African Population and Health Research Center

Understanding Community Knowledge, Attitudes, & Practices Towards Brain Imaging Techniques in Kenya

Baseline Report

June, 2025

CONTRIBUTORS

Paul Otwate, Salma Musa, Nelson Langat, Charity Waweru-Mwangi, Silas Onyango, Margaret Nampijja, Symon M, Kariuki, Patricia Kitsao-Wekulo and Charles Mwamino

ACKNOWLEDGMENTS

The African Population and Health Research Center (APHRC)'s Early Childhood Development (ECD) Research Unit would like to extend its appreciation to all the authors listed in the development of this report.

We thank the Nairobi City and Kisumu County Governments for their support to the study date, including during the data collection for the KAP phase. Specifically, we thank the County Health Directors and sub-County Health Management Team in the two counties who not only supported the MRI procedures, but also the mobilization of study participants. In addition, we thank all the caregivers, childcare providers, and health care providers who participated in the study.

This work was supported by the Gates Foundation. The views expressed herein do not necessarily represent those of the Gates Foundation or its Board of Governors.

TABLE OF CONTENTS

LIST OF TABLES

ABBREVIATIONS AND ACRONYMS

APHRC	African Population and Health Research Center
CT	Computed Tomography
FGD	Focus Group Discussion
IDI	In-depth Interview
IQR	Inter-quartile Range
JOOTRH	Jaramogi Oginga Odinga Teaching and Referral Hospital
KAP	Knowledge, attitudes, and practices
KII	Key Informant Interview
MRI	Magnetic Resonance Imaging
PET	Positron Emission Tomography
SSA	Sub-Saharan Africa
UK	United Kingdom
USD	United States Dollar

EXECUTIVE SUMMARY

Background

Magnetic resonance imaging (MRI) has gained prominence in clinical and research settings over the past decade due to its high-resolution imaging, non-ionizing nature, and superior sensitivity and specificity in detecting neuropathological and vascular conditions. Despite its critical role in diagnosis and scientific inquiry, access to MRI remains limited in many low- and middle-income countries (LMICs), where scanners are often concentrated in urban centers and largely inaccessible to rural populations. The use of MRI, especially in children, therefore, is often accompanied by misperceptions about its purpose and safety, particularly among communities with limited exposure to or access to MRI technology. The study was conducted to assess community and stakeholder perspectives on the use of MRI in early childhood research. The study aimed to understand how caregivers, childcare providers, and healthcare professionals perceive, interpret, and respond to the use of MRI, particularly in scanning healthy children in resource-constrained urban informal settlements.

Methods

We adopted a cross-sectional study design and utilized a mixed-methods approach, integrating both quantitative surveys and qualitative interviews. We engaged 294 participants (136 from Kisumu and 158 from Nairobi), comprising mothers (n=109), fathers (n=52), childcare providers (n=106), and healthcare professionals (n=27). Data collection involved structured interviews, focus group discussions (FGDs) and key informant interviews (KIIs), designed to capture diverse perspectives on knowledge, attitudes and practices (KAP) related to MRI use in children. Qualitative data were analyzed thematically approach, guided by research questions developed a priori. Quantitative data were coded, cleaned, and analyzed descriptively using Stata to identify patterns across demographic and KAP variables.

Results

Most caregivers (87%) and healthcare providers (70%) across Nairobi and Kisumu Counties recognized MRI as a tool for detecting brain disorders in young children. However, misconceptions about its safety were widespread; many respondents believed MRI scans could cause brain damage, with such beliefs more prevalent among community members than healthcare professionals. Most participants emphasized the importance of providing adequate information to parents about the MRI procedure and strongly supported having parents present during scans to help manage their children's anxiety. While healthcare stakeholders in both counties appreciated the clinical value of MRI, misperceptions and limited understanding, particularly regarding its non-invasive nature and research applications, were more pronounced in Nairobi than in Kisumu.

Conclusion

Based on our study findings, it is evident that most communities associate MRI with clinical diagnosis of illness, reflecting. However, beliefs about its safety remain mixed, particularly regarding its use in healthy children, due to limited exposure and persistent misconceptions. These findings underscore the need for timely and targeted sensitization efforts among caregivers, childcare providers and health stakeholders. Strengthening knowledge about the role of MRI in tracking brain development and supporting early childhood research can enhance community trust, increase acceptability and improve willingness to enroll children in studies involving neuroimaging techniques, especially in resource-constrained settings.

INTRODUCTION

1.1 Background of Study

The use of magnetic resonance imaging (MRI) in health and research has gained significant traction over the past decade (Murali et al., 2024). This is due to its high-resolution imaging, non-ionizing nature, and superior sensitivity and specificity in detecting neuropathological and vascular conditions (Anazodo et al., 2023; Tarnoki et al., 2015). MRI is widely used diagnose non-communicable diseases such as epilepsy, cancer, and cardiovascular disorders (Tarnoki et al., 2015). Despite its clinical and research value, access to MRI remains limited in low- and middle-income countries (LMICs) with scanners concentrated in urban centers and largely inaccessible to rural populations (Tarnoki et al., 2015).

In sub-Saharan Africa (SSA), MRI has the potential to expand access to universal health services, and improve outcomes for conditions like cancer (Murali et al., 2024). Estimates suggest that scaling up use of MRI in SSA could avert 207,800 deaths by 2030 (Anazodo et al., 2022). Beyond clinical benefits, neuroimaging technologies (X-ray, computerized tomography [CT] and MRI) are projected to yield productivity gains of over $27 billion between 2020 and 2030 (Anazodo et al., 2022; Murali et al., 2024). Importantly, MRI offers a more reliable method of tracking the developmental trajectories of children than traditional neuropsychological tests (Lia C. H. Fernald, Elizabeth Prado, Patricia Kariger, 2017). This reliability can be useful in neuroscience research in children, particularly from marginalized areas.

Available evidence suggests that perceptions of MRI vary widely across communities. In African contexts, caregivers and healthcare professionals predominantly view MRI as a clinical diagnostic tool (Aderinto, Abdulbasit, et al., 2023), and so may not appreciate its value in research and developmental science. Safety concerns rooted in experiences with ionizing imaging techniques like X-rays and CT scans (Aderinto, Olatunji, et al., 2023), are frequently extended to MRI and Positron Emission Tomography (PET), despite their non-ionizing nature. Misperceptions linking MRI exposure to cancer and brain damage persist, particularly among disadvantaged communities (Aderinto, Olatunji, et al., 2023; Anazodo et al., 2022). In vulnerable communities, children are perceived as more vulnerable than adults. High-field MRI scanners, which produce loud noise and require strong magnetic fields, further reinforce these fears. In contrast, low-field MRI technology offers a safer, quieter, cheaper and more portable alternative, addressing many of the access and safety concerns associated with conventional scanners. Its affordability and adaptability make it well suited for deployment in rural and peri-urban economically disadvantaged communities.

Misperceptions surrounding MRI use stem from both community-level and professional concerns. For community members, fears often center on safety risks and the perceived high cost of MRI procedures. Among health stakeholders, skepticism may relate to the adequacy of low-field MRI scanners in delivering sufficient image resolution and field strength for diagnostic or research purposes (Wedderburn et al., 2020). Additionally, there is a belief that for a low-field MRI to be viable in remote and resource-constrained settings, it must be easy to set up and operate when faced with infrastructural challenges such as power outages (Warsito et al., 2012). These functional, structural and health-related concerns can discourage early diagnosis and treatment-seeking behavior, potentially contributing to higher mortality rates and underdiagnosed neurodevelopmental disorders (MICHA, 2017). They may also reduce community willingness to participate in neuroimaging research projects, particularly studies involving healthy children. At present, there is no clear consensus on how to mitigate safety concerns associated with portable low-field MRI scanners, and how to ensure data integrity and proper device management in SSA (Aderinto, Olatunji, et al., 2023; Tarnoki et al., 2015). This lack of clarity raises important legal, ethical, and social considerations for communities and health systems seeking to benefit from MRI technology. Without targeted efforts to address these misperceptions, the adoption of MRI for developmental research may be delayed, hindering efforts to track brain development and respond to neurodevelopmental conditions such as autism and intellectual disabilities in early childhood.

A study conducted in Ghana revealed that most community members were educated on MRI by family and friends rather than from trained clinicians (Asante & Acheampong, 2021; Halpern, 2010). These informal sources often lacked medical expertise or training in MRI sensitization contributing to widespread misconceptions. As a result, over half of the respondents believed that MRI exposes individuals to harmful radiation and may cause cancer similar to other ionizing imaging modalities such as X-ray and CT scan (Dubois et al., 2021). Despite advancements in neuroimaging technologies, communities across SSA continue to have limited knowledge MRI's role in research, particularly in non-clinical applications (Asante & Acheampong, 2021). This underscores the urgent need for context-specific studies to assess caregiver knowledge and inform the design of neuroscience initiatives in low-resource settings in Africa.

Whereas evidence reveals that MRI is crucial in understanding underlying neurodevelopmental risks in young children, little is known about the myths and beliefs challenging its use in sub-Saharan Africa (Wedderburn et al., 2020), which is crucial in expansion of developmental and science studies in other parts of Africa. Addressing knowledge gaps and clarifying the safety and purpose of MRI, particularly its non-invasive role in studying healthy children, can foster trust, improve attitudes, and encourage participation in neuroimaging studies. This, in turn, represents a strategic investment in human capital and equitable research inclusion across underserved settings. This study was therefore designed to explore the KAP of different stakeholders regarding the use of MRI in healthy children. It further explores key factors underlying

hesitancy to the use of MRI for non-clinical purposes, and provides recommendations for enhancing knowledge, attitudes and acceptability for MRI. Findings from this survey will help develop targeted educational and engagement strategies to enhance acceptability, clarify the non-invasive nature of low-field MRI, and ensure ethical alignment with community values.

1.2 Objectives of the Study

As part of a study seeking to examine the association between caregiver-child interaction and brain function, and global development of the child, a survey was conducted to explore the perceptions, and acceptability towards brain imaging techniques for assessing child cognitive or neuropsychological performance and brain structure. The specific objectives of the study were: [1]To explore caregivers' knowledge about the use of MRI techniques in young healthy children; [2] To understand policy implementers' KAP regarding the use of brain imaging techniques for assessing child cognitive development and brain structure; [3] To establish strategies for addressing perceptions, attitudes, beliefs and practices of community related to MRI use in young healthy children.

METHODOLOGY

2.1 Study Design

This was a cross-sectional feasibility and acceptability study that employed a mixed-methods approach, combining quantitative surveys and qualitative interviews to assess community KAP related to MRI use, as well as its acceptability in early childhood research.

2.2 Study Site and Participants

The study was conducted in the urban informal settlements of Kisumu and Nairobi Counties, Kenya. The study sites were purposively selected because we and our partners have previously collaborated with them on childcare research projects in these counties. Residents in these settings typically face socioeconomic challenges, including limited education and restricted access to advanced health services. These health services include MRI, limiting neuroscience research in underserved communities in Kenya and SSA (Simiyu et al., 2019).

We targeted childcare providers, i.e., those providing childcare services for children between six months and two years within childcare facilities and home-based setting/home care providers within urban informal settings. In addition, we targeted primary caregivers (mothers or fathers) of children within the same age range. Policy makers and implementers who included healthcare professionals, radiographers and radiologists, nutritionists, and local community health implementers were also involved in the study. We sampled (n=267) participants comprising mothers (n=109), fathers (n=52), childcare providers (n=106), and (n=27) healthcare policy stakeholders. This diverse sample enabled a comprehensive assessment of KAP related to MRI use in early childhood research across both community and institutional perspectives.

2.3 Study Procedures

To prepare for data collection, we recruited and trained ten field interviewers in each county. We selected interviewers from within the study communities to enhance trust, cultural relevance and stakeholder buy-in. A week-long training was conducted to familiarize them with the study tools and protocols, followed by pre-testing to ensure quality, reliability and validity of the instruments.

We used structured questionnaires, focus group discussions (FGDs), key informant interviews (KIIs) and in-depth interviews (IDIs) to triangulate the findings and strengthen the evidence base. We interviewed 294 respondents face-to-face using electronic questionnaires administered via SurveyCTO, a secure digital data capture platform. Participants in the quantitative component of the study included caregivers, childcare center providers, and healthcare professionals. For the qualitative component, we conducted FGDs with caregivers and childcare providers in groups of 7-8 participants, each lasting approximately one hour. KIIs were held with healthcare providers and policy implementers to gather institutional perspectives. Additionally, we conducted IDIs with a purposive sample of 38 mothers across the two counties to clarify and deepen insights from the quantitative data

Interview tools explored key dimensions of knowledge, attitudes, and practices related to neuroimaging, including a) What respondents knew about imaging techniques such as X-ray, CT scan, ultrasound, and PET scan; b) Community perceptions regarding the use of imaging on young children; c) Views on the potential usefulness of neuroimaging, particularly MRI, in supporting child development.

2.4 Data Management and Analysis

The quantitative data were uploaded to the African Population and Health Research Center (APHRC) secure server through SurveyCTO. Trained team leaders, with oversight from the APHRC research team, supervised the data collection exercise. They verified the completeness of the data before submission, while the research team conducted regular spot checks and sit-ins to ensure data integrity during the data collection exercise.

For qualitative data, interviews were audio recorded and transcribed immediately to preserve accuracy. An experienced transcriber produced verbatim transcript, which were reviewed by the research team to confirm alignment with the FGD, IDI, and KII guides. The transcripts were then coded and analyzed thematically to extract patterns and insights relevant to the study objectives.

Quantitative data were cleaned and analyzed using Stata (v18) with support from the study statistician. Descriptive statistics were computed and presented in tables to illustrate distribution across key variables in line with the research questions. All data were stored in APHRC's password-protected microdata portal, accessible only by authorized study personnel to ensure confidentiality and compliance with ethical standards.

2.5 Ethical Considerations

The research protocol was first reviewed and approved by APHRC's Scientific Review Committee to ensure scientific rigor, participant safety and adherence to ethical principles. Subsequent ethical approval was obtained from Amref Health Africa's Ethics and Scientific Review Committee (ESRC), followed by a research permit issued by the National Commission for Science, Technology and Innovation (NACOSTI). Additional site-specific approval was secured from the Jaramogi Oginga Odinga Teaching and Referral Hospital (JOOTRH) in Kisumu County, as required for facility-based research. Additional site-specific approval was secured from the Jaramogi Oginga Odinga Teaching and Referral Hospital (JOOTRH) in Kisumu County, as required for facility-based research. Research authorization was also granted by both Kisumu and Nairobi County Governments.

We obtained written informed consent from all participants prior to data collection. The study team provided clear and culturally sensitive explanations about the purpose of the acceptability and the KAP survey. To build confidence among the participants, we explained to them about keeping all their data private and confidential and de-identification throughout coding, analysis, and during engagement and validation meetings. We also emphasized voluntary participation and the right to withdraw at any time.

RESULTS

This study engaged 294 participants across Nairobi and Kisumu Counties, comprising caregivers, childcare providers, and healthcare professionals. The findings reveal nuanced understandings and perceptions of neuroimaging techniques, particularly MRI, shaped by access, experience, and community beliefs.

3.1 Participant Characteristics

3.1.1 Sociodemographic Characteristics of Caregivers

As shown in **Table 1**, caregivers had a median age of 35 years and were predominantly female (78%). About half of the caregivers (52%) were self-employed, and most (61%) earned less than USD $80 per month, reflecting the socioeconomic context of urban informal settlements. More than half of the participants (61%) reported being either married or living with a partner. Sociodemographic characteristics varied notably between Kisumu and Nairobi, particularly in caregiver type, educational attainment, occupation and marital status. From the broader quantitative sample, we purposively selected 165 caregivers and 14 policy implementers, including health professionals and administrators, for qualitative interviews to deepen understanding of community perspectives and stakeholder experiences.

Table 1: Sociodemographic characteristics of caregivers

	Nairobi	Kisumu	Total	p-value
	N=144	N=123	N=267	
Respondent Age (ears); Median (IQR)	**35 (28-44)**	**36 (31-43)**	**35 (29-43)**	**0.24**
Sex				**0.69**
Male	31 (22%)	29 (24%)	60 (22%)	
Female	113 (78%)	94 (76%)	207 (78%)	
Caregiver Type				**0.038**
Mother	69 (48%)	40 (33%)	109 (41%)	
Father	24 (17%)	28 (23%)	52 (19%)	
Center provider	51 (35%)	55 (45%)	106 (40%)	
Highest Level of Education Completed				**0.041**
None/Pre-school	5 (3%)	3 (2%)	8 (3%)	
Primary	55 (38%)	39 (32%)	94 (35%)	
Secondary	56 (39%)	38 (31%)	94 (35%)	
Post-secondary	28 (19%)	43 (35%)	71 (27%)	
Main Occupation				**<0.001**
Self-employed	61 (42%)	77 (63%)	138 (52%)	
Employed – casual	62 (43%)	15 (12%)	77 (29%)	
Employed – salaried/formal	7 (5%)	16 (13%)	23 (9%)	
Unemployed	13 (9%)	13 (11%)	26 (10%)	
Student	1 (1%)	2 (2%)	3 (1%)	

	Nairobi	Kisumu	Total	p-value
	N=144	N=123	N=267	
Respondent age (years); Median (IQR)	**35 (28-44)**	**36 (31-43)**	**35 (29-43)**	**0.24**
Estimated Monthly Income				**0.15**
None	8 (6%)	14 (11%)	22 (8%)	
<10,000 Ksh	96 (67%)	66 (54%)	162 (61%)	
10,000 - 20,000 Ksh	29 (20%)	32 (26%)	61 (23%)	
>20,000 Ksh	11 (8%)	11 (9%)	22 (8%)	
Marital Status				**<0.001**
Currently Married/Living Together	71 (49%)	92 (75%)	163 (61%)	
Single (Ever Married)	53 (37%)	23 (19%)	76 (28%)	
Single (Never Married)	20 (14%)	7 (6%)	27 (10%)	
No response	0 (0%)	1 (1%)	1 (0%)	
Spouse's Highest Level of Education				**0.008**
None/Pre-school	3 (4%)	1 (1%)	4 (2%)	
Primary	12 (17%)	23 (25%)	35 (21%)	
Secondary	44 (62%)	36 (39%)	80 (49%)	
Post-secondary	12 (17%)	32 (35%)	44 (27%)	
Spouse's Main Occupation				**0.008**
Self-employed	21 (30%)	49 (53%)	70 (43%)	
Employed – casual	27 (38%)	17 (18%)	44 (27%)	
Employed – salaried/formal	13 (18%)	10 (11%)	23 (14%)	
Agriculture/farming	0 (0%)	3 (3%)	3 (2%)	
Unemployed	8 (11%)	12 (13%)	20 (12%)	
Student	2 (3%)	1 (1%)	3 (2%)	

3.1.2 Sociodemographic Characteristics of Healthcare Providers

More than half of the healthcare providers (56%) were female. The median age of participants was 44 years. The most represented cadres were nurses (30%) and community health promoters (26%), reflecting frontline roles in child health and service delivery. Gender distribution varied by county: Kisumu had a higher proportion of female healthcare providers, while Nairobi recorded more male respondents.

Table 2: Sociodemographic characteristics of policy implementers (healthcare providers)

	Nairobi	Kisumu	Total	p-value
	N=14	N=13	N=27	
Age in years [Median (IQR)]	**42 (29-49)**	**45 (33-50)**	**44 (31-50)**	**0.56**
Sex				**0.17**
Male	8 (57%)	4 (31%)	12 (44%)	
Female	6 (43%)	9 (69%)	15 (56%)	
Cadre				**0.60**
Nurse	5 (36%)	3 (23%)	8 (30%)	
Sub-County MOH	1 (7%)	0 (0%)	1 (4%)	
Nutritionists	1 (7%)	2 (15%)	3 (11%)	
Clinical officers	1 (7%)	1 (8%)	2 (7%)	
Community Health Assistant (CHAs)	1 (7%)	2 (15%)	3 (11%)	
Community Health Promoters (CHPs)	5 (36%)	2 (15%)	7 (26%)	
Assistant Director Radiography	0 (0%)	1 (8%)	1 (4%)	
Health Record Officer	0 (0%)	1 (8%)	1 (4%)	
Public Health Officer	0 (0%)	1 (8%)	1 (4%)	

3.2 Caregivers' Knowledge About Neuroimaging Techniques

Caregivers demonstrated high familiarity with conventional neuroimaging techniques, with 96% reporting knowledge of X-ray, and 88% of ultrasound (Table 3). However, awareness of MRI was notably lower, with only 53% of caregivers across both counties indicating familiarity with the technique. The majority (87%) understood that neuroimaging is primarily used to detect disorders in young children, while a smaller proportion (26%) recognized its potential for tracking developmental outcomes.

Perceptions of MRI safety varied significantly by location. In Kisumu, 22% of caregivers associated MRI with brain damage, compared to just 6% in Nairobi, suggesting localized differences in exposure and understanding. Across both counties, 63% of caregivers were aware that MRI scans are often conducted on the head or brain of a child.

Table 3: Caregivers' knowledge about neuroimaging techniques

	Nairobi	Kisumu	Total	p-value
	N=144	N=123	N=267	
Knows what an X-ray is	135 (94%)	122 (99%)	257 (96%)	0.020
Knows what a CT-scan is	91 (63%)	107 (87%)	198 (74%)	<0.001
Knows what ultra-sound is	114 (79%)	120 (98%)	234 (88%)	<0.001
Knows what MRI is	60 (42%)	82 (67%)	142 (53%)	<0.001
Perceived usefulness of neuroimaging techniques in young children				
Detect disorder(s)	49 (82%)	75 (91%)	124 (87%)	0.083
Track developmental outcomes	15 (25%)	22 (27%)	37 (26%)	0.81
Research	2 (3%)	3 (4%)	5 (4%)	0.92
Others	3 (5%)	4 (5%)	7 (5%)	0.97
Aware of health/safety concerns related to neuroimaging techniques on young children	16 (27%)	53 (65%)	69 (49%)	<0.001

	Nairobi N=144	Kisumu N=123	Total N=267	p-value
Safety concerns				
Brain damage	8 (6%)	27 (22%)	35 (13%)	<0.001
Causes Cancer	1 (1%)	3 (2%)	4 (1%)	0.24
Mental Illness	1 (1%)	3 (2%)	4 (1%)	0.24
Affects General health	7 (5%)	16 (13%)	23 (9%)	0.018
Causes Death	0 (0%)	0 (0%)	0 (0%)	
Other	1 (1%)	5 (4%)	6 (2%)	0.064
Body parts that can be scanned using MRI				
The brain/head	44 (73%)	45 (55%)	89 (63%)	0.025
All parts of the body	22 (37%)	41 (50%)	63 (44%)	0.11
Other	4 (7%)	9 (7%)	13 (7%)	0.87
Don't know	1 (2%)	8 (10%)	9 (6%)	0.051
Knows someone who has undergone MRI	34 (57%)	53 (65%)	87 (61%)	0.34

Qualitative interviews revealed that while center providers were familiar with commonly used imaging techniques such as X-ray, their understanding of more advanced neuroimaging modalities, particularly MRI, was limited. Many participants described X-ray as a tool used by doctors to detect internal problems, such as fractures or nerve damage. As one center provider explained:

> *"X-ray is just a machine used to take the picture in internal body of a human being to know where there is cracking in the nerves also some fractures in the body. It helps to know exactly what is happening in the body because you can get a problem, but you have the problem is internal." FGD with center providers*

This foundational understanding contrasted sharply with misperceptions of MRI, which were often shaped by fear and misinformation. Several caregivers expressed anxiety about undergoing MRI procedures, citing community narratives that portrayed the experiences as harmful or transformative. One caregiver shared:

> *"...I went there very afraid since people say you cannot leave that place the same again, I left there very fearful, I lived my life in fear till I went back for the second clinic." IDI with a caregiver*

Despite these fears, some caregivers recognized the potential of MRI to support child development research. They described the machine as capable of tracking brain growth and developmental milestones, suggesting an emerging awareness of its non-clinical applications. As one participant noted:

> *"MRI machine is used to know how the brain develops and, we can say it tests different milestones for children. At each milestone, a child is supposed to be doing something." FGD with caregivers*

These insights mirror the quantitative findings presented in Table 3, where caregivers demonstrated high familiarity with X-ray but limited understanding of MRI, and where safety concerns, particularly fears of brain damage, were more prevalent in Kisumu than Nairobi. Together, these qualitative narratives highlight the importance of targeted community engagement to address misconceptions and build trust in neuroimaging research.

3.3 Healthcare Providers' Knowledge About Neuroimaging Techniques

All healthcare providers interviewed demonstrated familiarity with MRI, underscoring its recognition within clinical practice. The majority (70%) identified MRI as a diagnostic tool for detecting disorders, while a notable proportion (59%) expressed concerns about its potential impact on general health in young children (**Table 4**). Perceptions of MRI's developmental utility varied by location: 71% of providers in Nairobi acknowledged its role in tracking developmental outcomes in children, compared to 46% in Kisumu, suggesting regional differences in exposure to research applications of neuroimaging. Importantly, 57% of healthcare providers reported that community members commonly associate MRI with brain damage in young children.

Table 4: Healthcare providers' knowledge about neuroimaging techniques

	Nairobi	Kisumu	Total	p-value
	N=14	N=13	N=27	
Knows what MRI is	14 (100%)	13 (100%)	27 (100%)	
Perceived usefulness of neuroimaging techniques in young children				
Detect disorder(s)	10 (71%)	9 (69%)	19 (70%)	0.90
Track developmental outcomes	10 (71%)	6 (46%)	16 (59%)	0.18
Research	0 (0%)	2 (15%)	2 (7%)	0.13
Brain development and function	0 (0%)	4 (31%)	4 (15%)	0.025
Assess the functioning of internal organs	0 (0%)	1 (8%)	1 (4%)	0.29
Aware of health/safety concerns related to neuroimaging techniques on young children	8 (57%)	8 (62%)	16 (59%)	0.82
Safety concerns				
Brain damage	4 (50%)	3 (38%)	7 (44%)	0.61
Causes cancer	2 (25%)	1 (12%)	3 (19%)	0.52
Mental illness	1 (12%)	1 (12%)	2 (12%)	1.00
Affects general health	2 (25%)	4 (50%)	6 (38%)	0.30
Causes death	0 (0%)	0 (0%)	0 (0%)	
Exposes children to too much light	0 (0%)	1 (12%)	1 (6%)	0.30
Affects body tissues	0 (0%)	1 (12%)	1 (6%)	0.30
Body parts that can be scanned using MRI				
The brain/head	12 (86%)	4 (31%)	16 (59%)	0.004
All parts of the body	3 (21%)	8 (62%)	11 (41%)	0.034
Chest	2 (14%)	1 (8%)	3 (11%)	0.59
Health/safety concerns of the community related to neuroimaging techniques on young children				
Brain damage	8 (57%)		8 (57%)	
Causes cancer	2 (14%)		2 (14%)	
Mental illness	2 (14%)		2 (14%)	
Affects general health	4 (29%)		4 (29%)	

Healthcare providers consistently reported familiarity with commonly used imaging techniques such as X-rays and ultrasound, noting that these modalities were well-established and widely recognized with the community. In contrast, CT scans and MRI were described as fairly new and less commonly understood techniques among community members. As one provider explained:

> *"X-ray is the one which has been there the longest. There may be ultrasound, but CT and MRI are fairly, new and also not too common." KII with a healthcare provider*

A healthcare provider emphasized that while parents were generally willing to pursue imaging when a child was ill, they required additional reassurance and explanation when the procedure was intended for research or developmental assessment among healthy children.

> *"...for a study such as this may be a bit more complicated, because we have to explain what we want to do for them to really understand to give consent for you, because at least as far they are concerned, there's nothing wrong with the child." KII with a healthcare provider*

3.5 Exploring Attitudes and Beliefs Towards, and Experiences with the Use of Neuroimaging Techniques

The study revealed a complex interplay of curiosity, caution, and conditional acceptance among caregivers and healthcare providers regarding the use of neuroimaging, particularly MRI, in children. While many participants acknowledged the potential benefits of imaging technologies, their attitudes were shaped by emotional responses, cultural beliefs, and perceived risks.

3.5.1 Caregiver Perspectives and Experiences

Caregivers expressed a strong desire for transparency and reassurance. As shown in Table 5, nearly all respondents (93%) emphasized the importance of explaining the MRI procedure beforehand, and 87% supported the provision of information packs to help them prepare emotionally and practically. Despite this, 68% reported feeling nervous when their child was scanned, with caregivers in Kisumu expressing higher levels of anxiety than those in Nairobi.
Safety perceptions were mixed. While 55% of caregivers believed MRI was safe for children, 27% expressed concerns and 18% were unsure. Notably, 81% were willing to have their child undergo an MRI scan, and 55% were open to scans conducted at night.

Table 5: Caregivers' attitudes, experiences, and beliefs on use of neuroimaging techniques

	Nairobi	Kisumu	Total	p-value
	N=144	N=123	N=267	
Experience with MRI: Personal or known individuals	42 (29%)	57 (46%)	99 (37%)	0.004
It is important to explain the process before doing a brain scan on a young child				0.003
Agree	126 (88%)	121 (98%)	247 (93%)	
Not sure/don't know	12 (8%)	1 (1%)	13 (5%)	
Disagree	6 (4%)	1 (1%)	7 (3%)	
It is important to provide an information pack before MRI scanning so as to help caregivers to familiarize themselves and cope accordingly after the procedure	108 (75%)	123 (100%)	231 (87%)	<0.001
Believes the MRI use is safe for children				0.52
No	35 (24%)	37 (30%)	72 (27%)	
Yes	84 (58%)	64 (52%)	148 (55%)	
Don't know	25 (17%)	22 (18%)	47 (18%)	
It is normal for caregivers to feel nervous when their children are going through MRI scan	85 (59%)	96 (78%)	181 (68%)	<0.001
It is important to have parents present when scanning young children using MRI				<0.001
Agree	105 (73%)	106 (86%)	211 (79%)	
Not sure/don't know	29 (20%)	5 (4%)	34 (13%)	
Disagree	10 (7%)	12 (10%)	22 (8%)	
Willing to have own child undergo MRI scan	103 (72%)	112 (91%)	215 (81%)	<0.001
Willing to have own child undergo MRI scan at night	50 (49%)	68 (61%)	118 (55%)	0.073

Qualitative interviews reinforced the findings from the quantitative survey. Caregivers described MRI as both a diagnostic and developmental tool, but also shared fears rooted in community narratives. For instance, some believed repeated scans could "drain blood" or harm children with heart conditions as illustrated below:

> *"They just believe that X-rays should be done once and not repeatedly because it is harmful to the body. They believe that when you take someone for an X-ray it drains their blood." FGD with caregivers*

> *"…those children with little blood, you find that they have heart problem and they cannot be taken into the MRI machine." FGD with center providers*

Others emphasized the importance of seeing the machine beforehand and having parents present during the procedure to reduce anxiety.

"I believe that the imaging techniques are good, but awareness has to be made on the importance of the scans. This awareness should be conducted on the parent, the caregiver at the daycare center, and the child. It would also be prudent if they can see the machine before the procedures are conducted." FGD with home-based care providers

3.6 Healthcare Provider Perspectives and Experiences

Healthcare providers unanimously supported caregiver engagement, with 100% advocating for clear explanations and informational materials prior to conducting brain scans (Table 6). A majority of healthcare providers (78%) reported having experience or knowing individuals who had undergone MRI procedures. Most (85%) acknowledged that caregiver nervousness was normal, and 93% supported parental presence during scans to provide emotional comfort to young children.

While 81% of healthcare providers believed MRI was safe for children, some expressed concerns about contraindications, such as metallic implants or sensory sensitivities. Providers also reported that community members often associated MRI with brain damage, reinforcing the need for targeted sensitization.

Table 6: Healthcare providers' knowledge, attitudes, beliefs, and practices on neuroimaging techniques

	Nairobi	Kisumu	Total	p-value
	N=14	N=13	N=27	
Experience with MRI: Personal or known individuals	9 (64%)	12 (92%)	21 (78%)	0.080
It is important to explain the process before doing a brain scan on a young				
Agree	14 (100%)	13 (100%)	27 (100%)	
It is important to provide an information pack before MRI scanning so as to help caregivers to familiarize themselves and cope accordingly after the procedure	14 (100%)	13 (100%)	27 (100%)	
Believes the MRI use is safe for children				0.22
No	0 (0%)	2 (15%)	2 (7%)	
Yes	13 (93%)	9 (69%)	22 (81%)	
Don't know	1 (7%)	2 (15%)	3 (11%)	
It is normal for caregivers to feel nervous when their children are going through MRI scan				0.51
Agree	12 (86%)	11 (85%)	23 (85%)	
Not sure/don't know	0 (0%)	1 (8%)	1 (4%)	
Disagree	2 (14%)	1 (8%)	3 (11%)	
It is important to have parents present when scanning young children using MRI				0.37
Agree	13 (93%)	12 (92%)	25 (93%)	
Not sure/don't know	1 (7%)	0 (0%)	1 (4%)	
Disagree	0 (0%)	1 (8%)	1 (4%)	

Findings from the qualitative interviews reinforced the patterns observed in the quantitative data, particularly regarding healthcare providers' perceptions of community beliefs about neuroimaging. Providers acknowledged that while MRI was generally considered safe within clinical practice, misconceptions persisted among community members, especially concerning its use in children. One provider emphasized the clinical safety of MRI, while also noting specific contraindications:

"MRI is a pretty safe method, of course, there are other contraindications to MRI, especially people who've had implants and people with mental surgeries." KII with a healthcare provider

Despite this clinical confidence, providers reported that many community members associate MRI with harm, particularly brain damage. These fears were attributed to limited understanding and lack of exposure to technology:

"The community thinks that if the person is scanned, he can have brain damage. I think it is everybody because we are not specialized in that area, but the moment we are sensitized, I think that perception will go out." KII with a healthcare provider

In addition to safety concerns, providers highlighted emotional and sensory barriers to MRI use. The physical experience of undergoing an MRI, particularly the noise and enclosed space, was described as intimidating for some individuals:

> *"MRI is just scary once you are in. It's quite noisy and has all kinds of sounds. So, we also just have people who do not like such kinds of enclosed spaces. You put them there, maybe start panicking." KII with a healthcare provider*

A policy stakeholder further noted that repeated imaging may not be appropriate for all individuals, especially those with certain medical conditions, reinforcing the need for careful screening and communication.

> *"...there are safety concerns, especially in terms of the frequency of doing imaging for individuals who have certain conditions because some are not eligible for imaging services." KII with a healthcare provider*

DISCUSSION, CONCLUSIONS, RECOMMENDATIONS

4.1 Discussion

The findings of this study reveal significant gaps in knowledge and perceptions regarding the use of MRI in children, particularly for research purposes. Many caregivers expressed uncertainty about MRI safety, with some associating it with harmful effects such as brain damage or cancer. These misconceptions likely stem from limited exposure to MRI technology and inadequate public health communication. Similarly, health providers demonstrated varying levels of understanding, suggesting that professional training on MRI applications remains insufficient.

Caregivers expressed concerns that the use of neuroimaging techniques on young children may pose health and safety risks, particularly the possibility of brain damage. Such misconceptions can significantly discourage participation in developmental science research involving MRI (Daniels et al., 2024). The findings from this study highlight the importance of assessing caregivers' knowledge and attitudes toward neuroimaging before implementing MRI-based assessments. Further, the results suggest the need to assess stakeholders' ethical perceptions in implementing future similar studies in economically disadvantaged communities across sub-Saharan Africa. Addressing these safety and ethical concerns through targeted education and community engagement may positively enhance willingness to participate in studies involving new investigational technologies (Daniels et al., 2024).

Evidence suggests that MRI research involving infants and children is relatively uncommon, particularly in sub-Saharan Africa. This may be attributed to limited resources and capacity to utilize the technique in both research and clinical settings (Raschle et al., 2012). Additionally, there may be concerns associated with safety in young children. Several factors contribute to the low deployment of MRI, including inadequate knowledge about its role in promoting healthy brain development, high costs associated with image acquisition and scanner maintenance, and insufficient human and structural capacity. These challenges create unique barriers for researchers and clinicians, such as issues of access, acceptability, and technical and procedural difficulties for the few MRI facilities available in the region (Raschle et al., 2012).

Experiencing sort of nervousness before or during MRI scanning is common among caregivers in sub-Saharan Africa, and our findings confirm that most parents consider it normal to feel anxious when their children undergo MRI scans. Overall, caregivers expressed greater willingness to allow their children to undergo brain scans in two study sites. This observation aligns with findings from a cross-sectional online survey of parents of autistic children in the UK, which identified anxiety in parents associated with MRI procedures (Stogiannos et al., 2023). The UK study is relevant to research practices in SSA, given the comparable burden rising neurodevelopmental delays in children (Dubois et al., 2021). The findings presented in this report, are consistent with those of previous studies, and indicate the urgency to address the hesitancy towards MRI due to underlying anxiety, associated with perceived health risks. It would be useful for parents of children undergoing MRI scans to be offered pre-visit familiarization. Further, health staff should be trained and sensitized on community perceptions towards MRI and how to address them. These insights also reinforce the importance of addressing caregiver anxiety and improving communication about MRI procedures to enhance participation in neurodevelopmental research.

The results of this study indicate that many healthcare providers are familiar with MRI technology. While a significant proportion correctly identified MRI as a tool for detecting disorders, some believed that community members associate its use with general health risks, including brain damage in young children. These findings highlight critical gaps in perceptions and knowledge among healthcare providers regarding the safety of MRI in pediatric populations. Training healthcare providers to address these misconceptions is essential, as they can serve as trusted champions to dispel myths within communities and healthcare facilities.

Previous studies confirm that healthcare professionals in LMICs recognize MRI primarily as a diagnostic tool, yet challenges persist in optimizing its use (Hilabi et al., 2023). Common barriers include a shortage of trained personnel, limited access to advanced technology, and inadequate infrastructure (Bray et al., 2022). Our study provides valuable insights for neuroscience researchers, emphasizing the need to promote community acceptability (Aderinto, Olatunji, et al., 2023). Additionally, there is need to strengthen healthcare workers through training before introducing neuroimaging studies on children.

Neuroimaging techniques such as CT scans, MRI, and skull X-rays have been widely utilized in developed countries (Aderinto, Abdulbasit, et al., 2023; Dubois et al., 2021). Primarily, these techniques have been used to advance diagnostic and therapeutic management of neurological disorders (Dubois et al., 2021). However, findings from this study revealed that some policy implementers in Kenya's health sector believed MRI scans pose health risks to young children. These perceptions by professional groups within health sector may partly explain the limited investment in these technologies. Similarly, healthcare providers reported concerns about brain damage and cancer as potential risks of MRI use. These perceptions contrast with evidence from a UK study on infants, which confirms that MRI scanning is safe and poses no health risks (Hughes et al., 2017). Such cross-country differences underscore the need to contextualize protocols for introducing new technologies before implementation in different settings.

In sub-Saharan Africa, the demand for MRI continues to rise, yet scanner availability remains extremely low, fewer than one per million population (Dubois et al., 2021). Despite ongoing efforts to stabilize energy supply for powering 1.5T scanners, only about 8% of clinical facilities consistently perform MRI scans (Anazodo et al., 2023). These findings highlight opportunities for researchers and policymakers to develop capacity-strengthening strategies for healthcare providers and radiographers. The skills will help the health stakeholders to optimize the use of ultra-low-field MRI in both clinical and research settings.

Healthcare providers and researchers at all levels play a critical role in shaping community perceptions of new technologies aimed at improving child health outcomes (Stogiannos et al., 2023). Our findings emphasize the importance of regular communication between neuroscience professionals, such as radiologists and radiographers, and caregivers whose children may undergo MRI scans. Low awareness remains a major barrier to MRI utilization in sub-Saharan Africa, slowing progress toward improved child health outcomes (Hilabi et al., 2023). Encouragingly, evidence from a South African birth cohort study involving MRI scans of children aged 2–3 years demonstrated high success rates following community sensitization efforts (Katus et al., 2019). These insights suggest that building trust and confidence among caregivers and healthcare providers is essential for increasing acceptability and uptake of neuroimaging techniques in pediatric research.

The implications of these findings are far-reaching. Our findings underscore the importance of increasing awareness about the benefits, risks, challenges, and opportunities associated with neuroimaging techniques like MRI. Such efforts are crucial for enhancing acceptability and scalability, not only in research but also in clinical diagnosis within resource-constrained settings across sub-Saharan Africa. Without targeted sensitization and stakeholder engagement, efforts to integrate MRI into neuroscience research may face resistance, potentially compromising study participation and ethical compliance. Addressing these gaps through community education, professional training, and policy support is therefore critical to ensuring safe and acceptable use of MRI in child health research.

4.2 Conclusions

This study highlights both the immense potential and the pressing challenges of integrating neuroimaging techniques into neuroscience research in sub-Saharan Africa. While communities and caregivers show some awareness of neuroimaging, their understanding is largely limited to X-ray. MRI is largely perceived to be used outside clinical diagnosis. Further, communities have less familiarity with MRI, especially among caregivers and misconceptions about its risks, such as brain damage or cancer. These perceptions, combined with infrastructural and resource limitations, reveal a critical knowledge gap that hinders progress. Addressing this requires targeted education and capacity-building efforts to boost community acceptance and healthcare provider confidence. Promoting affordable, low-field MRI technology offers a practical pathway forward, enabling crucial research into brain development and child health. Building trust and awareness is essential for increasing participation and for inspiring ECD policy investments. These policy investments can harness neuroimaging innovations to improve child health outcomes in socio-economically disadvantaged communities. By bridging these gaps, we can unlock new opportunities to transform neuroscience and child health across the region.

4.3 Recommendations

In the light of the findings of this study presented in this report, we recommend that any research and other non-clinical activities involving MRI should prioritize effective community sensitization before implementation. Developing, testing, and adopting feasible community-led awareness and sensitization strategies will be critical to enhance acceptability of MRI for investigating child developmental outcomes in Kenyan settings.

In addition, we recommend that researchers and policy implementers should jointly engage communities to demystify misconceptions about MRI safety and its role in supporting optimal child development. Additionally, the advantages of low-field MRI, including portability and affordability should be highlighted among healthcare stakeholders to encourage investment in this technology.

Finally, we recommend joint development of standard operating procedures to popularize MRI assessment procedures, address safety concerns and perceived risks, and build confidence among potential study participants. These steps are particularly important for research involving socio-economically disadvantaged populations in low-income settings.

REFERENCES

Aderinto, N., Abdulbasit, M., Olatunji, G., & Edun, M. (2023). The landscape of neuroscience research in Africa: current state, progress, and challenges; a perspective. ***Annals of Medicine & Surgery, 85***(10), 5267–5274. https://doi.org/10.1097/ms9.0000000000001219

Aderinto, N., Olatunji, D., Abdulbasit, M., & Edun, M. (2023). The essential role of neuroimaging in diagnosing and managing cerebrovascular disease in Africa: a review. ***Annals of Medicine, 55***(2). https://doi.org/10.1080/07853890.2023.2251490

Anazodo, U. C., Ng, J. J., Ehiogu, B., Obungoloch, J., Fatade, A., Mutsaerts, H. J. M. M., Secca, M. F., Diop, M., Opadele, A., Alexander, D. C., Dada, M. O., Ogbole, G., Nunes, R., Figueiredo, P., Figini, M., Aribisala, B., Awojoyogbe, B. O., Aduluwa, H., Sprenger, C., … Dako, F. (2023). A framework for advancing sustainable magnetic resonance imaging access in Africa. ***NMR in Biomedicine, 36***(3), 0–3. https://doi.org/10.1002/nbm.4846

Anazodo, U. C., Ng, J. J., Ehiogu, B., Obungoloch, J., Fatade, A., Mutsaerts, H. J. M. M., Secca, M. F., Diop, M., Opadele, A., Alexander, D. C., Dada, M., Ogbole, G., Nunes, R., Figueiredo, P., Figni, M., Aribisala, B., Awojoyogbe, B. O., Sprenger, C., Olakunle, A., … Dako, F. (2022). A Framework for Advancing Sustainable MRI Access in Africa. ***MedRxiv.*** https://doi.org/10.1101/2022.05.02.22274588

Asante, S., & Acheampong, F. (2021). Patients’ knowledge, perception, and experience during magnetic resonance imaging in Ghana: A single centre study. ***Radiography, 27***(2), 622–626. https://doi.org/10.1016/j.radi.2020.11.020

Bray, L., Booth, L., Gray, V., Maden, M., Thompson, J., & Saron, H. (2022). Interventions and methods to prepare , educate or familiarise children and young people for radiological procedures : a scoping review. In ***Insights into Imaging.*** Springer Vienna. https://doi.org/10.1186/s13244-022-01278-5

Daniels, F., Torres, E., Lawrenz, F., Wolf, S. M., & Shen, F. X. (2024). Scientists' perspectives on ethical issues in research with emerging portable neuroimaging technology: The need for guidance on ethical, legal, and societal implications (ELSI). ***NMR in Biomedicine, 37***(12), 1–10. https://doi.org/10.1002/nbm.5243

Dubois, J., Alison, M., Counsell, S. J., Hertz-Pannier, L., Hüppi, P. S., & Benders, M. J. N. L. (2021). MRI of the Neonatal Brain: A Review of Methodological Challenges and Neuroscientific Advances. ***Journal of Magnetic Resonance Imaging, 53***(5), 1318–1343. https://doi.org/10.1002/jmri.27192

Halpern, R. (2010). ***Child development in a birth cohort : effect of child stimulation is stronger in less educated mothers.*** https://doi.org/10.1093/ije/dyp272

Hilabi, B. S., Alghamdi, S. A., & Almanaa, M. (2023). Impact of Magnetic Resonance Imaging on Healthcare in Low- and Middle-Income Countries. ***Cureus, 15***(4). https://doi.org/10.7759/cureus.37698

Hughes, E. J., Winchman, T., Padormo, F., Teixeira, R., Wurie, J., Sharma, M., Fox, M., Hutter, J., Cordero-Grande, L., Price, A. N., Allsop, J., Bueno-Conde, J., Tusor, N., Arichi, T., Edwards, A. D., Rutherford, M. A., Counsell, S. J., & Hajnal, J. V. (2017). A dedicated neonatal brain imaging system. ***Magnetic Resonance in Medicine, 78***(2), 794–804. https://doi.org/10.1002/mrm.26462

Katus, L., Hayes, N. J., Mason, L., Blasi, A., Mccann, S., Darboe, M. K., Haan, M. De, Moore, S. E., Lloyd-fox, S., Elwell, C. E., & Forbes, S. H. (2019). ***neuroimaging and eye tracking methods to assess neurocognitive development of young infants in low- and middle-income countries [version 2 ; peer review : 2 approved] Gates Open Research.*** 1–26.

Lia C. H. Fernald, Elizabeth Prado, Patricia Kariger, A. R. (2017). A Toolkit for Measuring Early Childhood Development in Low- and Middle-Income Countries. International Bank for Reconstruction and Development/The World Bank. ***The Strategic Impact Evaluation Fund, the World Bank***. http://repositorio.minedu.gob.pe/bitstream/handle/20.500.12799/5723/A Toolkit for Measuring Early Childhood Development in Low and Middle-Income Countries.pdf?sequence=1&isAllowed=y

MICHA, R. (2017). 乳鼠心肌提取 HHS Public Access. ***Physiology & Behavior, 176***(1), 100–106. https://doi.org/10.1177/0022146515594631.Marriage

Murali, S., Ding, H., Adedeji, F., Qin, C., Obungoloch, J., Asllani, I., Anazodo, U., Ntusi, N. A. B., Mammen, R., Niendorf, T., & Adeleke, S. (2024). Bringing MRI to low- and middle-income countries: Directions, challenges and potential solutions. ***NMR in Biomedicine, 37***(7), 1–22. https://doi.org/10.1002/nbm.4992

Pid, R. N. (1818). ***Public Disclosure Authorized Public Disclosure Authorized Public Disclosure Authorized Public Disclosure Authorized.***

Raschle, N., Zuk, J., Ortiz-Mantilla, S., Sliva, D. D., Franceschi, A., Grant, P. E., Benasich, A. A., & Gaab, N. (2012). Pediatric neuroimaging in early childhood and infancy: challenges and practical guidelines. ***Annals of the New York Academy of Sciences, 1252***, 43–50. https://doi.org/10.1111/j.1749-6632.2012.06457.x

Simiyu, S., Cairncross, S., & Swilling, M. (2019). Correction to: Understanding Living Conditions and Deprivation in Informal Settlements of Kisumu, Kenya (Urban Forum, (2019), 30, 2, (223-241), 10.1007/s12132-018-9346-3). ***Urban Forum, 30***(2), 243–244. https://doi.org/10.1007/s12132-018-9360-5

Stogiannos, N., Pavlopoulou, G., Papadopoulos, C., Walsh, G., Potts, B., Moqbel, S., Gkaravella, A., McNulty, J., Simcock, C., Gaigg, S., Bowler, D., Marais, K., Cleaver, K., Lloyd, J. H., dos Reis, C. S., & Malamateniou, C. (2023). Strategies to improve the magnetic resonance imaging experience for autistic individuals: a cross-sectional study exploring parents and carers' experiences. ***BMC Health Services Research, 23***(1), 1–10. https://doi.org/10.1186/s12913-023-10333-w

Tarnoki, D. L., Tarnoki, A. D., Richter, A., Karlinger, K., Berczi, V., & Pickuth, D. (2015). Clinical value of whole-body magnetic resonance imaging in health screening of general adult population. ***Radiology and Oncology, 49***(1), 10–16. https://doi.org/10.2478/raon-2014-0031

Warsito, O., Khomsan, A., Hernawati, N., & Anwar, F. (2012). ***Relationship between nutritional status , psychosocial stimulation , and cognitive development in preschool children in Indonesia. 6***(5), 451–457.

Wedderburn, C. J., Subramoney, S., Yeung, S., Fouche, J.-P., Joshi, S. H., Narr, K. L., Rehman, A. M., Roos, A., Ipser, J., Robertson, F. C., Groenewold, N. A., Gibb, D. M., Zar, H. J., Stein, D. J., & Donald, K. A. (2020). Neuroimaging young children and associations with neurocognitive development in a South African birth cohort study. ***NeuroImage, 219***, 116846. https://doi.org/10.1016/j.neuroimage.2020.116846