REVIEW ARTICLE

Congenital disorders and community genetic services in Nigeria: A systematic review

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Abstract

Nigeria has a large number of congenital disorders (CD). For instance, two out of every hundred children born in Nigeria have sickle cell disorders (SCD). Making Nigeria the country with the highest incidence of SCD. This article reviews the prevalence of CD in Nigeria; with emphasis on those having a heavy statistical burden on the country, the availability of community genetics services in Nigeria and the efforts being made to tackle the challenges of CD. A systematic review of birth prevalence of congenital malformations (CM) in Nigeria was done through a literature search, with no time restriction for publication dates. Only studies that included the birth prevalence of CM were included. Eligible studies with incorrect or missing data were excluded. This revealed a dearth of data on CD in Nigeria, as in most Low- and Middle-Income Countries. A predominance of CM of the musculoskeletal and gastrointestinal systems was found in Nigeria. However, the pattern of CM in the South-South region was more of the central nervous system. There is scarcity of resources to address the challenges of CD in Nigeria with feeble government assistance. Meanwhile, 70% of CD can be prevented and adequately managed by well implemented community genetics services. *(Afr J Reprod Health 2020; 24[3]: 161-175).*

Keywords: Community Genetics, congenital disorders, sickle cell diseases, Genetic services, Nigeria

Résumé

Le Nigéria a un grand nombre de troubles congénitaux (MC). Par exemple, deux enfants sur cent nés au Nigéria souffrent de drépanocytose (SCD). Faire du Nigéria le pays avec la plus forte incidence de SCD. Cet article passe en revue la prévalence de la MC au Nigéria; en mettant l'accent sur ceux qui ont une lourde charge statistique sur le pays, la disponibilité de services de génétique communautaire au Nigéria et les efforts déployés pour relever les défis de la DC. Une revue systématique de la prévalence à la naissance des malformations congénitales (CM) au Nigéria a été réalisée grâce à une recherche documentaire, sans restriction de temps pour les dates de publication. Seules les études qui incluaient la prévalence de la CM à la naissance ont été incluses. Les études éligibles avec des données incorrectes ou manquantes ont été exclues. Cela a révélé une pénurie de données sur la DC au Nigéria, comme dans la plupart des pays à revenu faible et intermédiaire. Une prédominance de CM des systèmes musculosquelettique et gastro-intestinal a été trouvée au Nigeria. Cependant, le modèle de CM dans la région Sud-Sud était plus du système nerveux central. Il y a une pénurie de ressources pour relever les défis de la DC au Nigeria avec une faible assistance gouvernementale. Pendant ce temps, 70% des MC peuvent être évitées et correctement gérées par des services de génétique communautaire bien mis en œuvre. *(Afr J Reprod Health 2020; 24[3]: 161-175).*

Mots-clés: Génétique communautaire, troubles congénitaux, drépanocytose, services génétiques, Nigéria

Introduction

Community genetics is a sub-discipline of genetics[1]. It has been defined as "the art and science of the responsible and realistic application of health and disease-related genetics and genomics knowledge and technologies in human populations and communities to the benefit of individuals therein"[1]. Community genetics is multi-, inter- and trans-disciplinary and aims to maximize benefits while minimizing the risk of harm, respecting the autonomy of individuals and ensuring equity[1]. In low- and middle-income countries (LMIC), community genetics is increasingly being employed to identify and help those within the wider community with an increased risk of a genetic problem. This is done to prevent or reduce congenital disorders and genetic diseases by encouraging and respecting the educated and autonomous decisions of individuals

and families, and at the same time, providing genetics services (diagnosis and counselling) in the community for individuals and families[2].

Congenital disorders are also known as birth defects or congenital anomalies or congenital malformations[3]. They refer to 'any abnormality affecting body structure or function that is present from birth. They may be clinically obvious at birth or may be diagnosed only later in life'[4,5]. However, the term congenital malformation (CM), alluded to; as a synonym of congenital disorder above, is in many instances restricted to a type of congenital disorders with only structural defect. It is in that sense, that congenital malformations will be viewed in this review.

It is estimated that globally about 8 million infants are born with serious birth defects every year, of which several hundred thousand are caused by teratogens such as alcohol, Rubella, syphilis and iodine deficiency[4]. About three million (3.3 million) infants with birth defects will eventually die, while another 3.2 million will survive with severe disability[4]. There are however, compelling evidence, that up to 70% of birth defects can be prevented or adequately managed[6]. The causes of congenital disorders are many and complex; with approximately 50 percent of them being idiopathic[7,8]. It is expected that the percentage of congenital disorders of unknown causes will decrease in future, as more and more causes are identified[9]. However, known causes can be divided into two broad groups: genetic and partially genetic causes, and causes developing after conception[4].

Congenital disorders of genetic and partially genetic causes

These are congenital disorders that originate mostly before conception. They constitute most of the congenital disorders with known causes and are due to abnormalities of the genetic material chromosomes and genes[4]. Partially genetic birth defects are due to a combination of genes that puts the fetus at risk in the presence of specific environmental factors[4]. These could be complex and still multifactorial, since the risk they proffer is not only to the fetus but continue even after birth, and throughout the life cycle of the affected individuals. But could only be activated under certain conditions. Genetic abnormalities can be inherited, in which case they are found in families, or they can occur as an isolated event in a pregnancy[4].

Congenital disorders of causes originating after conception

These are congenital disorders with causes developing after conception but before birth. They are primarily non-genetic. In these disorders, the genetic material inherited by the fetus is normal and the birth defect is caused by an intra-uterine environmental factor[4]. These include teratogens that interfere with normal growth and development of the embryo or fetus, mechanical forces that deform the fetus, and vascular accidents that disrupt the normal growth of organs[4]. Teratogens can be physical agents such as radiation; environmental pollutants like methyl mercury; maternal illness or disturbances of the mother's metabolism such as maternal insulin-dependent diabetes mellitus or maternal iodine deficiency; maternal infections, including rubella and toxoplasmosis; and drugs, both medicinal and recreational[10].

Global efforts at preventing congenital disorders

The World Health Organization (WHO) at the sixty-third World Health Assembly Eighth plenary meeting, came out with Resolution 63.17 that made the following recommendations among others:

1. Raising of awareness about the importance of birth defects as a cause of child morbidity and mortality,
2. Development of expertise and capacity building on the prevention of birth defects and care of children with birth defects.
3. Strengthening research and studies on etiology, diagnosis and prevention of major birth defects and promoting international cooperation in combating them,
4. Raising awareness among all relevant stakeholders about the importance of newborn screening programs and their role in

identifying infants born with congenital birth defects[11].

These thus, mean that strengthening community genetics services all over the world is pivotal in achieving prevention and adequately managing congenital disorders.

The Seventh International Conference on Birth Defects and Disabilities in the Developing World (ICBD), held in Dar es Salaam, Tanzania, also called to action: maximization of the opportunity for every woman and couple to have a healthy child; reduction of the consequences of potentially avoidable congenital disorders for those affected, their families, the health care system, and the wider society; and promotion of the well-being of children who have a congenital disorder[12]. The pledge of the participants at this conference was to have an initial focus that supports improvement of data quality, reduction of risk, improvement of care and the empowerment of the public and civil societies[12]. All these measures are proposed to help in accelerating the prevention of congenital disorders and the improvement of care of affected children, especially in high burden, low-resource settings, globally[12].

Background information about Nigeria

Nigeria is divided into six geo-political zones: North West, North Central, North East, South West, South East and South-South. Nigeria is a lower middle-income country[13] with per capita income of $5,680. Some of the Nigerian population indicators includes: crude birth rate (CBR) of 38.113 births/thousand; Under 5 Mortality Rate (U5MR) of 103.015 deaths/thousand; Infant Mortality Rate (IMR) of 63.454 deaths/1000 live births; and Life Expectancy (both sexes) of 54.1 years[14]. According to the WHO, the total expenditure on health as percentage of GDP of Nigeria for 2014 was 3.7[15]. United Nations Children's Funds (UNICEF) reported that about 2,300 under-five year old die every single day in Nigeria. This makes the country the second largest contributor to the under–five mortality rates in the world[16].

It is thus pertinent that more prominence should be given to community genetics in Nigeria. This should be as part of efforts geared towards achieving goal number 3 of the sustainable development goal (SDG), tagged good health and well-being. It is the aim of this goal, among others to:

1. reduce, by one-third by 2030, premature mortality from non-communicable diseases through prevention and treatment and the promotion of mental health and well-being.
2. reduce the global maternal mortality ratio to less than 70 per 100,000 live births.
3. end preventable deaths of newborns and children under-five years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1,000 live births and under-five mortality to at least as low as 25 per 1,000 live births[17].

Overall, this SDG, as formulated by the United Nations, consists of 17 goals. The United Nations thus believe that if these goals are well implemented, they will lead to ending poverty, fighting inequality and injustice, and tackling climate change by the year 2030.

Genetic disorders in Nigeria

According to Milewicz[18], genetic disorders can be classified into: chromosomal disorders; single-gene disorders and multifactorial disorders. And it is in that format that the situation of genetic disorders shall be discussed as follows:

Chromosomal disorders in Nigeria

Of the chromosomal disorders, Down syndrome was reported to have an incidence of 1 in every 865 live birth[19] and Turner's syndrome of 1 in every 2745 live female birth in Nigeria[20]. Though these studies were done way back in 1982, but it appeared that no other notable study has been done on the birth prevalence of chromosomal disorders in Nigeria since then.

Single-gene disorders in Nigeria

Sickle cell disorder (SCD) is the most common inherited disorder in the world. More than 300,000 babies are born with severe forms of hemoglobinopathies worldwide each year. Seventy-five percent of all patients with SCD live

in sub-Saharan Africa[21]. About 150,000 Nigerian children are born each year with sickle cell anemia (HbSS): the prevailing type of sickle cell disorder (SCD) in this region, with over 40 million Nigerians being healthy carriers of the S gene[22]. Two out of every hundred children born in Nigeria have SCD thus causing suffering for innumerable patients and their families[23]. It was stated by Molineaux *et al*[24] that there is no other known inherited disorder that is present at such a high frequency in a large population and of comparable severity as sickle cell anemia in Africa.

Multifactorial disorders in Nigeria

These are birth defects due to complex genetic and environmental interactions. They are usually malformations of a single organ system or limb, and include congenital heart disease, neural tube defects, cleft lip and/ or cleft palate, clubfoot and developmental dysplasia of the hip[4]. There is no national survey on the prevalence of these disorders in Nigeria. Orimolade *et al*.[25] found 14.2 per 1000 live birth of external congenital birth defects in their study and that congenital talipes equinovarus and polydactyly were the two most frequent, each with a birth prevalence of 3.2 per 1000 live births. An incidence rate of 0.37 per 1000 live births of clefts of the lip or palate or both was reported in a hospital in Nigeria[26]. But several other authors have reported varying prevalence of this birth defect in Nigeria with the reported rates varied with each study and location. For example, Butali *et al* reported 0.5/1000[27], Abue, *et al* reported 3.2 /1,000[28] and Omo-Aghoja, *et al* reported 13.5/1000[29].

Many, usually systemic, diseases that commonly present later in life and having genetic origin involving no malformations are also classified as multifactorial disorders. Included among these disorders are hypertension, diabetes, stroke, mental disorders and cancer[4]. These diseases are of long duration and are often referred to as non-communicable diseases (NCDs). They disproportionately affect people in LMIC, where more than three quarters of global NCD deaths (32 million) occur[30]. NCDs in Nigeria accounted for an estimated 28 per cent of all mortality in 2008[31], but this was put at 24% by 2012[32]. Cardiovascular diseases (CVD) are the most prevalent NCDs in Nigeria and accounted for 12 per cent of total deaths across all age groups[31]. It was also reported that cancers, non-communicable variants of respiratory diseases, and diabetes contributed 4%, 3%, and 2% to total mortality respectively[31].

There are also evidences that there is an astronomical increase in incidences of hypertension and other CV risk factors and diseases in Nigeria. It was reported by Okunola *et al*[33], that CVD formed a large percentage of medical admissions in a study in Nigeria. There seems to be no national prevalence figure for any of the NCDs. But Kyari *et al*.[34] reported a national survey that puts the national prevalence of diabetes to be 2.8% (95% Confidence Interval: 2.6-3.1%) in persons aged ≥ 15 years.

The incidence of all cancers in Nigeria, as at 2012, was reported in a report to be 100.1 per 100,000[35]. The report also indicated that there were 102,100 new cases of cancer per year (excluding non-melanoma skin cancer), with 10.4% of Nigerians at the risk of getting any of the cancers before the age of 75. And with about 71,600 standing a chance of dying from cancer related deaths per year[35].

Intrauterine infections and exposure to teratogenic drugs in Nigeria

There are data suggesting high prevalence of congenital cytomegalovirus infection (cCMV) in developing countries, especially sub-Saharan Africa. However, the burden of disease and natural history of cCMV have still not been well defined[36]. This assertion further lays credence to the huge gap that still needs to be filled in the roles played by intrauterine infections and exposure to teratogenic drugs, to the occurrence of congenital disorders in Nigeria.

Rubella virus was reported by Yahaya *et al*.[37] to be prevalent in Nigeria, particularly in pregnant women, based on evidence gathered from their systematic review. Yet there is still no surveillance nor national incidence figure to determine the prevalence of rubella among women of child bearing age and pregnant women. More importantly, vaccination against rubella is still not part of antenatal care nor among the diseases

recommended for vaccination in the National Program on Immunization despite growing evidences that rubella may have a large contribution to the high perinatal mortality rate in Nigeria[38].

Though, HIV and malaria have not been established as direct teratogens, in this context they are assumed as such because they: are of high prevalence in Nigeria; have been associated with poor maternal health during pregnancy and in addition, malaria in pregnancy often presents as asymptomatic infection in areas of stable malaria transmission, like Nigeria[39,40]. The significance of this assumption further comes into play, when one considers the fact that Nigeria has the highest proportion of malaria cases globally (27%)[41], and second highest burden of HIV in the world[42]. These high proportions of malaria and HIV in Nigeria is a massive problem, when one further considers the huge population of Nigeria, estimated to be around 195.88 million[43].

The prevalence and manifestation of malaria in pregnancy and in children vary with: transmission intensity, access to treatment and quality of antenatal services, and drug resistance, among others[44]. Thus, the prevalence rates reported for malaria in Nigeria vary considerably. In South-West Nigeria, prevalence rates of between 36.5% and 72% have been reported[39,45,46]. However, Agomo *et al*.[47] reported a low prevalence of 7.7% (95% confidence interval; 6.29.4%) with a conclusion that their study exposed the over-diagnosis of malaria in pregnancy. This, they opined, might be due to inadequate training, experience, and motivation of laboratory staff in Nigeria as well as lack of malaria diagnosis quality assurance program to ensure the accuracy of malaria microscopy results at all levels. Luckily enough, no serious side birth defect has been linked with the concomitant infection of pregnant women with either HIV or malaria. Only severe maternal anemia, intrauterine growth retardation, intrauterine death, stillbirth, premature delivery and low birth-weight, have been associated with the presence of either one or two of the diseases in pregnancy[48-51].

Also, the use of antimalarial and anti-retroviral medications by pregnant women may act as independent risk factors for fetal outcomes[52]. The treatment of choice for *Plasmodium falciparum*, that is the most common type of malaria in Nigeria, is artemisinin-based combination therapy (ACT)[53]. Due to the associated risks of visceral and skeletal anomalies noticed in animal studies after exposure to artemisinins in early stages of pregnancy[54,55], WHO has not recommended the use of ACT in the first trimester, unless they are the only treatment available, or if the patient's life is threatened. Some studies have however established that these safety concerns may be unfounded since no association has been found between artemisinins drug exposure in early pregnancy and maternal or birth adverse outcomes[56-58]. However, evidence is still scarce to ensure safety of ACT during the first trimester.

Antiretroviral medications, on the other hand, are prescribed for the treatment of the mother and to reduce the risk of transmission of HIV to the fetus in pregnant women, despite the absence of proof of safety [57]. This is not the norm with most other new pharmaceutical agents. However, no increased risk of malformations has been demonstrated for most of these antiretroviral compounds whereas others have been associated with malformations or developmental abnormalities in rats, mice or rabbits and, in the case of efavirenz, monkeys[58].

Community genetic services in Nigeria

Community genetics services are a compendium of activities for the diagnosis, care and prevention of genetic diseases at community level[7,59,60]. The aim is to provide services for the diagnosis of congenital disorders and genetic diseases: clinical and laboratory (cytogenetics, biochemical assays, DNA testing, etc.); genetics counselling; pre-conception care; prenatal screening; prenatal and pre-implantation genetic diagnoses; newborn screening; carrier screening; and population genetic screening according to other established policies[2].

The Sickle Cell Foundation of Nigeria (SCFN) seems to be the most functional community genetics service center in Nigeria. But there are other centers in Nigeria where these services are also provided. The SCFN, like most

of these other centers, provides genetic counselling services and prenatal diagnosis of SCD using chorionic villus sampling, fetal blood sampling, amniocentesis methods, and offer post-test counselling[23]. Even though, the emphasis of many of these centers is on the intrauterine diagnosis of SCD, they still, accidentally or otherwise, detect other congenital disorders in the process.

Many religious organizations, especially the Pentecostal churches in Nigeria, have made it mandatory for intending couples to undergo some tests, especially genotype, before they are solemnized in marriages, so as to reduce the incidences of these birth defects[61]. Some of these religious organizations also offer counselling services to carriers of genetic diseases and dissuade them from getting married. And when they are recalcitrant about going ahead with their marriage plans, such institutions deny them of their facilities and blessings[62].

The Federal Government of Nigeria is working on policies that will serve as guidelines, and ensure that community genetics services become readily available, accessible and affordable to all Nigerians. For now, the emphasis is on SCD, and to legalize this, there is a bill before the Nigerian senate that proposes compulsory genetic testing for all intending couples in Nigeria[63]. The effective implementation of this bill, when it becomes a law, is expected to help in reducing marriages between carriers of SCD in Nigeria, and hopefully will reduce the incidence and prevalence of SCD in Nigeria.

Thirty-nine cleft care centers were identified by Oginni *et al*[64], in 22 states and the federal capital territory of Nigeria. This, they stated, was a significant improvement to what was available in Nigeria prior to 2006, but a dearth of professionals, especially speech pathologists and geneticists, are not making these centers to function optimally. They also observed that there are no identifiable efforts of government aside, funding training of residents in teaching hospitals in Nigeria and making these hospitals to be functional, to suggest that there are robust attempts to curtail the incidence and provide post repair services to cleft lip patients in Nigeria.

Clubfoot management in Nigeria is being spearheaded by the Ponseti Clubfoot Foundation in Nigeria, with clinics mostly in the South-western part of Nigeria and sparse representation in other parts. Though, there are other methods of correcting clubfeet, Adegbehingbe *et al.*[65], reported that because of fewer treatment complications, lower recurrence rates, more satisfactory early full correction outcomes and lower mean cost of care associated with the Ponseti method, there is an increasing use of this method of corrective intervention in Nigeria. Going by these advantages, the Ponseti method is thus considered the "gold standard" treatment for clubfoot health care workers in underprivileged areas of the world with limited access to surgical facilities[66]. Assistance of government of Nigeria in the prevention and management of this condition has not been well reported.

Neural tube defects (NTD) was reported by Uba *et al*[67], to have an incidence of 0.5/1000 live births and 1.9% of all admissions in a study in North Central Nigeria. But there is no national data available for NTDs in Nigeria. However, there is an incontrovertible evidence linking the occurrence of NTD to inadequacy of folic acid in nutrition, before and during pregnancy[68]. This thus calls for immediate and more forceful action of government in implementing this as a means of forestalling the occurrence of this defect in Nigeria.

Consanguineous marriages obviously exist in Nigeria, but not much studies have been done to show the true picture of it. However, among the three major tribes in Nigeria; Hausa, Yoruba and Igbo, Swanson and Lagace[69] stated that Muslim Hausa practice cousin marriage preferentially, but the actual prevalence of this is still uncertain. Scott-Emuakpori[70] reported 51% consanguineous marriages among resident of a town in Yoruba land, but this was not a general study of the Yoruba people, and that figure may not be relied upon as representative of the rate of consanguinity in Yoruba land. There is no evidence of consanguinity among the Igbos[71], it is even believed that they specifically prohibit both parallel- and cross-cousin marriages.This review is significant because it further revealed the sparsity

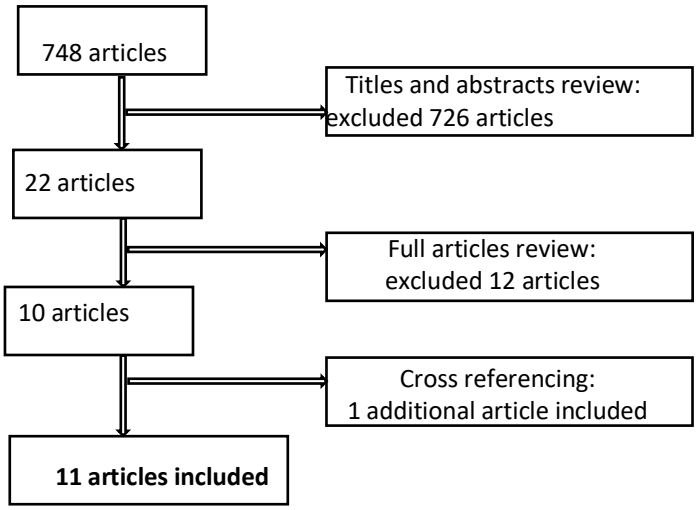

Figure 1: Illustration of the stepwise process of study selection

Table 1: A systematic review of birth prevalence of congenital malformations in South – South Nigeria

Author/Year	**Study type**	**Study setting**	**Study duration**	**Total no. of live births (denominator)**	**Total no. of babies with CM (numerator)**	**Birth incidence of CM (per1000 live births)**	**#Pattern of CM (incidence per 1000 live births)**
1). Ekanem et al. (2008) [72]	Retrospective	Hospital based	1980 - 2003	127,929	452	3.5	**SK** (1.0), **CNS** (0.9), **GUS** (0.7), **LPJ** (0.4), **GIT** (0.2), **RS** (0.2), **CA** (0.1), **E&E** (0.1), **CVS** (0.01)
2). **Ekanem et al. (2011)**[73]	Retrospective (UPTH)	Hospital based. (UPTH)	1990 - 2003	19,572	78	4.0	**CNS** (1.8), **SK** (1.7), **GUS** (0.2), **RS** (0.1), **GIT** (0.1).
Ekanem *et al*. (2011)[73]	Retrospective (BMH)	Hospital based. (BMH)	1990 - 2003	20,121	47	2.3	**CNS** (0.8). **SK** (1.1), **OSS** (0.1), **GUS** (0.2), **GIT** (0.1)
3). Eluwa *et al*. (2013)[74]	Retrospective	Hospital based	1992 - 2005	2,932	22	7.5	**CNS** (2.7), **GIT** (2.4). **SK** (1.4), **UGS** (0.7), **CVS** (0.3)
4). Abbey *et al.* (2017) [75]	Retrospective	Hospital based	August 2011 - December 2014	7,670	159	20.7	**CNS** (5.6), **GIT** (2.5), **CVS** (2.2), **AAW** (1.7), **SK** 1.3), **CA &UT** (1.2), **FACE** (1.0) **GT** (0.5),

			January 1, 2006 - December, 31, 2015				**N&S** (0.3)
5). Onyiriuka, Edorhe & Onyiriuka (2016)[76]	Retrospective	Hospital based		13,858	101	7.3	**MSK** (2.5), **GIT** (1.7), **GUS** (1.2), **MCA** (0.6), **CNS** (0.4), **CVS** (0.4), **CUT** (0.4), RS (0.2).

Table 2: A systematic review of birth prevalence of congenital malformations in South – East Nigeria

Author/Year	**Study type**	**Study setting**	**Study duration**	**Total no. of live births (denominator)**	**Total no. of babies with CM (numerator)**	**Birth incidence of CM (per1000live births)**	**#Pattern of CM (incidence per 1000 live births)**
1). Sunday-Adeoye, *et al.* (2007)[77]	Retrospective	Hospital based	January, 1980 – December, 1999	32,206 (singleton)	315 (singleton)	9.8	**MSK** (5.2), **CNS** (2.0), **GIT** (1.4), **GUS** (0.5), **E&E** (0.5) **CUT** (0.06).
Sunday-Adeoye, *et al.* (2007)[77]	Retrospective	Hospital based	January, 1980 – December, 1999	1,453 (twins)	58 (twins)	39.9	**MSK** (16.5), **GIT** (8.3), **GUS** (2.8), **E&E** (2.8), **CNS** (0.7).
2). Onyearugha and Onyire (2014)[78]	Retrospective	Hospital based	April 1, 2002 – March 31, 2012	14,446	61	4.2	**GIT** (1.52), **MSK** (1.30), **CNS** (0.06), **RS** (0.06)

Table 3: A systematic review of birth prevalence of congenital malformations in North – Central Nigeria

Author/Year	**Study type**	**Study setting**	**Study duration**	**Total no. of live births (denominator)**	**Total no. of babies with CM (numerator)**	**Birth incidence of CM (per1000 live births)**	**#Pattern of CM (incidence per 1000 live births)**
1). Anyanwu, Danborno &Hamann (2015)[79]	Prospective	Hospital based	April 2013 - December 2013	1456	41	28.2	**CNS** (6.9), **GUS** (6.9), **CUT** (4.1), **GIT** (3.4), **MCA** (3.4), **MSK** (2.1).

Table 4: A systematic review of birth prevalence of congenital malformations in North – Eastern Nigeria

Author/Year	Study type	Study setting	Study duration	Total no. of live births (denominator)	Total no. of babies with CM (numerator)	Birth incidence of CM (per1000 live births)	#Pattern of CM (incidence per 1000 live births)
11). Pius *et al*. (2018)[80]	Prospective	Hospital based	1st January 2016 30th June 2017	1,256	115	91.6	**GIT** (47.0), **CNS** (27.0), **MCA** (8.8), **UGS** (3.2), **CVS** (3.2).

Table 5: A systematic review of birth prevalence of congenital malformations in South – west Nigeria

Author/Year	Study type	Study setting	Study duration	Total no. of live births (denominator)	Total no. of babies with CM (numerator)	Birth incidence of CM (per1000 live births)	#Pattern of CM (incidence per 1000 live births)
1). Bakare *et al.* (2009)[81]	Prospective	Hospital based	August 2003 July 2004	624	43	68.9	**MSK** (33.7), **EG** (14.4), **HEAD** (12.8), **ABD** (11.2), **MCA** (8.0), CH (1.6), CUT (1.6)
2). Fajolu *et al.* (2016)[82]	Retrospective	Hospital based	January 2007 December 2014	14,581	167	11.5	**CNS** (3.6), **MSK** (2.1), **UGS** (1.3), **DIG** (1.1), **CA** (0.8), **CVS** (0.5), **RS** (0.3), **MISC** (1.8) (1

***UPTH:** University of Port Harcourt Teaching Hospital, **BMH:** Braithwaite Memorial Hospital*
*#**AAW:** Anterior abdominal wall, **ABD (**Abdominal defects), **CA:** Chromosomal abnormalities **CA&UT**: Chromosomal abnormalities & urinary tract, **CH** (Chest), **CNS**: Central nervous system, **CPS**: Cardiopulmonary system **CUT:** Cutaneous, **CVS**: Cardiovascular system, **DIG** (Digestive), **E&E:** Eye & Ear, **EG** External Genitalia, **FT**: Fetal tumors, **GIT**: Gastrointestinal, **GT**: Genital tract, **GUS**: Genitourinary system, **LPJ**: Lip, palate & jaw anomalies **MCA**: Multiple congenital anomalies, **Misc.:** Miscellaneous, **MSK**: Musculoskeletal, **N&S:** Neck & skin, **OSS**: Oral & special senses, **OC:** Ocular cataract, **RS**: Respiratory system, **SK**: Skeletal system, **U**: Unclassified birth defects*

of research works that can be relied on, to fully appreciate the burden of congenital disorders in Nigeria. It also showed that there is still a serious gap to fill in utilizing community genetics services in Nigeria, as it is being done in more scientifically advanced countries, to forestall the occurrence of birth defects.

Methods

A PubMed, EMBASE, Global Health Data Exchange and Google literature search was conducted on August, 8th, 2018, using the following search terms: "birth defects/congenital malformations in Nigeria," and "birth defects/congenital malformations incidence in Nigeria" or "birth defects/congenital malformations prevalence in Nigeria". The search was limited to original research papers. No time restriction for publication dates was used. All titles and abstracts were screened for study population (live births, children), pattern of congenital malformation (CM) and birth prevalence. Studies were eligible if they reported the birth prevalence of all major CM in Nigeria based on incidence per live births.

After exclusion based on the title and abstract, full papers were carefully read and reconsidered according to all above mentioned inclusion and exclusion criteria. Studies not including the birth prevalence of all forms of CM

were excluded. When a study was eligible for inclusion, the denominator and numerator were verified and the estimated birth prevalence were recalculated to check accuracy. Studies with incorrect or missing denominators or numerator were excluded. References of selected papers were crosschecked with the same inclusion and exclusion criteria. The following study characteristics were registered: author/year, study type, study setting, study duration, total number of live births, birth prevalence of total CM and pattern of CM.

Results

Figure 1 shows a stepwise diagrammatic representation of the way, studies were selected during the systematic literature search of congenital malformations in Nigeria. Initial search yielded 748 potential eligible studies. After reading titles and abstracts, 726 papers were excluded based on the exclusion criteria listed above. Furthermore, a total of 12 papers were excluded after evaluation of full text and recalculating denominators and nominators. One additional paper was included after cross-referencing. At the end, of the search, a total of 11 papers were included in this systematic review.

Discussion

From this review, it is clear that there is a dearth of studies on CM in Nigeria. This is the same trend that has been prevalent in many parts of Africa when compared to the availability of extensive literatures on CM from other regions of the world, this was similarly observed by many African researchers. Ndibazza *et al*.[83], for example reported this same problem of sparsity of data on CM in Africa in their study. This review also revealed that most of the included studies were conducted in the South-South region of Nigeria. Also, like in many countries in sub-Saharan Africa, the prevalence of major CM in Nigeria cannot presently be precisely ascertained[83].

All the included studies were hospital based. The rates reported, in all the studies, varied as widely as the individual study conducted, between 2.0 and 91.6 per 1000 live birth. It was also observed from the results of this review that retrospective study types tend to have lower birth incidences of CM compared to the prospective types. The reduced rate observed in retrospective studies may be due to human errors and health personnel incompetency. Ndibazza *et al*.[83] reported that only 22% of the CM they observed in their study were correctly identified by midwives at birth.

This review further showed that the pattern of CM in Nigeria seems to favor a predominance of those of the musculoskeletal (MSK) and gastrointestinal (GIT) systems, some other studies in sub-Saharan Africa also supported this findings, for example Ndibazza *et al*.[83], reported the same predominance of the CM of the musculoskeletal system in their study conducted in Uganda. It is interesting to note, however, that the results of the studies done in the South-South region of Nigeria, according to this review, showed a remarkable departure from the above stated pattern. A predominance of those of the central nervous system (CNS) was observed, this has also been the trend reported in many studies done in Africa[84-86].

This variance in CM pattern in the south-south region, when compared to other regions of Nigeria, according to Obire and Amusan[87], was possibly due to an increase in environmental teratogens due to oil pollution, which has rendered lands and waters, of the area, useless for farming and fishing. This becomes a plausible reason because environmental teratogens have been associated with central nervous system anomalies in new born in many studies[88-90]. Also, inadequacy of folate in nutrition, before and during pregnancy, has been incontrovertibly linked, in several studies, to the development of CM of the CNS[91,92]. Folate is the natural form of folic acid and known to be abundantly present in seafood, groundnuts, whole grains, dark green leafy vegetables, fresh fruits, beans etc.[93]. Oil pollution, due to the fact that it has a restrictive effect on the farming and fishing activities of the people of this area, may be a contributory factor, as well, to the preponderance of this type of birth defects in this area. However, a simple preventive measure of fortification of food may be enough to solve this problem. Arth *et al*.[94] have shown the efficacy of fortification of food as a way of preventing folic acid–preventable neural tube defects.

Conclusion

There are humongous evidences to support a heavy burden of birth disorders on Nigeria, like as in many LMIC, even though, there is a dearth of researches to clearly show this. Yet, the practice of community genetics is seriously lagging behind in Nigeria, like as in many LMIC, so there is an urgent need to address this. Several factors can be adduced to this overwhelming burden of birth disorders in Nigeria. These factors range from lack of political will; to dearth of skilled professionals; to lack of infrastructure; and to the restrictive impediments of adequate financing. But with Nigeria brandishing such statistics, it is now, and not later, that the public health system in Nigeria needs to adequately respond to the challenges of this worrisome trend. This can only be possible, if the Nigerian government can adopt a vibrant community genetics service, so as to ensure good health and well-being of all citizens and reducing childhood mortality due to congenital disorders. There is still an ample chance for the country to put her act together, and genuinely put measures in place geared towards meeting the objectives of the sustainable development goals by 2030.

Recommendations

Based on the findings of this research, the following recommendations are thus of great importance:

1. A more engaging pedagogy should be adopted to pass across the benefits of community genetics to more Nigerians, inclusive of training programs for medical professionals.
2. Factual presentations to policy makers, highlighting the state of congenital disorders in Nigeria, and the need for them to fashion a national policy, in collaboration with WHO, to combat the scourge and the precautions the general public need to take, to put an end to this quagmire.
3. Extending the fortification of foods to more food products, especially rice, with some essential vitamins to prevent the occurrence of some birth defects attributable to poor nutritional practices.
4. Strengthening genetic counselling and prenatal diagnosis of congenital disorders, especially sickle cell disease that is rampant in Nigeria, and controlling malnutrition, intrapartum infections and other illnesses in pregnancy.
5. Including rubella immunization as part of the routine immunization programs in Nigeria.

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Statement of Ethics

The author has no ethical conflicts to disclose.

Conflict of Interest

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