Food additives and their health implications on children in Africa: a systematic review

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Review Article

ABSTRACT

Objective: The safety of processed foods is an issue of public health importance, especially in Africa where there is unchecked rate at which many food industries turn out novel 'chemicals' aimed at increasing the acceptability of their products. This is particularly true for processed foods targeted at children, who remain the most vulnerable group. The aim of this review was to identify health implications of food additives on children in Africa based on findings from original research works.

Methods: We conducted a parallel search of Medline, EMBASE and Global Health for relevant studies from 1970 to 2014. We included studies conducted among African populations reporting effects of food additives among children (under age 17 years). Data on health implications of food additives were extracted and reviewed.

Results: Our search returned 479 studies, with only 4 studies meeting the selection criteria. Five countries were represented, namely Libya, Nigeria, Uganda, Tanzania and Sudan The total study population was 3326. All the studies were cross-sectional, and focused essentially on sugar as an important risk factor for the development of dental caries and/or erosion in children.

Conclusions: Studies on important food additives such as preservatives, colouring agents, sweeteners, anti-caking agents and their effects on health of children are largely unavailable in Africa, although anecdotal reports are suggestive of their deleterious effects. To ensure evidenced-based decision making and public policies in this regard, there is a need for original research works.

Keywords: Children, food additives, food industry, Africa

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Les additives alimentaires et leurs conséquences sur la santé des enfants en Afrique: Une revue systématique.

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Article De Revue

RÉSUMÉ

Contexte de L'Étude: La sécurité des aliments transformés est une question d'importance pour la santé publique. En particulier en Afrique où il est décoché taux à laquelle de nombreuses industries alimentaires sc.révèlent de nouveaux "produits chimiques" visant à accroitre l'acceptabilité de leurs produits. Cela est particulièrement vrai pour les aliments transformes destines aux enfants, qui restent le groupe le plus vulnérable le but de cette étudeétait d'identifier les conséquences ou les répercussions sur la santé des additives alimentaires sur les enfants en Afrique basée sur les résultants en Afrique basée sur les résultants des étudesoriginales.

Méthode de l'Étude: Nous avons effectué une recherché parallèle de Médine. EMBASE et la santé mondiale pour les études pertinentes de 1970 a ce jour. Nous avons indu les étudesmenées parmi les populations africaines déclarant L'effet des additives alimentaires chez les enfants (moins de 17ans). Les données sur les conséquences sur la santé des additifs alimentaires ont été extraites et examinées.

Résultats: Notre recherché a donné 479 études, avec seulement quatre études répondant à nos critères de sélection. Cinq pays étaient représentés à savoir: la Libye, le Nigeria, L'Ouganda, la Tanzanie et le Sudan. La population totale de l'étude était 3326. Toutes les etudes étaient transversales et ont essentiellement porté sur le sucre comme un facteur de risqué important pour le développement de la carié et/ou de l'érosion dentaire chez les enfants.

Conclusion: Les études sur les additifs alimentaires importants tels que des conservateurs, des colorants, des édulcorants, des agents de fourmis-agglomérant, etc., et leurs effets sur la santé des enfants sont largement indisponibles en Afrique. Bien que des rapports anecdotiques suggèrent de leurs effets délétères. Pour assurer la prise de décision et de politiques publiques fondées sur des données probantes à cet égard, il est nécessaire pour les études ou recherché originaux.

Mots-Cles: Enfants, additifs alimentaires, industrie alimentaire, Afrique.

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INTRODUCTION

It has been estimated that about 75% of the Western diet is made up of various processed foods, with an individual consuming an average of 8-10 pounds of food additives per year (1). These kinds of food are increasingly being embraced by many Africans perhaps in the name of globalization and or civilization. The usual traditional diets typical of Africans are gradually being substituted by processed foods, many of which have one form of additives or the other. Unfortunately, children are the ones particularly at risk as most of their diets contain appreciable amounts of these additives and hence are more likely to be affected by whatever adverse effects the additives may have.

The reason for this increased risk may not be far-fetched. For instance, children have been found to have complete compensation for calories compared to adults whose food consumption is greatly influenced by experience and social dynamics (2). Again, the blood brain barrier, being poorly developed early in life, is affected by alterations in blood flow as well as pore density thus allowing toxic substances to passively cross into the central nervous system (3, 4). Not many studies however have been carried out in humans to evaluate the safety of food additives that we consume; most studies were carried out in animal models (5). In humans, the highest tolerable amount of additives otherwise termed NOAEL ("no-observed-adverse-effect level"), is determined from the review of internationally available data from both human and animal models (6). This evaluation is made by the Joint Expert Committee from the Food and Agriculture Organization (FAO) and the World Health Organization (WHO) on Food Additives (JECFA), also known as Codex Alimentarius Commission(6). Historically, it was on the instance of such evaluation that Boric Acid, which has been in use as a preservative up till the 1920s, was banned after World War I, when it was discovered to be toxic in both human and animal subjects (7). Generally, the NOAEL describes a situation in which there is no significant increase in frequency or severity of adverse effects following exposure of a population to a certain substance (8, 9). This again is what is used to determine the Acceptable Daily Intake (ADI) for each food additive (10) that is allowed for public consumption. The ADI "provides a large safety margin and is the amount of a food additive that can be consumed daily over a lifetime without any adverse effect on health" (6, 11).

According to Codex Alimentarius, food additive means "any substance not normally consumed as a food by itself and not normally used as a typical ingredient of the food, whether or not it has nutritive value, the intentional addition of which to food for a technological (including organoleptic) purpose in the manufacture, processing, preparation, treatment, packing, packaging, transport or holding of such food results, or may be reasonably expected to result, (directly or indirectly) in it or its by-products becoming a component of or otherwise affecting the characteristics of such foods" (6, 11). This definition however does not include substances which are added to food with the primary intention of improving the nutritional values of the food (12).

Literature on health implications of these additives are scanty; majority of what we have are anecdotal, thus making it difficult to draw conclusions for evidenced-based decision making. With the increased propensity to embracing western diets by the Africans, it becomes imperative that we are sure of the safety profile of these additives especially as it relates to the health of children. It was in view of this that we sought to identify documented reports in Africa on health implications of food additives on children for whom additives have become "integral components" of their foods both at home and in schools. This is necessary to ensure well- informed policy responses for addressing the issue among these highly vulnerable individuals.

METHODS

We defined food additive in this review as any substance (be it natural or synthetic) that is added to food before consumption but which on its own is not consumed as food (6). We focused on these food additives and what effects (positive or negative) they have specifically on children. This age group was chosen because it is believed to include the most vulnerable group of individuals.

Search strategy: An initial attempt to identify key words and Medical Subject Headings (MeSH) for the review was made together with an input from a librarian to choose the final search terms (Table 1). We then undertook a systematic review of published literature across the following databases: 1) Medline (1970–2014); 2) EMBASE (1970–2014); 3) Global Health (1970–2014) and Academic Search Complete (1970-2014). An additional search of Google Scholar and the hand-searching of the selected studies' reference lists were also conducted.

Study selection: We broadly included studies conducted in Africa and reporting effects of food additives among children aged 0-17 years with no gender differences. We excluded studies that were published before 1970, conducted on non-human subjects, and with no specified additives (Figure 1). We further ensured the case definitions; study designs and the effects of these additives on the study population were clearly defined.

Data extraction and analysis: All data were double extracted and stored in Microsoft Excel file format. We systematically extracted data on study location and country, study settings, sample size, age range, and study designs. Each study was analysed based on these headings. The pattern of relationship existing between the subject's age and the effects of the food additive was examined.

RESULTS

Our search returned 479 hits and there were 3 additional articles from other sources. Of these, 322 articles remained after removing duplicates. After screening titles for relevance, 280 articles were removed. Of the 42 full texts found eligible, only 4 studies met our inclusion and exclusion criteria (see Figure 1); many of those excluded were related to prevalence of dental caries with no mention of a specific additive as the risk factor. Five countries were represented namely Nigeria, Libya, Uganda, Tanzania, and Sudan with a total study population of 3326. All the studies were cross-sectional. One of the studies was carried out in an urban setting in Nigeria, the second in Libya, the third was a comparative study carried out in both rural as well as urban communities of 2 countries namely Uganda and Tanzania and the forth study was carried out in Sudan. A detailed presentation of results is as shown in Table 2. In the Nigeria study (13), a significant association between increased sugar consumption and the development of dental caries was observed. The study was carried out among 205 consecutive, apparently healthy children in the paediatric clinics of two hospitals in the South -Western part of the country. For every year decrease in age, the researchers reported an odd ratio of 0.63 for rampant caries development, and 1.46 for every increase in frequency of daily sugar consumption beyond a threshold. According to the researchers, other independent variables with no significant association with dental caries included sex, birth rank, duration of breast feeding, form of breastfeeding and duration of bottle feeding. It is clear from this study that child's age and rate of consumption of sugar-containing diets were major risk factors for development of rampant caries, the latter being the stronger predictor. In the Libya study, Huew and others (14) reported a statistically significant association between intake of fruits-based sugared drinks and experience of dental caries among school children aged 12 years in a school community-based study. Here,

791 school children were randomly selected and examined for dental caries and dental erosion. Questionnaire was also administered to elicit possible dietary risk factors. The assessment of the dental caries and erosion were made based on WHO as well as UK National Diet and Nutrition Survey standards respectively. More than fifty percent of the study population had dental caries, while approximately forty percent had dental erosion. Using both bivariate and multivariate analyses, the frequency of consumption of fruit-based sugared drinks was found to be positively significantly associated with dental caries experience. In the comparative study conducted in both Tanzania (high fluoride, rural community) and Uganda (low fluoride, urban community), 1221 children were examined for early childhood caries (ECC) and enamel hypoplasia. The researchers reported a higher prevalence of ECC in the low fluoride, urban community of Uganda (17.6%) compared to the high-fluoride rural community of Tanzania (3.7%) with a high sugar intake as an important predictor (15). The Sudan study (16) was a school-based study among 12-year old children aimed at testing whether caries experience and socio-demographic characteristics are associated with the frequency of intake of sugar-sweetened snacks and beverages. The study employed the use of food questionnaire and behavioral checklist to elicit dietary information from 1109 respondents. Here, frequency of consumption of sugar-sweetened snacks was found to be a significant risk factor for dental caries experience especially in the higher caries experience group.

DISCUSSIONS

Although food additives could present with beneficial effects (6), their negative effects sometimes can be very pronounced especially on children who constitute the most vulnerable group. Whereas the negative effects of many of these substances have not been fully studied in Africa, the available data are indicative of their deleterious effects on the health of children (13, 14, 15, 16). This is consistent with findings in some developed nations of the world. In a randomized placebo control trial involving 297 children aged 3-9 years, for instance, it was found that the children showed increased hyperactive behavior following an intake of a mixture of food colorings and a preservative (sodium benzoate) (17). In the four studies included from Africa, dental caries and erosion were very prominent possible outcomes of undue sugar intake in children. Although not focusing on any specific food additives, several other studies from Africa have noted dietary indiscretion such as increased consumption of cakes, biscuits, soda and other high calorie diets in children as important risk factor for the experience of dental caries in children (18, 19).

Elsewhere, in a fluoridated community of Southern Illinois, Jain and Gary (20) recently reported that consumption of sugar- sweetened beverages is far more strongly associated with dental caries than the consumption of snack foods among young adults. Taken together, these findings underscore the significant role sugar as an additive in children diets plays on their health. It is noteworthy, however, that this largely preventable condition, if not promptly and properly managed, may lead to such conditions as periodontal disease (21) and abscess formation, including brain abscess (21, 22, 23).

In the African context, nevertheless, these findings are not enough to draw conclusions based on the following reasons. First, the studies were only from four countries, so not representative enough of all the regions of the continent. Secondly, the studies focused mainly on sugar as an additive, which is just one out of the hundreds of additives associated with children's diet; original research works on many other important food additives such as artificial colouring agents, anti-caking agents, sweeteners, humectants are lacking. Thirdly,

compared to randomized clinical trials, cross-sectional studies should be interpreted with extra caution, in that, inference on cause and effect relationship cannot be easily made (24) and this is obviously the case in this review.

Study limitations: While we aimed to provide a systematic, evidence -based review of the effects of food additives on children in Africa, we were limited by a number of factors. Original research data on food additives and their effects on the health of children are almost non-existent in the continent. We included only four studies from five countries that met our selection criteria, therefore, our findings may not really be representative of many African countries. Again, those studies included were cross-sectional, not randomized trials, and as such must be interpreted with caution, especially given the risk of confounders as well as recall bias which are often associated with cross-sectional studies. To the best of our knowledge, however, this article provides the first systematic review of food additives among children in Africa; it may therefore serve as template for future research and policy interventions.

Health implications of food additives on children: Evidences from other parts of the globe.

The need to establish a link between food additive consumption and a number of perceived health hazards in children has led many researchers in other parts of the world to carry out original studies, a number of which are randomized controlled trials. These food additives range from artificial colouring agents to sweeteners and preservatives. Hyperactivity for instance has been linked to increased consumption of a number of food additives in children (25, 26). In a study conducted in the UK, children with no previous history of hyperactive disorders were found to be hyperactive to some extent following consumption of some additive-containing fruit drinks (17). Additives which were included in the study are Sodium Benzoate, Tartrazine, Quinolone yellow, Sunset yellow, Carmosine and Allura red, among others (17). The findings strongly supported the view that food additives worsen hyperactivity disorders especially in children (17). Another link, between consumption of aspartame, a low-calorie sweetener, in newly diagnosed but untreated children with generalized absence seizures and exacerbation of EEG-spike wave discharge, has also been noted in Canada in a double-blind controlled study (27). In the Netherlands, consumption of sugar-sweetened beverages was reported to be significantly associated with increased weight gain in normal weight children (28). What lends credence to many of these studies is the fact that they were largely clinical trials. Table 3 gives a summary of a few of such evidenced-based health effects of food additives in other parts of the world.

CONCLUSION

Our research findings showed that there are very few original studies conducted on food additives and their effects on children in Africa. However, anecdotal reports and/or studies on food/nutrient fortifications, which technically are not food additives, have been the main stay of research in the continent. Majority of the studies carried out in Africa relate to cariogenic potentials of sugar and other high calorie diets. Studies on other very important food additives such as preservatives, colouring agents, sweeteners, anti-caking agents, etc and their effects on health of children are largely unavailable. It will be very unempirical therefore to make any justifiable conclusion on the health implications of these additives when there is obvious paucity of scientific evidences in the region. It follows, then, that if any reasonable interventional programme or policy is to be put in place in this regard, there must be original research works that will target this vulnerable group of individuals. We argue, nonetheless, that since the purpose of food intake is to provide essential nutrients that

will promote and maintain good health, any substance either natural or synthetic that will prevent the attainment of this goal is dangerous not only for the present, but also for the future of our children and as such must be avoided completely in their diets. Avoiding such "toxins" in their diets is an important step towards enhancing their health and lowering their risk for diseases. To this end, efforts must be made by the parents, Governments and corporate organizations to ensure the safety of the foods and food products the children consume. This is especially true with the increasing propensity to globalization and economic emancipation in Africa. Their future is our future and it must not be mortgaged for any present economic gains.

Conflict of interests: The authors declare no financial relationships with any organizations that might have an interest in the submitted work; and no other relationships or activities that could appear to have influenced the submitted work.

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Table 1: Search terms

#	Searches
1	*food additives/ or calcium citrate/ or edetic acid/ or pectins/ or fat substitutes/ or food colouring agents/ or carmine/ or tartrazine/ or food preservatives/ or benzoic acid/ or nisin/ or parabens/ or sodium benzoate/ or sodium nitrite/ or sorbic acid/ or sweeteners/ or anti-caking agents*
2	*africa/ or africa, northern/ or algeria/ or egypt/ or libya/ or morocco/ or africa, central/ or cameroon/ or central african republic/ or chad/ or congo/ or "democratic republic of the congo"/ or equatorial guinea/ or gabon/ or africa, eastern/ or burundi/ or djibouti/ or eritrea/ or ethiopia/ or kenya/ or rwanda/ or somalia/ or sudan/ or tanzania/ or uganda/ or africa, southern/ or angola/ or botswana/ or lesotho/ or malawi/ or mozambique/ or namibia/ or south africa/ or swaziland/ or zambia/ or zimbabwe/ or africa, western/ or benin/ or burkina faso/ or cape verde/ or cote d'ivoire/ or gambia/ or ghana/ or guinea/ or guinea-bissau/ or liberia/ or mali/ or mauritania/ or niger/ or nigeria/ or senegal/ or sierra leone/ or togo/*
3	*1 and 2*
4	*Limit 3 to "humans"*

Table 2: Study characteristics

Country Author	Additive	Age	Setting	Sample Size	Study design	Outcome measures	Effects
Libya (Huew, et al, 2012)	Sugar (fruit-based sugared drinks)	12 years	School community-based	791 randomly - selected	Crosssectional, with questionnaire administration	.Dental caries .Dental erosion	Increased risk of dental caries but not dental erosion
Nigeria (Folayan, et al., 2012)	Sugar	-	Urban, paediatric units of 2 hospitals	205 consecutive, healthy children	Cross-sectional	Dental caries	Increased risk for dental caries
Uganda &Tanzania (Masumo et al, 2012)	Sugar	6-36 months	Rural (Tanzania) & Urban (Uganda)	1221 (plus 816 care giver-pairs)	Crosssectional with oral interviews for the caregivers in an health care facility	Early childhood caries	High sugar intake significantly associated with early childhood caries (O.R=3.0)
Sudan (Nazik et al, 2013)	Sugar	12 years	Urban	1109	Crosssectional with 2-stage probability cluster sampling	Dental caries experience	Increased risk of dental caries associated frequency of intake of sugar sweetened beverages and snacks

[a]Table shows main characteristic features of the identified studies on food additives in Africa, including outcome measures and health implications

Table 3. Global Evidence of Health Implications of Food Additives on Children [b]

Author	*Country*	*Age group*	*Research Method*	*Additives*	*Effects*
McCann et al (17)	*UK*	*3-9 years*	*Randomized double-blind trial*	*Sodium Benzoate, tartrazine, quinolone yellow, sunset yellow, carmosine, allura red*	*Exacerbation of hyperactivity*
Cramfield et al (27)	*Canada*	*-*	*Double blind controlled trial*	*Aspartame*	*Exacerbation of EEEG-spike wave discharge in absence seizure children*
De Ruyter et al (28)	*Netherland*	*4-11 years*	*Randomized double-blind interventional trial*	*Sweetener (sugar)*	*Increased body weight*
Bateman et al (26)	*UK*	*3 years*	*Double-blind, placebo-controlled*	*Artificial food colouring and Benzoate preservative*	*Increased hyperactivity*
Fuglsang et al (29)	*Denmark*	*5-16 years*	*Double-blind placebo controlled trial*	*Preservatives, colouring agents, citric acid, flavouring agents*	*1-2% food additive intolerance in children with atopic dermatitis.*
Shimada et al (30)	*Denmark*	*-*	*Randomized-double blind*	*Monosodium glutamate*	*1. Mechanical sensitization in masseter muscle, 2.headache and 3. transient blood pressure elevation*
Al Malik et al (31)	*Saudi Arabia*	*2-5 years*	*Cross-sectional*	*Carbonated drinks/fruit syrup*	*Dental caries/erosion*
Szpunar et al (32)	*USA.*	*11-15 years*	*3-year longitudinal study*	*Sugar*	*Increased caries experience*

[b]The table gives a summary of a few studies on food additives including the country where they were carried out, the age group of the participants, study design and their health implications on children

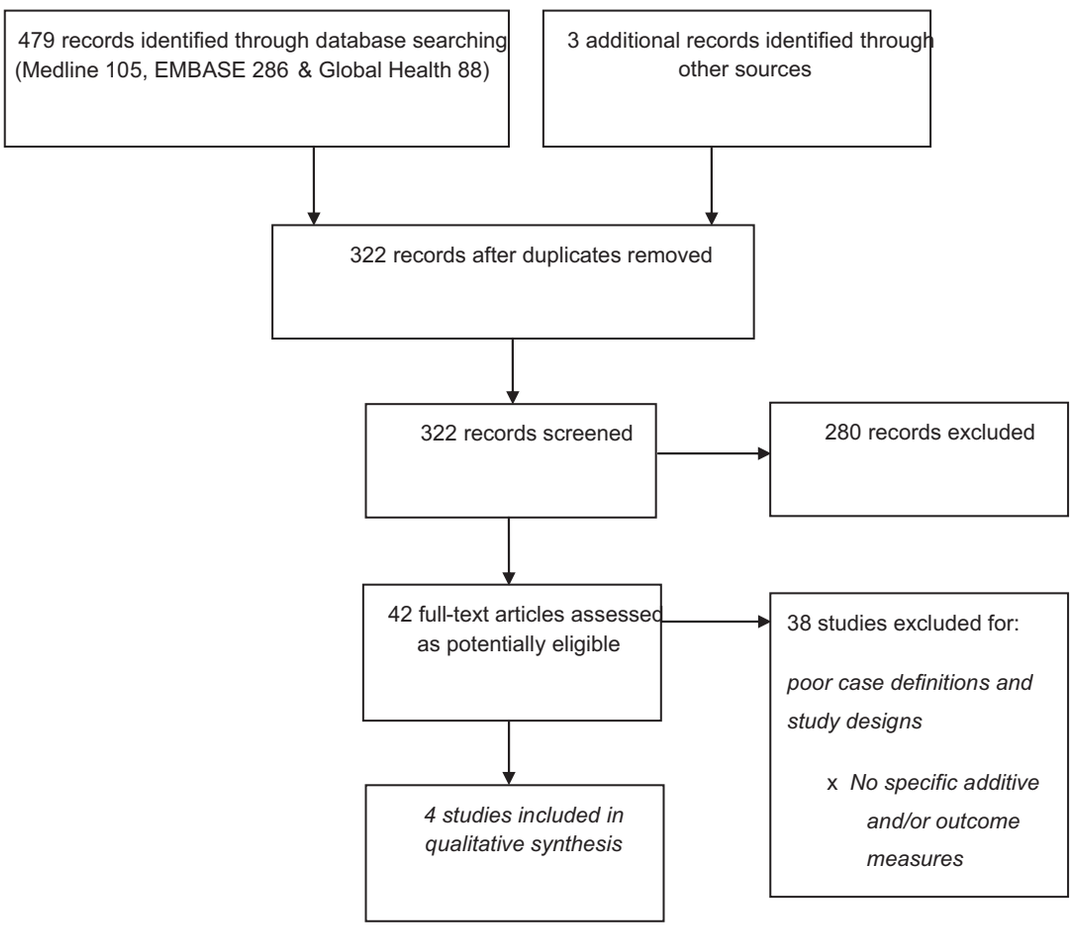

Fig. 1: Flow diagram of search strategy showing the number of studies included in the review after removal of duplicates and articles that did not meet our inclusion criteria.