



Katholieke Universiteit Leuven  
Faculty of Bioscience Engineering

# **VITAMIN D DEFICIENCY IN ADOLESCENTS IN LIVINGSTON, GUATEMALA**

Professor:

Christophe Matthys

Group:

Jiaqi He  
Guan Tong  
Fathinah Islami Hasyati  
Lisbeth Sofia Hernández Ruiz  
Vedika Kayasth

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# **1 ANALYSIS OF THE HEALTH PROBLEM**

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Despite efforts of food fortification, vitamin D deficiency remains common in children and adults worldwide, especially in developing countries. According to studies worldwide, the major cause of vitamin D deficiency is the lack of exposure to sun, combined with the fact that very few foods naturally contain vitamin D, and foods that are fortified with vitamin D are often inadequate to meet the requirements (Holick & Chen, 2008) (Hanson & Metzger, 2010). According to a study conducted in Guatemala, based on indigenous Mayan and Afro-Caribe groups it was observed that 65% of the adolescents residing in an optimal geographic location for sunlight had insufficient or deficient levels of vitamin D (Naqvi, et al., 2016). Vitamin D deficiency causes rickets in children and will precipitate and exacerbate osteopenia, osteoporosis, and fractures in adults (Holick & Chen, 2008). In children and adolescents, vitamin D deficiency negatively affects bone mineralization, bone mineral density (BMD), and causes defects in muscle function and development. It has also been linked to several common non-skeletal disorders of childhood, including acute respiration infection (ARI), asthma, atopic dermatitis, and food allergy (Saggese, et al., 2015).

For the present study it was decided that Vitamin D deficiency in adolescents (aged 12-18) in the town of Livingston, in the department of Izabal in Guatemala, can be targeted. According to the census reports, there are currently 17773 children and teenagers from the age group of 12 to 18 years old living in the town of Livingston (INE, 2018). It is hypothesized based on literature review that about 65% of this population is deficient in Vitamin D (Naqvi, et al., 2016), which is about 11,553 adolescents.

## **2 ANALYSIS OF BEHAVIOR**

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### **2.1 SUN EXPOSURE**

In Livingston, 75% of Q'eqchi' teenagers spend less than 1 h outdoors in the sun with a mean exposed skin area of 0.5 m<sup>2</sup>, while 30% of Garifuna teenagers spend 1-2 h and 40% spend more than 2 h outdoors in the sun with a mean exposed skin area of 0.4 m<sup>2</sup> (Naqvi, et al., 2016).

### **2.2 DIET**

Malnutrition and protein deficiency cause a decrease in the vitamin D binding protein in blood, which diminishes the ability of the body to conserve 25-hydroxyvitamin D (Laing & Fraser, 2002). Kurschner et al. (2019) showed that adolescent girls in schools had disrupted eating schedules and

consumed more energy-dense, nutrient-poor foods. Adolescents' food choices are influenced by their need for energy and to satisfy hunger, and by limited resources and convenience.

### **2.3 PRIORITIZE HEALTH BEHAVIORS**

According to the hypothesis, about 11,553 adolescents may have insufficient or deficient vitamin D levels despite living in an optimal geographic location for sunlight exposure. The target group is comprised mainly from q'eqchi's, garifunas and ladinos. They are part of a low socioeconomic group and traditionally in Guatemala this type of households tends to consume more corn and corn products, while meat, fish, eggs and dairy constitute less than 10% of their daily consumption (Asfaw, 2008). This indicates that this target population could benefit from vitamin D supplementation.

### **2.4 SELECT ONE BEHAVIOR TO ADDRESS**

The behavior selected to be addressed is the diet of the target population.

## **3 ANALYSIS OF DETERMINANTS OF BEHAVIOR**

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### **3.1 ENVIRONMENTAL DETERMINANTS**

#### **3.1.1 Low socioeconomic status (SES)**

The target group lives in predominantly indigenous households in Livingston whose families have a low household income, poor education and occupation which means low SES. SES has a very robust positive correlation with health (Bradley, 2002). It has been widely observed that lower socioeconomic groups turn to unhealthy food choices to reduce food expenditure (Pechey & Monsivais, 2016).

#### **3.1.2 Availability and accessibility to vitamin D**

Naqvi et al. (2016) reported that food sources of vitamin D, which occur naturally in food or from supplements, are scarce in Guatemala and Guatemala does not have a national vitamin D fortification policy. The food rich in vitamin D, like fatty fish, and milk is not only too expensive to afford, but also need cold chain to transport and storage. However, some households in Livingston still lack electricity and refrigeration (UNOSSC, 2012).

### **3.2 PERSONAL DETERMINANTS**

#### **3.2.1 Low perceived susceptibility and perceived severity**

The target group lives in Livingston, which is an optimal geographic location for sunlight exposure, as a result, people tend to forget the issue of vitamin D deficiency. Besides, the symptoms of vitamin D deficiency for adolescents is vague such as aches and pains in their legs

so that it is not serious enough for adolescents to produce perceived threat- vitamin D deficiency (Saggese, et al., 2015) .

### **3.2.2 Traditional diet pattern**

The traditional diet pattern is characterized by consumption of corn tortillas, beans, and sugar added to coffee and lacks dairy products (Ford, et al., 2017). In traditional diet pattern, dairy products, egg, and seafood which are rich in vitamin D are rarely consumed by our target group. Moreover, this diet habit makes adolescents deficient in protein. The protein deficiency causes a decrease of vitamin D binding protein in blood which diminishes the ability of the body to conserve 25-hydroxyvitamin D (Arabi, El Rassi, & Fuleihan, 2010).

## **3.3 PRIORITIZING AND SELECTING THE DETERMINANTS**

Traditional diet pattern habit is the most vital determinant because it directly affects the intake of nutrients such as protein and other nutrients which have complicated interactions with vitamin D and one subtle change of the diet pattern like providing additional Vitamin D drinks can alleviate the vitamin D deficiency.

Availability and accessibility to vitamin D is an indispensable determinant. Without this determinant, our target group is unable to get sufficient vitamin D. The factors of this determinant like cold chain problem can be addressed by developing a product independent from cold chain. And lower the price and increase the sale scales can expand the availability and accessibility.

Low perceived susceptibility and perceived severity are the determinants of behavior according to health belief model (Armitage & Conner, 2020). If the individual perceives threat of disease (i.e. high susceptibility and severity), health behavior is more likely to be carried out. By communication, the awareness of vitamin D deficiency in target group can be arisen.

Low socioeconomic status (SES) is difficult to change because it is related to the economic and social status of the whole country.

## **3.4 PRIORITIZED DETERMINANTS TO ADDRESS**

The chosen determinants are: Traditional Diet Pattern, and Availability and Accessibility to vitamin D

## 4 INTERVENTION DEVELOPMENT

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The proposed intervention is based on the distribution of an existing product fortified with vitamin D which ensures the targeted adolescents to obtain 600 IU vitamin D/day (Institute of Medicine, Food and Nutrition Board, 2010), as a part of the mandatory government school meal program.

Incaparina is a plant-based drink which has been used since the 1960's to supplement the diet of children and other population groups with nutritional deficiencies. Incaparina is composed of water, sugar, corn flour, soybean flour, stabilizers (micro-crystalline cellulose, carboxymethylcellulose sodium, and carrageenan), salt, cinnamon, natural and artificial vanilla flavor, vitamins and minerals (calcium carbonate, iron glycinate, zinc amino chelate, niacinamide, maltodextrin, vitamin A, vitamin D3, riboflavin, thiamine mononitrate, cyanocobalamin, and folic acid) (ICASA, 2020). Despite its acceptance by the population, it has not been widely adopted by the population who need it most due to inability to afford it in the prescribed quantities, and the government has not provided direct support (Wise, 1980). It is also proposed to run an awareness campaign by the government that, they are distributing the product once a day to all the students attending school and subsidizing the product in the market to make it available cheaply to all the adolescents currently not attending school.

### 4.1.1 Traditional diet pattern

Incaparina has features that make it consistent with dietary habits of the population and is formulated from locally available ingredients like maize flour and soya bean flour. The original product has a corn-like flavor which is consistent with dietary habits and practices of the target group and is similar to a traditional drink called *atole*. But different flavors like chocolate, strawberry, banana are also available and make it appealable to teenagers. The drink has succeeded in acceptability trials, especially in the highlands (Scrimshaw, 1980).

### 4.1.2 Availability and accessibility to vitamin D

The Institute of Nutrition of Central America and Panama (INCAP) established licensing requirements as well as a control system for packaging, identification, advertising and quality analysis including chemical composition, microbiological quality, biological nutritional quality of the product. By licensing of small-town millers and of agricultural cooperatives in Livingston to produce the product, the production scale can be enlarged, and the price can be reduced (Wise,

1980). The product is extremely competitive in price with other products on the market such as milk, instant cereals (Tartanac, 2000).

The intervention is designed to make the cold chain technology unnecessary for maintaining the food product stable and ensuring a long shelf life. The stability of vitamin D in the product is assured by using microencapsulation in multilamellar liposomes as it is one method that is successful in ensuring high chemical stability (Maurya, Bashir, & Aggarwal, 2020). Soybean phosphatidylcholine-based liposome offers a high stability of vitamin D in food fortification (Mohammadi, Ghanbarzadeh, & Hamishehkar, 2014), thus, it is suitable to be used in the intervention which contains soybean as one of its main ingredients. Regarding degradation, vitamin D is prone to oxidation (Hanson & Metzger, 2010), thus, the packaging of the product is designed to protect its content from light or oxygen, for example by using Tetra Pak technology. It is found that there is no significant loss of vitamin D during pasteurization and sterilization of milk (Maurya, Bashir, & Aggarwal, 2020), therefore, the long shelf life of the intervention product can also be achieved by UHT treatment.

Also, it is necessary to carry out communication methods to stimulate the buying and drinking behaviors. First, the government plays an important role in propagandizing it. The product will be introduced by a government program to give a nutritious breakfast to school-aged teenagers for free and be available in corner stores at relative low price. Second, based on the lack of knowledge, the primary step is propagandizing related knowledge of vitamin D deficiency which can be achieved by printing related knowledge on the packages, or putting slogans on the walls and making full use of social media. Third, it can provide different flavor, even different color, to attract the teenagers to drink it.

#### **4.1.3 Reflection**

The intervention offers a convenient and appealing product to an adolescent population who is used to consume junk food from corner stores. The intervention can be successful if it receives an economic subsidy from the government. But so far, the Guatemalan government has failed to even provide the bare minimum school meals. And the production of Incaparina in Guatemala has been controlled since the 1960s by a monopoly who has always felt the need to make a profit making it inaccessible to the people who need it the most. Also some people believed that foods that are “so potent and nourishing only need to be consumed in small quantities”, so an information campaign has to be introduced to inform to the public of the need to consume it frequently.

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5 ANNEX



Figure 1. Presentation of ready-to-drink Incaparina aimed for children and adolescents (ICASA, 2020)

Información Nutricional	
Tamaño de la porción 1 caja (200 mL)	
Cantidad Por Porción	
<b>Energía</b> 500 kJ (120 kcal)	
<b>Energía de Grasa</b> 20 kJ (5 kcal)	
	% VRN*
Grasa Total 0.5 g	
Grasa Saturada 0g	
Colesterol 0 mg	
Sodio 35 mg	
Potasio 120 mg	
Carbohidratos 25 g	
Azúcares 18 g	
Fibra Dietética 1 g	
Proteína 3 g	6%
Vitamina A	4%
Vitamina B1	20%
Vitamina B2	20%
Vitamina B12	20%
Vitamina D	20%
Ácido Fólico	20%
Niacina	20%
Hierro	20%
Zinc	20%
Calcio	20%
* Valor de referencia del nutriente de acuerdo a FAO/OMS Codex alimentarius.	

Ingredientes: Agua, azúcar, harina de maíz, harina de soya, estabilizantes (celulosa microcristalina, carboximetilcelulosa sódica y carragenina), sal, canela, sabor natural y artificial de vainilla, vitaminas y minerales (carbonato de calcio, glicinato férrico, zinc aminoquelado, niacinamida, maltodextrina, vitamina A , vitamina D3, riboflavina, mononitrato de tiamina, cianocobalamina y ácido fólico). CONTIENE SOYA. Elaborado en equipo que también procesa lácteos.

Figure 2. Nutritional Information of the original product that was modified for our target population (ICASA, 2020).