Vitamin A Deficiency among Young Ghanaian Children: A Cause and Effect Analysis and Possible Solution

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Figure 1*. Young Ghanaian Children Affected by Micronutrient Malnutrition

This cause and effect analysis examines the causes and consequences of vitamin A deficiency among young Ghanaian children. It also evaluates a possible solution that could be implemented by Global Medical Brigades to ensure the prevention of vitamin A deficiency in the future.
Executive Summary

Vitamin A deficiency (VAD) is a severe problem among young Ghanaian children ages 6-59 months. Currently, GMB has not initiated any plans to prevent VAD in Ghana. The purpose of this report is to provide a cause and effect analysis of VAD among young Ghanaian children and to evaluate a possible solution based on three criteria: prevention of VAD, cost-effectiveness, and sustainability.

The primary cause of VAD among young Ghanaian children is inadequate consumption of vitamin A due to low availability of vitamin A-rich foods. In the rural communities of Ghana where GMB provides medical relief, the staple crops are root vegetables, tubers, and plantains, which are not sources of vitamin A. Due to low socio-economic status of many rural communities, Ghanaians do not have the resources to provide vitamin A-rich foods for their children. In addition, many Ghanaians have received little, if any, education and may not understand the importance of vitamin A consumption.

Vitamin A is an essential nutrient required for many biological processes, mainly vision and gene regulation. Thus, the consequences of VAD, both direct and indirect, can be very severe. A direct consequence of VAD is the development of xerophthalmia, or ‘dry eyes,’ which can cause blindness if left untreated. Indirect consequences include increased risk of respiratory and diarrheal diseases and subsequently an increase in the childhood mortality rate.

VAD is a preventable disorder. There are several ways to prevent VAD, but the most practical solution for GMB is the implementation of a vitamin A supplementation program in GMB partner communities for children ages 6-59 months. After careful evaluation, it was determined that the Vitamin Angels’ Operation 20/20 program has the ability to prevent VAD among Ghanaian children and is cost-effective and sustainable. It is recommended that a feasibility study be completed to test the feasibility of establishing a partnership with Vitamin Angels.
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Introduction

The mission of Global Medical Brigades is to provide medical relief and promote sustainable development in underserved communities of Honduras, Panama, and Ghana. The organization not only focuses on the treatment of disease but also on disease prevention. Currently, disease prevention is mainly addressed through education of community members during each medical brigade. In addition, home water filters and mosquito nets have been installed in many Ghanaian homes to reduce the prevalence of water-borne illnesses and malaria. One problem in Ghana that has not yet been addressed by GMB is the high prevalence of vitamin A deficiency (VAD) among young children. Whereas VAD is not a major concern in Honduras or Panama, it was classified by the World Health Organization as a severe public health problem among Ghanaian children ages 6-59 months\(^1\).

Vitamin A is important for proper vision, immune system regulation, bone growth, and reproduction\(^2\). Pre-formed vitamin A (retinol) or vitamin A precursors (carotenoids) must be obtained from an individual’s diet\(^2\). Inadequate intake of either pre-formed vitamin A or vitamin A precursors results in VAD. Young children are at a greater risk for developing VAD because their body systems are rapidly developing\(^1\). Chronic VAD in childhood often leads to blindness and increases the rate of childhood mortality.

One indicator of VAD is a serum retinol level of <0.70 μmol/l\(^1\). In a survey by the World Health Organization covering about 82.5% of the Ghanaian population ages 6-59 months, approximately 75.8% had a serum retinol level of <0.70 μmol/l\(^1\). This amounts to a stifling number of children in Ghana with VAD, a preventable disorder. Prevention of VAD would not only eliminate the direct consequences of VAD but would also reduce the prevalence of diseases that are indirectly linked to VAD. Thus, it is pertinent that GMB consider initiating a plan to prevent VAD in Ghana.

The purpose of this report is to provide a cause and effect analysis of VAD among young Ghanaian children and to evaluate a possible solution. The proposed solution will be evaluated based
on three criteria: the ability to prevent VAD among Ghanaian children ages 6-59 months in GMB partner communities, cost-effectiveness, and sustainability. It is most important that a solution is able to prevent VAD by providing adequate levels of vitamin A for consumption. If the solution is to be implemented, it must also be cost-effective because GMB is a non-profit organization with limited funds. Finally, the solution should be sustainable in order to prevent the severe problem of VAD from reoccurring.

The report is divided into three main sections: potential causes of VAD among Ghanaian children, effects of VAD, and a possible solution to the problem of severe VAD among young children in Ghana. The feasibility of a possible solution will not be explored in this report.

**Potential Causes of VAD Among Ghanaian Children**

Inadequate consumption of pre-formed vitamin A or vitamin A precursors leads to VAD. The primary cause of inadequate consumption of vitamin A is the low availability of vitamin-A rich foods. Factors that contribute to low availability include low socio-economic status of GMB partner communities and poor education.

*Availability of Vitamin A*

Low availability of vitamin-A rich foods is the most probable cause of VAD among young children in Ghana. Excellent sources of vitamin A or vitamin A precursors include liver, fish, eggs, mangos, carrots, and dark leafy green vegetables. In the rural areas of Ghana where GMB provides medical relief, most of the population produces their own food for consumption. According to a 2008 study by the Ghana Statistical Service, 50.6% of the food produced for home consumption consisted of roots, tubers, and plantains; 18.9% consisted of grains and flour; 15.7% consisted of vegetables; and 5.9% consisted of meat, poultry, and fish. Thus, Ghanaians cultivate mostly carbohydrate-rich crops and likely do not produce enough vitamin A-rich foods for consumption. Because the children rely
mainly on the family crops to meet their nutritional needs, an inadequate amount of vitamin A-rich crops results in inadequate consumption of vitamin A and the development of VAD.

The primary source of vitamin A for infants during the first months of life is breast milk. Mothers who are vitamin A deficient due to low availability of vitamin A-rich foods cannot supply their infants with adequate amounts of vitamin A through breast milk. This leads to an early onset of VAD among infants.

*Socio-Economic Status*

One factor that may contribute to the low availability of vitamin A is the low socio-economic status of rural GMB partner communities, where the average family income per day is less than 2 USD. According to The World Bank, 29% of all Ghanaians are below the poverty level. Several factors that define the socio-economic status in Ghana were evaluated by the Ghana Statistical Service. One of those factors is employment rate. In the 2008 Ghana Statistical Service study, 74.9% of adults in rural areas of Ghana were employed; of those employed, 35.1% worked less than 35 hours per week. The percentage of unemployed adults in rural areas of Ghana was 25.1%. Household income is a second factor that defines socio-economic status. In 2008, the average annual income per household was approximately 1,327 USD. Additionally, the average annual income per household was lower for rural areas than for urban areas.

In the rural communities of Ghana where GMB provides medical relief, approximately one quarter of the adult population is unemployed. Those who are employed may not work enough hours to be able to provide their families with adequate food for a proper diet. In addition, low income may limit their ability to cultivate vitamin A-rich foods. Thus, vitamin A is not readily available for children and leads to the development of VAD.
Education

The Ghana Statistical Service also assessed education levels in Ghana. The study found that 30.8% of the population greater than 15 years of age (approximately 4 million people) had never been to school, 17.1% attended school but did not complete middle school, 38.6% completed middle school, and only 13.6% received secondary or higher education. Poor education contributes to low socio-economic status and low availability of vitamin A-rich foods. Without proper education, Ghanaians do not learn the fundamental principles of nutrition, such as the importance of obtaining essential nutrients from their diet. Consequently, they may not cultivate or purchase vitamin A-rich foods for their families, which results in VAD among young children.

Conclusion

The main cause of VAD among young Ghanaian children is inadequate intake of vitamin A, which results from the low availability of vitamin-A rich foods in rural communities of Ghana. Many factors contribute to low availability; the most prominent factors include low socio-economic status and poor education. Although the entire population is not living in poverty, the rural areas of Ghana are largely impoverished and do not have the resources for children to obtain a proper diet.

Consequences of VAD

VAD has many consequences, both direct and indirect. Major consequences include xerophthalmia, the leading cause of childhood blindness, as well as increased risk of infection. Because of the severe consequences of VAD, childhood mortality rates are greatly increased. This section examines the important functions of vitamin A, as well as direct and indirect consequences of VAD.

Biological Functions of Vitamin A

Vitamin A is an essential part of the human diet as it regulates various biological functions. These include processes involved in morphogenesis, growth, maturation, vision, reproduction,
immunity, and cellular differentiation. Without vitamin A, humans cannot survive. Therefore, it is necessary that adequate amounts are obtained to ensure proper physiological functioning. Vitamin A, also known as retinol, is found in many natural food sources as pre-formed retinyl esters or provitamin A carotenoids.

Once absorbed in the body, vitamin A is integrated into many biological processes. However, there are two main functions of vitamin A: vision and gene regulation. Vitamin A is required for the production of rhodopsin, a protein involved in light absorption by the rod cells of the eye. The rod cells are responsible for vision under low-light conditions. The second function of vitamin A is regulation of gene transcription. Derivatives of vitamin A bind and activate retinoic acid (RAR) and retinoid X (RXR) receptors. Next, these receptors bind short sequences of DNA called retinoic acid response elements (RAREs) and signal gene transcription, eventually leading to the synthesis of new proteins. It has been reported that approximately 500 genes are regulated or respond to retinoic acid either directly or indirectly.

**Direct Consequences of Vitamin A Deficiency**

The consequences of inadequate consumption of vitamin A depend on the amount of vitamin A stored in the liver. If there is an excess of vitamin A stored in the liver, inadequate consumption will cause release of vitamin A from the liver to the bloodstream and normal functioning will not be impaired. However, low intake for a prolonged period of time will result in the depletion of liver reserves and a decrease in serum retinol levels. When serum retinol levels are decreased, cellular processes are disrupted and disease begins to manifest. A direct consequence of low serum retinol levels is xerophthalmia, or ‘dry eyes,’ which has many clinical stages. The earliest clinical manifestation of xerophthalmia is ‘night blindness,’ where individuals lose their ability to adapt to low levels of light due to decreased production of rhodopsin. As the deficiency becomes more severe, eyes become dry and unable to produce tears. Eventually, corneal ulceration and necrosis occur,
resulting in permanent damage to the cornea and blindness. Xerophthalmia is mostly limited to developing countries, where it is estimated that 5-10 million children develop the disease each year. Of those that develop xerophthalmia, between one quarter and one half a million children become blind.

**Indirect Consequences of Vitamin A Deficiency**

VAD has been associated with decreased immune competence, which increases the risk of infection and disease. Consequently, the childhood mortality rate is greatly increased among children with VAD. In general, children with VAD are more likely to develop respiratory diseases and diarrheal diseases. According to a study on rural Indonesian children, the risk of respiratory disease was twice as frequent among children with xerophthalmia when compared to children without xerophthalmia. Also, the study showed that diarrhea was three times more likely in children with xerophthalmia than in ‘normal’ children. One disease that is commonly associated with VAD is measles, a respiratory disease. Children with VAD are at a much greater risk for developing measles than children who consume adequate amounts of vitamin A.

![Figure 2. Consequences of VAD](image)

Figure 2 shows the consequences of VAD and the associated mortality risk. Low intake of vitamin A for a prolonged period of time leads to depletion of vitamin A from the tissues and
bloodstream. When vitamin A (retinol) levels are decreased, xerophthalmia develops and can lead to blindness. In addition, infection results from impaired immunity. When vitamin A is depleted from the body, the mortality risk increases substantially.

**Conclusion**

The consequences of VAD, both direct and indirect, can be very severe. Thus, it is important that steps be taken to prevent VAD. With proper consumption of vitamin A, approximately one million child deaths could be prevented every year.

**Possible Solution**

There are several possible ways to prevent VAD among young children in Ghana. Three principal solutions include: increasing the availability of vitamin A-rich foods, fortifying foods in the normal diet with vitamin A, and providing vitamin A supplements. Increasing the amount of vitamin A-rich foods available to children or fortifying foods with vitamin A are undoubtedly the most sustainable solutions; however, GMB does not currently have the capacity to implement these solutions and they will not be considered further. A more practical solution to be considered is vitamin A supplementation of Ghanaian children in GMB partner communities. More specifically, the solution that will be evaluated is supplementation of children ages 6-59 months through Vitamin Angels, a nonprofit organization.

Vitamin Angels was founded by Howard Schiffer in 1994. The organization’s mission is to improve micronutrient availability and use among at-risk children less than 5 years of age. In 2010, the organization supplied approximately 20 million children in 40 countries with micronutrients and aimed to reach 40 million children in 2011. Vitamin Angels’ international vitamin A campaign is known as Operation 20/20 and benefits children less than 5 years of age (6-59 months) and pregnant women. Qualified non-profit organizations can apply for a supplement grant from Vitamin Angels in
order to connect underserved children with vitamin A. To qualify, organizations must plan to benefit at least 1,000 children in the U.S. or VAD priority countries with little or no access to vitamin A\textsuperscript{10}.

**Prevention of Vitamin A Deficiency**

The following vitamin A supplementation regimen has been recommended by the World Health Organization for the prevention of vitamin A deficiency: a 100,000 IU (International Units) dose of vitamin A every 4-6 months for infants ages 9-11 months and a 200,000 IU dose of vitamin A every 4-6 months for children ages 12-59 months\textsuperscript{11}. Through Operation 20/20, Vitamin Angels provides qualified non-profits with supplements that follow this regimen exactly: 2 annual 100,000 IU doses of vitamin A per infant and 2 annual 200,000 IU doses of vitamin A per child age 12-59 months\textsuperscript{11} (Table 1).

| Table 1. Recommended and Proposed Vitamin A Supplementation Programs |
|---------------------------------|-----------------|-----------------|
| **WHO Recommendation**          | **Vitamin Angels’ Operation 20/20 Program** |
| Age                             | 9-11 months     | 6-11 months     |
|                                | 12-59 months    | 12-59 months    |
| Dose                            | 100,000 IU      | 100,000 IU      |
|                                | 200,000 IU      | 200,000 IU      |
| Frequency                       | 4-6 months      | 4-6 months      |
|                                | 4-6 months      | 4-6 months      |

Thus, if Vitamin Angels’ supplementation program is implemented in GMB partner communities in Ghana, it should be able to prevent VAD among young Ghanaian children. Prevention of VAD by means of vitamin A supplementation requires that the following measures be taken by GMB: parents must be informed of the supplementation program and the distribution of supplements must be tracked.

Through Operation 20/20, Vitamin Angels also provides 2 annual doses of albendazole, an anti-parasitic medication, for children ages 12-59 months\textsuperscript{10}. The purpose of the anti-parasitic medication is to eliminate intestinal parasites that cause decreased absorption of essential vitamin A in the small intestines. Combining anti-parasitic treatment with vitamin A supplementation ensures that an adequate amount of vitamin A is consumed and absorbed by the body for prevention of VAD.
Cost Effectiveness

Vitamin Angels is able to offer supplement programs because the organization is supported by numerous corporate sponsors, promotional partners, and product donors. Because of generous donations, Vitamin Angels supplies vitamin A and albendazole at no cost to qualified non-profits for distribution. However, Vitamin Angels only covers the cost of delivery to a U.S. shipping address. If the products must be shipped to a location outside of the U.S., shipping and handling fees must be paid by the organization that was granted a supplement request.

Vitamin A supplementation and anti-parasite treatment through the Operation 20/20 program of Vitamin Angels should be considered by GMB because the products are entirely donated. Currently, each GMB chapter is responsible for bringing vitamins and medications to the brigade site, which often requires that chapters purchase these items if they cannot get donations. Instead of requiring chapters to purchase vitamin A and anti-parasite medication, the Operation 20/20 program could be implemented through Vitamin Angels at no cost to students. Because the products must be shipped to Ghana, though, GMB would be responsible for the shipping and handling costs. GMB must determine whether it is feasible to cover the cost of delivering products to Ghana, but the solution is certainly more cost-effective than purchasing and shipping vitamin A supplements and albendazole.

Sustainability

It is important to consider the sustainability of the Operation 20/20 supplementation program because GMB is constantly striving to make healthcare more sustainable in partner communities. Thus, the proposed solution should have some degree of sustainability. Indeed, supplementation through the Operation 20/20 program of Vitamin Angels is sustainable as long as the resources continue to be available to Vitamin Angels for donation. Qualified organizations are only granted a one-year supply of vitamin A supplements and albendazole for each beneficiary but the recipient organization can reapply for a micronutrient grant every year.
Supplementation is not a fully sustainable solution to prevent VAD among young Ghanaian children. Increasing the availability of vitamin A in a fully self-sustainable manner would require growth of vitamin-A rich foods as well as complete access to those foods. Unfortunately, GMB does not have the resources to implement a fully self-sustainable solution. However, GMB chapters could increase sustainability by educating parents and children of the importance of obtaining adequate levels of vitamin A. This could be incorporated into the health education portion of each medical brigade in Ghana.

Conclusion

After careful evaluation, it is evident that supplementation of children ages 6-59 months through the Operation 20/20 program of Vitamin Angels should be considered by GMB. The solution has the ability to prevent VAD among young Ghanaian children. It is also cost-effective and sustainable provided the program continues to be available through Vitamin Angels.

Conclusion

Global Medical Brigades is an organization that provides medical relief to communities of Honduras, Panama, and Ghana but has not yet addressed the issue of VAD among young Ghanaian children, which was classified as a severe public health problem by the World Health Organization\(^1\). The purpose of this report was to provide a cause and effect analysis of VAD among Ghanaian children and to evaluate a possible solution. The proposed solution was evaluated based on its ability to prevent VAD among Ghanaian children ages 6-59 months in GMB partner communities, cost-effectiveness, and sustainability.

Vitamin A and its precursors are primarily found in breast milk, liver, eggs, orange and yellow vegetables, and dark green leafy vegetables. An inadequate intake of pre-formed vitamin A or vitamin A precursors results in VAD. Inadequate consumption of vitamin A is primarily caused by low
availability of vitamin A-rich foods. Factors that contribute to low availability of vitamin A-rich foods include low socio-economic status of GMB partner communities and poor education.

Vitamin A has an important role in vision and gene regulation. Inadequate consumption of vitamin A results in the development of xerophthalmia, which may lead to blindness if left untreated. Indirect consequences of VAD include increased risk of respiratory diseases and diarrheal diseases. In particular, children with VAD are much more likely to develop measles than children without a vitamin A deficiency. In addition, the mortality rate is greatly increased for children with VAD.

Vitamin A supplementation through the Operation 20/20 program of Vitamin Angels was suggested as a possible solution to prevent VAD among young Ghanaians, ages 6-59 months. It was determined that the proposed solution should be able to prevent VAD. It is also relatively cost-effective and sustainable. The feasibility of establishing a partnership with Vitamin Angels was not explored in this report; however, it is recommended that a feasibility study be completed in order to evaluate the practicality a partnership between GMB and Vitamin Angels.
**Recommendations**

Implementation of a vitamin A supplementation program through Vitamin Angels would prevent Ghanaian children from developing xerophthalmia and greatly reduce the number of respiratory and diarrheal infections indirectly caused by VAD. It is therefore recommended that the following steps be taken:

- Complete a feasibility study testing whether it is feasible for GMB to establish a partnership with Vitamin Angels
  - Determine the approximate number of beneficiaries (children ages 6-59 months in GMB partner communities in Ghana)
  - Evaluate whether there is enough funding to cover the cost of shipping and handling of supplements to Ghana
  - Establish a possible distribution and tracking system
- Increase sustainability of VAD prevention by educating the Ghanaians about the importance of vitamin A during the health education portion of each medical brigade
References

*Figure 1 retrieved from http://www.icrisat.org/what-we-do/SASA/sasa_april2011.htm


