

Agent-Based Modelling for Evaluation Malnourished Children in Nigerian Internally Displaced Persons (IDP) Camps

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ABSTRACT

This paper aims to provide a multidisciplinary approach to the problem of child malnutrition in Nigeria IDP camps. It offers a scientific method to complement effort by international agencies and the Nigerian government in managing the post-insurgency crisis in IDP camps, especially with child health. We implement an agent-based model from child malnutrition and treatment data. The ABM model was analysed compared to existing child malnutrition and treatment data. The ABM result compared to prevalence data indicates suitable recovery and unrecovered rate from children with confirmed cases of malnutrition after treatment.

Keywords - Agent-Based Modelling, Child Health, Internally Displaced Persons, Malnutrition.

Aims Research Journal Reference Format:

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1. INTRODUCTION

1.1 IDP camps in Nigeria

The prevalence of conflict and natural disasters in the world has resulted in the movement of people from areas of danger to an environment where they feel secure and safe, thereby making them either to become an internally displaced person or refugees. According to ECHO-Factsheets (2015), and the Internally Displacement Monitoring Centre (IDMC) 2015, there are over 38.2 million internally displaced persons in the world. In Africa, an estimated 12 million people (almost half of the world's IDP population) are internally displaced as a result of protracted conflicts, massive human rights violations and natural disasters.

Nigeria, a country situated in the Western part of Africa has been faced with armed conflict, natural disaster, communal clashes and terrorist activities that have engulfed the African continent. The northeastern part of Nigeria has been home to the terrorist group called the Jama'atu Ahlis Sunna Lidda'awati wal-jihad commonly known as the Boko Haram since 2011 (UNHCR 2015). The group has unleashed terror on the Nigeria State particularly in the northeastern part Nigeria, thereby leading to mass exodus of people from their original place of origin or abode to a place where they can be better secured, have some level of comfort, refuge, safety and succour. This group of people are regarded as the Internally Displaced Persons (IDPs).

The IDPs upon movement from their original place of abode have had to contend with living in camps, transitional centres and collective centres with its attendant challenges. According to the Displacement Tracking Matrix (DTM) report for 2015 estimated a total of 1,235,294 IDPs in Nigeria. 1,188,018 IDPs were identified in Adamawa, Bauchi, Borno, Gombe, Taraba, and Yobe states comprising of 149,357 households. 47,276 IDPs were also identified in Plateau, Nasarawa, Abuja, Kano, and Kaduna states. Borno State was been identified as the state with the highest number of IDPs. It has an estimated number of 672,714 IDPs followed by Adamawa State with an estimated 220, 159 IDPs and Yobe State, 135,810 IDPs.

The IDPs population is composed of 53% women and 47 % men. 56% of the total IDPs are children between age 0 and 5 years, while the remaining 42% are adults. The DTM report further States that 92% of IDPs were displaced by insurgency and they come mainly from Borno state, Adamawa state, and Yobe State. The Borno IDPs comprised of 62% of the total IDP population while Adamawa and Yobe states constitute 18% and 13% respectively.

Based on more recent assessment conducted from November to December 2015 by the International Organization for Migration' (IOM) and DTM team in 207 Local Government Areas (LGA) covering 13 states of Northern Nigeria: Abuja has 13,481 IDPs, Adamawa State has 136,010 IDPs, Bauchi State has 70,078 IDPs, Benue 85,393, Borno 1,434,149, Gombe 25,332, Kaduna 36,976, Kano 9,331, Nassarawa 37,553, Plateau 77,317, Taraba 50,227, Yobe 131,203, and Zamfara 44,929 (IOM/NEMA). The assessment indicates that 12.6% were displaced due to communal clashes, 2.4% by natural disaster and 85% as a result of insurgency attacks by the Islamic extremist, Boko Haram.

Zard (2002) enumerated some challenges facing IDPs. This challenge includes protection (security), access to shelter, food and clothing as well as other basic services such as health, nutrition, water, sanitation, hygiene, education, the threat of death from violence, and diseases. Rape and sexual violence against women and girls, and forced recruitment into armed groups are also challenges facing IDPs.

1.2 Child Health: Malnutrition and Treatment Rates

In a report from the United Nations (UN), an estimate of 4.6 million Nigerians are currently at risk of food insecurity, with at least 3 million people projected to require emergency food assistance between July and September 2015 in IDP camps. From this report, it can be deduced that malnutrition is one of the many challenges in Nigeria IDP camps.

The high prevalence of malnutrition in the Nigeria IDP camps has become a serious issue and a source of concern. This is beginning to destabilise the already traumatised IDP population in various camps. The Nigeria Humanitarian Report (2015) recorded that 20,002 children under the age of five were diagnosed with Severe Acute Malnutrition (SAM) in the states of Adamawa, Borno and Yobe (see Table 1). SAM is when a child is severely malnourished and the symptoms observed generally are: Severe wasting characterised by a massive loss of body fat and muscle tissue and oedema present on the lower limbs.

TABLE 1: REPORT OF MALNOURISHED CHILDREN IN ADAMAWA, BORNO AND YOBE IDP CAMPS

Age 0-5	Number of Children	Ratio	Percentage
Total Children	209,577		
Malnutrition Death	450	0.00215	0.215
SAM	20,002	.03075	3.075
Defaulters	25,511	0.12173	16
Cure of Malnutrition	12,349	0.84753	81

According to the World Health Organisation report (WHO) 2016, malnutrition is estimated to contribute to more than one-third of all child deaths. Malnutrition at an early age leads to reduced physical and mental development during childhood. (UN World Food Programme, 2016). Candyce et al, (2015) stated that malnutrition remains an important cause of childhood morbidity and mortality. The report described the levels of childhood malnutrition in Nigeria as one of the highest in the world.

Individuals are malnourished if their diet does not provide them with adequate calories, carbohydrates, vitamins and minerals needed for maintenance and growth, or they cannot fully utilise the food they eat due to illness and Infection, particularly frequent or persistent diarrhoea, pneumonia, measles and malaria also undermines a child's nutritional status. Feeding practices, such as inadequate breastfeeding, offering the wrong foods, and not ensuring that the child gets enough nutritious food, also contribute to malnutrition.

To understand the purpose of the study, the following study question will be addressed. To identify the exiting study report of malnourished children within the said region, to identify relevant interactions within agents and to compare the model to existing child malnutrition and treatment data.

1.3 Agent-Based Modelling

Coppin (2004) defined an agent as an entity which can be biological, robotic, or computational with the capability of carrying out tasks. Coppin further noted that the primary concern for any agent is intelligence. Russel and Norvig (2003) had previously identified intelligence as central to the concept of agents and the approach they are used for building successful agents. This implies that intelligent agents are able to learn from its environment, other agents and users.

In certain studies, scientific scholars have identified agent-oriented research as relevant to software development approach, such as the proposed agent-based computing; AgentLink III (McKean, Shorter et al. 2005). Furthermore, specialists are of the opinion that agents-based orientation represents the most important new paradigm for software development since object-orientation (Cervenka and Trencansky 2007). In comparing objected oriented approach to

agent-based approach, Wooldridge (2009) and Teahan (2010) explained that agent-based takes the approach of object-oriented software development paradigm further to a self-made decision viewpoint i.e. autonomous agents. Autonomous agents are intelligent agents that make its own decisions about how to act in its environment without any influence from the ownership (Franklin and Graesser 1996, Shiffman, Fry et al. 2012).

The term agent has a diverse definition based on the context of use, however, our primary concern is agent-based modelling (ABM). Bryson, Ando et al. (2007) defined ABM as a method that “allows the examination of macro-level effects from micro-level behaviour”. In another definition, Wilensky and Rand (2015) noted that ABM is a form of computational simulation for modelling phenomenon in term of agents and its interactions. This implies that component behaviour is observed within the environment they exist and examined to determine if the models match the set target.

In ABM, the agent’s behaviour generates dynamic structures influenced by given parameters in the environment (Luna and Stefansson 2012). An agent’s behaviour is a way an agent acts in given situation or sets of situations while the environment is everything in the world that surrounds the agent and not part of the agents (Teahan 2010). Moreover, the environment that influences an agent’s behaviour can itself be influenced by the agent.

2. METHODOLOGY

2.1 Study Area

The study area is the northeast Nigeria IDP camps. The IDPs are distributed throughout 28 camps located within northeast insurgency crisis zone of Borno State (See Fig 1 for details). The main sources of livelihood in the area are crop and livestock farming. Access route to some of the remote farming villages is difficult. Due to insurgency, many have fled their homes and abandon their source of livelihood. Many leave in fear of reprisal attack and find it difficult to return home even when insurgency has been brought under control.

Surviving has become the only option for the affected IDPs. Hence feeding becomes event difficult as the need to source for food becomes increasingly problematic and depending on donor agencies continues to overstretch the limited supplies. The DTM Nigeria Report Round II (2015) noted that many of the IDPs are living in spontaneous or planned settlements.

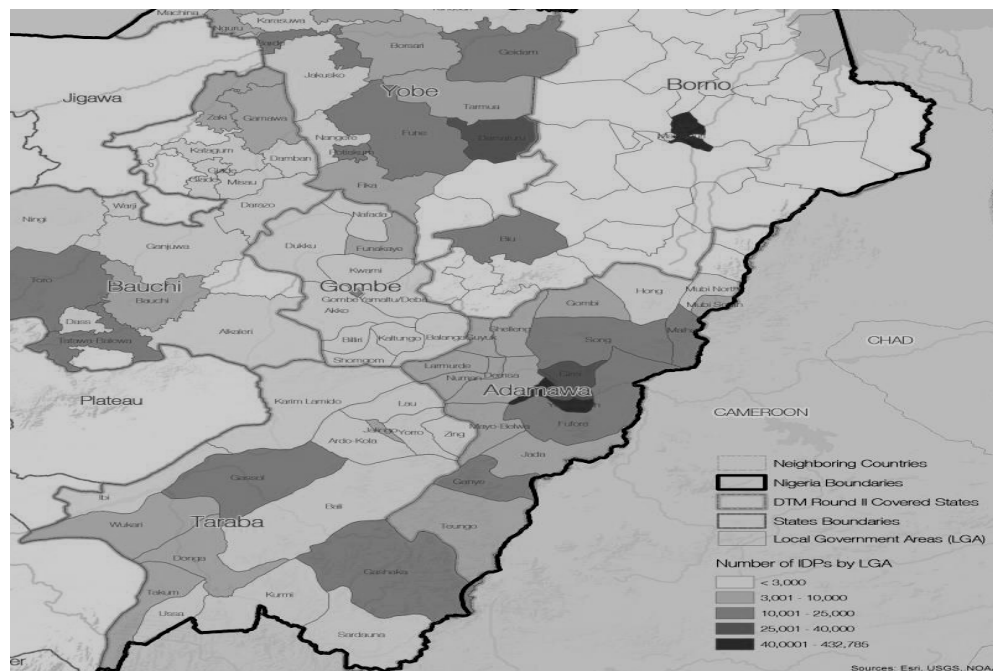


Figure 1: Map of North East Nigeria Showing IDP Camps (Source: Esri, USGS, NOAA)

2.2 Data Collection

Published data were gathered to parameterize the agent-based model of the IDP camps. Data for the ABM simulation were obtained from published research projects data including identified cases of child malnutrition; and treatment plan for confirmed cases with recovered, unrecovered, and death result. The data collected was used to verify the ABM simulation results. Other required data were not available at the IDP camps were inaccessible for empirical data. However, the UNESCO and Borno Emergency Management report were aggregated for the ABM simulation results.

1) *Demographics* The base statistics describing the ABM environment were derived from the report by the Borno Emergency Management (NAN 2016), which estimated 450 children, aged between one and five years old died of malnutrition, 6, 444 severe cases of malnutrition and an estimated 25,511 children have mild to moderate symptoms of malnutrition (see table II). The statistic was obtained from 28 internally IDP camps.

TABLE 2: REPORT OF MALNOURISHED CHILDREN IN BORNO IDP CAMPS

Age 0-5	Number of Children	Ratio	Percentage
Total Children	209,577		
Malnutrition Death	450	0.00215	0.215
Severe Malnutrition	6,444	.03075	3.075
Mild Symptoms	25,511	0.12173	12.173
Not Malnourished	177,622	0.84753	85.000

The DTM Nigeria Report Round II (2015) noted that 10% of displaced persons are between ages 0 to 5 with a marginal difference of female to male children (Hence described as Child IDPs (CIDPs)). Due to lack of spatial information on the specific locations, there was a reduction in the number of CIDPs that could be spatially represented in the ABM for the spontaneous or planned settlements. It also led to the failure in establishing a child's location relative to a specific case of malnutrition. As a result, model input data on the demographic profile of the settlements were based only on aggregated data.

2) *Food and Nutrition* In terms of food distribution, many households in the settlements have access to food distribution in the region. Distribution of food is carried out daily in some sites, irregular in some sites and few have never received food distribution. Furthermore, supplementary feeding was not available for children or breastfeeding mothers with the exception of one and up to 27 sites have been screened for malnutrition.

3. ABM MODEL DEVELOPMENT

3.1 Modelling Environment

The model used in this study is described in full in (Wilensky and Evanston 1999). Briefly, the simulation is an agent-based model, written in NetLogo. The conceptual model [Figure II] of the ABM for the IDP camps was developed based

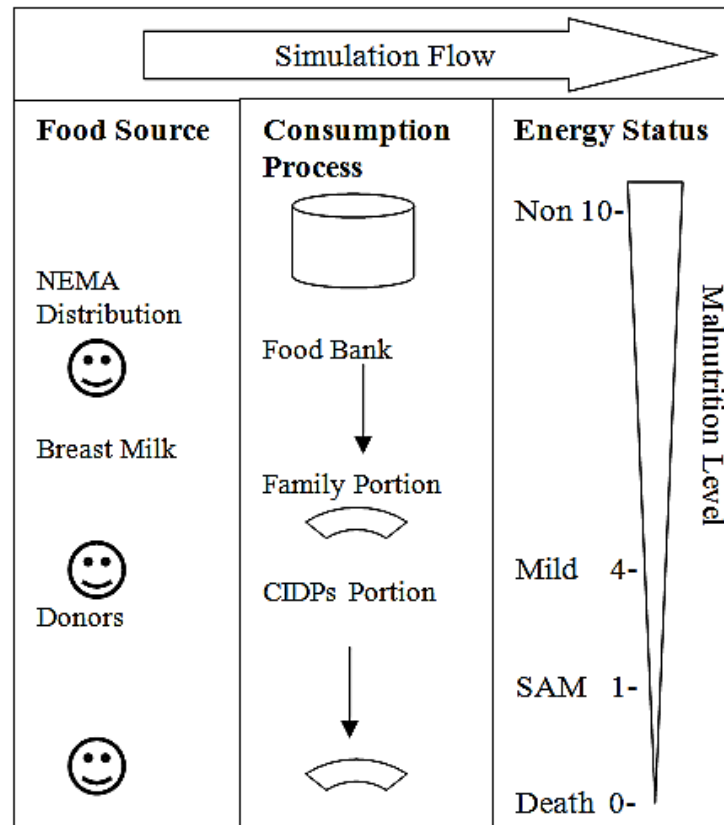


Figure 2: Conceptual Model of the ABM

on the observation relevant interactions. It depicts how CIDPs lack of access to highly nutritious food in the camps, poor feeding practices such as inadequate breastfeeding, offering wrong food and not ensuring that the child gets enough nutritious foods. The result is a high prevalence of malnutrition in the IDP camps and treatment to ensure recovery.

1) *Food Source* All CIDPs get their food sources from the mother via breastfeeding and supplies brought to camps from donor agencies and the Nigerian government agencies responsible for emergency management projects (NEMA). Breast milk is essential for nursing mothers but can only be available if the nursing mother is feeding regularly to produce milk.

2) *Consumption Process* Food supplies are stored in the food banks. Distribution of food supplies for IDPs is managed by camp office. Families are allotted portions and frequency of allocation depends on food bank supply. The frequency of food supplied determines the availability of food to family, mother and child. The distribution and intake of essential micro-nutrients, vitamins and mineral components to meet the required daily nutritional level determines the nutritional state of a child. The food supplied is also high in carbohydrates and low in protein, vitamins and minerals essential for healthy growth.

3) *Energy Status* Well fed CIDPs will be healthy and energy level high. As food sources reduce, energy level also reduces to mild malnutrition, Severe/ Chronic malnutrition and eventually death if unattended to. To study the malnourished children, information was collected by health workers on the child health status. Child weight is measured, physical symptoms are observed. Other information gathered from the nursing mothers include, frequency of feeding, micronutrients availability, weakness, and other concerns. Stunting growth, low immunity, late development, significant illness, recurrent infections, chronic disease and death has been identified as symptoms of malnutrition.

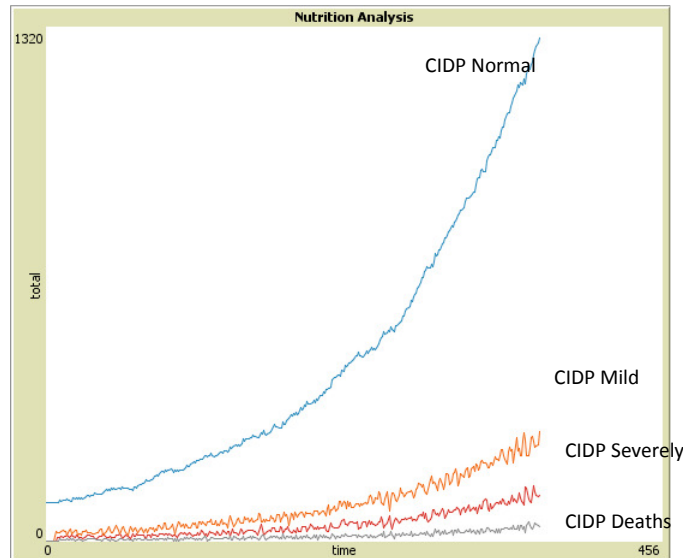


Figure 3: Nutrition Analysis for CIDPs

As indicated in the graph (Figure 3), data simulated indicates growing CIDP death, CIDP severely malnourished, CIDP mildly malnourished and CIDP normal in less than two years period with birth of over one thousand five hundred children.

TABLE 3: ANALYSIS OF MALNOURISHED CHILDREN IN BORNO IDP CAMPS WITH AGENT-BASED MODEL

	Total Children	Malnutrition Death	Severe Malnutrition	Mild Symptoms	Not Malnourished
Actual	209,577	450	6,444	25,511	177,622
Ratio		0.0021472	0.0307476	0.1217261	0.8475262
%		0.2147182	3.0747649	12.172614	84.752621
ABM	1,291	38	119	282	852
Ratio		0.029435	0.092177	0.218435	0.659954
%		2.943455	9.217661	21.84353	65.99535
Error		-2.72874	-6.1429	-9.67092	18.75727

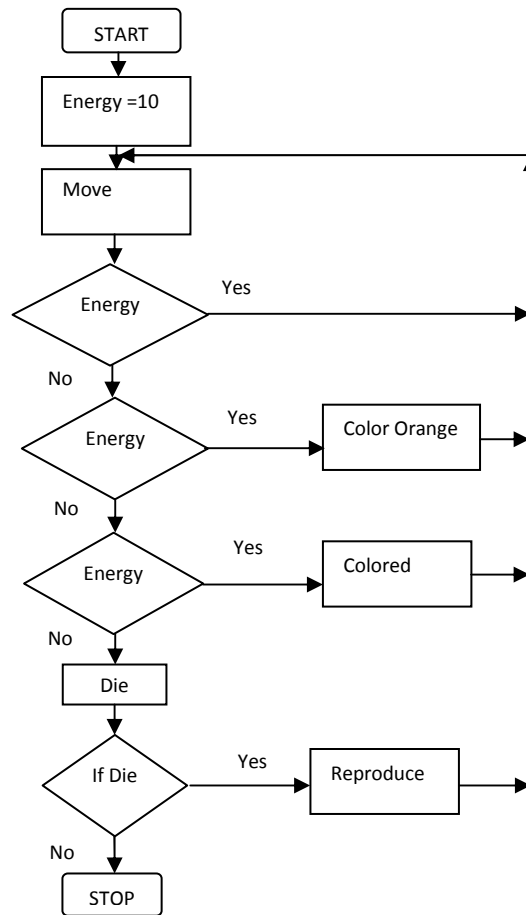


Figure 4: A Sample Flowchart Showing ABM Agents Interaction of Procedures and Variables for the ABM Environment in the Simulation.

4. CONCLUSIONS

The first stage of the model, presented within this article, involves the design and implementation of an agent-based model in selected Nigeria IDP camps. The generalised malnutrition data was drawn from published research projects data including identified cases of child malnutrition; and treatment plan for confirmed cases with recovered, unrecovered, and death result. We found that child malnutrition can be simulated with a set of relatively autonomous agents in a defined environment.

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