic tensions, pandemic recovery, and widespread misinformation. These cumulative challenges are extremely demanding on our brains and minds (Hynes et al., 2023). Appendix 1 outlines key Brain Capital challenges and opportunities across various sectors. The economic burden of brain and mental health-related disorders (e.g., depression, anxiety, Alzheimer's disease, stroke, and long COVID-19) has recently prompted the need for policymaking (Eyre et al., 2023; Smith et al., 2022). Promoting creativity, innovation, and brain health will help economies flourish.

The Brain Capital Grand Strategy was launched in early 2021. The strategy urged the need for Brain Capital in all policies, for more investment in Brain Capital, and a global dashboard to monitor essential trends for more informed policymaking (Smith et al., 2021). Within the same period, the OECD Neuroscience-inspired Policy Initiative (NIPI) was launched by the then OECD Secretary-General, Angel Gurria, and Admiral William H. McRaven (Rtd). Appendix 2 outlines activities vis a-vis Brain Capital policy innovation.

In this paper, we hereby launch the Global Brain Capital Dashboard. This has been developed by the OECD NIPI, Brain Capital Alliance, and the Global Brain Capital Dashboard Working Group since mid-2021. The members of the Working Group are outlined in Appendix 3. The Dashboard aims to quantify and track Brain Capital as well as provide a platform to inspire novel policy innovation. This paper follows the structure of the dashboard. It describes Brain Capital and then presents evidence around the relevance of the selected pillars and dimensions. It concludes by offering a vision of what is next for the Brain Capital Dashboard.

To build the complete Dashboard, novel indicators were extracted from a wide range of data sources under the banner of three pillars: Brain Capital Drivers, Brain Health, and Brain Skills. Brain Capital Drivers refers to the

[1] *The co-authors acknowledge the contributions from the Working Group members (listed in Appendix 3) for the development of the Brain Capital definition, the identification of the Brain Capital dimensions and the provisional list of indicators added to the first version of the Brain Capital Dashboard available at https://research.euromed-economists.org/brain-capital-dashboard/. They also acknowledge very helpful comments from Richard Frank of Brookings and excellent fact-checking by Isabel Shaheen O'Malley.*

factors that boost or impede the accumulation of brain capital throughout the life course. Some of these factors include digitalization, health services, the natural environment, education, and social connections. Brain Health examines the mental and neurological health of the population at scale. The domain chronicles the absence of disorders, as well as different issues throughout the human lifespan (childhood, adolescence, and aging-related issues). The Brain Skills domain captures key areas for the accumulation of Brain Capital such as cognitive skills, non-cognitive skills, mental flourishing, and mental resilience.

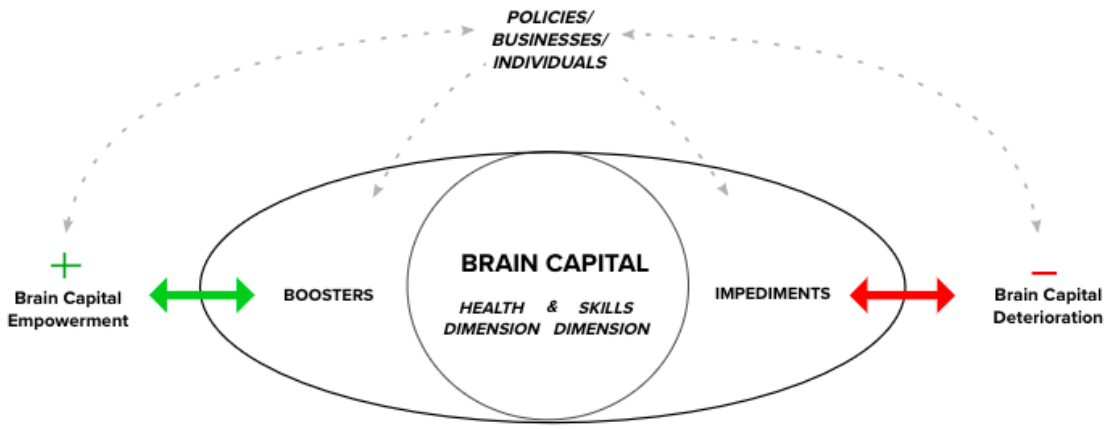
Brain Capital itself is a productive and complex capital stock that accumulates over the lifecycle. It is constructed by a multi-dimensional set of factors varying from physical to socio-cultural, enabling the brain to remain healthy, develop, and avoid deterioration. The policies guiding the development of both the natural and sociocultural environments are important drivers of Brain Capital since they may either promote or impede its development. The Brain Capital concept provides a better understanding of the economic value that can be derived through identifying and unlocking latent human brain potential.

Further Details on Brain Capital

We present Brain Capital as a circular concept summarized in Figure 1. The figure resembles an eye with Brain Capital at the center. Brain Capital is measured as the cumulative brain health and brain skills of a society. It is influenced by drivers that either favor or jeopardize Brain Capital development. Depending on the prevalence of boosters or impediments, Brain Capital will be enhanced or reduced. The presence of empowering Brain Capital drivers expands opportunities for preserving, improving, and enhancing individual, societal, and economic benefits. On the contrary, the prevalence of factors that impeded Brain Capital development implies that such opportunities will be limited or nonexistent.

All the stakeholders (i.e., governments, businesses, and individuals) can impact the drivers of Brain Capital. They each can contribute to the creation or deterioration of Brain Capital. The development of Brain Capital favors people, society, and the economy's well-being by building flourishing communities that can better resist increasing global challenges. To promote Brain Capital development, the aim is to minimize the space for impediments while increasing space for boosters.

Figure 1 - Brain Capital Components and Development



Source: Authors elaboration.

Pillar 1 of the Brain Capital Dashboard (BCD): Brain Capital Drivers

Brain Capital Drivers are all the key factors impacting the accumulation of Brain Capital over the life course. For example, the social, cultural, and natural environments that a person experiences throughout their life influence

how they build and maintain Brain Capital. The Global Brain Capital Dashboard Working Group gathered a team of experts to identify the key factors affecting the accumulation of Brain Capital over the life course. Based on the group discussions and a review of the literature, the factors were organized into dimensions, and data was gathered to measure them as indicators. The dimensions that represent Brain Capital Drivers are:

- Pre-natal related issues
- Food and nutritional security
- Health services and public policies
- Natural environment and climate
- Cultural environment
- Social conditions
- Education
- Digitalization

The provisional list of indicators included for each dimension in the Brain Capital Dashboard are available in Appendix 4.

Brain Capital Drivers Dimensions: Pre-natal related issues

The early years of a person's life are a crucial period for the development of Brain Capital. The development of cognitive and noncognitive skills during childhood is strongly influenced by in-utero conditions and birth risks (Coneus et al., 2012). The brain development of children is particularly vulnerable to factors such as maternal nutrition, infection, substance misuse, and stress during pregnancy (Fitzgerald et al., 2020; Shankaran et al., 2007). There is a growing body of literature suggesting that these modifiable factors are important contributors to atypical brain development (Ibid.).

In addition to the physical health of mothers during pregnancy, the mental health of parents must be considered. Perinatal and postpartum depression are phenomena that are increasingly being studied for their critical impact on child development. Perinatal depression is a mood disorder that can affect women and men during pregnancy and after childbirth (National Institute of Mental Health, 2023a). Perinatal depression has detrimental and potentially long-lasting effects on infant and child development and is very common (Waxler et al., 2011). Perinatal and postpartum depression are not only experienced by pregnant parents; they are found to be prevalent among their partners as well (Goodman, 2004). Both mothers and fathers experiencing depression during and after pregnancy may experience difficulties in effectively bonding with and caring for their infants, which can influence various aspects of child development. Impacts that have been found in the literature include negative effects on breastfeeding, diminished mother-infant interactions, poor temperament, sleep habits, health, and mental development among infants, and behavior issues spanning into adolescents (Howard & Khalifeh, 2020; A. Stein et al., 2014). Some potential interventions include paternal education, music therapy during labor, cognitive behavior therapy (CBT), and administering oxytocin (Dennis & Hodnett, 2007; Poyatos-León et al., 2017). Providing access to services and information about how to care for children's brain health from pregnancy is, therefore, an important step towards a more brain-healthy society.

Brain Capital Drivers Dimensions: Food and Nutritional Security

Having secure access to food with the necessary nutrients is vital to the brain health and development of people of all ages. As a result, the accumulation and preservation of Brain Capital is dependent on the whole population having the means to eat enough and to eat well. Following from the previous dimension, there is a wide body of evidence on the relationship between maternal nutrition during pregnancy and the healthy neurodevelopment of children (Cortés-Albornoz et al., 2021). As children grow, nutrition impacts their brain development and other signals of brain health. For example, poor nutrition is known to have a significant negative effect on children's school performance (Jamison, 1986; Sorhaindo & Feinstein, 2021). Among aging populations, there is a link between nutrition and cognitive function that suggests that eating well is a key aspect of preventing cognitive decline and disorders such as Alzheimer's disease (Allès et al., 2012).

In recent years, a new field, called nutritional psychiatry, has emerged that stresses the importance of nutrition for mental health (Adan et al., 2019). Nutritional psychiatry seeks to improve the mental health of individuals and the population by improving the nutritional quality of their diet. Studies in the field have also provided

evidence of the negative impact of poor diet on mood and mental health (O'Neil et al., 2014). Ensuring food and nutritional security is consequently vital to boosting Brain Capital.

Brain Capital Drivers Dimensions: Health Services and Public Policies

In the face of compounding crises, governments and international institutions are becoming increasingly aware of the need to ensure that all people have access to effective health services without financial hardship (Institute for Health Metrics and Evaluation (IHME), 2023). The COVID-19 pandemic and the effects of climate change have highlighted the importance of adequately preparing health systems to respond to shocks in an equitable manner. Financial risk protection through government health and private health financing services are key to preventing medical impoverishment. Providing efficient access to health care acts as a preventative measure against deterioration in brain and physical health.

Improving access to health services and having thoughtful health policies is key to the achievement and maintenance of Brain Capital. The Brain Capital Dashboard therefore monitors each country's financial dedication to public health services and the ease of access to services for the citizens, both for treatment and for prevention of disease.

In addition to increased spending, authorities can actively inform people and implement policies and programs promoting lifestyles that positively impact brain health and disincentivize those with negative impacts. A lack of corruption and perceived corruption is also important for the public to be able to avail of health services from the state.

Brain Capital Drivers Dimensions: Natural Environment and Climate

It is largely recognized that the brain is positively impacted by the presence of green and blue spaces. Systematic reviews demonstrate that most green and blue spaces yield positive effects on both short-term and long-term mental health outcomes (Braubach et al., 2021). The authors observed a reduction in perceived stress and decreased severity of symptoms from mental disorders (Ibid.). Green spaces have also been found to positively impact early childhood neurodevelopment (Liao et al., 2019) and lower the risk of cognitive impairment in later life (Besser, 2021). As a result, providing fair access to green and blue spaces is an effective tool that governments may use to boost Brain Capital.

Unfortunately, the impact of the natural environment isn't always beneficial to the accumulation of Brain Capital, especially with regard to pollution and climate change. In past years the effects of climate change have become increasingly severe, from rising temperatures to extreme weather events. An effort is being made to understand the link between climate change and brain development. Information is available on how pollution alters the course of brain development (Brockmeyer & d'Angiulli, 2016). However, more research is needed regarding the impact of climate change on mental health.

Climate change poses a significant threat to mental health and the psychosocial well-being of all people impacted (Pörtner et al., 2022). The 2022 report of the Lancet Countdown shows health harms of extreme heat exposure are rising, affecting mental health, undermining the capacity to work and exercise, and resulting in annual heat-related deaths in older people (Romanello et al., 2022). While more frequent and extreme weather events are increasingly affecting physical and mental health directly and indirectly, with economic losses, particularly in vulnerable countries where losses are mostly uninsured, the risk of infectious disease outbreaks and global food insecurity is exacerbated (Ibid.). The term 'eco-anxiety' was coined to describe the increase in stress, anxiety, depression, grief, feelings of loss, tension in social relations, substance abuse, and post-traumatic stress disorders related to climate change (Coffey et al., 2021). Considering this body of evidence, climate change mitigation is a key aspect of boosting and preserving Brain Capital.

Brain Capital Drivers Dimensions: Cultural Environment

Similar to the presence of green and blue spaces, access to art and culture has a positive association with well-being. Exposure to art and culture impacts physical and mental health through multiple channels (Fancourt & Finn, 2019). First, the channel of prevention where the arts may be used to address social determinants of

health, support child development, encourage health-promoting behaviors, help to prevent ill health, and support caregiving. Second, the channels of treatment and management where arts and culture help people experiencing mental illness, support care for people with acute conditions, help to support people with neurodevelopmental and neurological disorders, assist with the management of non-communicable diseases and support end-of-life care.

There is strong evidence that music has a role in supporting social and cognitive development in infants (i.e. increasing infant attention, and supporting speech and language in infants) and that other arts activities play a role in the social development of children (Fancourt et al., 2020). Arts are related to an increase in prosocial behavior, reducing aggression and discrimination, and improving well-being overall at all ages, increasing pleasure ("hedonia"), flourishing ("eudemonia"), and quality of life (Ibid.). There is also strong evidence for the benefits of arts engagement for cognition in older age, including memory and executive function. Studies suggest arts can reduce physical decline in older adults, including improving gait, strength, and balance, while also improving cognition in older age (Ibid.).

It is evident that art, music, and culture have a positive role in the accumulation of Brain Capital. Access to these services should therefore be a priority for policy makers. However, improving access to cultural services involves more than increasing the quantity available. Policies and funding need to specifically address inequality in access. A recent study in Spain found that both education and income-related variables are important determinants of cultural event attendance (Muñiz et al., 2017). If the use of cultural services is unequal, then the opportunity to experience the positive effects for brain development and resilience and unequal as well.

Brain Capital Drivers Dimensions: Social Conditions

How society is organized has important implications for the brain health of the population. In particular, the presence of inequality in wealth, education, and opportunities gives way to further inequality in brain health and development (e.g., see National Academies of Sciences, 2021). Those with more resources may engage in activities (e.g., high-quality education, exposure to arts and culture, and close access to green and blue spaces) that support the accumulation of Brain Capital. Policies that decrease all types of inequality and improve access to opportunities to build resilience against cognitive decline and other brain issues are therefore imperative.

Researchers have gathered evidence of this phenomenon across several different types of inequality and conditions in the home. For example, relative poverty and early life exposure to intimate partner violence show direct and indirect effects on the development of emotional, behavioral, and psychiatric problems (Mueller & Tronick, 2019; Murali & Oyebode, 2004). Similarly, the material and social resources that a child grows up with were found to be one of the strongest predictors of lifelong well-being (Tooley et al., 2021). Additionally, studies have shown that the adverse effects of air pollution are exacerbated among those with low socio-economic status (Wang et al., 2020). This suggests that the most vulnerable populations are more likely to be the most constrained to Brain Capital development.

Other key components of the social conditions of a society are the norms around social support, trust, and connectedness. Having relationships and support from a social network is important for brain health at all stages of the life cycle. Creating and maintaining social connections aids neurodevelopment, enables the brain to stay healthy, and reduces the risk of brain disorders (Shankar et al., 2013). For aging populations, social connections are particularly important in preventing cognitive decline and the development of dementia (Brayne et al., 2010; National Academies of Sciences, 2021b; Shankar et al., 2013). In addition to having social connections, communities with high levels of trust are generally much more resilient to social, economic, and environmental crises. Trust and cooperative social norms facilitate rapid and cooperative responses to crises and improve the happiness and overall well-being of citizens (Helliwell et al., 2023). Therefore, fostering societies with strong social relationships and trust is an important part of creating a brain-healthy society.

Brain Capital Drivers Dimensions: Education

Education is essential for the accumulation of Brain Capital as it plays a pivotal role in brain development throughout the entire life cycle. From early childhood to old age, education enables individuals to engage in a rapidly changing world. For children, offering accessible and stimulating education that encourages creativity is

vital for neurodevelopment (Yoshikawa et al., 2013). Additionally, adults need to participate in lifelong learning to keep the brain engaged and adaptable to all of life's challenges.

For policymakers, ensuring equal education opportunities should be a top priority. This is because education is often a determining factor in individual outcomes, including brain health. For example, the level of education of parents has a great impact on the development of a child and therefore future adult brain development. With more education, parents are more equipped to provide early childcare that favors healthy brain development (Currie & Stabile, 2003). A higher level of education is also associated with a lower risk of developing dementia (Brayne et al., 2010). Providing equal access to quality education is consequently critical to support the conservation and development of Brain Capital throughout the generations.

Brain Capital Drivers Dimensions: Digitalization

The digital revolution has brought technology into almost all aspects of life, including human health. Social media, education, employment, and health care are being transformed by the new tools available. Rising digitalization has both positive and negative implications for the accumulation of Brain Capital. Evidence of the impact of digitalization on brain function and behavior is mixed.

Some experts have found evidence of a potential increase in attention-deficit symptoms, impaired emotional and social intelligence, and delays in brain development linked to extensive screen time and technology use (Small et al., 2022). Others have demonstrated that certain digital tools have a positive impact on memory development, multitasking skills development, fluid intelligence, and other cognitive abilities development (Ibid.). Some technological advances are directly improving individuals' ability to monitor blood pressure, deal with depression, and improve nutrition and exercise habits, namely through the use of mobile applications (Aitken & Nass, 2021). This may constitute a major positive increase in instruments allowing for an easy improvement and monitoring of Brain Capital factors over the lifecycle. Conversely, there is a wide body of evidence demonstrating the harmful effect of social media on mental health, in particular for the youth population (Abi-Jaoude et al., 2020; Bashir & Bhat, 2016).

More empirical work is needed to better understand the mechanisms and causal relationships between digital tools and brain functioning. In the meantime, the Brain Capital Dashboard contains indicators capturing the rate of digitalization and access to the internet worldwide. As a result of the COVID-19 pandemic, digital tools held increased importance in learning, not only for remote learning but also for providing new types of educational programs. Unequal access to digital technologies generates inequality in access and quality of education which negatively impacts Brain Capital formation and accumulation during the lifecycle.

Pillar 2 of the Brain Capital Dashboard (BCD): Brain Health

A central component of Brain Capital is achieving the brain health of the population at scale. Brain health refers to, "the preservation of optimal brain integrity and mental and cognitive function and the absence of the overt neurological disorders" (Wang et al., 2020). However, there is a lack of understanding about what optimal brain health is and how to promote it (Wang et al., 2020). This pillar aims to pave the way for the identification of key dimensions to monitor it. The dimensions identified below seek to capture the presence of healthy brains across all stages of the life cycle.

The indicators included for each dimension in the Brain Capital Dashboard are available in Appendix 4.

Brain Health Dimensions: Brain Disorders

The dimension of brain disorders encompasses both mental and neurological disorders. The National Institute of Mental Health (2023b) defines Any Mental Illness (AMI) as a mental, behavioral, or emotional disorder that can vary from no impairment to severe impairments; on the extreme, there are Serious Mental Illnesses (SMI) considered a mental, behavioral or emotional disorder impacting via serious functional impairment substantially interfering or limiting major life activities. The World Health Organization (2016) defines neurological disorders as a set of disorders including epilepsy, Alzheimer's disease and other dementias, cerebrovascular diseases, multiple sclerosis, Parkinson's disease, neuro infections, brain tumors, traumatic disorders of the nervous

system, and malnutrition-related conditions. The presence of AMI, SMI, or other neurologic disorders limits resiliency and the building of healthy societies over the lifespan.

Mental illness, cognitive impairment, and neurological disorders are becoming increasingly prevalent globally. Between 1990 and 2016 the absolute number of deaths from all neurological disorders combined increased by approximately 40 percent (Feigin et al., 2019). There are a number of reasons why this increase may be occurring along with a higher prevalence of mental health issues. Recent studies have examined the rise of social media, the COVID-19 pandemic, and societal trends that have resulted in smaller family units and less community involvement as contributing factors (Occhipinti et al., 2023; Smith et al., 2021, 2022). Other more established causes include adverse childhood experiences (ACEs), alcohol or drug use, biological factors, genetic factors (including family history), experiences from having medical conditions such as cancer or diabetes, identity issues, significant life changes (like becoming a parent or losing a job), traumatic brain injuries (TBIs), traumatic experiences, and women's health concerns (such as infertility, menopause, the postpartum period, and pregnancy) (Occhipinti et al., 2023; Röhr et al., 2022). Better diagnostic systems and procedures may have played a role in the increase in the number of people being diagnosed with mental and brain disorders. For example, improved diagnostic procedures have led to better identification of mental disorders in children and adolescents, who were previously underdiagnosed (Merten et al., 2017). However, some experts disagree that diagnostic advances have included rates of diagnosis (D. J. Stein et al., 2022).

The absence of neurological disorders and the prevention, treatment, and remission of AMI and SMIs contribute to the well-being of people and society. Helping the brain avoid or manage disorders allows the brain's capacity to develop and to be resilient over time, contributing to the well-being of people and society. This dimension aims at mapping and monitoring some of the key brain diseases among the most widespread globally. The Brain Capital Dashboard incorporates trends in the prevalence of mental and neurological disorders including depression, Alzheimer's disease and other dementias, Parkinson's disease, multiple sclerosis, schizophrenia, stroke, motor neuron disease, bipolar disorder, autism, anxiety disorders, brain and central nervous system cancer, and idiopathic epilepsy. This data is principally sourced from the Institute for Health Metrics and Evaluation (IHME) Global Burden of Disease (GBD) study.

Brain Capital Heath Dimensions: Healthy Brain Functioning

The dimension of Healthy Brain Functioning aims to monitor the "positive" part of the Brain Health pillar. It counterbalances brain disorders by trying to represent signals of good brain health for the population at large. In some ways, signs of healthy brain functioning are less tangible than unhealthy functioning. Data, in particular, are more widely available for the presence of disorders. As the Brain Capital Dashboard evolves, the Working Group hopes to devise a novel approach to measuring healthy brain functioning at scale.

One sign of healthy brain functioning that could be incorporated into the dashboard is perceived control. Some studies reveal that the level of freedom of choice and locus of control (LOC) can predict life satisfaction better than other factors (i.e. health, employment, income, marriage, or religion, across countries and within countries) (Verme, 2009). While freedom of choice is quite intuitive and more related to societal components, LOC is strictly related to brain functioning. The locus of control refers to the extent to which an individual believes they are in control of the things that happen to them (Goddard, 2012). Having a more external LOC, which is commonly associated with anxiety and depression, leaves individuals more vulnerable to physical illness (Ibid.). Even though LOC is difficult to measure, the Working Group is investigating possible indicators to account for it under this dimension.

Other factors that may capture healthy brain functioning are closely connected with the cognitive sphere, which is the focus of the third pillar of the Brain Capital Dashboard. First, sleep patterns, or the maintenance of regular and restorative sleep, support cognitive functioning and overall well-being (Golombek et al., 2023). Second, neurochemical balance factors are crucial in guaranteeing the proper regulation of neurotransmitters and hormones that influence mood, motivation, and other cognitive processes (Teleanu et al., 2022). There are some vital signs such as heart rate, pulse oxygenation, and blood pressure that are considered essential to monitoring the health of the body system. However, there are very few vital signs identified for the brain (Ghosh Hajra et al., 2016) beyond patient health questionnaires and concussion baseline testing. Overall, more research is required to better understand how to monitor healthy brain functioning.

Pillar 3 of the Brain Capital Dashboard (BCD): Brain Skills

The final pillar of the Brain Capital dashboard seeks to monitor the key skills that indicate a well-functioning brain. Strong brain skills provide individuals and societies the ability to adapt to the accelerating global environment of social, political, and economic change. Central to this adaptation are the brain processes orchestrated by the prefrontal cortex for dealing with the external world, including goal setting, goal implementation, innovative thinking and creativity, attentional focus, problem-solving, and strategic memory (Friedman & Robbins, 2022). Equally as important are the processes for dealing with the internal world including emotional control, self-awareness, behavioral control, and executive function. Additionally, the skills for interacting with other people, such as empathy, the ability to read other's emotions, and social judgment (tact), are vital for social function. Honing each of these brain processes is essential for people to flourish in their social spheres and the workplace.

The Brain Skills component of the Brain Capital Dashboard is composed of two dimensions: Cognitive Skills and Non-Cognitive Skills. While most of the literature until recent decades was focused on cognitive skills, there is now evidence being gathered showing the capacity of non-cognitive skills (i.e. perseverance) to predict future outcomes in life (e.g., future income), and even better than classical cognitive skills measures (i.e. IQ) (Coneus et al., 2012; Kautz et al., 2014).

The indicators included for each dimension of Brain Skills in the Brain Capital Dashboard are available in Appendix 4.

Brain Capital Skills Dimensions: Cognitive skills

The American Psychology Association defines cognitive intelligence as one's abilities to learn, remember, reason, solve problems, and make sound judgments, particularly as contrasted with emotional intelligence.[2] Cognitive abilities are those skills involved in performing the tasks associated with perception, learning, memory, understanding, awareness, reasoning, judgment, intuition, and language (APA, 2023).

Cognitive skills are vital for Brain Capital development over the life course. Studies have revealed that early years are a sensitive period for cognitive skills (Kautz et al., 2014). Nevertheless, skill development is a dynamic process both for cognitive and non-cognitive skills, therefore requiring monitoring for the entire lifecycle. The indicators selected for this dimension aim at providing a monitoring of the trends in cognitive skills at the early and latest stages of life globally. While there is still a lack of data available on cognitive skills, there are many more indicators accessible than that of non-cognitive skills.

Brain Capital Skills Dimensions: Non-cognitive Skills

Non-cognitive skills refer to "soft skills" related to motivation, integrity, and interpersonal interaction, associated with an individual's personality, temperament, and attitudes. Examples of non-cognitive skills include perseverance ("grit"), conscientiousness, self-control, trust, attentiveness, self-esteem and self-efficacy, resilience to adversity, openness to experience, empathy, humility, tolerance of diverse opinions, and the ability to engage productively in society. All of these skills are highly valued in the labor market, in school, and in society at large (Kautz et al., 2014).

[2] The same source defines emotional intelligence a type of intelligence that involves the ability to process emotional information and use it in reasoning and other cognitive activities, proposed by U.S. psychologists Peter Salovey and John D. Mayer. According to Mayer and Salovey's 1997 model, it comprises four abilities: to perceive and appraise emotions accurately; to access and evoke emotions when they facilitate cognition; to comprehend emotional language and make use of emotional information; and to regulate one's own and others' emotions to promote growth and well-being. Their ideas were popularized in a best-selling book by U.S. psychologist and science journalist Daniel J. Goleman, who also altered the definition to include many personality variables.

Soft skills are malleable longer into the life cycle than cognitive ones and can be obtained into middle and old age (Heckman & Kautz, 2012). Achievement tests often fail to adequately capture non-cognitive skills (Ibid.). However, it is valuable to find ways to measure these skills as they are important tools to develop for societal well-being.

While non-cognitive skills are not easy to measure there are an increasing number of projects and initiatives aimed at better understanding and collecting data on non-cognitive skills. A relatively well-accepted taxonomy of non-cognitive skills is the Big Five, with the acronym OCEAN, which stands for Openness to Experience, Conscientiousness, Extraversion, Agreeableness, and Neuroticism. Samuel Gosling, a professor at the University of Texas has been collecting personality test data (specifically the Big 5 personality traits) online for around 20 years (Gosling et al., 2003). Another example is the SAPA Project, from Northwestern University, which is a collaborative research tool for studying patterns of human behavior among the vast number of ways that people differ from one another in terms of their thoughts, feelings, interests, abilities, desires, values, and preferences. They score participants based on the 27 personality dimensions that were identified through statistical analyses of 300,000 SAPA participants, then further score participants based on the Big Five factors of personality plus an overall cognition score (Kajonius & Mac Giolla, 2017). Data from these projects is not included in the Brain Capital Dashboard as the sampling methods are not representative (too small samples or self-selection in the case of the Personality Project).

While data collection and understanding of non-cognitive skills is progressing, the availability of quality data at the global level remains scarce. Some recent works are trying to analyze the cross-country dimension but with a lot of limitations in methodologies used and limited geographical coverage, particularly for what concerns developing countries (Danon et al., 2023; Kajonius & Mac Giolla, 2017).

The Future of Brain Capital

Frontier Data Points for Future Versions of the Global Brain Capital Dashboard

There is a wide range of frontier data points and biomarkers that could be used in future versions of the Global Brain Capital Dashboard. The data points and sources chosen for the Dashboard presented in this paper were used due to feasibility (cost, accessibility, and ease of use). Other more time-intensive but cost-effective strategies could be employed in the future. For example, search engine data has demonstrated potential for predicting the prevalence of anxiety disorders at the country level (Gilbert et al., 2023). Advances in science and medicine may soon offer more data available on the impact of different environments on the brain. For instance, low-field strength MRI scanners have shown a capacity for assessing early childhood brain development in low and middle-income settings (Deoni et al., 2021; Wolfson, 2022).

A Yearly Monitor for Global Brain Capital Data

Advancing Brain Capital into policy discussions will involve a carefully orchestrated approach to convening stakeholders, receiving feedback on optimizing Brain Capital data collection, and funding future activities. A yearly 'monitor' process will be established to convene experts from international organizations, regional development banks, think tanks, and other interest groups (such as professional organizations like mental health professional associations). This monitoring process will allow for incremental improvements to Brain Capital and ensure it maps to policy priorities. For example, the recent G7 communique in Hiroshima highlighted that there are new lenses for thinking about these problems that focus on industrial strategy, more resilience rather than efficient trading and investment arrangements, and increased use of government intervention in strategic sectors to counter Chinese leadership, military or otherwise (The White House, 2023). All of this has meant that 'economic security' is now a top priority for Western nations. Our coauthors recently published a Policy Brief via Rice University's Baker Institute for Public Policy to explore linkages between Brain Capital and economic security (Hynes et al., 2023). This now requires further primary data analysis. Other policy innovations we have explored are outlined in Appendix 2 and would benefit from mapping to the Global Brain Capital Dashboard to track the outcome of interventions over time. The development of country-level dashboards will also aid in tracking the outcomes of national-level interventions over time.

The Challenge of a Brain Capital Index

It is enticing to aggregate Global Brain Capital Dashboard indicators into a single index, to afford for national ranking of countries and a competitive 'league table' of sorts. However, this is highly complex and challenging (Graham et al., 2022). The many components are independently important and have different weights in different countries' desired outcomes. In contrast, the literature on the social determinants of health treats its variables of interest as separate if interlinked components in a complex process (Ibid.). That also allows us to distinguish between factors that tend to operate the same way among whole populations and those that differ significantly across races, genders, and other traits. Two countries with identical Brain Capital Driver scores, for example, may be very different because one has high (- i.e., bad) scores on racism, migration, and poverty whereas another has high scores on social disconnection, early life trauma, and cannabis use. They will need markedly different intervention approaches.

Conclusion

The Global Dashboard presented here will monitor key indicators for each dimension on a country level and provide information about Brain Capital. The dashboard is seen as an instrument for creating general awareness at more levels for all the stakeholders: citizens, businesses, entrepreneurs, and governments. In particular, the dashboard could function as an instrument for building informed policies aimed at Brain Capital formation and development. Indeed, we believe that policies play a central role in impacting the drivers, possibly enhancing boosters and counterbalancing impediments.

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Appendix

Appendix 1: Brain Capital Challenges and Opportunities

Mental Health:

Challenges:

- Mental health disorders alone are estimated to cost the global economy $5 trillion per year, and this is projected to rise to $16 trillion by 2030.
- New CDC data shows US suicide deaths reached record highs in 2022.
- There is a global shortfall in investment in mental health. The WHO Mental Health Atlas showed that in 2020, global governments spent on average just over 2% of their health budgets on mental health.
- The biomedical industry (i.e., manufacturers, producers, and sellers of drugs, diagnostics, and early detection and preventive products) is only addressing 10% of all human maladies — those that generate maximum profits. Mental health solutions rank at the bottom of all health indications being invested in worldwide.
- By 2030, the economic burden of mental disorders will be similar to cardiovascular disease and higher than cancer, chronic respiratory disease, and diabetes.
- One-third of chronic physical illnesses are associated with mental illness comorbidity.
- The COVID-19 pandemic exacerbated mental health problems, leading to an increase in the global prevalence of major depressive disorder by 27.6%, and anxiety disorders by 25.6%.
- People with mental disorders have an increased risk of physical conditions, suicide, unemployment, reduced productivity, and poverty.
- 75% of mental illnesses have their onset during childhood and adolescence, and therefore, impact the sufferers and their families for several more decades than physical illnesses that typically begin in later life.
- In Sept. 2022, the U.S. Congress Joint Economic Committee (JEC) — led by Chairman Don Beyer (D-VA) — released a new analysis that finds the opioid epidemic will cost the United States a record of nearly $1.5 trillion in 2020. This is up 37% from 2017, when the CDC last measured the cost.

Opportunities:

- Four of the six priorities of the U.S. Surgeon General relate to mental health (i.e., social connection, youth mental health, workplace well-being, and health worker burnout).
- In 2023, the White House announced a major Report on Mental Health Research Priorities.
- The European Commission recently announced the European Mental Health Initiative and committed $1.3 billion.
- There is a burgeoning mental health venture capital industry searching for scalable mental health solutions. However, the traditional VC model drives profits over health outcomes, such that investments are not likely to generate a future of effective mental health solutions.

Neurology:

Challenges:

- According to the World Health Organization, every year, dementia costs the global economy more than $1.3 trillion and is predicted to increase to $2.8 trillion by 2030.
- People who contracted COVID-19 and experienced mild to severe symptoms (including those who were and were not hospitalized), have experienced challenges with attention, memory, and executive functioning.
- According to the American Heart Association, stroke is the fifth leading cause of death in the U.S. and the leading cause of serious long-term disability. Hospitalizations for acute ischemic stroke are increasing among younger adults 18 to 54 years of age. From 1995 to 2012, hospitalization rates almost doubled for males 18 to 44 years of age. The global age-standardized prevalence of stroke increased by 2% from 2010 to 2020.
- Between 2015 and 2035, total direct medical stroke-related costs are projected to more than double from $36.7 billion to $94.3 billion, with much of the projected increase in costs arising from those 80 years of age or older.

Opportunities:

- The G7 Hiroshima Leaders' Communique recommitted to promoting policies and resources to care for people living with dementia and welcomed the development of potentially disease-modifying therapies for the various types of dementia, including Alzheimer's disease. It is committed to sharing efforts for early detection, promoting healthy aging, implementing care pathways, and strengthening primary care.
- In 2022, the World Health Assembly endorsed the Intersectoral Global Action Plan on Epilepsy and Other Neurological Disorders 2022–2031 to reduce the stigma, impact, and burden of neurological disorders, including their associated mortality, morbidity, and disability, and to improve the quality of life of people with neurological disorders.
- The Alzheimer's Association's Factors and Figures 2023 report notes that the incidence rate of Alzheimer's appears to have declined in the last decade or so. This decline in incidence has been attributed to improvements over the 20th century in Alzheimer's risk factors, such as increased prevention and treatment of hypertension and greater educational attainment.
- The U.S. Department of Health and Human Services announced the formation of the Office of Long COVID Research and Practice to lead the federal government's response to long COVID.

Education:

Challenges:

- 65% of young people reported having learned less since the beginning of the COVID-19 pandemic.
- K-12 school districts serving predominantly lower-income communities receive 7% less funding compared to school districts serving higher-income communities; as an example, this can result in a funding gap of $5 million for a school district with 5,000 students.
- Compared to 25 years ago, the gap in standardized test scores for students from low-income versus high-income families has now become 40% larger.
- Recent results from the National Assessment of Educational Progress (NAEP) showed historic declines in American students' knowledge and skills and widening gaps between the highest- and lowest-scoring students.
- The rapid advent of advanced AI technologies is impacting learning curves and brain functioning in ways that are yet to be explored and defined.
- The Varying Degrees 2022: New America's Sixth Annual Survey on Higher Educati--on noted the share of Americans who believe colleges and universities have a positive impact on the country has dropped by 14 percentage points since 2020.

Opportunities:

- "Averting a Lost COVID Generation" was the first UNICEF report to comprehensively outline the dire and growing consequences for children as the pandemic drags on. It shows that while symptoms among infected children remain mild, infections are rising and the longer-term impact on the education, nutrition, and well-being of an entire generation of children and young people can be life-altering.
- Integrating technology into classrooms has shown significant improvements in students' learning outcomes and equips them with essential career skills.

- Interdisciplinary teaching has been linked to improvements in cognitive development, specifically affecting students' abilities to recognize bias, think critically, embrace ambiguity, and reflect on ethical concerns.

Workforce:

Challenges:

- COVID-19-related educational disruptions could result in this generation losing $17 trillion in lifetime wages, impacting the future United States economy.
- The World Economic Forum's Future of Jobs Report 2023 noted the top three core skills for modern workers as 1) analytical thinking, 2) creative thinking, and 3) resilience, flexibility, and agility.
- Employment and workforce readiness is an important medium for social inclusion and well-being, illustrated by its prominence in the United Nations Sustainable Development Goals, the International Labour Organisation's Decent Work Agenda, and the European Pillar of Social Rights.
- It is predicted that by 2030 the equivalent of more than 2% of all total working hours globally will be lost each year. This is due to it being too hot to work or having to work at a slower pace due to climate change, as predicted by the International Labor Organization's recent report on Working on a Warmer Plant.
- The U.S. Department of Energy Jobs Report found that the energy workforce has steadily increased, outpacing the growth rate of the overall U.S. workforce. There is a major demand for closing emerging skills gaps, reskilling, upskilling workers, and improving training and education in K-12 as demand for green talent is outstripping supply.

Opportunities:

- Workplace well-being is a key priority of the U.S. Surgeon General.
- Workplace mental health is a key focus for many organizations including the Society for Human Resource Managers and the International Stanford Organization.
- The U.S. Federal Government Executive Order on Advancing Diversity, Equity, Inclusion, and Accessibility underscores the linkage and importance between DEI and mental health in workforce development.
- A circular future and cleaner energy transition requires access to a diverse workforce with a variety of skills in alternative energy, waste management, and resource recovery that not only seeks to protect the rights of the workforce but also offers opportunities to communities. The transition to the circular economy presents an opportunity to redefine work and reimagine how resources are valued, including labor.

Appendix 2: Brain Capital-related policy activities and innovations

Brain Capital integration into high-level public sector reports:

- UNDP Human Development Report 2022
- WHO Brain Health Position Statement 2022
- OECD Book Chapter 2023
- UNGA Science Summit 77 2022

Brain Capital integration into high-level events:

- United Nations Climate Change Conference COP 27 2022
- FENS Forum 2022
- NGO Committee on Aging, United Nations, NYC 2023
- Center for European Policy Studies 2022
- Presentation to the US House Select Committee on Economic Disparity and Fairness in Growth 2021
- Presentation to the Congressional Neuroscience Caucus 2022

Brain Capital integration into high-level private sector reports:

- Lundbeck Brain Health Position Statement 2022
- HKS Architects 2023
- Price Waterhouse Coopers 2022

- Chief Finance International 2022
- AARP via Nature Aging 2023
- National Innovation Center for Ageing 2022

Policy Innovation in Specific Sectors:

- Food and Nutrition: Research has linked ultra-processed food consumption to health problems like obesity, cardiovascular disease, diabetes, and cancers, and we are now just starting to realize how these foods affect the mind. Ultra-processed foods cause inflammation, which can affect healthy neural pathways in the brain. According to a recent research paper, today's food environments and food systems around the world are dominated by the corporate-industrial food industry, which is undermining brain capital and therefore sustainable human development and public health on a global scale. There are several recommendations for reforming the industrialized food system to build brain health — these range from transforming the food system through public policy to reforming clinical care to defending against misinformation driven by the food industry, engaging the brain health field in a "Global Plastics Treaty," and converging planetary and brain health.
- Sustainability: Sustainability issues are a major contemporary global concern for our century and our generation, predicated on a complex set of inseparable and interconnected environmental, societal, and economic problems. Strategies to date have been slow to effect change toward environmentally constructive, science-based sustainable, or "green" approaches and, for the most part, have proven inadequate. This, in part, stems from their failure to account for individual and collective human psychology, particularly through understanding the drivers and motivations underpinning human behavior. The Green Brain Capital model corresponds to a sustainability-focused type of brain capital. Green brain capital is underpinned by brain health, environmental determinants of brain health, green skills, creativity infrastructure, ecological intelligence, and digital literacy. Green brain capital intends to be politically pragmatic, economically aware, and lifespan-focused. Growing green brain capital will require transformations across hierarchical levels in social-ecological systems, ranging from individuals to populations to entire societies.
- Built environment: The cities and buildings we live in are often not conducive to physical or mental fitness. Simple principles like daylight, air quality, acoustics, access to nature, accessible sidewalks, walkable/bikeable neighborhoods, opportunities for social connection, and access to housing, health care, arts, and other amenities, can go a long way to develop a health-built environment. When layered with the right digital infrastructure, this can set communities up for harnessing brain capital. The convergence of emerging digital technologies with those in the physical and biological spheres could play a central role in enabling a sustainable circular economy. Additionally, building systems have the incredible potential to leverage AI to learn and respond to human needs and balance them against climate objectives. The question is, how do we maximize the value of data, optimize the use of mobile telecommunications and cloud computing, and bring the Internet of things (IoT) to life? Effectively, IoT represents the systems that will enable sensors deployed across various built environment systems and equipment to speak to one another using AI and machine learning, increasing both the volume and velocity of data movement and creating new opportunities to interconnect physical and brain operations.
- Foreign: Brain Health Diplomacy (BHD) is an approach to mitigate the complex threats to brain health at an individual, community, national, and international level. BHD aims to influence the global policy environment for brain health (i.e., dementia, depression, and other mind/brain disorders) and bridges the disciplines of global brain health, international affairs, management, law, and economics. BHD builds on existing theoretical frameworks such as health diplomacy and science diplomacy to improve global brain health. A Brain Health Diplomat Toolkit for Latin America and the Caribbean was launched in 2023.
- Industrial: The brain capital industrial strategy — outlined in detail in a recent paper published by Rice University's Baker Institute for Public Policy -— is a public sector strategy that focuses on building economic resilience through an emphasis on cultivating citizens' brain health and brain skills to contribute to an innovative and thriving economy. It is comprised of the following seven core components: Developing and investing in brain capital technologies; Aligning the built environment; Utilizing novel financial incentives and innovations; Ensuring workforce preparedness; Leveraging a mission-oriented approach for brain capital; Articulating supportive policies; Coordinating within government.

- Social infrastructure: Social isolation and loneliness (SIL) are also major contributors to impaired well-being and mental health. The U.S. Surgeon General has emphasized in a recent report the importance of societal approaches to enhancing social connection, with far-ranging consequences for the well-being of the country. Resilience may also benefit from reduced SIL. The report calls out social media among youth as a particular problem and emphasizes six pillars to enhance social connectedness: 1) strengthen social infrastructure in local communities; 2) enact pro-connection public policies; 3) mobilize the health sector; 4) reform digital environments; 5) deepen our knowledge; and 6) cultivate a culture of connection. Others have emphasized the importance of participation in the arts to combat the effects of SIL.
- AI: As noted previously, there's an urgent need to support citizens with a system of digital self-defense. Steps to regulate advanced artificial intelligence and AI-enhanced social media are needed to protect people from AI "hacking" our interpersonal relationships and collective intelligence. Although such technology brings the entire world to our devices and offers ample opportunities for individual and community fulfillment, it can also distort reality and create false illusions. By spreading dis- and misinformation, social media and AI pose a direct challenge to the functioning of our democracies. There's an urgent need to design neuroscience-based policies to support citizens against AI — for example, a "neuro-shield." The neuro-shield would involve a threefold approach: 1) developing a code of conduct with respect to information objectivity, 2) implementing regulatory protections, and 3) creating an educational toolkit for citizens.
- National security: The paper "From Neuroweapons to 'Neuroshields': Safeguarding Brain Capital for National Security" explores the dangerous potential of neuroweapons and the need for a "Neuroshield" to protect democracies from the risks of mis- and disinformation. The authors also discuss the implications of neural enhancement via brain-computer interfaces and other innovative research agendas related to national security and brain health. They argue that policymakers must develop clear guidelines and policies to protect brain capital and recognize how it can be utilized to enhance national security.
- Economic security: The paper "From Markets to Minds: Brain Capital to Drive Economic Security" discusses the importance of economic security in the West following the disruptions caused by COVID-19, the Russia-Ukraine war, and the growing threat of China. The authors argue that brain capital, or an individual's cognitive, emotional, and social brain resources, will play a central role in strategies to encourage, develop, and adopt innovations on which future economic success will depend. They propose a brain science-inspired industrial strategy that would boost economic resilience by reducing the economic burden of brain and mental disorders while stimulating creativity and entrepreneurship.
- Women's affairs: There is a clear sex and gender gap in outcomes for brain health disorders across the lifespan, with strikingly negative outcomes for women. This understanding calls for a more systematic way of approaching this issue of inequality. Closing the Brain Health Gap will help economies create recovery and prepare our systems for future global shocks. Solutions that include women are more likely to have success and create structural change across sectors, from neuroscience and health care to racial equality, public policy, and workplace norms.
- National governance: The need for a White House Brain Capital Council is driven by the recognition that a country's most valuable asset is its human capital and that investing in education, research and development, and innovation is critical to ensuring that human capital is developed to its fullest potential. The Brain Capital Council would bring together government leaders, industry executives, and academic experts to develop and implement policies that support the growth of human capital and promote long-term economic growth and prosperity. One of the key benefits of a Brain Capital Council is that it would provide a platform for coordination and collaboration across government agencies and departments, as well as between government, industry, and academia. This would help to ensure that policies related to education, research, development, and innovation are aligned and coordinated and that there is a shared understanding of the importance of developing human capital as a driver of economic growth. Another benefit of a Brain Capital Council is that it would provide a forum for identifying and addressing key challenges related to human capital development. This might include issues related to workforce training and education, access to capital for entrepreneurs and small businesses, and barriers to innovation and entrepreneurship. By bringing together experts from government, industry, and academia, the Brain Capital Council would be well-positioned to develop solutions to these challenges and promote policies that support human capital development. In addition to coordination and problem-solving, a Brain Capital Council would also be able to help prioritize investments in education, research and development, and innovation. This would be

particularly important in the context of limited resources and competing demands for government funding. By bringing together diverse perspectives and expertise, the Brain Capital Council would be able to identify the most promising areas for investment and help to ensure that resources are used effectively.

- Public procurement: A brain capital public procurement strategy is essential for creating the future market for innovative products and services in these areas. In line with international best practices in the area of public procurement as the cornerstone of strategic governance documented by the OECD, such a strategy, apart from dedicated sufficient budgets and creating other financial incentives, should define relevant targets, set up the legal framework with user-friendly definitions and templates, provide specific training to build staff capabilities and skills, create competence centers with multidisciplinary teams, build dedicated knowledge-sharing platforms, define standards and certification systems, and undertake the necessary risk management. An active procurement policy, by means of which the government acts as the creator of demand at an early stage of the market creation process, is one of the most effective ways of supporting the rollout of innovation in the brain capital space.

Appendix 3: OECD NIPI/Brain Capital Alliance Global Brain Capital Dashboard Working Group

This multidisciplinary group was tasked with designing, drafting, and launching the Global Brain Capital Dashboard. The authors of this paper acknowledge all the members for the precious comments provided to this paper. The development of the Brain Capital concept and Dashboard has been possible thanks to several workshops and discussions with the Working Group, which is composed as follows.

Working group co-leadership:

- Rym Ayadi PhD, Euro-Mediterranean Economists Association
- Andrew S. Nevin, PwC Nigeria and Center for BrainHealth at The University of Texas at Dallas

Research coordination, dashboard design and data collection:

- Sara Ronco, Researcher at the Euro-Mediterranean Economists Association, and PhD Candidate at the University of Insubria

Research assistance, dashboard design and data collection:

- Elena Stotts-Lee, Junior Researcher at the Euro-Mediterranean Economists Association

Working group members:

- Andy Keller President and CEO, Meadows Mental Health Policy Institute
- Carol Graham Leo Pasvolsky Senior Fellow, Brookings Institution and Meadows Mental Health Policy Institute
- Conal Smith Senior Associate, Institute for Governance and Policy Studies
- Carlo Sessa Research Director, ISISNNOVA
- Ian H. Robertson Co-Director, Global Brain Health Institute
- Erin Smith, Senior Atlantic Fellow for Equity in Brain Health, Global Brain Health Institute
- Harris A. Eyre Lead, Brain Capital Alliance - Co-Lead, OECD Neuroscience-Inspired Policy Institute - Senior Fellow, Meadows Mental Health Policy Institute
- Husseini Manji Global Therapeutic Head for Neuroscience, Janssen Research & Development in Johnson & Johnson
- Jennifer Gonzalez Vice President of Population Health, Meadows Mental Health Policy Institute
- Katelyn Jetelina Director of Population Health Analytics, Meadows Mental Health Policy Institute
- Paweł Świeboda Director General, Human Brain Project - CEO, EBRAINS, Org
- Theo Edmonds Cultural Futurist - Research Associate Professor, University of Colorado Denver
- William Hynes Head, OECD New Approaches to Economic Challenges (NAEC) Unit

- Eric Storch Professor and Vice Chair, Baylor College of Medicine
- Shekhar Saxena Professor of the Practice of Global Mental Health at the Department of Global Health and Population, Havard T. H. Chan School of Public Health
- Igor Linkov Senior Science and Technology Manager, U.S. Army Engineer Research and Development Center (ERDC)

Appendix 4: Provisional list of indicators in the Brain Capital Dashboard

Pillar 1: Brain Capital Drivers			
Dimension	**Indicator**	**Primary Source**	**Access Source**
Prenatal Related Issues	Lifetime risk of maternal death	World Bank	
	Prevalence of malnutrition in women	Global Burden of Disease Collaborative Network	
Food and Nutritional Security	Global Food Security Index - *Overall Score*	Economist Impact	
	Global Food Security Index - *Affordability Score*	Economist Impact	
	Global Food Security Index - *Availability Score*	Economist Impact	
	Global Food Security Index - *Quality and Safety Score*	Economist Impact	
	Global Food Security Index - *Sustainability and Adaptation Score*	Economist Impact	
Health Services and Policies	Current health expenditure (% of GDP)	WHO Global Health Expenditure database	World Bank
	Out-of-pocket expenditure (% of current health expenditure)	WHO Global Health Expenditure database	World Bank
	Expected health spending (per capita)	Global Burden of Disease Collaborative Network	Countdown Mental Health
	Plan or strategy for child and/or adolescent mental health	WHO Mental Health Atlas 2017	Countdown Mental Health
	Presence of a stand-alone policy or plan for mental health	WHO Mental Health Atlas 2017	Countdown Mental Health
	How do the majority of persons with mental disorders pay for psychotropic medicines?	WHO Mental Health Atlas 2017	Countdown Mental Health
	Level of social support from the government for people with mental disorders	WHO Mental Health Atlas 2017	Countdown Mental Health
	Corruption Perception Index	Transparency International	
	Research and development expenditure on health	UNESCO Institute for Statistics	World Health Organization Global Health Observatory
Cultural Environment	Cultural services as a share of	OECD Data	

	total government spending real spending per capita at PPP		
	Total per capita expenditure on the preservation, protection, and conservation of all cultural and natural heritage	UNESCO Institute for Statistics	UN Sustainable Development Goals
	Employment in cultural occupations	UNESCO Institute for Statistics	
	Number of indoor cinemas	UNESCO Institute for Statistics	
	International trade of cultural goods	UNESCO Institute for Statistics	
Social Conditions	Trust - Percentage (%) of people agreeing with the statement, "Most people can be trusted"	World Values Survey	Our World in Data
	Social Support National average of binary responses (YES = 1, NO = 0) to the following question: "If you were in trouble, do you have relatives or friends you can count on to help you whenever you need them, or not?"	Gallup World Poll	World Happiness Report
	Inequality (GINI Coefficient)	World Bank Poverty and Inequality Platform	World Bank
	Multidimensional poverty index	United Nations Development Program (UNDP)	
Education	Total government expenditure on education	UNESCO Institute for Statistics	World Bank
	Participation rate in organized learning (one year before the official primary entry age)	UNESCO Institute for Statistics	World Health Organization Global Health Observatory
	Adult education level (Below upper secondary education, Upper secondary education, and Tertiary education)	OECD Data	
Natural Environment and Climate	The death rate from air pollution	IHME, Global Burden of Disease	Our World in Data
	Annual mean levels of fine particulate matter (e.g., PM2.5 and PM10) in cities	World Health Organization	U.N. Sustainable Development Goals
	Annual surface temperature change	UN Food and Agriculture Organization	IMF Climate Change Dashboard
Digitalization	Individuals using the Internet	International Telecommunication Union (ITU)	World Bank
	School-age digital connectivity (Pre-Primary)	UNICEF	

Pillar 2: Brain Health			
Dimension	**Indicator**	**Primary Source**	**Access Source**
Brain disorders	Suicide rate	IHME, Global Burden of Disease	Our World in Data
	Prevalence of depression	IHME, Global Burden of Disease	Our World in Data
	Idiopathic epilepsy	IHME, Global Burden of Disease	
	Alzheimer's disease and other dementias	IHME, Global Burden of Disease	
	Parkinson's disease	IHME, Global Burden of Disease	
	Multiple sclerosis	IHME, Global Burden of Disease	
	Schizophrenia	IHME, Global Burden of Disease	
	Stroke	IHME, Global Burden of Disease	
	Motor neuron disease	IHME, Global Burden of Disease	
	Bipolar disorder	IHME, Global Burden of Disease	
	Autism spectrum disorders	IHME, Global Burden of Disease	
	Brain and central nervous system cancer	IHME, Global Burden of Disease	
	Anxiety disorders	IHME, Global Burden of Disease	
	Death rate from Alzheimer's	IHME, Global Burden of Disease	Our World in Data
	Prevalence of stunting, in children under 5	UNICEF	World Bank
	Mortality rate, children under 5	UN Inter-agency Group for Child Mortality Estimation	World Bank

Pillar 3: Brain Skills			
Dimension	**Indicator**	**Primary Source**	**Access Source**
Cognitive Skills	Participation rate in organized learning (one year before the official primary entry age)	UNESCO	U.N. Sustainable Development Goals
	Percentage of children who are developmentally on track in at least three of the following domains: literacy-numeracy, physical development, social-	Global Health Observatory	Countdown Mental Health

	emotional development, and learning (%)		
	Are literacy and basic skills a top priority for Adult Learning and Education (ALE) programs in your country?	UNESCO	
	Reading ability at age 15	PISA 2018 Results (Volume I) - © OECD 2019	
	Mathematical ability at age 15	PISA 2018 Results (Volume I) - © OECD 2019	
	Scientific ability at age 15	PISA 2018 Results (Volume I) - © OECD 2019	
Non-cognitive skills	Patent applications	World Intellectual Property Organization	
	Happiness score / subjective well-being	Gallup World Poll	World Happiness Report
	Positive affect	Gallup World Poll	World Happiness Report
	Negative affect	Gallup World Poll	World Happiness Report