# Brain health determinants



#### Safety and security

Physical safety and financial shourty can also insure be an health over the lifecourses in mittgle-ways. Physical safety of the abover of distulpings of the including above mathematics are not reglectional the threat of physical barms increasing safety and safety hashing and safety within the borne and by sadercommunity. Primarate descripty is of metery the above for povers, but also the asserted of make as safety shad to financial concerns; it means that one on insurancially about the encourses or the e-moderage foods social, passing care industrial mis surreport. Both influsional safety and the entitle of faced in production in the safety of the encourse of the encourse of the safety of faced in production of the safety of the faced in the safety of the sa

#### Physical health



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#### **Healthy environments**



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#### Learning and social connection



open-matter for the animality force the file course and overlap in multiple ways; (Lammy metal) life, for industrie, is shall, primorized with seponate and fundaming designing Similars, formal learning value principles and some required sometimes, but in superior commands in vital shiftened in other industries consequent and solven industries in vital shiftened in other industries of consequent and solven interview with communities. Additionally, interviews with previous animality in animality in contrast, the consequence of the contrast of the contrast special properties of the format production contrast contrast production of the format production contrast contrast production of the format production contrast contrast production of the format production contrast contrast production.

#### Access to quality services



Managing many resil factors of brain health will require access to quality that in and social services. Despite basis factors in religions that affects the CEA is some point and elevery the CEA is some point in their libraries. Therefore, access to quality services present an interest libraries. Therefore, access to quality services present and important advantament of brain reside and, sisterity, prompties regulated and social same systems so that they provide explicited access to disciprocultivations, care and enhanced access to disciprocultivations and enhanced access to the care of the c





### **Developmental Population Neuroscience**

发展人口神经科学(个体脑健康与病史)

左西年 (Xi-Nian Zuo)

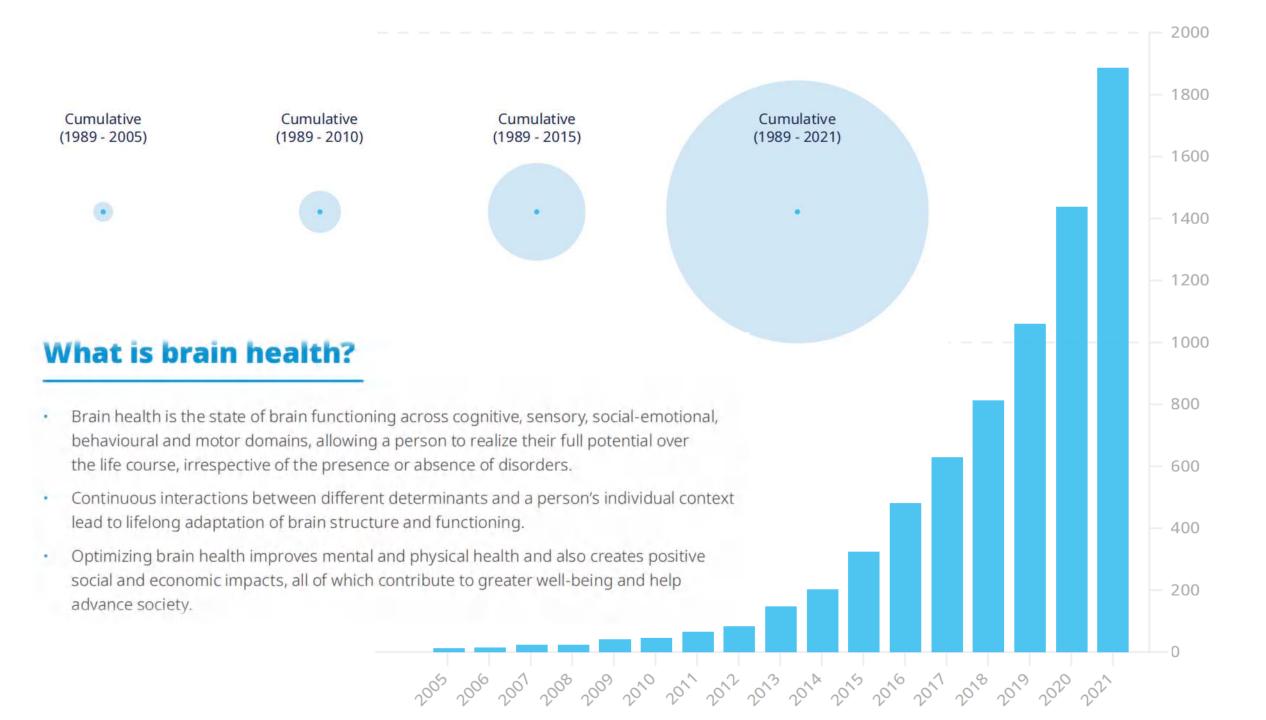
**Beijing Normal University** 

**State Key Lab of Cognitive Neuroscience & Learning** 

**National Basic Science Data Center** 

**Chinese Data-sharing Warehouse for In-vivo Imaging Brain** 





# Why is Brain Health So Important?



Brain health is not only a crucial outcome in and of itself, but also an important mediator for other health and societal outcomes



of children under the age of five in low- and middleincome countries were at risk of not reaching their developmental

potential due to

extreme poverty

and stunting



One in three people globally will develop a neurological disorder at some point in their lifetime

# Key facts and figures on the global need for action on brain health

### **Worldwide, only 15 countries**

report having three essential, family-friendly national policies that provide caregivers with resources and time needed for their child's development (8).





### 2 years

of tuition-free preprimary school education.

#### 6 months

of paid breastfeeding breaks. paternity leave.

#### 6 months

of paid maternity leave and one month of paid



### 85 million children

under the age of 5 globally were not protected by any of these essential policies (8).

### **Nearly 250 million children**

in low- and middle-income countries risk not reaching their developmental potential due to extreme poverty and stunting (6).

### Missed developmental potential

due to poverty and stunting is projected to cause 26% lower annual earnings in adulthood (7).

## Growing environmental threats to brain health¹

- · Air pollution
- Heavy metals
- Certain pesticides
- Industrial solvents
- Other toxic chemicals

### Over 200 chemicals

are known to be neurotoxic.

### Over 200 million

people are exposed to arsenic in their ground water.

99% of the world breathes polluted air (9).

### Global burden associated with brain health

### **Neurological disorders**

are the #1 cause of DALYs. with the biggest contributors being stroke, migraine, dementia, meningitis and epilepsy (10).

Neurological disorders are the second leading cause of death (10).

### Over 70% of people with neurological disorders reside in low- and middle-income countries

Yet, access to services is grossly insufficient.2

### Only 1 in 10

people living with dementia in low-income countries receive a diagnosis.

### Only 1 in 4

people with epilepsy receive treatment.

### Only 1 lowincome country

had warfarin available for stroke prevention compared with 73% of high-income countries.

#### Stroke units

are operational in >90% of high-income countries, compared with only 18% of lowand middle-income countries.

### Distribution of neurological workforce

is grossly uneven. There is 7.1 neurological workforce/100K population in high-income countries vs 0.1/100K in low-income countries.

# Stages of Brain Development across the Life Course







Perinatal Infancy Early Adolescence Early Mid-life Older age period childhood adulthood

# **Disorders Affecting the Central Neural System**

# Common neurological conditions

- Dementia
- Epilepsy
- Headaches disorders
- · Motor neuron disease
- Multiple sclerosis
- · Parkinson disease
- Stroke

### **Injuries**

- · Spinal cord injury
- Traumatic brain injury

### **Tumours**

 Tumours of the nervous system Neurological complications associated with infections

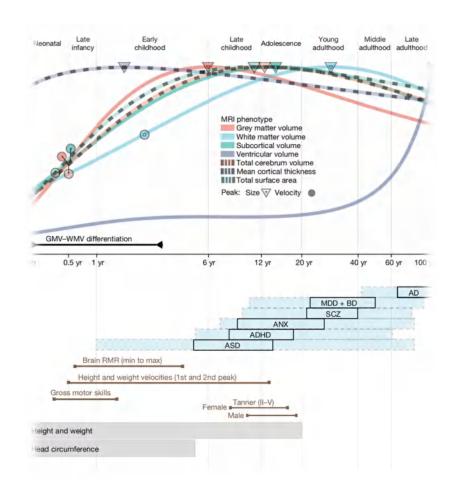
- Cysticercosis
- · COVID-19
- Encephalitis
- · Guillain-Barré syndrome
- · HIV
- · Malaria
- Meningitis
- Rabies
- Syphilis
- Tetanus
- Zika virus

# Neurodevelopmental disorders

- Attention-deficit/hyperactivity disorder
- Autism spectrum disorders
- · Cerebral palsy
- Fetal alcohol syndrome
- Idiopathic developmental intellectual disability

### **Congenital conditions**

- Congenital birth defects
- Down syndrome
- Neural tube defects
- Other genetic defects



# **Brain health determinants**



### Safety and security

Physical safety and financial security can also impact brain health over the life course in multiple ways. Physical safety is the absence of actual physical harm (including abuse, maltreatment and neglect) and the threat of physical harm; it requires stable and safe housing, and safety within the home and broader community. Financial security is not merely the absence of poverty, but also the absence of strain or stress due to financial concerns; it means that one can reasonably afford the necessities of life – including food, housing, health care, education and transport. Both physical safety and financial security can have impacts on individuals and their families, as well as the communities in which people live.

### **Physical health**



A person's physical health and their health behaviours can impact their brain health in innumerable ways across their life course. This is because there are multi-directional interactions between the brain and the body. Important aspects of physical health that influence the brain include: maternal health and the intrauterine environment; genetic and epigenetic factors; nutrition; infections; noncommunicable diseases and sensory impairments; health behaviours (including good-quality sleep, physical activity and substance use); and traumatic injuries.

### **Learning and social connection**



Access to opportunities for learning and social connection are important determinants for brain health across the life course and overlap in multiple ways. Learning in early life, for instance, is closely connected with responsive and nurturing caregiving. Similarly, formal learning relies on schools and other educational institutions, while cognitive stimulation in adulthood is often linked to employment and social networks within communities. Additionally, interventions aimed at optimizing brain health – especially in early life – may involve support for both learning and social connection.

### **Healthy environments**



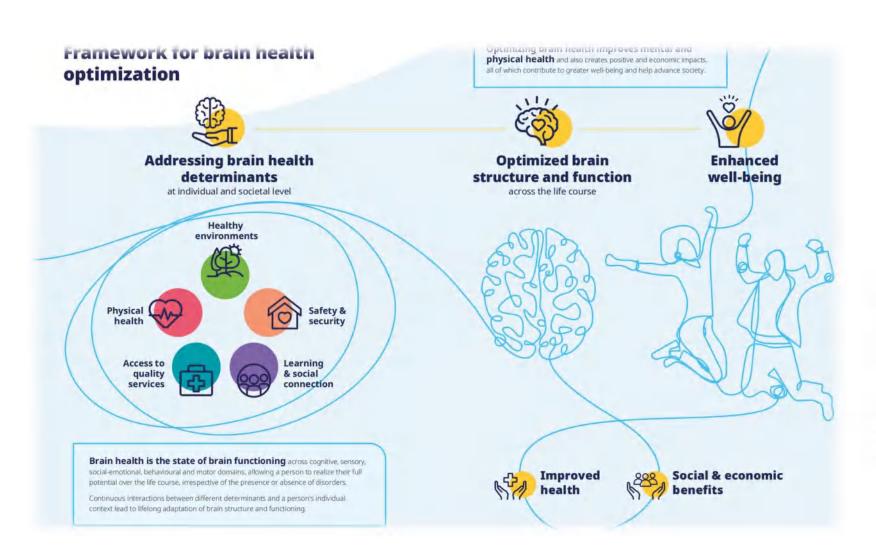
Healthy environments can also have a profound impact on brain health, especially during developmentally sensitive stages such as early childhood, adolescence and older age. There has been increasing information in recent years on environmental factors that affect brain health, including pollutants found in air, water and food. Neurotoxic chemicals include heavy metals and inorganic compounds, pesticides, organic solvents and other organic compounds. In addition, natural disasters (e.g. volcanic eruptions), man-made disasters (e.g. nuclear explosions or chemical spills), climate change contributing to ambient air pollution and increased risk of wildfires threaten the brain health of individuals and society as a whole.

### **Access to quality services**



Managing many risk factors of brain health will require access to quality health and social services. Despite best efforts to minimize risk factors, many people still develop conditions that affect the CNS at some point in their lifetime. Therefore, access to quality services represents an important determinant of brain health and, similarly, strengthening health and social care systems so that they provide equitable access to diagnosis, treatment, care and rehabilitation, as and when needed, is crucial for optimizing brain health for all.

# What is Brain Health Optimization? How?





Optimizing brain health is paramount to ensuring that individuals can achieve their full potential

## Determinants of Brain Health across the Life Course



A child's brain creates over 1 million new neuronal connections each second in the first few years of life













### Physical health

Maternal health, intrauterine environment

Genetic and epigenetic factors

Nutrition

Infections

NCDs

Health behaviours

Traumatic injuries

# Healthy environments

Safe use of chemicals

Protection from radiation

Healthy and safe workplaces and agricultural practices

Air and water quality

Stable climate

Access to preserved nature and health-supportive built environments

# Safety & security

Physical safety

Financial security

Humanitarian crises and emergencies

# Learning & social connection

Education

Lifelong learning

Nurturing care

Social connection/ social isolation Access Social networks

Carer support

### Access to quality services

Integrated care at all health/social care levels

Skilled workforce and Interdisciplinary teams

Access to essential medicines, diagnostics and health products Addressing brain health determinants is a crucial element of brain health optimization



# Physical health

Maternal health, intrauterine environment

Genetic and epigenetic factors

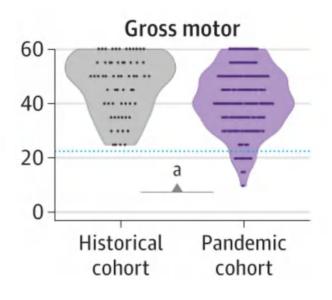
Nutrition

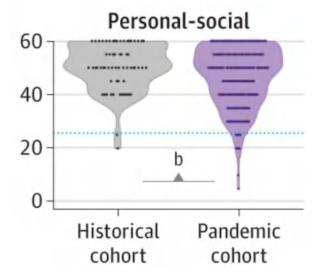
Infections

**NCDs** 

Health behaviours

Traumatic injuries









Original Investigation | Obstetrics and Gynecology

### COVID-19 Pandemic and Infant Neurodevelopmental Impairment A Systematic Review and Meta-analysis

Kamran Hessami, MD; Amir Hossein Norooznezhad, MD; Sonia Monteiro, MD; Enrico R. Barrozo, PhD; Abolfazl Shirdel Abdolmaleki, MD, MPH; Sara E. Arian, MD; Nikan Zargarzadeh, MD; Lara S. Shekerdemian, MD; Kjersti M. Aagaard, MD, PhD; Alireza A. Shamshirsaz, MD

**RESULTS** A total of 8 studies were included, including 21 419 infants (11 438 screened in pandemic and 9981 in prepandemic period). NDI was present in 330 of 8992 infants (7%; 95% CI, 4%-10%) screened during the COVID-19 pandemic from January 2020 to January 2021. Among the pandemic cohort, the prevalence of NDI among infants with gestational exposure to SARS-CoV-2 was 77 of 691 (12%; 95% CI, 6%-18%). Compared with the prepandemic cohort (2015-2019), the pandemic cohort was more likely to have communication impairment (OR, 1.70; 95% CI, 1.37-2.11; P < .001), without significant differences in other ASQ-3 domains (eg, gross motor, fine motor, personal-social, and problem-solving). In contrast, maternal SARS-CoV-2 infection was not associated with significant differences in any neurodevelopment domain in offspring, except for increasing the odds of fine motor impairment (OR, 3.46; 95% CI, 1.43-8.38; P < .001).

conclusions and relevance In this systematic review and meta-analysis examining the association between COVID-19 pandemic and the risk of NDI, findings suggest that overall neurodevelopment in the first year of life was not changed by either being born or raised during the SARS-CoV-2 pandemic or by gestational exposure to SARS-CoV-2. Interestingly, the first year of life during the COVID-19 pandemic, regardless of maternal infection, was significantly associated with the risk of communication delay among the offspring.



# **Physical** health

Maternal health, intrauterine environment

Genetic and epigenetic factors

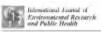
Nutrition

Infections

NCDs

Health behaviours

Traumatic injuries



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#### Impact of the COVID-19 Pandemic on Loneliness and Social Isolation: A Multi-Country Study

Roger O'Sullivan 1.2.4 Annette Burns 1.2, Gerard Leavey 3. Iracema Leroi 3, Vanessa Burholt 4.5 , James Lubben \*, Julianne Holt-Lunstad 7. Christina Victor \*, Brian Lawlor 1, Mireya Vilar-Compte \* Carla M. Perissinottu 10, Mark A. Tully 116, Mary Pat Sullivan 12, Michael Rosato 2, Joanna McHugh Power 13, Elisa Tiilikainen 1479 and Thomas R. Prohaska 15

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- Seamon University, Singleton Park, Swamsea SA2 8PP, DR. Schunt of Social Work, Essent College, Chestnut Hill, MA 62467, USA, Inhibertific edu
- Department of Psychology, Brigham Young University, Provp. UT 84602, USA. ulcome holf-kinstadeliyu.edu
- christina vignir@branel.ac.uk
- School of Social Work, Faculty of Education and Professional Studies, Naposing University North Bay, ON PJB NL7, Canada: muryps minus ingues
- Department of Social Sciences, University of Lintern Finland, FI-70211 Knopky, Firdand
- College of Health and Human Services, George Misson University, Paintry, VA 22050, D8A.

Abstract: The COVID-19 global pandemic and subsequent public health social measures have challenged our social and economic life, with increasing concerns around potentially rising levels of social isolation and loneliness. This paper is based on cross-sectional online survey data (available in 10 languages, from 2 June to 16 November 2020) with 20,398 respondents from 101 different you regard to pure fermance course in countries. It aims to help increase our understanding of the global risk factors that are associated paid in the region of management and with social isolation and timeliness, irrespective of culture or country, to support evidence-based policy, services and public health interventions. We found the prevalence of severe loneliness was 21% during COVID-19 with 6% retrospectively reporting severe loneliness prior to the pandamic A fifth were defined as isolated based on their usual connections, with 12" reporting a substantial increase in isolation during COVID-19. Personal finances and mental health were overarching and Engraph: # 2021 to the source consistently cross-cutting predictors of loneliness and social isolation, both before and during the SIDPL and Secondary pandemic With the likelihood of future waves of COVID-19 and related restrictions, it must be a This is the transport of the section public health priority to address the root causes of loneliness and social isolation and, in particular, dondround under the norms and address the needs of specific groups such as caters or those living alone.

Arminian (C. W) name (https:// Keywords: inneliness/social isolation; public health; COVID-19; ttsk factors

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Variable (N Completed Item)	N (%)		
Gender (n = 18,991)			
Females	14,917 (79%)		
<b>Age</b> $(n = 17,436)$	Mean = 53 (SD)		
	17.6)		
Education ( $n = 18,056$ )	13,504 (75%)		
Degree +	10,001 (10,10)		
Needs met by financial resources ( $n = 18,231$ )	A		
Very well	8046 (44%)		
Fairly well	8456 (46%)		
Poorly	1729 (10%)		
Member of minority group ( $n = 18,353$ )			
Yes	1977 (11%)		
<b>Care provider</b> (n = 19,046)			
Yes	5236 (27.5%)		
Outcomes	N (%)		
UCLA pre-COVID pandemic (n = 16,452)			
None/low (0-4)	13,204 (80%)		
Moderate (5–6)	2314 (14%)		
Severe (7+)	934 (6%)		
UCLA during COVID pandemic (n = 16,343)	0277 (579/)		
None/low (0-4)	9277 (57%)		
Moderate (5–6)	3659 (22%)		
Severe (7+)	3407 (21%)		
Lubben pre-COVID pandemic (n = 15,408)			
Isolated (<12)	3188 (21%)		
Not isolated	12,220 (79%)		
Lubben change during COVID pandemic (n = 15,322)			
Large increase in isolation (score $< -2$ )	1989 (13%)		
Small or no increase in isolation	13,333 (87%)		



# **Physical** health

Maternal health, intrauterine environment

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Infections

**NCDs** 

Health behaviours

Traumatic injuries

#### Article

### SARS-CoV-2 is associated with changes in brain structure in UK Biobank

https://doi.org/10.1038/s41586-022-04569-5

Received, 19 August 2021

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Published online: 7 March 2022

. Check for updates

Gwenzëlle Douaud' , Soojin Lee', Fidel Alfaro-Almagro', Christoph Arthofer', Chaoyue Wang', Paul McCarthy', Frederik Lange', Josper L. R. Andersson', Ludovica Griffanti<sup>12</sup>, Eugene Duff<sup>13</sup>, Saad Joabdi<sup>1</sup>, Bernd Tauchler<sup>2</sup>, Peter Keaturo<sup>3</sup>, Anderson M. Winkler', Rory Collins', Paul M. Malthews', Naomi Allen', Karla L. Miller', Thomas E. Nichols\* & Stephen M. Smith

There is strong evidence of brain-related abnormalities in COVID-1911 However, it remains unknown whether the Impact of SARS-CoV2 infection can be detected in milder cases, and whether this can reveal possible mechanisms contributing to brain pathology. Here we investigated brain changes in 785 participants of UK Biobank. (aged 51-81 years) who were imaged twice using magnetic resonance imaging, including 401 cases who tested positive for infection with SARS-CoV-2 between their two scans - with 141 days on average separating their diagnosis and the second scanas well as 384 controls. The availability of pre-infection imaging data reduces the likelihood of pre-existing risk factors being misinterpreted as disease effects. We identified significant longitudinal effects when comparing the two groups, including (I) a greater reduction in grey matter thickness and tissue contrast in the orbitofrontal cortex and parahippocampal gyrus; (2) greater changes in markers of tissue damage in regions that are functionally connected to the primary olfactory cortex; and (3) a greater reductioning lobal brain size in the SARS-CoV-2 cases. The participants who were infected with SARS-CoV-2 also showed on average a greater cognitive decline between the two time points, Importantly, these imaging and cognitive longitudinal effects were still observed after excluding the 15 patients who had been hospitalised. These mainly limbic brain imaging results may be the in vivo hallmarks of a degenerative spread of the disease through olfactory pathways, of neuroinflammatory events, or of the loss of sensory input due to anosmin. Whether this deleterious effect can be partially reversed, or whether these effects will persist in the long term, remains to be investigated with additional follow up.

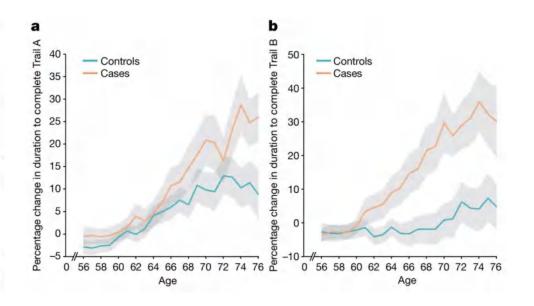
seroes the world. There has been an increased been by the scientific and medical community on the effects of mild-to-moderate COVID-19 in the longer term. There is strong evidence for brain-related pathologies, some of which could be a consequence of viral neurotropism. by or virus-induced neuroinflammation (-), including the following. neurological and cognitive deficits demonstrated by patients<sup>47</sup>, with an incidence of restrological symptoms in more than 80% of the severecases, radiological and post mortem tissue analyses demonstrating the impact of COVID-19 on the brain and the possible presence of the coronavirus in the central nervous system!

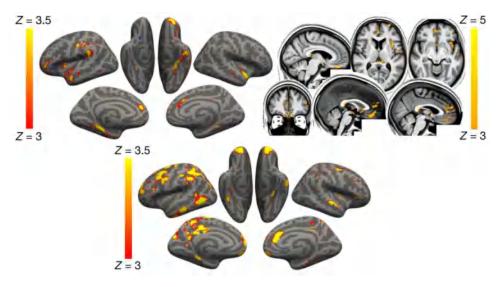
in particular, one consistent clinical feature, which can appear before

lead to a loss of grey matter in olfactory-related brum regions?", Office tory cells-whether neuronal or supporting-concentrated in the olfac-Anny epithelium are also narticularly volnerable monniquents myasing. and this seems to be also the case specifically with SARS-CoV Quantum Wittim the olfactory system, direct neuronal connections from and to the olfactory bulb encompass regions of the piriform cortex (the primary offactory cortex), parabippogampal gynis, enrorbinal enrice and orbitol rontal areas

Most brain imaging studies of COVID 19 to date have focussed on acute cases and radiological reports of single cases or case series based oncomputed tomography (CT), positron emission comography (PET) the onset of respiratory symptoms, is the disturbance in offaction and or magnetic resonance imaging (MRI) scans, revealing abroad array of gustation in patients with COVID-1910. In a recent study, 100% of the gross cerebral abnormalities, including white matter hyperintensities patients in the subscure stage of the disease were displaying signs of hypoperfusion and signs of ischaemic events spread throughout the gustatory impairment (hypogeusia), and 86%, signs of either hyposmia. hrain, but found mum consistently in the development. Of the few larger

VASIB Centre, Wellcome Centre to Integrative Neuromaging (WH), Multing Department of Clinical Neuromaging, (WH), Department of Clinical Neuromaging (WH), Depart Learning on the Department of Psychians, University of Oshara Disharation. Generation of Partition of University of University of University College Landon, London U. Managai Institutional Mensai Meast. Yang nai bestitutes of health, their amin. MO, USA "No." sep Department of Population Health University of Orders. Children. Co. London. ratings and Department or timin Sciences, imperial College, Landing III. Was Institute time traversity of Oxford County III. Was and ywerstelle abaguidge straves but the







# **Physical** health

Maternal health, intrauterine environment

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**NCDs** 

Health behaviours

Traumatic injuries

To cite: Pindus DM, Selzer-Ninomiya A, Nayak A, et al. Effects of reducing sedentary behaviour duration by increasing physical activity, on cognitive function, brain function and structure across the lifespan: a systematic review protocol. BMJ Open 2022;12:e046077. doi:10.1136/

BMJ Open Effects of reducing sedentary behaviour duration by increasing physical activity, on cognitive function, brain function and structure across the lifespan: a systematic review protocol

### STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ A comprehensive synthesis of acute and chronic effects of reducing sedentary behaviour duration by increasing time spent in physical activity on cognitive functions, brain function and structure in apparently healthy adults and children.
- ⇒ A rigorous systematic review methodology follows the guidelines of the Preferred Reporting Items for Systematic Reviews and employs the Effective Public Health Practice Project quality assessment tool to evaluate the risk of bias.
- ⇒ The heterogeneity of cognitive outcomes is accounted for by a structured synthesis based on the cognitive typology according to the involvement of controlled processes.
- ⇒ The generalisability of study results is limited to healthy children and adults.

School-aged children and adolescents (4-17 years),<sup>32</sup> younger adults (18-44 years), middle-aged adults (45-64 years)<sup>76 77</sup> and older adults (≥65 years)<sup>77</sup> will be included. The definition of midlife was based on the cognitive decline on several measures of higher order cognitive functions (e.g., inductive reasoning, episodic memory) observed in mid 40s and early 40s,7778 and the definition of midlife adopted in cancer prevention literature. 76 Definition of older adulthood has been adopted to align with the transition to retirement, and accelerated cognitive decline compared with middle age. 77 Children younger than 4 years will not be included due to underdeveloped EFs,79-81 consistent with studies of PA and cognition in children. 82 83



### ORIGINAL ARTICLE

### PSYCHOPHYSIOLOGY WILEY

# Physical health

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### Brain network modularity predicts changes in cortical thickness in children involved in a physical activity intervention

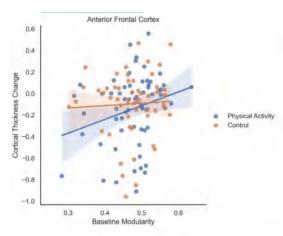


FIGURE 1 For children randomized to the 9-month after-school physical activity intervention, higher brain network modularity at baseline was positively associated with change in cortical thickness in the ametion frontal cortex. Brain network modularity at baseline did not positively predict changes in cortical thickness of the anterior frontal cortex in children in the wait-list control group, Change scores were computed as the difference in post-intervention and pre-intervention (or baseline) scores for each participant

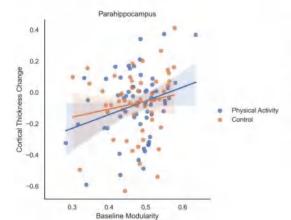
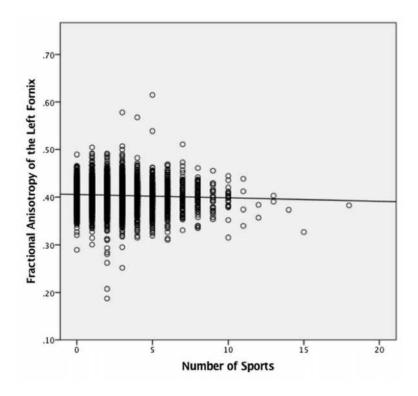


FIGURE 2 For children randomized to the 9-month after-school physical activity intervention, higher brain network modularity at baseline was positively associated with change in cortical thickness in the parahippocampus. Brain network modularity at baseline did not positively predict changes in cortical thickness of the parahippocampus in children in the wait-list control group. Change scores were computed as the difference in post-intervention and pre-intervention (or baseline) scores for each participant

Child Psychiatry & Human Development (2020) 51:490–501 https://doi.org/10.1007/s10578-020-00960-3

#### ORIGINAL ARTICLE

### White Matter Tract Integrity, Involvement in Sports, and Depressive Symptoms in Children





PLOS ONE

# Physical health

Maternal health, intrauterine environment

Genetic and epigenetic factors

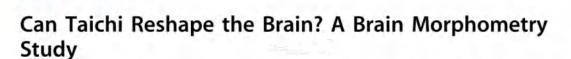
Nutrition

Infections

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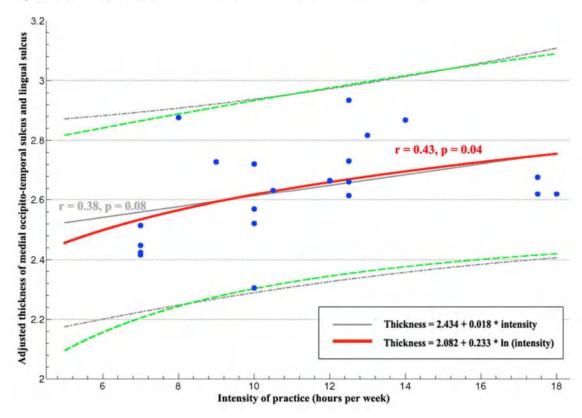
Health behaviours

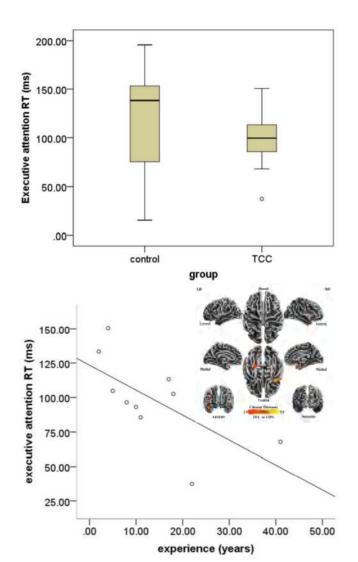
Traumatic injuries



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Gao-Xia Wei<sup>1,2</sup>, Ting Xu<sup>1</sup>, Feng-Mei Fan<sup>1,3</sup>, Hao-Ming Dong<sup>1,5</sup>, Li-Li Jiang<sup>1</sup>, Hui-Jie Li<sup>1</sup>, Zhi Yang<sup>1</sup>, Jing Luo<sup>2,4</sup>\*, Xi-Nian Zuo<sup>1</sup>\*







# Physical health

Maternal health, intrauterine environment

Genetic and epigenetic factors

Nutrition

Infections

**NCDs** 

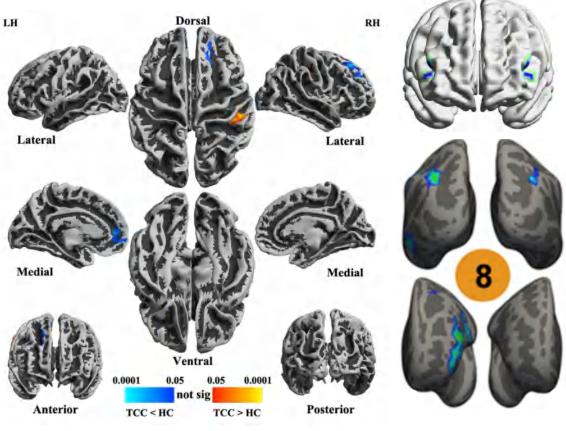
Health behaviours

Traumatic injuries



Tai Chi Chuan optimizes the functional organization of the intrinsic human brain architecture in older adults

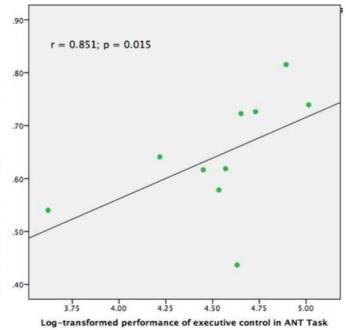
Gao-Xia Wei 1,2,3,4, Hao-Ming Dong 1,3,5, Zhi Yang 1,3,4, Jing Luo 2,6 \* and Xi-Nian Zuo 1,3,4 \*





Mind-Body Practice Changes Fractional Amplitude of Low Frequency Fluctuations in Intrinsic Control Networks

Gao-Xia Wei121\*, Zhu-Qing Gong134, Zhi Yang14 and Xi-Nian Zuo13





# **W**

### **Physical health**

### Health and social care sector

- Increase access to perinatal, child and adolescent health care, including neurodevelopmental assessments.
- Improve access and appropriate use of essential medicines and diagnostics.
- Implement infectious disease management, eradication/control and immunization programmes.
- Run targeted prevention efforts to address obesity, hypertension, high cholesterol and diabetes.
- Improve post-accident emergency care and long-term rehabilitation.
- Promote tobacco cessation and reduction of harmful alcohol use, as well as physical activity and healthy diets.

### Education

- Include growth monitoring and neurodevelopmental assessments in school health programmes.
- Design school curricula to teach children and adolescents about brain health promotion in an age-appropriate way.
- Implement healthy food programmes in schools.
- Include quality physical activity programmes in schools.
- Require helmet use for contact sports within schools to reduce the incidence of head injuries.

# Finance and economy

- Dedicate a portion of the health budget to promoting brain health.
- Dedicate funding for school food and physical activity programmes.
- Introduce tobacco, alcohol and sugar taxation schemes.

### **Employment**

 Promote physical activity and other healthy behaviours in the workplace, such as smoke-free workplaces.

# Infrastructure, urban planning and housing

- Implement safety measures for roads and vehicles.
- Improve safety of home and community environments to reduce the risk of falls and traumatic brain injury, especially for older adults.
- Design cities to promote access to outdoor spaces for safe physical activity.
- Encourage urban planning and infrastructure development that improve access to outdoor spaces for safe physical activity and alternatives to a sedentary lifestyle.

# Ecology, nature and climate

- Strengthen vector control for infectious diseases (e.g. Zika virus, malaria, taenia solium).
- Coordinate closely for the implementation of water, sanitation and hygiene actions to increase access to safe/clean drinking-water.







# Healthy environments

Safe use of chemicals

Protection from radiation

Healthy and safe workplaces and agricultural practices

Air and water quality

Stable climate

Access to preserved nature and health-supportive built environments







Walter A. Rosenblith New Investigator Award

RESEARCH REPORT



Number 209 February 2022

# Associations of Air Pollution on the Brain in Children: A Brain Imaging Study

Mònica Guxens, Małgorzata J. Lubczyńska, Laura Pérez-Crespo, Ryan L. Muetzel, Hanan El Marroun, Xavier Basagaña, Gerard Hoek, Henning Tiemeier



# Healthy environments

Safe use of chemicals

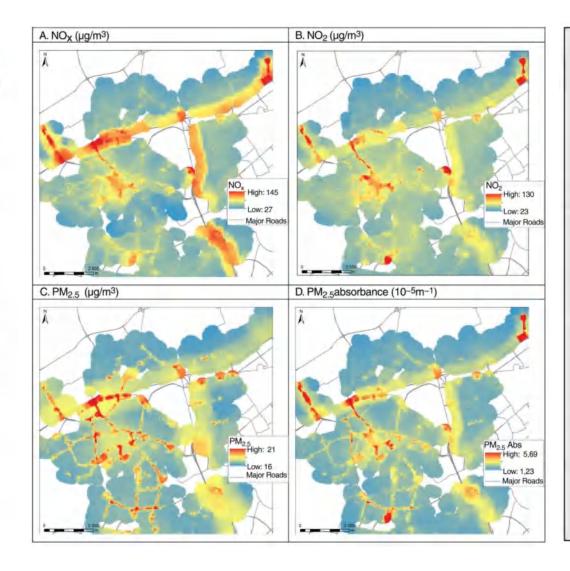
Protection from radiation

Healthy and safe workplaces and agricultural practices

Air and water quality

Stable climate

Access to preserved nature and health-supportive built environments



### What This Study Adds

- The goal of the study was to assess whether early life air pollution exposure affects brain outcomes using neuroimaging data from an existing birth cohort (Generation R) in Rotterdam, the Netherlands.
- The study focused on brain structural and functional measures in children.
- Strengths of the study were the availability of high-resolution neuroimaging data for a large subset of the cohort, the wealth of individual-level covariate data, and estimation of a large suite of air pollution exposure metrics.
- The study found some evidence of associations between early life air pollution exposure and various measures of brain structural morphology, structural connectivity, and functional connectivity in children.
   For example, exposure to air pollution during early life was associated with a thinner cortex in various regions of the brain in both school-age children and pre-adolescents. The clinical relevance of the findings remains unclear.
- The results add to the limited evidence of air pollution effects on the developing brain, with only a few MRI studies in children so far.



# Healthy environments

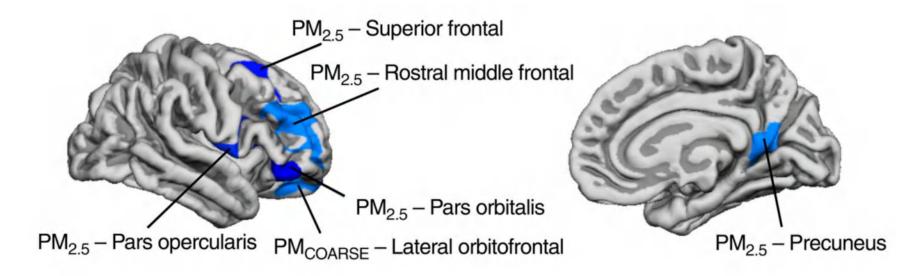
Safe use of chemicals

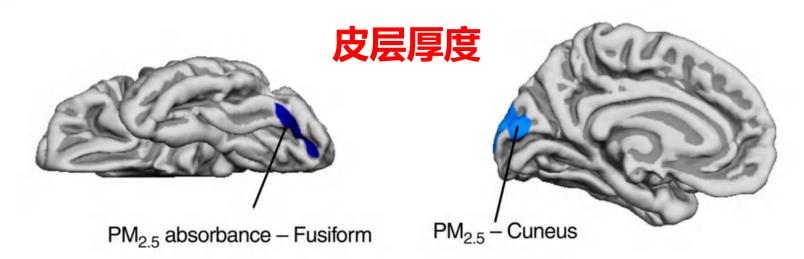
Protection from radiation

Healthy and safe workplaces and agricultural practices

Air and water quality

Stable climate







# Healthy environments

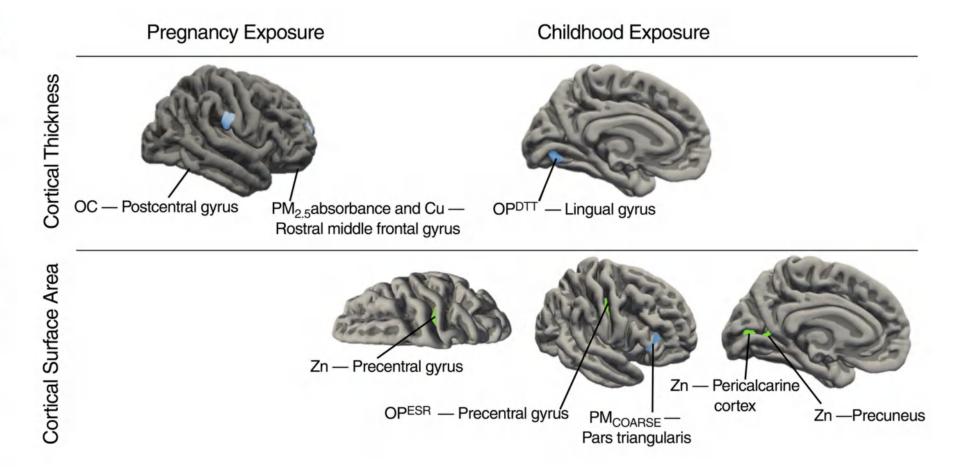
Safe use of chemicals

Protection from radiation

Healthy and safe workplaces and agricultural practices

Air and water quality

Stable climate





# Healthy environments

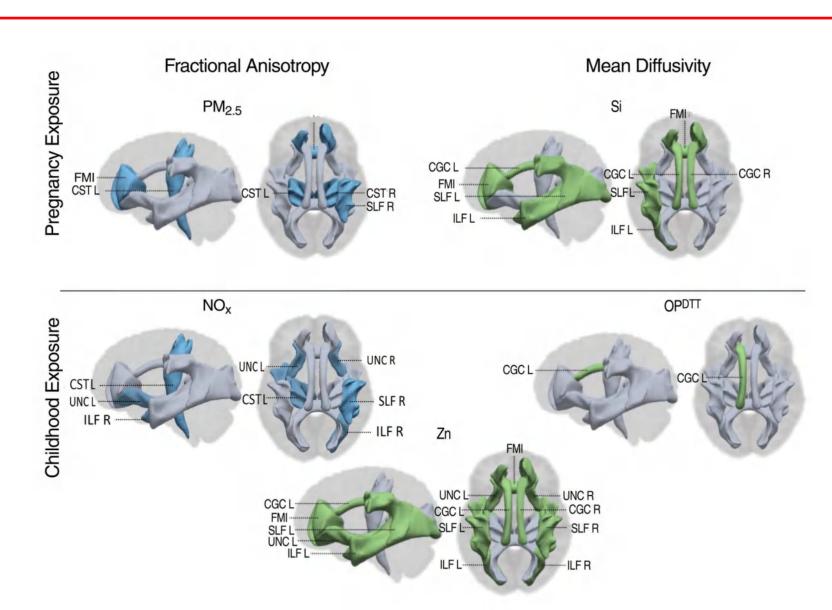
Safe use of chemicals

Protection from radiation

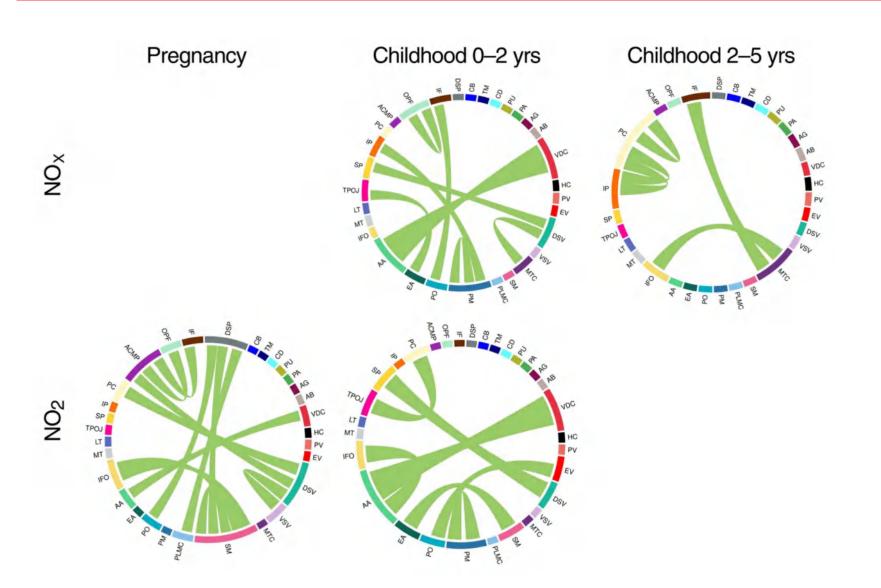
Healthy and safe workplaces and agricultural practices

Air and water quality

Stable climate







# Healthy environments

Safe use of chemicals

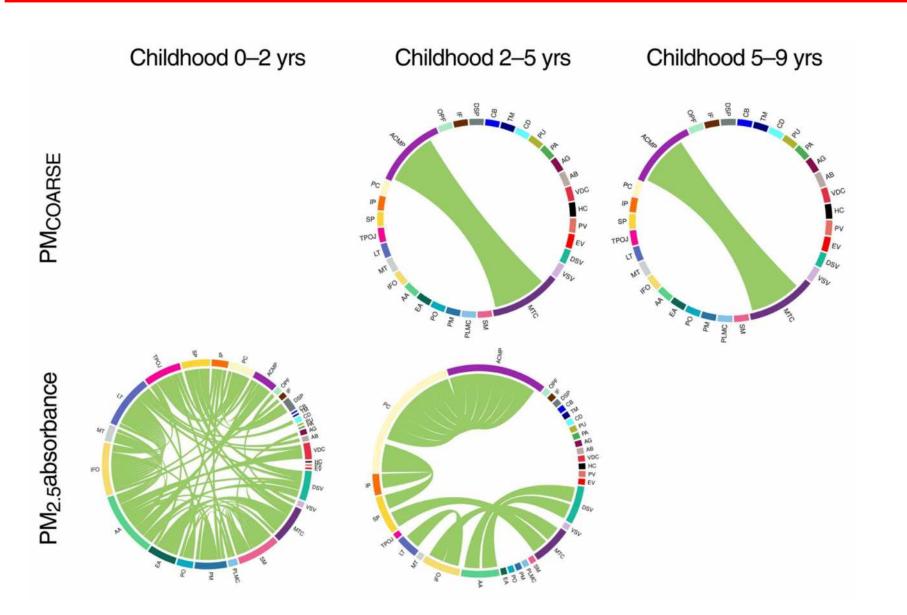
Protection from radiation

Healthy and safe workplaces and agricultural practices

Air and water quality

Stable climate





# Healthy environments

Safe use of chemicals

Protection from radiation

Healthy and safe workplaces and agricultural practices

Air and water quality

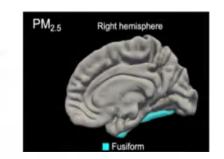
Stable climate

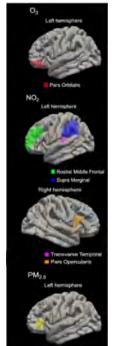


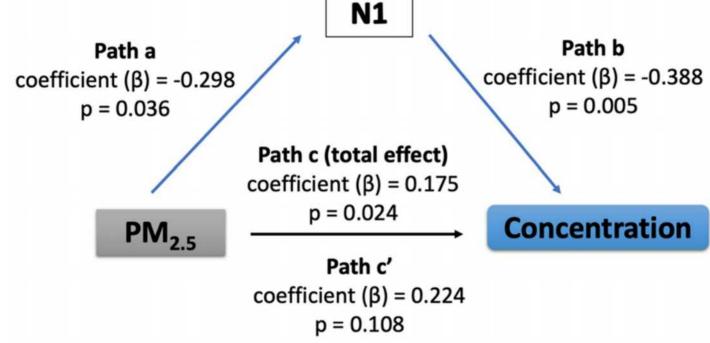
Environmental Science and Pollution Research (2022) 29:52355–52366 https://doi.org/10.1007/s11356-022-19482-7

### **RESEARCH ARTICLE**

Air pollution associated with cognitive decline by the mediating effects of sleep cycle disruption and changes in brain structure in adults







# Healthy environments

Safe use of chemicals

Protection from radiation

Healthy and safe workplaces and agricultural practices

Air and water quality

Stable climate



#### RESEARCH ARTICLE

# Association of Air Pollution and Physical Activity With Brain Volumes

Melissa A. Furlong, PhD, Gene E. Alexander, PhD, Yann C. Klimentidis, PhD, and David A. Raichlen, PhD  $Neurology^{\otimes}$  2022;98:e416-e426. doi:10.1212/WNL.000000000013031

### Abstract

### **Background and Objectives**

In high-pollution areas, physical activity may have a paradoxical effect on brain health by increasing particulate deposition in the lungs. We examined whether physical activity modifies associations of air pollution (AP) with brain volumes in an epidemiologic framework.

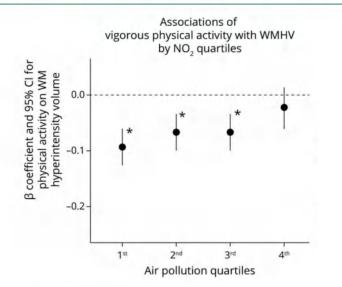
#### Methods

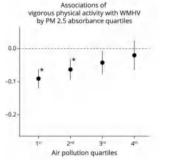
The UK Biobank enrolled >500,000 adult participants from 2006 to 2010. Wrist accelerometers, multimodal MRI with T1 images and T2 fluid-attenuated inversion recovery data, and land use regression were used to estimate vigorous physical activity (VigPA), structural brain volumes, and AP, respectively, in subsets of the full sample. We evaluated associations among AP interquartile ranges, VigPA, and brain structure volumes and assessed interactions between AP and VigPA.

#### Results

Eight thousand six hundred participants were included, with an average age of 55.55 (SD 7.46) years. After correction for multiple testing, in overall models, VigPA was positively associated with gray matter volume (GMV) and negatively associated with white matter hyperintensity volume (WMHV), while NO<sub>2</sub>, PM<sub>2.5absorbance</sub>, and PM<sub>2.5</sub> were negatively associated with GMV. NO<sub>2</sub> and PM<sub>2.5absorbance</sub> interacted with VigPA on WMHV (false discovery rate-corrected interaction p = 0.037). Associations between these air pollutants and WMHVs were stronger among participants with high VigPA. Similarly, VigPA was negatively associated with WMHV for those in areas of low NO<sub>2</sub> and PM<sub>2.5absorbance</sub> but was null among those living in areas of high NO<sub>2</sub> and PM<sub>2.5absorbance</sub>.

Figure 1 Associations of VigPA With WMHV, by Air Pollution Quartiles







# Healthy environments

Safe use of chemicals

Protection from radiation

Healthy and safe workplaces and agricultural practices

Air and water quality

Stable climate



# **Healthy environments**

### Health and social care sector

- Train health workers to recognize risks to brain health, signs and management of environmental toxicants.
- Implement testing of lead poisoning for infants and children.
- In partnership with humanitarian actors, strengthen emergency preparedness plans for natural and man-made disasters to ensure access to services for people with pre-existing or emergency-induced CNS disorders such as traumatic injuries.



### Education

 Design school curricula to teach children and adolescents in an age-appropriate way about environmental impacts on brain health.



of all people worldwide breathe polluted air in their ambient environment which threatens brain health across the life course

# Finance and economy

- Dedicate a portion of the health budget to identifying and managing environmental risks to health.
- Dedicate funding for monitoring of environmental healthrelated legislation.

### **Employment**

- Invest in civil engineers, scientists, educational and health workers.
- Protect workers
   against/limit exposure
   to pesticides, heavy
   metals such as mercury,
   industrial solvents and
   other high-priority
   chemicals known to be
   neurotoxic.

# Infrastructure, urban planning and housing

- Design new buildings to promote cleaner household and indoor air.
- Design cities to improve walkability and use of public transport versus personal vehicles.

# Ecology, nature and climate

- Protect the population against/limit exposure to pesticides, heavy metals such as mercury, industrial solvents and other highpriority chemicals known to be neurotoxic.
- Monitor air and water quality with routine testing, make results publicly available and implement measures to improve air and water quality.
- Strengthen national capacity to prepare for, respond to, and recover after natural disasters, chemical spills and radiological and nuclear emergencies.



214 chemicals are recognized as neurotoxic to the human brain





# **Determinant-III: Safety & Security**

PAPER

WILEY Developmental Science

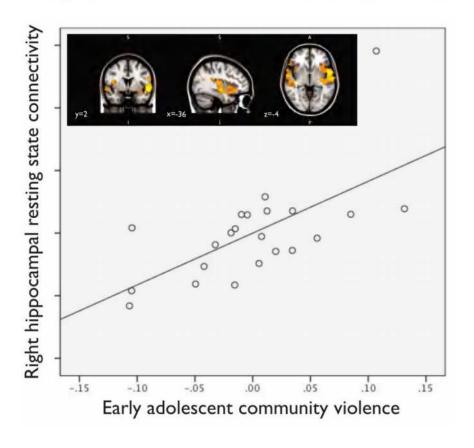
Community violence exposure in early adolescence: Longitudinal associations with hippocampal and amygdala volume and resting state connectivity

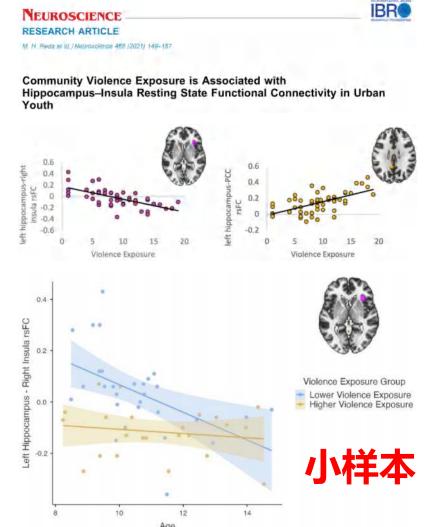
# Safety & security

Physical safety

Financial security

Humanitarian crises and emergencies







# **Determinant-III: Safety & Security**

DOI: 10.1002/jts.22793

RESEARCH ARTICLE





# Safety & security

Physical safety

Financial security

Humanitarian crises and emergencies

# Associations between potentially traumatic events and psychopathology among preadolescents in the Adolescent Brain and Cognitive Development Study<sup>®</sup> • •

Full model <sup>b</sup>						
Accidents	1.11	[0.74, 1.66]	0.95	[0.68, 1.34]	1.03	[0.81, 1.33]
Natural disaster	1.17	[0.75, 1.84]	1.19	[0.81, 1.75]	1.22	[0.90, 1.65]
Death	1.03	[0.78, 1.36]	1.43**	[1.08, 1.66]	0.91	[0.76, 1.08]
Community violence	0.65	[0.26, 1.65]	1.04	[0.56, 1.94]	1.10	[0.66, 1.82]
Domestic violence	1.28	[0.85, 1.94]	1.22	[0.88, 1.73]	1.18	[0.91, 1.52]
Victimization	0.88	[0.42, 1.85]	1.18	[0.66, 2.12]	0.98	[0.62, 1.54]
Sexual trauma	0.83	[0.41, 1.69]	0.88	[0.49, 1.58]	1.17	[0.78, 1.75]
Polyvictimization	1.34	[0.79, 2.28]	1.01	[0.67, 1.52]	1.54**	[1.12, 2.12]
Caregiver mental health	1.01**	[1.00, 1.01]	1.01***	[1.00, 1.01]	1.01***	[1.01, 1.02]

## **Safety and security**



# Infrastructure, urban planning and housing

 Design communities and neighbourhoods to enhance physical safety (e.g. adequate lighting, frequent transportation stops).



Ecology, nature

and climate

### Health and social care sector

- Train health and social care workers to recognize signs of violence, abuse, maltreatment and neglect (especially of children, adolescents and older adults) and establish appropriate protective mechanisms.
- Streamline protection of brain health and neurological care within response plans for humanitarian crises.

### Education

 Train education workers to identify cases of abuse, maltreatment and neglect in children and adolescents.

### Legislature and governance

- Implement policies and programmes to:
  - prevent abuse/maltreatment/ neglect of children, adolescents and older adults;
  - protect survivors of violence, including domestic/intimate partner violence; and
  - reduce violence at community level.
- Introduce social and financial protection schemes to increase financial security, prevent catastrophic health spending and prevent poverty.

# Finance and economy

 Dedicate funding for housing protection programmes, as well as social and financial protection schemes.

### **Employment**

 Abide by fair labour and minimum wages Acts and legislation.



# **Determinant-IV: Learning & Social Connection**



Article



# Learning & social connection

Education

Lifelong learning

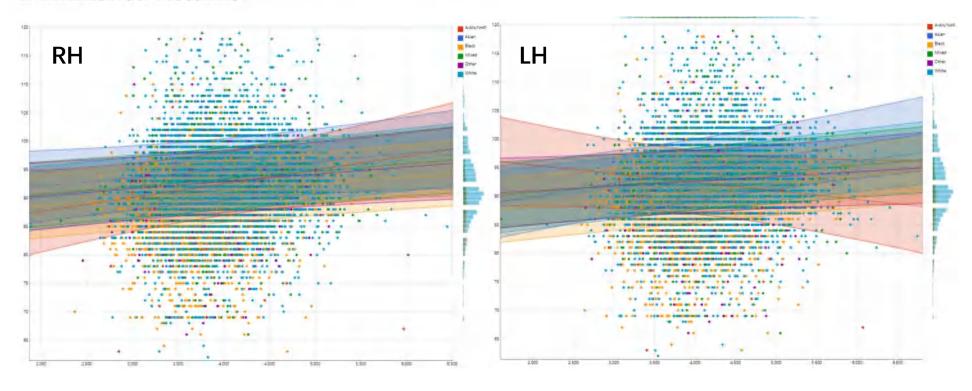
Nurturing care

Social connection/ social isolation

Social networks

Parental Educational Attainment, the Superior Temporal Cortical Surface Area, and Reading Ability among American Children: A Test of Marginalization-Related Diminished Returns







# **Determinant-IV: Learning & Social Connection**

## **Learning &** social connection

Education

Lifelong learning

Nurturing care

Social connection/ social isolation

Social networks

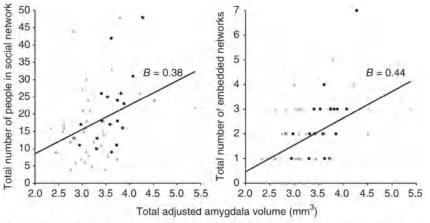


Figure 1 Amygdala volume correlates with social network size and complexity. (a,b) Plot of social network variables (y axis) against total adjusted amygdala volume (x axis). Data points from young participants, black circles; older participants, gray triangles. A line of best fit with standardized regression coefficients (B) is also displayed for the entire sample.

Table 1 Linear regressions using amygdala and hippocampal volumes as independent variables and social network characteristics as dependent variables

	Amiye	dala	Hippocampus		
	Left	Right	Left	Right	
Whole group (n = 58)					
Social network size	0.38, 2.84 (0.006)	0.29, 2:15 (0.036)	0.23, 1.66 (0.103)	0.10, 0,72 (0.472)	
Social network complexity	0.39, 3.13 (0.003)	0.30, 2.32 (0.024)	0.25, 1.89 (0.064)	0.15, 1.08 (0.286)	
oung group (n = 19)					
Social network size	0.58, 2.96 (0.009)	0.54, 2.61 (0.018)	0.22, 0.94 (0.359)	-0.07, -0.27 (0.792)	
Social network complexity	0.56, 2.81 (0.012)	0.57, 2.85 (0.011)	0.22, 0.94 (0.360)	-0.11, -0.45 (0.656)	
Older group $(n = 35)$					
social network size	0.32, 2.05 (0.048)	0.24, 1.52 (0.138)	0.27, 1.68 (0.102)	0.18, 1.11 (0.274)	
iocial network complexity	0.38, 2.50 (0.017)	0,28, 1.76 (0,086)	0.32, 2.06 (0.047)	0.27, 1.69 (0.099)	
emales (n = 37)					
Social network size	0.30, 1.88 (0.069)	0.18, 1.05 (0.301)	0.19, 1.15 (0.258)	0.06, 0.35 (0.729)	
Social network complexity	0.43, 2.85 (0.007)	0.27, 1.67 (0.105)	0.36, 2.25 (0.031)	0.23, 1.39 (0.174)	
Males (n = 21)					
Social network size	0.51, 2.60 (0.017)	0.62, 3.48 (0.002)	0.18, 0.78 (0.448)	0.19, 0.85 (0.405)	
Social network complexity	0.41, 1.98 (0.062)	0.57, 2.99 (0.008)	0.04, 0.18 (0.859)	0.09, 0.38 (0.708)	

### BRIEF COMMUNICATIONS

neuroscience

#### Amygdala volume and social network size in humans

Kevin C Bickart<sup>1</sup>, Christopher J Wright<sup>2,3</sup>, Rebecca J Duntoff<sup>2,3</sup>, Bradford C Dickerson2-4 & Lisa Feldman Barrett1.15

We found that amygdala volume correlates with the size and complexity of social networks in adult humans. An exploratory analysis of subcortical structures did not find strong evidence for similar relationships with any other structure, but there were associations between social network variables and cortical thickness in three cortical areas, two of them with amygdala. connectivity. These findings indicate that the amygdala is Important in social behavior.

For many species, but particularly for primates, living in groups is a major adaptive advantage. But living in a social group also presents. its own challenges. To get along while getting ahead, it is necessary to learn who is who, who is friend and who is fee It might be productive to form an alliance with certain group members in one context, but to outmaneuver them in another. The social brain hypothesis' suggests that, evolutionarily, living in larger, more complex social groups. (Table 1), indicating no lateralization of the effect. selected for larger brain regions with a greater capacity for performing relevant computations. On the basis of its central functional role." and anatomic position" in the social brain, investigators have proposed that amygdala volume should be related to the size of social ils processing capacity".

Comparative neuroanatomical studies in nonhuman primates strongly support a link between anygdala volume and social network size" and social behavior. Species characterized by larger social. groups have a larger corticobasolateral complex within the amygdala. The corticulus olateral complex conjointly expanded with evolutionarily newer cortex and the lateral geniculate nucleus, particularly the layers of the lateral geniculate nucleus that project to the ventral stream visual system. Taken together, these comparative findingssuggest that a larger amygdala provides for the increwed processing demands required by a complex social life.

In this study we examined whether amygdala volume varies with individual variation in the size and complexity of social groupings. within a single primate apocies, humans. In 58 healthy adults (37 females mean age M = 52 h, val. = 21.2, range = 19-83 years) with confirmed absence of DSM-IV Axis I diagnoses and normal performance on cognitive texting, we examined social network size and compleasity with two subscales of the Social Network Index (SNI<sup>2</sup>). One participants gray transfer. A line of part fit with mandardized recession SNI subscale [Number of People in Social Network) measures the confluents (8) is also displayed for the entire sample.

total number of regular confacts that a person maintains reflecting overall network size. A second subscale (Number a) Embedded Networks) measured the number of different groups these contacts. belong to, reflecting network complexity. Despite the fact that the twosocial network variables were strongly correlated within the present sample (+ 0.86, P = 0.00)), we opted to consider their separate relazion to amygdala and hippocampal volumes. For more details, sec-Supplementary Results.)

To ansess amygdala (and, as a control region, hippocampal) volume, we performed quantitative morphometric analysis of T1-weighted MRI data using an automated segmentation and probabilistic regionof-interest (ROI) labeling technique (FreeSurfer, http://surfer.nini. mgh harvard.edu/). Fin methodological detalls see Supplementary Methods. To adjust for differences in head size, amygdala and hippocumpal volumes were divided by total intricranial volume, as performed previously 10.11

Linear regression analyses revealed that indeviduals with larger and mure complex social networks had larger amygdala volumes (Fig. 1). These relationships held when controlling for the age of the participant (because older individuals have, on average smaller amygdala rolumes than do younger individuals, Table 1). These relationships held when left and right amygdala volumes were analyzed separately

To assess discriminant validity, we performed a linear regresion using right and left hippocampal volumes (corrected for total intracranial volume) as independent variables and social network size and complexity as dependent variables while controlling for age groups, in part because the size of a brain region is one indicator of (because hippocampa) volume typically diminishes with age). For the whole group, these analyses showed no significant relationship

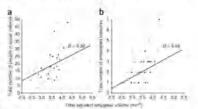


Figure 1. Actividate volumes correlates with focul individuace and complexity ta.b) Plot of vocal network versibles (y.axii.) applied total adjusted invegdifus yourself axis). Data points from young participants, black circles, older

Department of Austrony and Technology, Boston University Softwold Meaning Residen Missachusetts, USA, "Psychiatric Neuronimagni insure in Program, Maria Trunds Geberal Househol and Harverd Medical School, Charlestown, Manusch users. USA. "Martinos Cepter for Biomedical Imaging, Manusch usertis Geberal Householder Modest School, Charlestows, Massachusetts, USA, \*Georgeset of Responses Messachusetts General Housts and Harvest Modest School, Boston, Messachusetts, USA, Composition of Physiology, Renticenses University, Boston, Massachusetts, USA, Compositions and the extremed to 1, ETI (Charletti

Received 6 October, accepted 24 November published online 26 December 2010, corrected after print \$ 4.5, 2011, doi:10.10de/nn.2124



# Infrastructure, urban planning and housing

 Design cities, towns and communities to ensure easy access to school for children and adolescents, as well as access to workplaces, social and leisure activities for adults.



# Ecology, nature and climate

# Finance and economy

- · Eliminate school fees.
- Introduce payment schemes for childcare and early childhood education programmes.

### **Learning and social connection**

#### Health and social care sector

- Implement interventions for responsive caregiving and early learning.
- Train health and social care workers to identify loneliness and social isolation across the life course.

#### Education

- Increase access to early childhood learning programmes.
- Increase access to formal education and inclusive education.
- Implement interventions to promote adolescent brain health and development.
- Design school curricula to teach children and adolescents how to combat stigma, prejudice and discrimination in an ageappropriate way.

### Legislature and governance

- Implement laws and legislation that:
  - mandate school attendance for primary and secondary schoolage children;
  - · prohibit child labour; and
  - aim to protect the rights of, and reduce stigma, prejudice and discrimination against, vulnerable populations, people with CNS conditions and their carers.

### **Employment**

- Strengthen adequate monitoring to ensure that children are not used for labour.
- Promote lifelong learning in the workplace.





# **Determinant-V: Access to Quality Services**

# Access to quality services

Integrated care at all health/social care levels

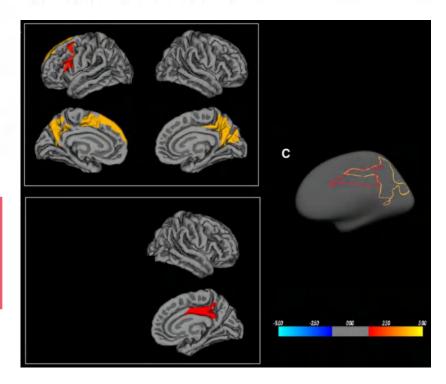
Skilled workforce and Interdisciplinary teams

Access to essential medicines, diagnostics and health products

Carer support

Qual Life Res (2017) 26:1209-1222 DOI 10.1007/s11136-016-1433-0

Proxy-reported quality of life in adolescents and adults with dyskinetic cerebral palsy is associated with executive functions and cortical thickness



#### **Original Article**

# Hospital value-based purchasing, market competition, and outpatient imaging efficiency

Mei Zhao<sup>1</sup>^, Hanadi Y. Hamadi<sup>1</sup>^, D. Rob Haley<sup>1</sup>^, Kelly Pray<sup>2</sup>, Paul A. Heyliger-Fonseca<sup>3</sup>, Aaron Spaulding<sup>4</sup>^

Background: The Centers for Medicare & Medicaid Services (CMS) collects data on hospital outpatient imaging efficiency (OIE) to reduce unnecessary exposure to contrast materials and prevent wasteful use of Medicare resources. In 2013, CMS implemented the Inpatient Hospital Value-Based Purchasing Program to improve quality and efficiency. There has been no systematic study that examines the association between hospital inpatient hospital value-based purchasing (HVBP) total performance, market competition, and OIE. This study fills the gap in the literature.

Methods: Using a longitudinal study design, data from the 2015–2018 American Hospital Association Annual Survey, the Medicare Hospital Compare, and the Area Health Resources Files (AHRF) database were utilized. Statistical analyses were conducted using fixed effects multivariate linear panel regression model for all hospitals (n=4,093). The main outcome variables for this study were the six OIE variables measuring the efficient use of medical imaging tests, including magnetic resonance imaging (MRI) lumbar spine for low back pain, mammography follow-up rates, thorax computerized tomography use of contrast material, abdomen computerized tomography use of contrast material, cardiac imaging for preoperative risk assessment for non-cardiac low-risk surgery, and simultaneous use of brain computerized tomography and sinus computerized tomography. The main predictor variables were hospital inpatient total performance score (TPS) and hospital market concentration, defined by Herlindahl-Hirschman index (HHI).

Results: The multivariate panel data analysis indicated that hospitals with low TPSs also had a significantly lower rate of imaging services utilization for abdomen computerized tomography use of contrast material [coefficient (b) = 0.58; standard error (SE) = 0.22], indicating higher efficiency, also, hospitals in more competitive markets had a significantly higher rate of thorax computerized tomography use of contrast material (b=0.59; SE = 0.28), indicating lower efficiency of these services.

Conclusions: The findings from this study provide significant policy and practice implications. On the one hand, hospitals located in more competitive markets should consider strategies to improve their total performance to be hetter reimbursed by Medicare instead of offering more expensive outpatient imaging services. On the other hand, policymakers should monitor high performing hospitals since these hospitals also tend to provide more unnecessary outpatient imaging tests.



# **Determinant-V: Access to Quality Services**

# Access to quality services

Integrated care at all health/social care levels

Skilled workforce and Interdisciplinary teams

Access to essential medicines, diagnostics and health products

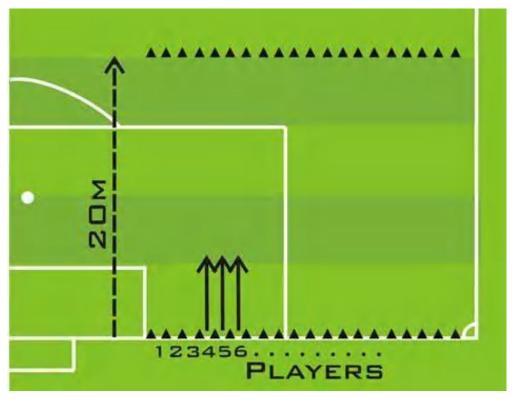
Carer support

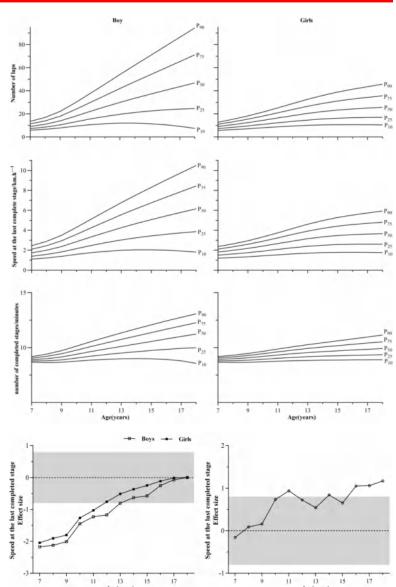


Article

The Multistage 20-Meter Shuttle Run Test Reference Values for Tibetan Children and Adolescents in Tibet, China

Xiaojian Yin 1,2,\*, Feng Zhang 1,2, Pengwei Sun 1,2, Yuan Liu 1,2 and Yaru Guo 1,2





## **Access to quality services**

### Health and social care sector

- Develop evidence-based coordinated health and social care services and integrate CNS disorders into existing relevant health services (at all three levels), ensuring continuity of care across levels and disciplines.
- Establish, strengthen and train skilled interdisciplinary health and social care teams to diagnose, treat and manage CNS disorders and identify/treat carer stress.
- Expand the role of specialists to train and supervise generalists.
- Improve availability and appropriate use of essential medicines and diagnostics for CNS disorders, including workforce training on their use.
- Provide accessible and evidence-based information on available resources for carers in the community.
- Develop mechanisms to involve people with neurological disorders and their carers in care planning.

### Education

- Include growth monitoring and neurodevelopmental assessments in school health programmes for early diagnosis and intervention.
- Provide robust primary, secondary and university-level education for the future health and social care workforce, including continuing education.

### Legislature and governance

- Implement social and financial protection schemes for people with CNS disorders and their carers (e.g. general health insurance, disability pension, tax benefits, or flexible working hours).
- Establish transparent regulatory frameworks for health products and diagnostics.
- Develop mechanisms to involve people with CNS disorders and their carers in policy-making and legal review.

# Infrastructure, urban planning and housing

 Ensure availability of public transportation to access health facilities within the community.

### Finance and economy

- Dedicate a portion of the health budget to the management and prevention of CNS disorders, including access to essential medicines.
- Implement social and financial benefits/ financial protection for carers.

### **Employment**

- Address projected health workforce needs in the future.
- Establish compensation and incentives for workforce trained in CNS disorders to work in underserved areas.
- Implement employment protection schemes for carers (e.g. leave or flexible working hours).



# Ecology, nature and climate



Civil society
can play a
fundamental role
in driving popular
discourse about
brain health,
raising population
awareness, and
reducing stigma

