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Sensitivity Analysis of the Model for Determining the Impacts of Child Labour, Vagrancy, and Ineffective-Almajiri-Mentorship Factors on Schooling in Nigeria

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Abstract

This research is concerned with the modelling of factors influencing the schooling environment in Nigeria, with a specific focus on the impact of child labour, vagrancy, and ineffective Almajiri mentorship. Employing epidemiological approaches within the framework of endemic modeling, the study treated schooling-disruption as an epidemic situation that needs urgent attention using a four compartmental S_l - C_l- V_g - A_m modelling structure. Where: S_l = School-learning, C_l = Child labour, V_g = Vagrancy and A_m = Almajiri-mentorship. Hence, by unraveling the interconnectivity dynamics between these highlighted social issues that affect schooling in Nigeria and their impacts on education, this research aims at providing valuable insight for policy makers and educators to develop targeted interventions. The Sensitivity analysis of the model on the other hand, provides insight into the varying impact of different parameters on the schooling outcomes, projecting which of the model's parameters is most sensitive or not. However, from the sensitivity report of the model, the most sensitive model parameter is the Progression rate of learners from vagrancy compartment to Almajiri-mentorship compartment (

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δ). Hence the decision makers ought to discourage children's homelessness which eventually leads to a strange and unhealthy movement to the inefficient Almajiri-mentorship. The law makers should enact laws which must compel every religions mentorship to combine the official schooling dynamics with the orthodox, traditional and religious children mentorship. Furthermore, based on this research findings, the study recommends a comprehensive implementation of strategies that address the root causes of schooling-disruption outcomes in Nigeria.

Keywords: Compartmental model, Sensitivity Analysis, School-learning, Child labour, Vagrancy, Almajiri-mentorship

INTRODUCTION

Child labour and vagrancy have deep historical roots of problems in Nigeria, stemming from socio-economic challenges and systemic issues that persist despite the country's strides in economic development (Ugbajah *et al.*, 2015). The prevalence of child labour in Nigeria is alarming.

Child labour as defined by the International Labour Organization (ILO) is the work that deprives children of their childhood, interferes with their ability to attend regular schools, and is mentally, physically, socially, or morally harmful, remains a critical concern (ILO, 2020). Vagrancy among children often associated with homelessness and lack of proper guardianship, further compounds the challenges faced by these vulnerable populations (Uduigwomen, 2019).

The Almajiri system, initially designed to provide religious and secular education, has faced criticism for its ineffectiveness in delivering a holistic education, leaving many children without basic literacy and numeracy skills (Hansen *et al.*, 2016). Traditionally, the Almajiri system involves children living with a mentor, or "Malam," who provides both religious and secular education. However, the system has faced criticism for its inability to cater to the holistic development of these children, often resulting in a lack of basic education and exposure to exploitative labour practices (Ushie, 2020).

Despite governmental efforts to improve access to education, the coexistence of child labour, vagrancy, and an ineffective Almajiri mentorship system presents a formidable challenge to the goal of achieving comprehensive and equitable education in Nigeria (Abbo

et al., 2017). The impact of these intertwined issues extends beyond individual children, affecting the nation's socio-economic development and reinforcing cycles of poverty and inequality (Taiwo, 2014).

The aim of this study is to employ mathematical modelling to comprehensively examine the combined impact of child labour, vagrancy, and ineffective Almajiri mentorship on Schooling outcomes in Nigeria. In order to effectively achieve the above aim, the following objectives are considered;

To formulate a mathematical model for the combined impact of child labour, vagrancy, and ineffective -Almajiri mentorship on Schooling outcomes in Nigeria and to perform sensitivity analysis of the formulated model.

MODEL FORMULATION

This section presents the methodology of the work. The following headings will be considered as they unfold below:

Flowchart for the model:

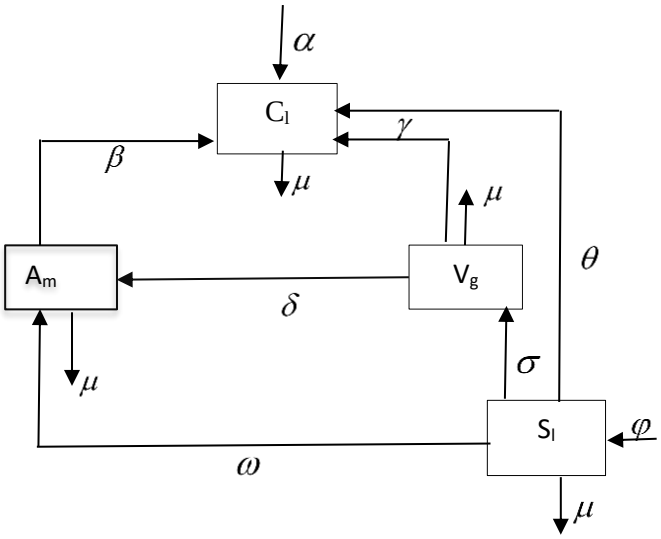


Fig 1: Schematic flow chat for the model.

Model equations and their parameter descriptions:

$$\left.\begin{aligned}
\frac{dS_l}{dt} &= \varphi - \omega A_m S_l - \theta C_l S_l - \mu S_l - \sigma S_l V_g \\
\frac{dC_l}{dt} &= \beta A_m + \gamma V_g + \theta S_l C_l - \mu C_l + \alpha C_l \\
\frac{dA_m}{dt} &= \omega A_m S_l + \delta V_g - \beta A_m - \mu A_m \\
\frac{dV_g}{dt} &= -\delta V_g - \gamma V_g - \mu V_g + \sigma S_l V_g
\end{aligned}\right\} \quad (1)$$

Variables.	Description.
S_l	School-learning.
C_l	Child labour.
A_m	Almajiri mentorship.
V_g	Vagrancy.

Parameters.	Description.
φ	The rate of recruitment/admission rate into school-learning environment.
δ	Progression rate of Learner from vagrancy compartment to Almajiri mentorship compartment.
μ	Natural death rate of learners that occurs in the entire compartment.
ω	Progression rate of learners from school-learning compartment to Almajiri mentorship compartment.
γ	Progression rate of learners from vagrancy compartment to child labour compartment.
θ	Progression rate of learners from school-learning compartment to child labour compartment.
σ	The rate at which school-learners drop out from school due to homelessness /Progression rate of learners from school-learning compartment to vagrancy compartment.
α	The rate of recruitment/admission rate into child labour compartment.
β	Progression rate of learners from Almajiri mentorship compartment to child labour compartment.

RESULTS

After the model became ready, the following analysis were carried out in order to ensure whether our proposed model has answered some basic and compulsory modelling questions. These questions are: stability, positivity of the model solution, graphical profiles and sensitivity analysis.

Thus, as shown in the work of Ubanede (2024).

The model was found to be locally asymptotically stable with its Reproduction Number less than 1 $(R_0 < 1)$,

And mathematically,

$$R_0 = \frac{\delta\mu + \gamma\mu + \mu^2 + \sigma\varphi}{\mu};$$

The model's solution exist and it is unique

Sensitivity analysis of the model

Data and Sources

(a). Out of school children: 81% of 10 million by Geoffrey Njoku, communication specialist, UNICEF Nigeria as at 2020.

(b). Individuals or population not enrolled in school: Approximately 20 million Nigerian individuals of its approximately 200 million population are not enrolled in school by UNESCO (2022).

$$\therefore\ A_m = \frac{0.81\times 10\,million}{20\ million} \times \frac{20\,million}{200\,million} = 0.0405$$

(c). According to the international labour organization (ILO), an estimated 15 million children between the ages of 5 and 17 are engaged in child labour in Nigeria.

(d). Child labour: $\dfrac{15\ million\ by\ Agbakwuru\ (2023)}{226.2\ total\ population\ of\ Nigeria\ by\ Statista\ (2023)} = 0.066$

(e). The rate of recruitment/admission rate into school-learning environment (φ):

$$\frac{47\ million\ of\ \ pupils\ now\ enrolled\ \ for\ basic\ education\ in\ Nigeria\ (UBEC, 2022).}{216.7\ \ population\ in\ Nigeria\ \ 2022\ \ (National\ \ Bureau\ of\ \ Statistics).} = 0.216$$

Table2: Sensitivity analysis table.

S/N	Parameters	Value	Author/Reference.
1	β	0.05	Assume value.
2	γ	0.1	Assume value.
3	μ	0.12	Assume value.
4	ω	0.23	Assume value.
5	δ	0.155	Assume value.
6	θ	0.43	UNICEF (2022)
7	α	0.31	Sasu(2022)
8	φ	0.216	UBEC (2022)
9	$A_m(0)$	0.0405	UNICEF (2022)
10	$C_l(0)$	0.066	Statista(2023)
11	$S_l(0)$	77.62%	Global Data (2021)
12	σ	0.002	Assume value.
13	$V_g(0)$	0.25	Assume value.

Table 3: Model's Sensitivity Index Table.

S/N	Parameter	Description	Sensitivity Index	Rank
1	δ	Progression rate of learners from vagrancy compartment to Alma Jiri mentorship compartment.	0.4094	1st
2	μ	Natural death rate of learners that occurs in the all the compartment.	0.3074	2nd
3	γ	Progression rate of learners from vagrancy compartment to child labour compartment.	0.2641	3rd
4	φ	The rate of recruitment/admission rate into school-learning environment.	0.0095	4th

5	σ	The rate at which school-learners drop out from school due to homelessness /Progression rate of learners from school-learning compartment to vagrancy compartment.	0.0095	4th

DISCUSSION

The sensitivity analysis of the study followed a set of similar approaches as used by (Ogwumu *et al.,* 2023; 2020a 2020b; 2015) and (Ogofotha *et al.,* 2023a 2023b). The sensitivity analysis of the study upheld that, the parameter that has the highest impact on the model on schooling disruption in Nigeria is the rate of which school children move from the stage of homelessness to the Almajiri's compartment. Which means homelessness is what gives rise to ineffective Almajiri mentorship houses to still have pupils. And this have to be discouraged if we want to achieve a schooling-disruption-free environment in Nigeria.

Secondly, the next parameter that has the next highest impact on schooling in Nigeria is the increasing Natural death rate of children. And this obviously because of the Adult measure of stress that is being inflicted of children as a result of child labour, homelessness and poor Almajiri mentorship. This sudden death needs to be cured as a way forward to a fruitful schooling policy in Nigeria.

The third highest and impactful parameter on the schooling process in Nigeria is the rate of movement from homeless compartment to child labour compartment (γ). This means that a child homelessness triggers their ability to give in to the pressure of labour activity brought their ways in order to have their daily food provision.

Moreover, the rate at which school learners drop out of school due to homelessness has the fourth but lower impact on schooling model in Nigeria.

Finally, the model suggests that the number of admitted students has lower impact in the schooling model process in Nigeria.

Summary

In this study, the mathematical model on the impact of vagrancy, child labour and ineffective Almajiri mentorship on schooling in Nigeria was formulated. The model describes the impact of vagrancy, child labour and ineffective Almajiri mentorship on

learning in Nigeria schooling system. In the study, we used schooling interruption-free equilibrium state to obtain the local stability of the model and it was deduced that when the model's Reproduction Number is less than 1 $(R_0 < 1)$,where $R_0 = \frac{\delta\mu + \gamma\mu + \mu^2 + \sigma\varphi}{\mu}$; then the model is said to be locally asymptotically stable whenever the relation $\frac{\delta\mu + \gamma\mu + \mu^2 + \sigma\varphi}{\mu} < 1,$ otherwise we can say that the model is unstable.

Similarly, the sensitivity analysis of the study upheld that, the parameter that has the highest impact on the model on schooling disruption in Nigeria is the rate of which school children move from the stage of homelessness to the Almajiri's compartment. Which means homelessness is what gives rise to ineffective Almajiri mentorship houses to still have pupils. And this have to be discouraged if we want to achieve a schooling-disruption-free environment in Nigeria.

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CONCLUSION

Conclusively, by means of our model parameter substitution, $R_0 = 0.3786166667$ which is less than 1, implying that the rate of schooling-disruption in Nigeria is controllable and the

epidemics will die-out with time if all the assumptions, winning effort and specifications of the model are adhered to. Moreover, for the model to be recommendable to the would-be users of our model, some analyses were carried out on the model.

The first analysis was the stability analysis.

The model was found to be locally asymptotically stable with its Reproduction Number less than 1 $(R_0 < 1)$,

And mathematically, $R_0 = \frac{\delta\mu + \gamma\mu + \mu^2 + \sigma\varphi}{\mu}$;

And finally, the last analysis performed on the model is the sensitivity analysis which gives the users of the model the perspective of the most sensitive parameters of the model in case of any governmental intervention, Non-governmental or World Health Organisation's disease control intervention and subsides.

Thus, from the sensitivity report of the model, the decision makers ought to discourage children homelessness which eventually leads to a strange and unhealthy movement to the inefficient Almajiri mentorship. The law makers should enact laws which must couple every religions mentorship to combine the official schooling dynamics with the orthodox, traditional and religious children mentorship. If this is not taken seriously and as a matter of priority, since the certificates obtainable from this un-official mentorship is not recognised and could not give better jobs, then the future of this children under them is chartered and in jeopardy.

Also, this unofficial arrangement and mentorship could create a void of emptiness and un-fulfilment in the lives of the children involved; which leaves them with no other option than to resort to carrying illegal arms in other to fend for themselves.

However, since homelessness is caused by poverty, and the children of the poor are the ones involved in this emergency and unplanned out-of-school-syndrome, then everyone needs to rise to fight against school-drop-out tendencies due to vagrancy, child labour and ineffective Almajiri mentorship. This is because guardian news (2020) resounded Chief Awolowo's warning that "The children of the poor you failed to train will never let your children have peace"

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