

Clinical Research and Innovation in Pediatric Neurorehabilitation in West Africa: The World Medical Aid Experience in Bonoua, Ivory Coast

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Received: October 08, 2025; **Published:** October 14, 2025

Abstract

Pediatric neurological disorders pose a severe, under-addressed public health crisis in Sub-Saharan Africa. To counter this, the World Medical Aid (WMA) in Bonoua, Ivory Coast, implemented advanced non-pharmacological care.

Their pilot study on children with drug-resistant epilepsy (DRE) successfully utilized Neurofeedback (NF) training, demonstrating a statistically significant and sustained reduction in seizure episodes. This validates NF as a viable, accessible intervention in resource-limited settings.

Sustained funding is crucial for overcoming operational hurdles. Future research will combine NF with multispecies probiotics to modulate the gut-brain axis, creating a holistic treatment strategy to improve neurodevelopmental outcomes and contribute vital data from West Africa.

Keywords: Drug-Resistant Epilepsy (DRE); Neurofeedback (NF); Pediatric Neurorehabilitation; World Medical Aid (WMA)

Abbreviations

NFB: Neurofeedback; SMR: Sensory-Motor Cortical Rhythm; CP: Cerebral Palsy; EEG: Electroencephalography; PWE: People with Epilepsy; LMICs: Living in Low-and Middle-Income Countries; AAN: American Academy of Neurology; SA: South Africa; WHA: World Health Assembly; WHO: World Health Organization; AED: Antiepileptic Drug; DRE: Drug Resistant Epilepsy; BCI: Brain-Computer Interface; fMRI: Functional Magnetic Resonance Imaging; ADHD: Attention Deficit Hyperactivity Disorder; HRV: Heart Rate Variability; DMNs: Default Mode Networks; FC: Functional Connectivity

Neurological disorders in children represent a vast and often overlooked public health crisis in low- and middle-income countries (LMICs), particularly across Sub-Saharan Africa. The burden of diseases such as epilepsy and cerebral palsy is estimated to be significantly higher than in high-income countries, with the prevalence of epilepsy being two to three times greater [1,2]. These conditions often lead to profound chronic morbidity, placing an immense socioeconomic burden on patients and their families. Furthermore, the high rates of preventable infections and birth trauma contribute disproportionately to neurodevelopmental disabilities [3].

Citation: Maddalena Castelletti and Gloria Crocetti. "Clinical Research and Innovation in Pediatric Neurorehabilitation in West Africa: The World Medical Aid Experience in Bonoua, Ivory Coast". *EC Paediatrics* 14.11 (2025): 01-04.

Despite this alarming disease burden, the region suffers from a severe paucity of literature and research studies on the epidemiology, diagnosis, and innovative management of pediatric neurological diseases [4,5]. The lack of reliable data, coupled with a critical shortage of pediatric neurologists and limited access to essential diagnostic and therapeutic services, underscores the imperative for dedicated clinical research efforts in this setting [6].

Pioneering neurofeedback research in Ivory Coast

Against this background, the clinical research conducted by the Pediatric Neurorehabilitation Department of the Non-Governmental Organization World Medical Aid (WMA) at the Don Orione Hospital in Bonoua, Ivory Coast, represents a crucial step forward. This department, coordinated by Dr. Maddalena Castelletti and Dr. Gloria Crocetti, is a pioneering force in bringing advanced, non-pharmacological neuromodulation techniques to a resource-limited West African setting.

Their work has been documented in the scientific article, "Treatment of Drug-Resistant Epilepsy with Neurofeedback in a Pediatric Population in Ivory Coast: A Pilot Study," published in *EC Paediatrics* [7]. This study investigated the efficacy of SMR (Sensorimotor Rhythm)-promotion.

Neurofeedback training in children aged 3 to 10 years with drug-resistant epilepsy (DRE). A significant proportion of the 87 recruited children had epilepsy secondary to neonatal cerebral palsy, a common and often preventable etiology in this context.

The study's results demonstrated a statistically significant and long-lasting reduction in the number of weekly seizure episodes in the pediatric population studied, with beneficial effects observed up to 90 days post-treatment [7]. This evidence is invaluable, as it not only validates neurofeedback as a viable, non-invasive therapeutic option for DRE in a difficult setting but also challenges the notion that complex neurorehabilitation techniques are only accessible in high-income centers. The research team, led by Drs. Castelletti and Crocetti, has established a pioneering role by successfully implementing and scientifically validating this advanced intervention, thereby setting a new standard for clinical care and research in West African pediatric neurorehabilitation.

Operational difficulties in fragile contexts and funding needs

The execution of high-quality clinical research in a fragile socioeconomic context like Bonoua presents substantial operational difficulties. These challenges extend beyond the direct healthcare provision to include logistics, technology maintenance, and ensuring consistent follow-up care. Specific issues include:

- **Infrastructure limitations:** Reliable electricity, internet, and climate control necessary for specialized neurorehabilitation equipment (like EEG/Neurofeedback devices) are often inconsistent.
- **Supply chain instability:** Securing a consistent supply of consumables, pharmaceuticals, and specialized nutritional supplements is frequently unpredictable.
- **Patient access and adherence:** Economic hardship, long travel distances, and a lack of local transportation can severely limit patient recruitment and adherence to rigorous treatment and follow-up protocols.

To sustain and expand this vital work, there is an acute need to seek sustained funding from external donors. Grant support is essential not only for purchasing and maintaining cutting-edge technology but, crucially, for local capacity building, including training Ivorian clinical staff and covering the operational costs necessary to mitigate the infrastructure and logistical difficulties inherent in this environment. Securing international financial support is a moral and scientific imperative to ensure the long-term viability of this specialized neurorehabilitation program.

Future perspectives: The gut-brain axis and targeted probiotics

The success of the Neurofeedback pilot study opens promising avenues for future clinical research. A logical next step is to explore synergistic approaches by integrating neuromodulation with other emerging therapeutic targets. Specifically, modulating the gut microbiota along the gut-brain axis offers a compelling future perspective.

The gut-brain axis is a bidirectional communication system involving the central nervous system, the autonomic nervous system, the enteric nervous system, and the gut microbiota [8]. Dysbiosis (imbalance in the gut microbiota) can alter the production of neurotransmitters (like GABA and serotonin), short-chain fatty acids (SCFAs), and inflammatory cytokines, all of which can influence neuronal excitability and seizure threshold [9].

Future research in Bonoua should investigate the effect of specific multispecies probiotics on pediatric DRE patients, perhaps in combination with the established neurofeedback protocols. The rationale for using multispecies probiotics lies in their potential to restore a healthy gut barrier function, increase the production of neuroactive SCFAs, and reduce systemic inflammation—all factors linked to improved seizure control [10]. Specific probiotic strains, such as combinations involving *Lactobacillus* and *Bifidobacterium* species, have shown promise in preclinical and early clinical studies related to epilepsy. A clinical trial in Bonoua, evaluating an SMR-Neurofeedback protocol combined with a defined multispecies probiotic regimen, would:

- Contribute vital African data to the global understanding of the gut-brain axis in DRE, an area currently dominated by studies from high-income countries.
- Provide a holistic, multimodal therapeutic strategy, combining established brain training with accessible, low-cost nutritional/microbiotic support, potentially enhancing seizure control and improving overall neurodevelopmental outcomes in these vulnerable children.

This expanded research focus would solidify the World Medical Aid department's role as a center of excellence for innovative and context-appropriate neurorehabilitation research in West Africa.

Acknowledgement

In living memory of Giampietro Poledri, my son's beloved grandfather and supporter of our scientific work since my first day at university. Thank you with all my heart.

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Volume 14 Issue 11 November 2025

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