

Profound Hearing Loss: A Global Review with Particular Reference to Sub-saharan Africa

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Abstract: It is well established that profound deafness or any other grade of deafness exists globally. The aim of this study was to review literature on the incidence and prevalence of hearing impairment in developed countries including possible aetiological factors and experiences, and compare same with developing countries of Sub-saharan Africa. The study was carried out by reviewing publications on researches conducted in America, United Kingdom, Canada, Belgium, Australia, Pakistan, Taiwan, Nigeria, South Africa, Cameroun and Egypt. It was found that there was a global increase in the number of people with profound deafness from 42 million in 1985 to 538 million in 2015 with an indication that 80% of hearing impaired persons live in low and middle income countries. At the end of 2013, the number of persons with severe to profound hearing impairment in the United Kingdom was estimated to be 1.2 million. In America, the incidence of newborn deafness was found to be higher in rural areas of Appalachia compared to non-Appalachia regions due to socioeconomic differences. In Canada, an increase from 5% to 13% of people with hearing impairment over a 24 year period has been recorded. In Australia, 27% of inhabitants over 5 years of age have been reported to have a hearing loss. In Sub-saharan Africa, one in seven children in Nigeria, for instance, has impaired hearing loss, suggesting high prevalence. Even in Jos, Nigeria, 44(31%) out of 142 children have hearing loss. Incidence and prevalence of profound hearing loss in developed countries are generally attributed to aetiological medical factors, for instance, congenital factors and genetic abnormalities account for 19.8% among neonates who have hearing impairment in Flanders and Belgium. In Sub-saharan Africa, hearing impairment is attributed to the combined effect of ignorance, poverty, medical aetiology, lack of neonatal screening facilities, poor healthcare services and a spiritual cause. In South Africa, admittance into the neonatal intensive care unit appears to be the most prevalent risk factor, while environmental factors account for 52.6% cases in Cameroun. In the United Kingdom, the experiences of mothers of children with impaired hearing are worry, frustration and shock. In Sub-saharan, the experiences of mothers are worry, frustration, absence of newborn screening test, wrong diagnosis by unskilled health workers, poverty and a spiritual cause. In conclusion, the management of hearing impairment in Sub-saharan Africa needs serious attention.

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1. Introduction

Profound deafness is defined by WHO (2012) as the inability of the better ear to detect the quietest sound at a frequency of 81 decibels or greater. This implies that the better ear is unable to hear and understand even the loudest sound. This abnormality is global. WHO (2012) reports that the number of people with disabling hearing impairment has gradually increased from 42 million in 1985, to about 360 million in 2011, out of which 328 million are adults and 32 million are children less than 15 years of age, although recent estimate of hearing impaired people is 538 million globally (Sanders *et al.*, 2015). Some persons have been diagnosed of hearing loss due to congenital or genetic abnormality before speech and language acquisition, and some others diagnosed of hearing loss due to any cause but after language or speech has been learnt (Oyewunmi and Adejumo,

2011). This implies that those with post lingual hearing loss are still able to communicate and integrate to an appreciable extent in the society, if hearing aids are provided on time since timely auditory stimulation during periods of peak receptiveness is critical to prevent long term hearing loss (Kral and Odonoghue, 2010).

WHO (2012) reports that out of 141 million live births globally recorded in 2012, 127 million were found to be from developing countries. Of this number, the estimated incidence of permanent or early onset of hearing impairment was 6 per 1000 live births being three times higher in developing countries (Olusanya *et al.*, 2014; Roux *et al.*, 2015). It has also been reported that about 80% of people who have hearing impairment live in low and middle income countries (Swanepoel *et al.*, 2013; Olusanya *et al.*,

2014; Sanders *et al.*, 2015), and about 75% live in Sub-saharan Africa (Adoga *et al.*, 2014).

The exact incidence and prevalence of profound deafness in Sub-saharan Africa, especially Nigeria, is not known due to paucity of data in this subject area (Wonkam *et al.*, 2013). However, Amusa *et al.* (2013) report that in Nigeria, one out of seven children have impaired hearing, while Adoga *et al.* (2014) report that, of the 75% of hearing impaired people in Sub-saharan Africa, 2.8% resides in Nigeria.

Several factors, seemingly, can be linked to incidence and prevalence of profound deafness globally and especially in Sub-saharan Africa. Kalu *et al.* (2017) state that high poverty rate affects the capacity of average parents to acquire proper education and choices of health seeking behaviours for their children during pregnancy, peripartum and infancy. For instance, healthcare service provision for deaf children and elders is virtually not existing in most West African countries. According to Kalu *et al.* (2017), the situation is further compounded by very poor feeding patterns and general food insecurity. Another factor is deficiency in healthcare systems which is evident in low and middle income countries like Nigeria where millions of people are below the poverty line (Balaran *et al.*, 2011), coupled with lack of financial protection for the cost of healthcare, causing individuals to be responsible for payment for their health needs (Mills, 2014). Sina *et al.* (2014) report that those who do not seek healthcare have no ability to pay. In this way, the global effort of the World Health Organization (WHO) and the United Nations in achieving universal coverage of healthcare for all is subverted (Kalu *et al.*, 2017). One other factor is that most cases of hearing loss are not syndromic, and that makes it difficult to diagnose early (Swanepoel *et al.*, 2013; Roux *et al.*, 2015). This suggests that there is no associated distinctive feature that will easily draw a person's attention to it, and hence overlooked. That is to say that the routine screening which could have been done to detect this disability on time is not performed to avert the disability (Kalu *et al.*, 2017).

The aim of this study was to review the incidence and prevalence of profound hearing loss world-wide with particular reference to Sub-saharan Africa.

2. Profound deafness

Profound deafness is one of the prevalent disabilities worldwide (CBM, 2011). However, public health measures and interventions such as health education, can improve access to services at the primary level, while mass vaccination can help reduce the prevalence and adverse impact of hearing loss (WHO, 2015). This will work best especially in low income people in developing countries of Sub-saharan Africa and Asia where effective governmental efforts

and public policies and systems have not been appropriately harnessed to ameliorate some of these important public health concerns (Olusanya *et al.*, 2014).

3. Types and classification of hearing impairment

There are basically three types of hearing loss (Adebayo and Oluwale, 2014). These are conductive, sensorineural and mixed hearing loss. Conductive hearing loss is due to an anomaly of the outer ear or middle ear which reduces the intensity of sounds reaching the cochlear which is the organ of hearing. This can occur in occlusion of the outer or middle ear by cerumen (ear wax), or any middle ear infection. Sensorineural hearing loss, on the other hand, occurs when hearing loss results from lesions of the cochlear (known as the sensory type or lesions to the vestibulocochlear nerve), called the neural type. This type of hearing loss does not have definitive treatment. However, adequate rehabilitative management is very possible. Mixed hearing loss is the type that combines the elements of both conductive and sensorineural hearing loss.

Other authors have classified hearing loss according to their degrees of severity into mild, moderate, moderately severe and profound hearing loss (Sanders *et al.*, 2015). However, WHO (2012), has graded hearing impairment as the inability to hear, as well as someone with normal hearing based on the audiometric pure tone value into Grade 0 (referred to as no impairment with a corresponding audiometric value of 25 decibels or better in the better ear). There is normal hearing or very slight hearing problems and the individual to hear whispers. Another is Grade 1 which is known as slight or mild impairment with an audiometric value of 26 to 40 decibels (better ear). Such individual is able to hear and interpret. Word spoken in normal voice at one meter counseling is however recommended for such individuals, though hearing aids may be provided. Grade 2 is also called moderate hearing impairment corresponding to an audiometric value of 41 to 55 decibels (better ear). An individual in this category is able to hear and interpret words spoken in raised voice at one meter. Hearing aid is usually recommended. In Grade 3, people can have moderately severe hearing loss where an audiometric tone value corresponds to 56 to 70 decibels (better ear) and those who have severe hearing with an audiometric value of 71 to 90 decibels in better ear. Individuals in this grade of hearing impairment are able to hear some words when shouted into better ear. Hearing aid is needed and if no hearing aid is available, lip reading is recommended by WHO (2012) to be taught to the child. In Grade 4, also called profound impairment of deafness, there is an audiometric pure tone average corresponding to 91 decibels or greater in the better ear. Such an individual

is unable to hear and understand even a shouted voice. In this case, additional rehabilitation is recommended and sometimes sign language is essential. Grades 2, 3 and 4 are classified as disabling hearing impairments, defined by WHO (2012) as a hearing loss of greater than 40 decibels in the better ear in adults, and a hearing loss of greater than 30 decibels in the better hearing ear in children. Hearing impaired people can be said to be hard at hearing or deaf, but if a person cannot hear at all, such a person is said to have deafness (WHO, 2012).

4. Incidence and prevalence of hearing loss

The incidence and prevalence of hearing loss have been shown to have increased more than seven folds globally between 1985 and 2011 (WHO, 2012). However, there is no documentary evidence of the reason for this tremendous increase which may be due to ineffective preventive and management efforts, hence it has remained a global problem (Adoga *et al.*, 2012).

In the news article of the American Academy of Audiology, it was stated that, from the study conducted by Trak (2009), there were about 34.25 million people with hearing loss in the United States, with 3.4% having severe to profound hearing loss which translates to about 1,165,000 people with severe to profound hearing loss with further estimate of the number increasing to about 1.2 million of severe to profound hearing loss by the end of 2013.

Likewise, Bush *et al.* (2014), in their retrospective review of children's record with congenital deafness, diagnosed in a major tertiary centre in central and eastern Kentucky in America, found that the incidence of newborn deafness was higher in the rural areas of Appalachia (about one per 536 births) compared to the non-Appalachia regions. This implies that even in the American population, the incidence of hearing loss has been found to be higher in more rural areas which apparently lack healthcare services (Bush *et al.*, 2014). This suggests a socioeconomic inequality in health and the effect of a wider health determinant on hearing loss. The alarming figure further suggests that even in developed countries, e.g., America, hearing loss remains a significant problem.

In Canada, Synnes *et al.* (2012) conducted a research on the pattern and incidence of deafness in extremely low birth weight neonates by the extraction of data from subjects up to 5 years of age between 1983 and 2006. The results showed that, of the 586 extremely low birth weight children studied, 50 had hearing loss of different grades and this has increased from 5% to 13% over a 24 year period. Although the reason for this increase is not known and a single sight was used for the study, it however highlights the

severity of this problem and suggests a public health approach in solving this problem.

Action on hearing loss in 2012, as reported by Kalu (2015) showed that about 10 million people in the United Kingdom were hard at hearing or deaf which represents about one in six people with its prevalence reported to be about 800,000 people who had hearing loss. However, the actual proportions of hearing impairment has been estimated by WHO to be about 17% in the United Kingdom (Sanders *et al.*, 2015), implying that a significant proportion of the population in the United Kingdom live with this disability.

Turton and Smith (2013) conducted a retrospective study of some 32,761 patients' files from which they estimated the prevalence of severe to profound hearing loss in the United Kingdom to be 6.7%, corresponding to about 2,199 patients who had a bilateral pure tone average of greater than 70 decibels which represents about 0.7% of the entire population of the United Kingdom. This suggests that emphasis should be placed on the prevention of this disability, given its high prevalence.

In the Pacific countries of Australia, e.g., Cook Island, Sanders *et al.* (2015) conducted a quantitative research to estimate the prevalence of hearing impairment, and found that greater than 27% of the Pacific Island inhabitants over 5 years of age, had a hearing loss greater than 20 decibels with about 20.9% out of a total population of about 16,996 people in Cook Island having profound deafness. These results further suggest higher incidence and prevalence of profound deafness in the middle income countries of the Pacific Island than their counterparts in developed countries. In Taiwan, a similar study by Lai *et al.* (2014) to examine the impact of childhood vaccination on hearing loss showed that the registered cases of hearing impaired persons less than 17 years of age between years 2000 and 2011, ranged from 3,427 to 4,075 of the total population with an increase in prevalence between 2000 and 2006, which decreased drastically till 2011 after introduction of a mass rubella vaccination programme, suggesting that rubella is known to cause congenital deafness, and can be prevented and treated through public health intervention.

In Pakistan, Iqbal *et al.* (2014) showed that the incidence and prevalence of congenital deafness was very high mainly due to high rates of first cousin marriages which remained a cultural practice among the Pakistanians. This implies that cultural practices and religious norms contribute to the burden of this disease in some parts of the world. Hence the aetiologies of profound deafness go beyond medical causal factors alone, since other health factors significantly contribute to this.

Data on the incidence and prevalence of hearing impairment are lacking in Africa. However, a number of researches have tried to estimate this in selected populations. Taha *et al.* (2010) report that 20.9% of the entire population in Egypt has high prevalence of hearing loss among school age children.

In Nigeria, Amusa *et al.* (2013) report that one in seven children has impaired hearing loss, suggesting a high prevalence of this disease in Nigerian children. Adoga *et al.* (2012), in their retrospective study of pure tone audiogram of children seen in a tertiary hospital in Jos, Northern Nigeria, further affirmed that, out of 142 children studied, about 44 (31%) had profound deafness, and the overall disabling hearing loss accounting for about 86(60%), suggesting a high prevalence of this disability among this cohort.

Though hearing impairment is prevalent globally, although to different proportions, higher incidence and prevalence have been shown to occur in resource limited developing and Sub-saharan African countries, as evidenced by the systematic review by Stevens *et al.* (2014) in which they made an estimate of the prevalence of hearing impairment using Bayesian model which has been shown to be effective for sparse data from literature published in different countries. The hearing impairment in Sub-saharan Africa is attributed to the combined effect of ignorance, poverty, medical aetiologies, lack of neonatal screening facilities and poor healthcare services (Swanepoel *et al.*, 2013; Olusanya *et al.*, 2014; Sanders *et al.*, 2015; Kalu *et al.*, 2017).

5. Impact of profound deafness

The impact of profound deafness can be seen in three main facets (WHO, 2012), namely: functional, social/emotional and economic impacts. Under the functional impacts, one of the main impacts of hearing loss is the inability of the individual to communicate with others because spoken language development depends on hearing, hence, language delay in children with deafness has an adverse effect on the academic performance of children since cognitive skills are delayed as well (Sanders *et al.*, 2015). Regarding social/emotional impacts, Fellingner *et al.* (2012) state that the rates of emotional and behavioral problems in deaf children are about two times higher than there are for children without this disability. This implies that children with profound hearing loss are more likely to show aggressive and unruly behaviours. More so, a combined effect of limited access to services and social exclusion especially from day to day communication, can have a significant impact on everyday life causing feelings of loneliness, isolation, frustration, dependency and poverty (WHO, 2012) which are more felt in developing countries (Sanders *et al.*, 2015). From economic point of view, children from developing countries with profound deafness

hardly receive any schooling, while adult with this disability have a higher unemployment rates (WHO, 2012). Also, it affects social and economic development in communities and countries (Sanders *et al.*, 2015). Data from Australia have indicated a direct cost of hearing impairment in 2006 alone to be 11.75 billion Australian dollars (about 1.4% of gross domestic product) and the loss in productivity accounting for about 57% of this figures (Sanders *et al.*, 2015). Apparently, there has been no estimate of economic loss arising from hearing so far in developing countries (Kalu *et al.*, 2017).

6. Aetiological risk factors of profound deafness

In a study to determine the role of cytomegalovirus which has caused hearing loss in a group of non-syndromic children in America, Karltorp *et al.* (2012) showed that 20% of these children were positive for cytomegalovirus which caused a mutation leading to the appearance of numerous genes especially in carriers among the children. This study showed consistency with a number of other studies on infectious molecular epidemiology and genetic mutation regarding non-syndromic severe hearing loss (Avettand-Fenoel *et al.*, 2013; Rehman *et al.*, 2014; Chakchouk *et al.*, 2015).

A study in Flanders and Belgium by Lammens *et al.* (2013) showed that congenital deafness and genetic anomalies accounted for about 19.8% among neonates. This was in line with a study conducted by Parker *et al.* (2014) in the United Kingdom to investigate the genetic aetiology of sensorineural hearing loss in which it was found that this condition may be caused by mutation in the genetic makeup of an individual, making it one of the most common birth anomalies in developed economies of unknown aetiologies. This therefore suggests that in developed countries, genetic mutation accounts for a significant amount of the burden of this disability, although ear infection has been attributed to be the cause of hearing loss in developed countries (Rabbanni *et al.*, 2014). Apart from aetiological factors, it is also important to focus on studies on socioeconomic determinants to this disability.

Boss *et al.* (2011) undertook a study on the socioeconomic differences among hearing impaired children in America, and identified that, of the 76012 cohort of children studied, families of profoundly deaf children were more likely to report poor health due to low socioeconomic status like living in poor neighbourhood and single parenthood. It can therefore be inferred that there might have been a complex interplay of some wider health determinants in addition to some unknown medical factors that have played a contributory role to mothers having children with this disability. This is in keeping with a study conducted in England by Benova *et al.* (2014) on the

socioeconomic position and health seeking behaviour of individuals with impaired hearing in which results showed that people in higher social class were less likely to have hearing loss (odds ratio of 0.87). In contrast to this, Pearson *et al.* (2013) argue that there is no significant association between hearing thresholds and socioeconomic indicators, based on their study conducted in Newcastle, United Kingdom.

A bulk of these researches have been carried out in Europe and the developed countries of America, and cannot be conclusive and completely generalized in terms of the causative risk factors to profound deafness in developing countries like Nigeria, and other Asian and African countries.

Several authors have shown a significant aetiological risk factor of profound deafness to be hereditary which is most pronounced among Asian population where consanguineous marriages are practised (Selvarajan *et al.*, 2013; Anjum *et al.*, 2014). Selvarajan *et al.* (2013) conducted a case control study to determine the association of hereditary factors to permanent hearing loss and found out that a family history and consanguinity were higher in groups with hearing loss than in the control, therefore it might be credible to point to the role of heredity as a causal risk factor for profound deafness. This was consistent with a number of other studies carried out in Japan and China (Xin *et al.*, 2013; Hayashi *et al.*, 2013). However, in Sub-saharan Africa, Nigeria to be precise, a study conducted by Lasisi *et al.* (2014) to determine genes for non-syndromic deafness showed that these genes were not found among their cohort of study, indicating that it is uncommon in Africa. Moreover, when compared to developed nations of Europe and America, they further highlight the role of unidentified aetiological risk factors to this disability, especially due to cultural practices other than medical risk factors which cut across nations.

Other authors in India (Arumugam *et al.*, 2015) have identified the prevalence of infections, especially congenital rubella syndrome to account for deafness in children. This was in keeping with a cross-sectional study among Peruvian children by Czechowicz *et al.* (2010) which showed that identified risk factors for hearing impairments were medical conditions like neonatal jaundice and seizures in neonates which required admission into the neonatal intensive care unit and consequently profound deafness ensued as a complication. Thus, it can be argued that, in as much as these medical aetiological risk factors are inevitable globally, the extent and severity of hearing loss differ among children who suffer a medical cause of hearing impairment in developed and developing countries, therefore implying some other determinants to the acquisition of this disability.

In a retrospective review of patients' files for cochlear implantation in South Africa, Roux *et al.* (2015) identified the most prevalent risk factors for profound hearing loss to be admittance into the neonatal intensive unit, implying that the reasons for the admittance may be a medical aetiology. In line with this, Amusa *et al.* (2013) conducted a cross-sectional descriptive study in Nigeria on the aetiology of hearing loss in children who had impaired hearing, and their result showed a high prevalence of hearing loss amongst children whose mothers had maternal illnesses during pregnancy requiring these neonates to be admitted into the neonatal care unit, hence suggesting the role of an infectious maternal aetiology on hearing impairment which has been shown to be more common in developing than developed countries (Lai *et al.*, 2014). Besides, Olusanya (2015) also states that bilirubin-induced neurological dysfunction is contributory to hearing impairment among Nigerian children. Other medical illnesses like malaria and meningitis which are common in tropical countries of Africa, have also been implicated in causing hearing loss in children (Opoku-Buabeng and Brobby, 2013). De-Barros *et al.* (2014) also state that the most common cause of acquired hearing loss in children is bacterial meningitis and hence accounting for significant proportions of sensorineural deafness among Sub-saharan African children.

In Cameroun, Wonkam *et al.* (2013) determined the causes of hearing impairment among Cameroun children, and identified environmental causes to account for about 52.6% of cases of severe deafness due to poor parental awareness of signs of deafness to account for about 75.1% of prelingual deafness. This implies that some socioeconomic factors such as inability to afford good housing on the part of parents leading to poor housing location especially near noisy areas, has been shown to be a major avoidable aetiology of hearing impairment. Ignorance which depicts the level of education of these patients, plays a significant role to the burden of this disability in Sub-saharan Africa.

In Nigeria too, a study by Olusanya (2011) to determine the predictors of early onset of deafness among undernourished infants, showed that about 66.7% of the children had moderately severe to profound deafness. Emmett and West (2014) further state that gestational vitamin A deficiency during a critical period in early gestation and fetal formation contributes to inner ear malformation and sensorineural deafness in neonates given the essential role that vitamin A plays during embryogenesis of organ formation. This therefore provides that pregnant mothers in disadvantaged circumstances with lack of balanced diets may contribute to having children with severe non-syndromic hearing impairment. This is so

in malnourished children, which further suggests a socioeconomic determinant to this disability. However, Oyewunmi and Adejumo (2011) have argued that their study based in Western Nigeria to investigate the causes of impaired hearing found no significant association between socioeconomic status and hearing loss. However, this cannot be conclusive since this quantitative study was only designed and carried out to measure the degree and extent of different causal factors of hearing impairment.

7. Experiences of parents with hearing impaired children

Literature on the experiences of parent with hearing impaired children is lacking. Only very few authors have researched in this aspect. Archibold *et al.* (2015) have conducted a mixed method research (qualitative and quantitative) in the United Kingdom, to explore the experiences of parents of children with mild/moderate hearing loss, and found out that parents of this group experienced a form of worry from the birth of their children who failed the newborn test and subsequent hearing test. Other parents were said to experience shock when first confronted with the news of the situations of their children's disability, while some experienced frustration. Another set of parents experienced a sense of relief when their children were given a hearing aid after a much later diagnosis, suggesting that an intervention is important as this could ameliorate this problem to a great extent.

Uus *et al.* (2015) also conducted a qualitative study in the United Kingdom to explore the experiences of parents for choices of hearing management for their children who have auditory neuropathy spectrum disorder, and their findings showed that parents narrated experiences that highlight the barriers in early management due to different opinions of experts, suggesting a need for research based guidelines for the management of disabilities as such.

Frank-Briggs (2013), in his qualitative research to determine parents perception about the hearing impairment of their children, found that about 72.9% of their cohort of study attributed deafness to be due to a spiritual cause, indicating ignorance on the part of such parents. Recently, Kalu *et al.* (2017) conducted a qualitative study in Calabar, Nigeria, to investigate the experiences of five mothers of profoundly deaf children, including how these five mothers interpreted their children's disability relative to the socioeconomic situations in Nigeria. They found out that parents initially suffered from frustration and worry. There was no newborn screening test, and mothers' ignorance on the aetiological factors of the abnormality, wrong diagnosis by unskilled health workers in available hospitals and spiritual belief and

socioeconomic factors, all were the experiences of mothers (Kalu *et al.*, 2017).

8. Symptoms/signs of hearing loss

WHO (2012) states that the symptoms of hearing loss is basically the same in all locations, implying that geographic location is not associated with different symptoms in children. Most often, children and toddlers are not able to obey command because they are unable to hear (Kalu, 2015). A number of authors have stated that in prelingual hearing loss, these children are unable to communicate or speak because of dependence on speech acquisition on hearing (Oyewunmi and Adejumo, 2011). Furthermore, other children show signs of developmental delays at early infancy, especially those who have suffered an infectious cause of hearing loss, like meningitis (Opoku-buabeng and Brobby, 2013).

9. Management of hearing impairment

Several countries have adopted preventive management strategies to avoid the long term consequences of this disability. It has been stated that hearing loss is mainly managed depending on the grades and severity of hearing loss (WHO, 2012). For instance, grade I hearing loss is mostly managed by counseling where parents of such children are taught on healthy ear care practices, ear hygiene and how best to prevent traumatic ear injuries (WHO, 2012). Hearing aid has been recommended for grade 3 hearing loss and lip reading and singing should be taught (WHO, 2012). More so, cochlear implantation has been shown to be a remarkable success in different parts of the world on the treatment of severe to profound hearing loss (Barros *et al.*, 2014; Arumugan *et al.*, 2015).

In Australia, Ching *et al.* (2007) reviewed the effectiveness of binaural-bimodal fitting and bilateral implantation for the management of severe to profound deafness and found that patients who had a cochlear implantation on one ear with a hearing aid on the opposite ear which had residual hearing, could hear with patients who had cochlear implants in both ears. This suggests that cost and surgical complications can be reduced in the management of this disability by proper screening and a single surgical cochlear implantation. This agrees with the findings of De-Barros *et al.* (2014) whose retrospective study of five patients with severe bilateral deafness due to meningitis showed that after cochlear implantation was performed even after ossification of the tiny bones had occurred, good outcomes were still obtained.

Successful implantation of the cochlear with good outcome has been reported as early as 1983 in developing countries of Africa like Egypt, South Africa, Namibia and Libya (Adoga *et al.*, 2012). In Nigeria, Adoga *et al.* (2014) state that cochlear

implantation is the most satisfying treatment for profound hearing loss. However, it poses an enormous challenge in Nigeria since the trial of cochlear implantation was unsuccessful as the patients were referred to the United States of America where they subsequently had it implanted. The failure in Nigeria could be as a result of lack of trained manpower. Thus, a huge emphasis has now been placed on preventive measures especially in developing countries like Nigeria where multifactorial causes coupled with inappropriate skilled personnel and poor healthcare services promote the role to be the burden of this disability (Swanepoel *et al.*, 2013; Adoga *et al.*, 2014).

A number of documentations have also been found on the effectiveness of immunization and vaccination as public health actions on the prevention/reduction of the incidence/prevalence of profound deafness (WHO, 2012; De-Barros *et al.*, 2014; Lai *et al.*, 2015). De-Barros *et al.* (2014) have stated that among children in France, the introduction and implementation of *Haemophilus influenzae* vaccination for children less than five years of age was shown to remarkably reduce the incidence of *Haemophilus influenzae* meningitis which is normally complicated with severe to profound sensorineural hearing loss in sufferers. Besides, Lai *et al.* (2014) studied the impact of childhood vaccination on hearing loss and found that the incidence and prevalence of hearing impairment reduced drastically after the introduction of a mass vaccination programme in Taiwan within a specific period of time. This therefore suggests the importance and effectiveness of public health actions in the prevention of this disability especially in resource limited countries like Nigeria.

10. Conclusion

Profound deafness is global and has increased in 2015 (Sanders *et al.*, 2015). Out of 141 million live births globally recorded in 2012, 127 million were found to be from developing countries. Of this number, the estimated incidence of permanent or early onset of hearing impairment was 6 per 1000 live births being three times higher in developing countries (Olusanya *et al.*, 2014; Roux *et al.*, 2015). Also, 80% of people who have hearing impairment live in low and middle income countries (Swanepoel *et al.*, 2013; Olusanya *et al.*, 2014; Sanders *et al.*, 2015), and about 75% live in Sub-saharan Africa (Adoga *et al.*, 2014).

There were about 34.25 million people with hearing loss in the United States with further estimate of the number increasing to about 1.2 million of severe to profound hearing loss by the end of 2013 (Trak, 2009). Also, the incidence of newborn deafness was found to be higher in the rural areas of Appalachia compared to non-Appalachia regions (Bush *et al.*, 2014). This suggests that even in America (a

developed country), there is socioeconomic inequality in health implying that hearing loss is significant.

In Canada, it has been shown that, of the 586 extremely low birth weight children studied, 50 had hearing loss of different grades and this increased from 5% to 13% over a 24 year period (Synnes *et al.*, 2012). It has been reported by Action on Hearing Loss that there were about 10 million in the United Kingdom who were hard at hearing (Kalu, 2015). Also, in the United Kingdom, a retrospective study of 32,761 patients' files has estimated the prevalence of severe to profound hearing loss to be 6.7%, corresponding to about 2,199 patients with hearing loss (Turton and Smith, 2013).

In the Pacific countries of Australia, 27% of inhabitants over 5 years of age, had a hearing loss (Sanders *et al.*, 2015). In Taiwan, a similar study showed that the registered cases of hearing impaired people less than 17 years of age ranged from 3,427 to 4,075. In Pakistan, Iqbal *et al.* (2014) showed that the incidence and prevalence of congenital deafness was very high mainly due to high rates of first cousin marriages which remains a cultural practice among the Pakistanians.

Data on the incidence and prevalence of hearing loss in Africa are lacking. However, Taha *et al.* (2010) report that 20.9% of the entire population of Egypt has high prevalence of hearing loss among school age children. In Nigeria, Amusa *et al.* (2013) report that one in seven children has impaired hearing loss, suggesting a high prevalence. Adoga *et al.* (2012) further affirmed that, in Jos, Nigeria, out of 142 children studied, about 44 (31%) had hearing loss.

The incidence and prevalence of profound hearing loss in developed countries are generally attributed to aetiological medical factors. For instance, congenital factors and genetic abnormalities accounted for 19.8% among neonates in Flanders and Belgium who had hearing impairment (Lammens *et al.*, 2013), or by mutation in the genetic make up of an individual (Parker *et al.*, 2014). Furthermore, profoundly deaf children in America were more likely to report poor health due to low socioeconomic status like living in poor neighbourhood and single parenthood (Boss *et al.*, 2011).

On the other hand, the hearing impairment in Sub-saharan Africa is attributed to the combined effect of ignorance, poverty, medical aetiologies, lack of neonatal screening facilities, poor healthcare services and spiritual cause (Swanepoel *et al.*, 2013; Olusanya *et al.*, 2014; Sanders *et al.*, 2015; Kalu *et al.*, 2017). In the United Kingdom, for instance, parents of hearing impaired children experience worry; some experience frustration and shock (Archibold *et al.*, 2015). Kalu *et al.* (2017) report when such parents come to know of their children's disability, they suffer from frustration

and worry. In the first place there is no newborn screening test coupled with mothers' ignorance of the aetiological factors of the abnormality, wrong diagnosis by unskilled health workers in available hospitals, spiritual belief and socioeconomic factors, all are the experiences of mothers (Kalu *et al.*, 2017). In conclusion, much needs to be done for effective management of profound deafness in Sub-saharan Africa.

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