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How to Combine Hunger Solutions to Improve their Effectiveness: Building the Framework for a Country Profile Approach

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Abstract. Hunger continues to be a major problem in developing countries despite various efforts. Countries with differing socioeconomic profiles, as reflected in their level of development, seem to respond differently to identical programs. The aim of this paper is to therefore propose a new conceptual tool, namely our *hunger-management model*, which takes into account a country's developmental level. To investigate the role of a country's developmental level in making progress in its GHI score over time, data for 124 developing countries were gathered. These countries were divided into two groups according to whether they used a high or low number of "criteria" (i.e., approaches such as school meals and direct food aid) to fight hunger. To assess the effect of this distinction, repeated measures ANOVAs were applied for the various GHI scores and outcomes for a selection of representative years. To reveal any differences between the years, a post hoc analysis was conducted using Bonferroni correction. The findings suggest that (i) the rate of change for a country's GHI score and other examined indicators depends upon its developmental level, and (ii) there is a direct relationship between the hunger-management model and the level of hunger in developing countries.

Keywords. country profile, developing countries, hunger criteria, hunger-management model, hunger solution

1. Introduction

Addressing the hunger problem may involve adopting various approaches if the basic needs of the hungry people in developing countries are to be met. Indeed, various agencies and organizations that are committed to addressing the hunger problem have promoted a number of different programs, yet hunger is still considered the primary problem facing developing countries. In 2002, the Food and Agriculture Organization (FAO) indicated that 800 million people were suffering from chronic hunger in developing countries. It also predicted that by 2009, a further 100 million people would become trapped in a cycle of hunger, mostly in developing countries [18]. Statistical analysis from the FAO in 2010 has also revealed an increase in the total number of hungry people, with it rising to 842 million. This means that approximately 13.1% of the world's population is in a state of hunger. What is more, about half of the children born in famine-stricken areas die [24,23]. The FAO's hunger report of 2019

highlighted how more than 820 million people in developing countries were still hungry, with hunger still rising in almost all the various sub-regions of Africa, Latin America, and Asia [30].

This therefore prompts two questions: (1) Could a dose-specific hunger solution address the hunger problem more effectively in countries with differing economic and social profiles? (2) Would a dose-specific hunger solution need new approaches or insights to apply it more effectively? There is a general consensus about the importance of a country's profile (i.e., level of development) when making decisions in various areas, such as deciding a policy for addressing the poor economic growth of a developing country [7]. Schwab in 2013 pointed out that a country's performance—in terms of economic, social, and political indicators—can be linked to driving development and ensuring food security [63]. Indeed, the social and economic context of a developing country is critically important, because this influences how quickly a country can make progress in addressing its hunger problem. For example, a lower performance in economic, social, and political areas will limit a developing countries progress in reducing its hunger level over time. Ross states that government performance has long been recognized as a determinant of the effectiveness and efficiency of the public sector. Public sector reform can therefore be a key to addressing the poor economic growth of developing countries [58].

Despite the challenges, tracking the GHI scores of countries over time does show that positive progress has been made, with these improvements reflecting countries' performances and their success in applying different hunger solutions to address the problem. Indeed, clear improvements have been made in all four component indicators of the GHI [32]. This study interprets this positive progress in GHI scores and outcomes over time as follows: (1) Any action to address hunger inevitably leads to positive results, to some degree, in terms of improved GHI scores over time; and (2) countries with differing socioeconomic profiles react differently to the same program, thus manifesting in differing levels of progress in improving their GHI scores over time. Considering these insights, addressing the hunger problem in a more effective and controlled way would seem to warrant a more-tailored approach that better fits a particular country's profile.

This study therefore offers a new tool in the fight against hunger in the form of a new conceptual approach that follows a working plan when making decisions. It involves applying an effective, controlled, and tailored program to better suit a country's profile (i.e., development level). No similar approaches have thus far been proposed in the research literature. Most hunger solutions follow the FAO's concept of food and nutrition security (FNS), which will be discussed in the literature review [19]. Our new conceptual approach proposes a dynamic program that seeks to maximize the benefits in terms of reducing the GHI score and other indicators over time. To introduce this idea, the following subjects are discussed: combating poverty and hunger; critical analysis of common hunger-management models; the profile of a developing country; the concept of hunger criteria and hunger-management models; the materials and methods used; this study's results; and a discussion of this study's findings and the conclusions that can be drawn from them.

2. Literature Review

2.1 Combating poverty and hunger

The Hunger Project (THP) considers hunger to be a symptom of poverty and inequality, so it can be viewed as a dimension of extreme poverty [73]. For E. Seery et al., hunger, like poverty and inequality, is a negative aspect of the human social condition, one commonly found in economic configurations where financial resources are unequally distributed [62]. In 2003, the FAO also suggested that hunger is essentially a poverty-related problem. Its study found

that rapid income growth, sustained in the long term, leads to less poverty and better food security and nutrition for the population, thus hinting at a strong relationship between hunger and poverty [19].

Shah, meanwhile, pointed out that hunger is about more than just food production levels and a population's food demands. Indeed, the issue does not exist in a vacuum, with the causes of hunger being related to the causes of poverty, because people in poverty are often simply unable to afford food. Among the different determinants of hunger, poverty is one of the most significant [60].

Although hunger in developing countries is portrayed as a local problem, it definitely exerts a wider effect. As the FAO Director General Diouf said, the "silent hunger" crisis threatens stability and peace in the world [23]. There has therefore been a great effort to find ways to reduce and preferably eradicate hunger, as discussed in the research literature. These studies have examined various hunger-management programs that have been promoted by different organizations and agencies.

Food and nutrition security (FNS) is an important leading concept when attempting to reduce poverty and hunger in developing countries [19,21]. This concept has evolved significantly over the recent decades, both in theory and practice. There are two perspectives for addressing food security: One asserts that raising the volume of food production is the core answer to hunger. This concept therefore focuses on the agricultural side, implying that food insecurity must be addressed by producing more food. S. Maxwell et al. and T. Lang et al., however, challenge this concept and put forward a new perspective based on a more complex analysis that adopts a food-system approach, where social and ecological concepts are used to address a complex array of problems. From this viewpoint, our world's food system is unsustainable, as is strikingly apparent from the impacts that our consumption and production patterns have had on environmental degradation and climate change [48,44].

The different food-security solutions and programs presented in the research literature are mostly recognized by the agencies that promote them, and one of the leading agencies in this field is the Food and Agriculture Organization (FAO). The FAO's well-known programs on food security include (1) the Special Program for Food Security (SPFS), which employs a two-phase approach to improve nations' food security through rapid increases in food production and productivity, therefore improving people's access to food [12,22,25]; (2) the twin-track approach, which achieves food security by simultaneously fulfilling the four pillars of i) the physical availability of food, ii) economic and physical access to food, iii) food utilization, and iv) the stability of the other three dimensions over time [20]; and (3) Zero Hunger, which is a broad, integrated strategy that involves four lines of action, namely (1) access to food, (2) stronger family farming, (3) income generation, and (4) social empowerment, mobilization, and oversight [26].

Other leading programs on food security include (1) the World Food Program (WFP), which is built around different targets: providing the right assistance to the right people at the right time in the right way; working in close partnership with internal and external stakeholders; and finding a balance between speed and quality. Next, (II) the NIFA (National Institute of Food and Agriculture) addresses hunger and food security through its programs based on community food security. Finally, (III) the Canadian International Development Agency (CIDA) employs different programs that engage in reducing global poverty and hunger through international development. Its strategy to achieve food security in developing countries includes meeting basic needs, finding sustainable solutions, and encouraging innovation [71,51,10].

It is clear that many of the basic concepts behind these programs are similar. Moreover, they share similar working plans, such as promoting agricultural and rural development, supplying direct and immediate food aid to fight hunger, and providing agricultural training. This leads to the next part, which examines the common hunger-management models.

2.2 A critical analysis of common hunger-management models

This critical analysis and discussion of common hunger-management models focuses on two points of interest: (i) leading hunger-management models with similar approaches and working plans and (ii) how these common hunger-management models neglect the important role that a country's level of development can play in achieving better outcomes in terms of improving its GHI score over time. The leading hunger-management models with similar approaches and working plans are promoted by the following major organizations that are heavily involved in reducing hunger. The *European Union* (EU), The Food and Agriculture Organization (FAO), The Hunger Project (HP), and The World Food Program (WFP).

These organizations have developed four basic policies based on the FNS concept for addressing the problem of hunger in developing countries. In addition to all adopting the FNS, these solutions share similar working plans, with the most noticeable of these being rural development, the implementation of modern agricultural technology and improved farming skills, food aid action at different levels and school meals, socioeconomic development, and local government cooperation.

The European Union (EU) is a leading adopter of the FNS concept, and its framework policy has four main areas: (i) rural development and food aid action, (ii) investment in modern agriculture and multilateral agreements, (iii) genetically modified foods, and (iv) integrated approaches like organic farming and genetically modified (GM) crops, as well as increased investment, policy reforms, and the development of human capital [47,50].

The Food and Agriculture Organization (FAO) has a leading rural-development policy that includes the agricultural and non-agricultural aspects of rural life, with the FAO working on integrating agricultural and economic growth while also balancing this with socioeconomic development [17].

The Hunger Project's (HP) leading policy is based on an approach with three pillars: (1) empowering women as key agents of change, (2) mobilizing entire communities for self-reliant action, and (3) promoting effective partnerships with local government [65].

The World Food Program's (WFP) leading policy focuses on strengthening individual and government capacities in various aspects. To achieve an appropriate level of sustainable food and nutrition security, the WFP focuses on the following objectives: climate-based action through different programs; innovations and technical support to become climate resilient and food secure; gender equality through food assistance such as school meals; and support for smallholders, including help to access the skills, knowledge and infrastructure needed to develop their livelihoods and reduce their risks. The WFP works directly with governments and other national actors to develop strategies for achieving food and nutrition security for people living under challenging conditions [71].

As has already been indicated, some policies apply similar criteria/methods when addressing the hunger problems of developing countries. While the above discussion focused attention on the first point of interest, the second point of interest, namely whether a hunger solution's effectiveness is affected by the country's level of development, is discussed below.

However, the common hunger-management models neglect the important role that a country's level of development plays in achieving better outcomes in terms of improving the

GHI score over time. Indeed, a country's socioeconomic performance influences the effectiveness of an implemented hunger-management model, as supported by various scientific publications, such as those of Schwab [63] and Ross [58]. According to these two publications, a higher development level helps to ensure food security, because socioeconomic performance affects how much a country will succeed in addressing its hunger problem. Indeed, a lower level of socioeconomic performance limits a developing country's progress in reducing its level of hunger over time. P. Kingstone and T. J. Power analyzed the case of Brazil's fight against hunger. Brazil showed poor socioeconomic performance between 1987 and 1993 and recorded high rates of poverty, inequality, and hunger. Between 1994 and 2010, Brazil adopted the FAO's Zero Hunger program, which focuses on multiple channels of activity to fight hunger. In 2010, Brazil showed sharp improvements in its performance for all the key socioeconomic indicators, as well as the GHI. The case of Brazil leads to the following insight: There is a direct link between a country's socioeconomic performance and its progress in fighting hunger through a hunger-management model that focuses on multiple channels of activity. It seems that improving socioeconomic performance leads in turn to a greater capacity to fight hunger [42].

The direct link between a country's level of development and the level of hunger becomes particularly evident when developing countries implement the same hunger program, as shown in Table 1. The countries listed in this table all implemented the WFP program based on the FNS concept. It can be clearly seen that developing countries with a high HDI exhibit relatively low GHI values when compared with countries with a low HDI. For example, Cuba with a HDI of 0.783 has a GHI of 5, but Cameroon with a lower HDI of 0.563 shows a higher GHI of 21.1. Similarly, Tanzania with a low HDI of 0.529 has a GHI of 29.5.

Table 1. 2018 GHI and HDI scores for countries that implemented WFP's FNS concept

Country	GHI* score	HDI* score	HDI ranking
Cuba	5	0.783	70
Colombia	7.7	0.767	83
Nicaragua	13.6	0.660	128
Ghana	15.2	0.611	138
Cameroon	21.1	0.563	153
Kenya	23.2	0.601	143
Mauritania	27.3	0.542	157
Mali	27.8	0.427	184
Guinea	28	0.477	178
Angola	29.5	0.581	148
Tanzania	29.5	0.529	163
Nigeria	31.1	0.534	161

Source: Own elaboration based on data for GHI and HDI in 2018.

<https://www.globalhungerindex.org/pdf/en/2018.pdf> ;

<http://hdr.undp.org/en/content/latest-human-development-index->

*GHI scores of 20.0–34.9 are “serious.”

*Developed countries score a HDI of 0.9 or more.

While the various hunger-management models presented in the research literature are mostly based on the FAO's FNS concept in various forms, it is notable that these solutions do not account for a country's level of development, despite this clearly being an important factor in the fight against hunger, as can be seen in improvements in GHI scores over time. Indeed, a country's level of development essentially determines how well it will succeed in reducing its level of hunger. Countries with different levels of development have different socioeconomic capabilities, so they respond differently to the same hunger-management model in terms of improvements in their GHI scores and other indicators over time.

2.3 Developing countries' profiles

This study highlights two reasons for introducing the concept of a country's profile in the context of the fight against hunger in developing countries. First, a country profile can act as a tool to help tailor a hunger-management model to fit a particular country's level of development. It may bring superior results for addressing the hunger problem by improving a country's performance in the various socioeconomic and political indicators. Second, such profiles could represent an effective tool for tracking and analyzing different countries' progress over time when using different hunger policies.

A country profile provides an overview of key indicators that summarize a country's economic, social, and political situation [16]. The extent of a developing country's hunger problem is inevitably reflected in its socioeconomic profile. Thus, the socioeconomic profile of such countries presents various factors that help to gain a better understanding of their hunger problems. Recognizing these factors helps to clarify a country's present situation, and this could be a unique tool for informing decisions aimed at fighting hunger in a more focused way. While developing countries have varying socioeconomic achievements, they share the common challenge of trying to eradicate hunger. Each developing country also has its own nature and character, and this is reflected in performance in the three dimensions covered by social, economic, and political indicators. These indicators give a relatively good overview of the strengths and weaknesses of a country. Developing countries typically score low in the various economic and social indicators, with these often being directly and indirectly related to various facets of its hunger problem. In addition, socioeconomic factors can also influence the number of means/criteria a country applies to deal with its hunger problem, such as whether to apply a low or high number of criteria in a hunger-management model [56,5]. A country's profile is designed to summarize various economic factor and therefore becomes an important tool for assessing a country's performance by tracking improvements in different key indicators [55,75, 14].

It is worth noting, however, that developing countries often feature six basic characteristics that reflect on their socioeconomic profiles. In no particular order, these are (1) rapid population growth and constant threats to food security; (2) serious crop failures and subsequent hunger crises; (3) impoverished rural households; (4) high GHI scores; (5) an unstable economy; and (6) internal and external challenges. These are discussed in more detail below.

2.3.1 Rapid population growth and constant threats to food security. In 2020, the rate of population growth in developing countries was more than seven times that of developed countries. According to the World Data Atlas, 2020, Ethiopia's natural growth in 2020 was 25.15 persons per thousand population. In comparison, France in 2020 had a rate of 1.6. Ethiopia's population growth rate is the fifth highest in the world. Developing countries like this are considered trouble hotspots, because rapid population growth makes the country more

vulnerable to the effects of droughts caused by climate change. These present a serious ongoing threat to the population's food security [76].

2.3.2. Serious crop failure and hunger crises. Serious crop failure in developing countries is another major factor causing hunger. As the FAO reported in 2016, Ethiopia faced one of the most severe droughts in half a century in 2015 due to the effects of El Niño, with this causing between 50 and 90 percent crop loss. In addition, the livestock sector has seen extreme mortality and morbidity rates. Many families that depend on agriculture have accumulated debt and/or become dependent on humanitarian assistance [28]. Locke's study indicated that India suffers from severe drought, while Haiti was severely affected by climate-related problems between 2010 and 2012. Such events affect a country's crop production and threaten the population's food security [46].

2.3.3. Impoverished rural households. Rural populations in developing countries have a very low level of wellbeing, being characterized by poverty. Most people who live in villages mainly rely on agriculture. When crop yields significantly decline, it threatens the incomes and nutritional security of these people. Laurie [45] pointed out that most of the Ethiopian population live in villages and mainly rely on agriculture. The crop production is related to the country's annual rainfall patterns, and more than 95% of the land is cultivated this way. In India, about 75% of the population lives in rural areas, and the problem of water over-pumping causes poverty and hunger for rural households. In addition, most of Haiti's population lives in rural areas, making agriculture a significant element of the country's economy. Haiti's agriculture has been extremely affected by extreme climate-related problems, with crops often being decimated, leading to many rural communities experiencing hunger [40,8,45].

2.3.4. High GHI scores. High GHI scores show that most developing countries are classed as having hunger problems that are serious (20.0-34.9), alarming (35.0-49.9), or extremely alarming (over 50.0). The GHI score is based on four component indicators: (a) the percentage of undernourished people in the population, (b) the percentage of children under five who are underweight, (c) the percentage of stunting in children under five, and (d) the mortality rate of children under five. Ethiopia and India—which have 2020 GHI scores of 26.2% and 27.2%, respectively—are in the serious region, while Haiti, with a 2020 GHI score of 35.5%, is in the alarming region [32].

2.3.5. An unstable economy. Developing countries are often characterized by unstable economies due to internal and external influences. For example, Ethiopia has had a permanent budget deficit since 1990. International organizations are therefore compelled to compensate for these deficits by providing grants and loans to ensure the country's continued existence. Ethiopia's debt-sustainability rating deteriorated to "high risk" in 2018 due to worsening trade terms and poor export performance. The country is dependent upon external help to avoid a total collapse [2]. Haiti, meanwhile, has never overcome the legacy of colonialism. It has a weak economy combined with political unrest and a poor social situation, and the country is unable to cope with sharp increases in food prices. Over 2000–2010, its economy grew by 7.8%, while the neighboring Dominican Republic experienced growth of about 35% over the same period [41,40]. India is an exceptional case among developing countries, with the sixth-largest economy in the world in terms of GDP. Over the last two decades, this developing economy has experienced an average annual growth rate of approximately 7%. However, political corruption has negatively impacted government efficiency and hindered economic performance [74,43].

2.3.6. Internal and external challenges. Political, social, and ethnic instability prompts developing countries to face their internal and external challenges. The social problems in Ethiopia relate to the government's economic decisions. For example, the government sold

millions of acres of prime agricultural land to outside investors, leaving local farmers with only unproductive land that was insufficient to provide for their needs. This led to most Ethiopians living in abject poverty with a per capita income that is among the lowest in the world [45]. The Ethiopian government also faces external challenges, not just in terms of keeping its own land peaceful but also dealing with the numerous refugees fleeing from Southern Sudan, Somalia, and Eritrea. This causes social tension between refugees and the local population, who are themselves deprived [69,6]. Haiti, meanwhile, is characterized by an unstable political situation and serious government corruption. The political instability of 2019 continued to hinder the Haitian government's ability to meet the basic needs of its people, resolve long-standing human rights issues, and address humanitarian crises. This in turn led to social tensions and disturbances. In India, terrorism from ethno-nationalists, religious fanatics, and other terror groups poses a significant threat to the people. The regions facing long-standing terrorist activity include Jammu and Kashmir. Killings there have highlighted the government's continued failure to restrict terrorist activities [39,64].

The above characteristics of a developing country's profile highlight the vulnerability and limited resilience of its population to poverty and hunger.

2.4 The concepts of hunger criteria and hunger-management models

The hunger-fighting models of developing countries reveal two important insights: (i) concepts for solving hunger and (ii) countries' behaviors when addressing their hunger problems.

2.4.1. Concepts for solving hunger. A leading concept for fighting hunger in developing countries is based on the FAO's 2011 study that focused on finding the causes of hunger and concluded that hunger is a food-insecurity problem that arises for three basic reasons: (a) low agricultural productivity, often caused by unsuitable policies and institutional and technological constraints; (b) seasonal influences on food supplies; and (c) a lack of off-farm employment opportunities in rural areas [25]. The FAO's policies focus on improving a nation's food security by rapidly increasing agricultural productivity and enhancing people's access to food [12]. Other leading organizations engaged in fighting hunger have adopted the FAO's concept of Food and Nutrition Security (FNS), such as the World Food Program (WFP), the National Institute of Food and Agriculture (NIFA), and the Canadian International Development Agency (CIDA [25,70,52,9]. In their interventions, however, while the various measures (criteria) attempt to remedy the causes of hunger, they are not tailored to a country's level of development.

2.4.2 Countries' behaviors when addressing their hunger problems. Different policies are promoted by various organizations and agencies for addressing the hunger problems of developing countries. However, developing countries often have their own considerations, leading to them only adopting part of a program offered by an organization. This partial program implementation may reflect a country's progress in reducing its score for the GHI and other indicators over time, as we demonstrate later in the data analysis.

Considering the two insights above, this study suggests a new concept for approaching the fight against hunger in developing countries. This involves applying well-fitted hunger solutions for countries at different levels of development to create a more controlled and effective approach to the hunger problems of developing countries. This novel approach has some advantages over the existing approaches proposed in the research literature: (1) It is an original hunger-management model that applies an effective combination of existing solutions for countries at different levels of development. (2) It allows a tailored solution that suits a

country's level of development in order to address hunger more effectively. This new hunger model is based on two modes for addressing hunger, namely the high use of hunger model criteria and the low use of hunger model criteria, which will be explained later, in order to link a hunger-management solution with a country's level of development. (3) This unique tool takes the approach of fighting hunger in a more focused and controlled manner. (4) It represents a dynamic program that allows improvements in GHI scores and component indicators to be maximized over time according to a country's progress in the various indicators. (5) It is a novel approach for tracking and analyzing countries' achievements under different policies over time through the direct relationship between the level of hunger and the number of criteria applied in the hunger model. (6) It helps to gain new insights that may support future decision-making.

2.4.3. Hunger criteria. This study uses the word "criteria" to refer to the various means for addressing the hunger issue in developing countries. *Over 15* criteria have been suggested by various organizations based on three aspects (environmental, financial, and social) that need to be addressed in a developing country with an ongoing hunger problem. The social aspects could include food aid actions, **gender equality, social empowerment, and social transformation**. The economic aspects, meanwhile, could include multilateral agreements, financial resources, external financial aid, and market support for smallholders. Finally, agricultural aspects could include rural development, genetically modified crops, investment in modern agriculture, interventions to achieve climate resilience, and programs to reduce food waste [25,31,70,52,10]. More specifically, the FAO presents a broad policy package with four basic objectives: to ensure access to food, to strengthen family farming, to support income generation, and to enable social empowerment [25]. The FAO also has food aid programs that focus on providing food assistance at different levels, such as through emergency food transfers, food stamps, school meals, food for work projects, and so on [49]. The FAO's efforts also include a package of objectives focused on food and agricultural interventions that help to improve the living standards in an economically, socially, and environmentally sustainable way [31]. The WFP's program, meanwhile, works through various policies, with nutrition being a core element of the program. The WFP therefore provides food assistance, helps develop sustainable food systems, and establishes school meals programs in addition to providing direct food aid or cash-based transfers [71]. Next, the HP's programs are based on an innovative, holistic approach to providing assistance that helps to promote self-reliance and build confidence, to improve the availability of suitable work, to support healthcare, to provide education, to promote environmental sustainability, and to support social justice [66]. What stands out in these various programs is the strong focus on intervening in the field of agriculture at its various facets. This is likely because the people of developing countries mainly live in rural areas, so they are highly dependent on agricultural production [29].

It is important to point out that developing countries usually only implement a subset of the available criteria for tackling the root causes of hunger. Based on this study's data sample, Table 2 demonstrates which of the various criteria developing countries chose to implement in their fights against hunger.

Table 2. Different hunger criteria used by countries in their fight against hunger

Country	Hunger program	Encouraging farming/ smallholder farmers	School meals	Food waste program	Food aid/cash for opening food	Knowledge	Agriculture-development program	Food banks
Angola	WFP food security	✓	✓	✓	✓	✓	✓	
Bangladesh	Hunger Project	✓	✓		✓	✓	✓	✓
Benin	Food security	✓	✓		✓	✓		✓
Bhutan	WFP	✓	✓				✓	
Bolivia	Zero Malnutrition	✓	✓		✓	✓	✓	
Botswana	FNS	✓	✓				✓	
Brazil	Zero Hunger Program	✓	✓		✓	✓	✓	✓
Cambodia	WFP food security	✓			✓	✓	✓	
Cameroon	WFP Food Security	✓	✓		✓	✓	✓	
Colombia	WFP Food security	✓	✓				✓	
Cuba	WFP Food security	✓			✓		✓	
Eritrea	Food insecurity	✓				✓	✓	
Ethiopia	WFP Food Security	✓	✓		✓		✓	✓
Fiji	Food security	✓			✓		✓	
Gabon	Developing agricultural	✓					✓	
Ghana	WFP Food security	✓	✓		✓	✓	✓	
Kenya	WFP Food security	✓	✓		✓	✓		
Liberia	WFP Food security	✓	✓		✓		✓	
Malawi	WFP Food security	✓	✓		✓			
Malaysia	WFP Food security	✓		✓	✓			
Mali	WFP Food security	✓	✓		✓		✓	
Mongolia	WFP Food security	✓			✓	✓	✓	
Namibia	WFP Zero hunger	✓	✓		✓	✓		
Nicaragua	WFP Food security	✓	✓		✓		✓	
Niger	WFP Food security	✓	✓		✓	✓	✓	
Nigeria	WFP Food security	✓			✓	✓	✓	
Yemen Rep.	WFP Food security				✓			

Source: Own elaboration, based on this study's data sample.

For this study's sample, seven hunger-fighting criteria have been implemented by various developing countries in their hunger-management models. These include encouraging smallholder farmers, providing food aid or cash for purchasing food, supplying school meals, implementing food waste programs, increasing the knowledge and skills of farmers in different areas, implementing agricultural-development programs, and setting up food banks. Agricultural development, in its various facets, is clearly the main tool for fighting hunger [37].

2.4.4. The new hunger-management model. The new hunger-management model introduced in this study represents a new concept for addressing the hunger problems of developing countries in a more effective and controlled way. It is based on two different approaches to fighting hunger, namely the low use of hunger-management criteria and the high use of hunger-management criteria. This differentiation is made based on the number of criteria a country applies to address its hunger problem. This study's sample comprised 124 developing countries that had applied some or all of the seven criteria. We therefore classified countries that applied three or fewer criteria in their hunger-management models into the "low use of criteria" group. In contrast, countries that applied four or more criteria in their hunger-management models were classified into the "high use of criteria" group (Table 3 demonstrates high and low use of hunger criteria). The number of criteria applied by a country (i.e., a high or low number of hunger-management criteria) is an important factor that reflects directly on a country's progress in reducing its level of hunger, as will be demonstrated in the results section.

Table 3. Number of criteria implemented by developing countries in their fight against hunger

Country	Hunger program	Number of criteria implemented	of Low/high use of hunger criteria
Angola	WFP Food Security	6	High
Bolivia	Zero Malnutrition	5	High
Namibia	WFP Zero hunger	4	High
Bhutan	WFP Food Security	3	Low
Yemen, Rep	WFP Food Security	1	Low
Gabon	Developing Agriculture	2	Low

Source: Own elaboration, based on this study data sample

3. Material and Methods

3.4 Sample description

To examine the association between the model used by countries to address hunger (i.e., the hunger policy) and any decrease in hunger levels over time, data for 124 countries were gathered. In this study, the data analysis draws on applicable data for the Global Hunger Index (GHI). The GHI scores countries on a 100-point scale, which is then summarized into five levels of hunger: low, moderate, serious, alarming, and extremely alarming [33].

3.2 Measures

Measures were gathered for each country as follows.

Type of hunger policy: Various programs are implemented to address the hunger issue in different developing countries. Some 71.8% of the countries in this sample apply the WFP

model, while 28.2% use other models such as the “Hunger and poverty program” or the “Rural-development program”.

Applied criteria for hunger models: Several criteria are applied for addressing the hunger issue of a country, such as: encouraging farming, school meals, food waste programs, food aid, knowledge, agriculture-development programs, and food banks. For each criterion, a score of 1 was assigned if the country uses it and 0 otherwise. The score of each country were then summed to give a value between 0 and 6, which is effectively the number of criteria applied by that country. For the sample data, there was a median of 3 criteria, meaning that half the sample used three criteria or less, while the other half used four criteria or more. The countries were therefore divided into two groups, namely the low use of hunger criteria and the high use of hunger criteria, based on this distinction. This measure served as the independent variable (categorical *predictor*) for this research.

Global Hunger Index: To assess the effects of using differing hunger model criteria, the Global Hunger Index was used. This index considers several outcomes: the proportion of undernourished people in the population (%), the prevalence of wasting in children under five (%), the prevalence of stunting in children under five (%), the under-five mortality rate (%), and the general score. Data for these factors were gathered for several representative years (1992, 2000, 2008, and 2016), so the trends over time could be identified [33]. The choice of these representative years was constrained by data availability, because some developing countries do not regularly report data due to conflicts, lack of statistical capacity, and other reasons.

3.3 Data analysis

The main goal of the current study is to evaluate the effect of implementing hunger-management strategies on hunger outcomes at a national level using a longitudinal design. To do this, we first classified the various countries according to the number of hunger-management criteria they applied. Second, we used hunger outcomes for each country over time (specifically for the years 1992, 2000, 2008 and 2016) to reveal any continuous trend in the effect of applying their hunger models.

To assess the effect of the number of criteria used by countries to cope with the hunger issue (in terms of improvements in the GHI over time), repeated measures ANOVAs were conducted for each outcome, as well as for the general hunger score. This statistical model enables the testing of the following effects: the main effect of time (the within-subject effect) in terms of a significant change over time for a respective hunger outcome in total; main effect of group (the between subject effect), namely any general significant difference between the low use and high use groups. Interaction effect - specifically whether there is a differing trend over time between the two types of countries. This interaction effect emphasizes the differences in progress for the hunger indices over time.

To probe the differences between years, post hoc analysis was conducted using Bonferroni correction. The assumptions for the ANOVA were examined and validated. More specifically, the dependent variables for the analyses were normally distributed under the central limit theorem. In addition, the sphericity assumption was also examined using Mauchly's tests. Following these results, we used the appropriate F values, and Bonferroni post hoc tests.

4. Results

Table 4 shows the frequency that each criterion was used in hunger models. As can be seen in this table, almost all the countries implemented an agricultural development program, while most countries encourage farming (79.4%) and provided food aid (65.6%). In addition,

just over half of the countries (52.7%) provided school meals. However, only 42.7% of countries in this sample applied the knowledge component, and relatively fewer of them implemented food banks (10.4%) or food waste programs (7.6%).

Table 4. Frequencies that each criterion was used in hunger models

	Criterion for Hunger Model	% of use in total sample
1	Encouraging Farming	79.4
2	School Meals	52.7
3	Food Waste Program	7.6
4	Food Aid	65.6
5	Knowledge	42.7
6	Agriculture-development program	98.1
7	Food Banks	10.4

4.1 Countries' proportion of undernourished people in the population

Table 5. Means and standard deviations for countries with low- and high-use of criteria in hunger models in terms of the proportion of undernourished people

Year	M	SD	N	Year	M	SD	N		
1992	Low use in hunger criteria	21.4	13.1	61	2008	Low use in hunger criteria	12.08	9.69	61
	High use in hunger criteria	29.21	15.91	63		High use in hunger criteria	20.32	12.5	63
	Total	25.37	15.06	124		Total	16.26	11.9	124
2000	Low use in hunger criteria	15.73	11.21	61	2016	Low use in hunger criteria	10.87	11.82	61
	High use in hunger criteria	26.43	14.03	63		High use in hunger criteria	16.71	12.65	63
	Total	21.16	13.76	124		Total	13.84	12.54	124

For total countries in the sample, a main effect of time was found, $F(3,366)=66.72$, $p<.001$, $\eta^2=.354$. More specifically, a significant decrease was found in proportion of undernourished in population between 1992 (25.37%) to 2000 (21.16%) ($p<.05$), from 2000 to 2008 (16.26%) ($p<.01$), and from 2008 to 2016 (13.84%) ($p<.01$). (See Figure 1). In addition, a significant difference was found across all years between countries, while countries that used 4 criteria or more from hunger model had higher proportion of undernourished in population at all examined years, $F(1,122)=16.34$, $p<.001$, $\eta^2=.12$. No significant interaction was found between usage in criteria for hunger model and time for proportion of undernourished in

population, $F(3,366)=2.52$, $p=.089$, $\eta^2=.020$. In other words, change of proportion of undernourished in population over time did not differ between the two groups of countries according to level of use in hunger model criteria.

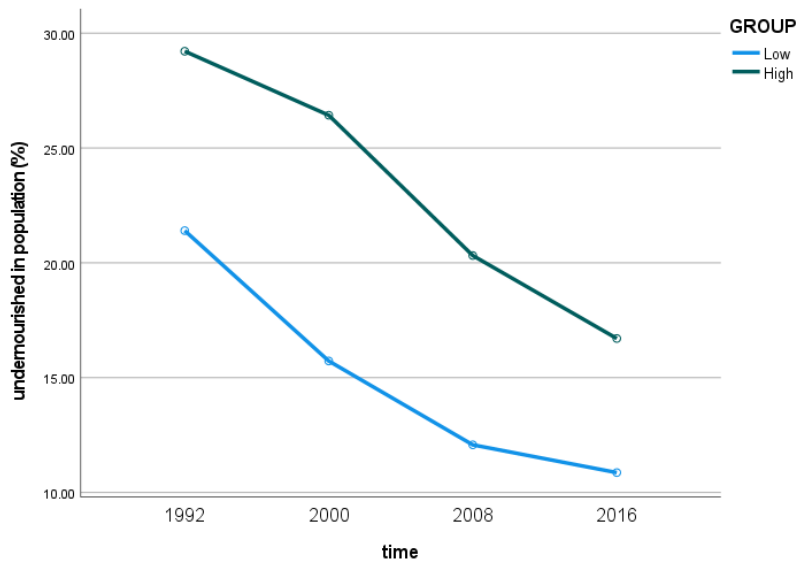


Figure 1. The change over time in the proportion of undernourished people in the population depends upon the intensity of criteria use in the hunger model

4.2 Prevalence of wasting in children under five

Table 6. Means and standard deviations for countries with low and high use of criteria in their hunger models in terms of wasting in children under five (%)

Year		M	SD	N	Year		M	SD	N
1992	Low use in hunger criteria	6.28	4.03	61	2008	Low use in hunger criteria	5.43	4.72	61
	High use in hunger criteria	8.7	4.58	63		High use in hunger criteria	8.71	9.41	63
	Total	7.51	4.47	124		Total	7.1	7.63	124
2000	Low use in hunger criteria	8.62	18.92	61	2016	Low use in hunger criteria	5.1	4.32	61
	High use in hunger criteria	8.91	4.83	63		High use in hunger criteria	7.01	4.84	63
	Total	8.77	13.65	124		Total	6.07	4.67	124

For all the countries in the sample, no main effect of time was found: $F(3,366)=3.08$, $p=.061$, $\eta^2=.025$. This means that, no change over time has occurred for all countries in the sample in prevalence of wasting in children under five years (See Figure 2). However, a

significant difference was found across all years between countries while countries that used 4 criteria or more from hunger model, had higher proportion of wasting in children under five years at all years examined: $F(1,122)=3.66, p<.05, \eta^2=.029$. No significant interaction was found between usage of different hunger models and time: $F(3,366)=0.964, p=.364, \eta^2=.008$. In other words, change of prevalence of wasting in children under five years over time did not differ between two groups of countries according to the level of use in hunger model criteria. It is important to note that significant differences were found between two types of countries at 1992 ($p<.01$), 2008 ($p<.05$) and 2016 ($p<.05$) using post hoc analyses. No difference was found in 2000 ($p=.904$). That is, in mostly years tested, countries which highly implemented hunger model had higher prevalence of wasting in children under five years.

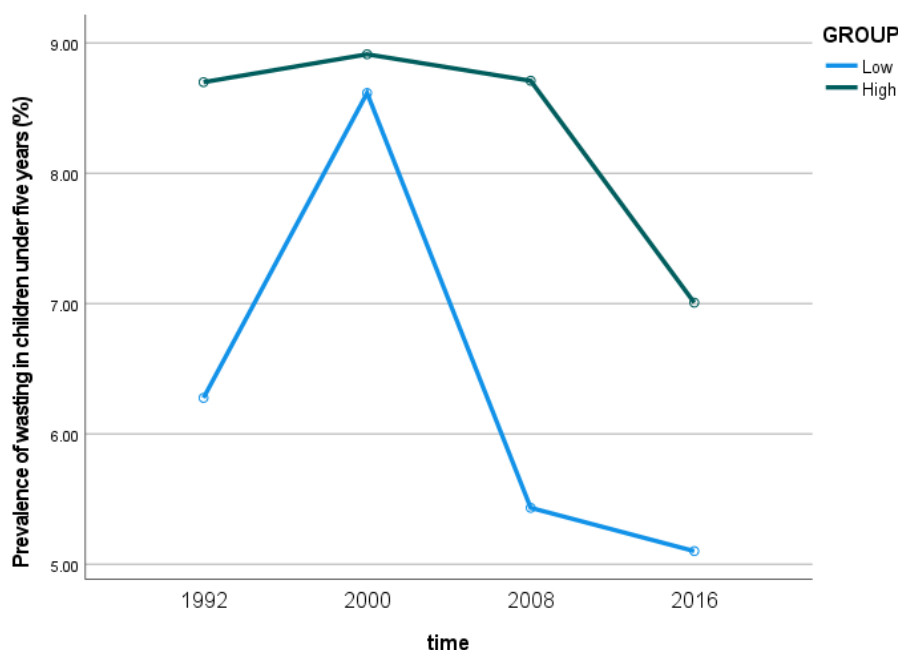


Figure 2. Prevalence of wasting in children under five years depends on intense of use in hunger model criteria

4.3 Prevalence of stunting in children under five

Table 7. Means and standard deviations for countries with low and high use of criteria in their hunger models in terms of the prevalence of stunting in children under five (%)

Year	M	SD	N	Year	M	SD	N
1992	Low use in hunger criteria			2008	Low use in hunger criteria		
	26.83	14.9	61		19.97	15.03	61
	High use in hunger criteria				High use in hunger criteria		
	40.53	13.22	63		31.9	12.35	63
Total				Total			
	33.79	15.61	124		26.03	14.93	124
2000	Low use in hunger criteria			2016	Low use in hunger criteria		
	23.24	15.14	61		18.45	15.55	61

High use in hunger criteria	37.03	13	63	High use in hunger criteria	32.89	45.63	63
Total	30.25	15.65	124	Total	25.78	34.93	124

For total countries in the sample, a main effect of time was found, $F(3,366)=6.695$, $p<.001$, $\eta^2=.052$. More specifically, a significant decrease was found in prevalence of stunting in children under five years between 1992 (33.79%) to 2000 (30.25%) ($p<.05$), from 2000 to 2008 (26.03%) ($p<.01$), and from 2008 to 2016 (25.78%) ($p<.01$). (See Figure 3). In addition, a significant difference was found across all years between countries while countries that used 4 criteria or more from hunger model had higher prevalence at all years examined: $F(1,122)=23.53$, $p<.001$, $\eta^2=.162$. However, no significant interaction was found between usage in criteria for hunger model and time: $F(3,366)=0.132$, $p=.941$, $\eta^2=.001$. That is, the change of prevalence of stunting in children under five years over time did not differ between the two groups of countries according to level of use in hunger model criteria. It is important to note that significant differences were found between two types of countries at 1992 ($p<.001$), 2000 ($p<.001$), 2008 ($p<.001$) and 2016 ($p<.05$) using post hoc analyses. That is, in all years tested, countries which highly implemented hunger model had higher prevalence of stunting in children under five years.

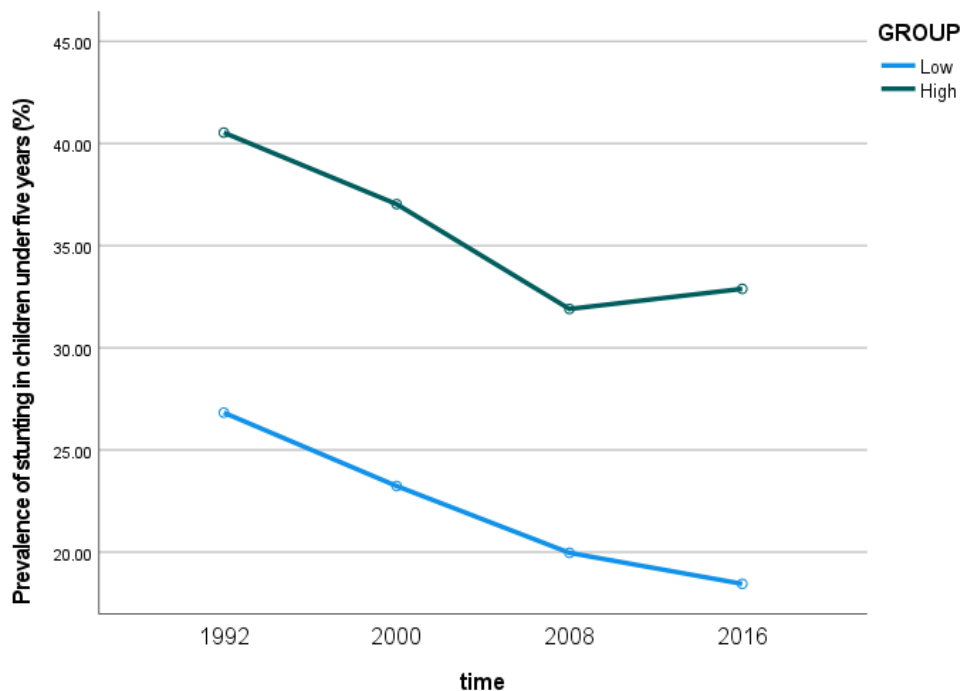


Figure 3. The change over time in the prevalence of stunting in children under five depends upon the intensity of criteria use in the hunger model

4.4 The under-five mortality rate

Table 8. Means and standard deviations for countries with low and high use of criteria in their hunger models in terms of the under-five mortality rate (%)

Year		M	SD	N	Year	M	SD	N	
1992	Low use in hunger criteria	6.62	5.28	61	2008	Low use in hunger criteria	3.9	3.74	61
	High use in hunger criteria	12.2	6.84	63		High use in hunger criteria	7.2	4.57	63
	Total	9.45	6.71	124		Total	5.58	4.48	124
2000	Low use in hunger criteria	5.41	4.98	61	2016	Low use in hunger criteria	2.93	2.67	61
	High use in hunger criteria	10.13	5.87	63		High use in hunger criteria	5.51	3.68	63
	Total	7.81	5.92	124		Total	4.24	3.46	124

For total countries in the sample, a main effect of time was found, $F(3,366)=172.04$, $p<.001$, $\eta^2=.585$. More specifically, a significant decrease was found in prevalence of children mortality between 1992 (9.45%) to 2000 (7.81%) ($p<.05$), from 2000 to 2008 (5.58%) ($p<.01$), and from 2008 to 2016 (4.24%) ($p<.01$). (See Figure 4). In addition, a significant difference was found across all years between countries while countries that used 4 criteria or more from hunger model had higher mortality rates at all years examined, $F(1,122)=24.28$, $p<.01$, $\eta^2=.166$. A significant interaction was found between usage in criteria for hunger model and time, $F(3,366)=14.83$, $p<.001$, $\eta^2=.108$. Specifically, in 1992 and 2000, countries with high use in hunger model criteria showed significant higher rates of children mortality in compare with countries with low use in 1992 ($p<.001$), 2000 ($p<.001$), 2008 ($p<.001$) and 2016 ($p<.001$). However, differences in 2008 and 2016 were smaller in comparison with differences in 1996 and 2000.

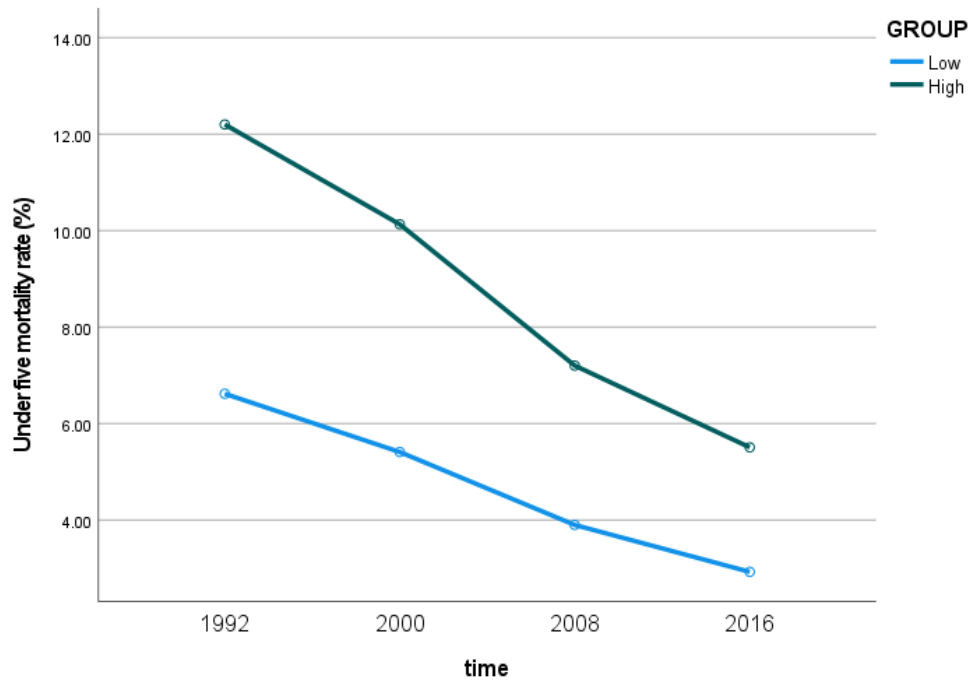


Figure 4. The change over time in the under-five mortality rate depends upon the intensity of criteria use in the hunger model.

4.5 General hunger score

Table 9. Means and standard deviations for countries with low and high use of criteria in their hunger models in terms of the general hunger score

Year	M	SD	N	Year	M	SD	N	
1992	Low use in hunger criteria	27.25	11.78	61	2008	Low use in hunger criteria	18.57	10.29
	High use in hunger criteria	38.3	14.15	63		High use in hunger criteria	26.65	10.97
	Total	32.86	14.12	124		Total	22.67	11.35
2000	Low use in hunger criteria	21.47	11.62	61	2016	Low use in hunger criteria	17.43	10.91
	High use in hunger criteria	33.91	13.19	63		High use in hunger criteria	22.74	9.16
	Total	27.79	13.87	124		Total	20.13	10.37

For total countries in the sample, a main effect of time was found, $F(3,366)=107.93$, $p<.001$, $\eta^2=.469$. More specifically, a significant decrease was found in hunger score between 1992 (32.86%) to 2000 (27.79%) ($p<.05$), from 2000 to 2008 (22.67%) ($p<.01$), and from 2008 to 2016 (20.13%) ($p<.01$). (See Figure 5). In addition, a significant difference was found across all years between countries while countries that used 4 criteria or more from hunger model had

higher hunger score at all years examined, $F(1,122)=24.49$, $p<.01$, $\eta^2=.167$. A significant interaction was found between usage in criteria for hunger model and time, $F(3,366)=8.59$, $p<.001$, $\eta^2=.066$. That is, in 1992 and 2000, countries with high use in hunger model criteria showed significant higher rates of hunger general score in compare with countries with low use ($p<.001$). These difference were also significant at 2008 ($p<.001$) and 2016 ($p<.01$) but to less extent.

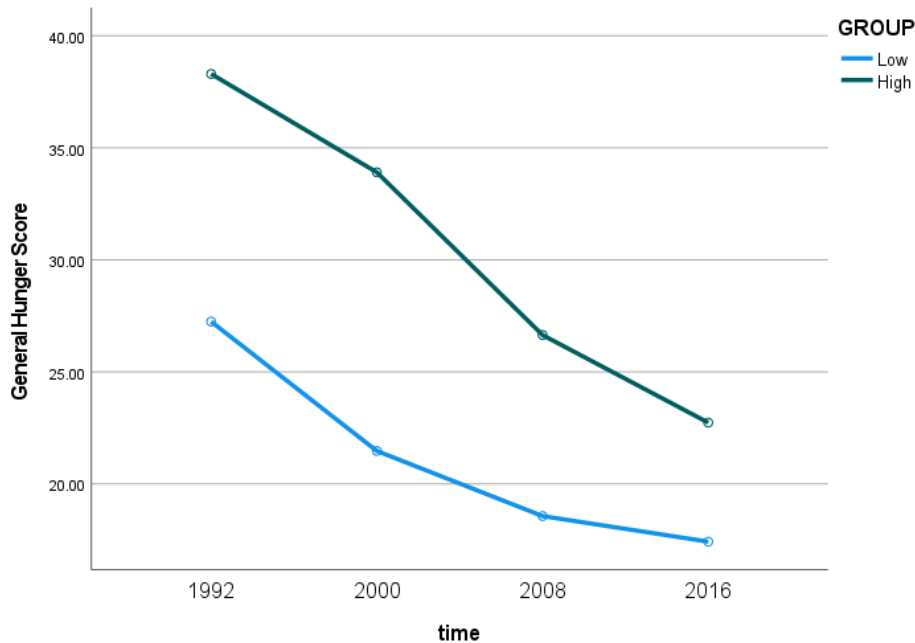


Figure 5. The change over time in the general hunger score depends upon the intensity of criteria use in the hunger model

5. Discussion and Conclusions

5.1 Discussion

The discussion part focuses on the following three topics:

- i. The various results presented in Figures 1 to 5, thus supporting the observed trend.
- ii. Summarizing the ANOVA four effects.
- iii. The regional development theory and public choice theory.

5.2 The various results presented in Figures 1 to 5

Positive progress in the GHI score and its four component outcomes has been achieved by various hunger programs that have been discussed in various research studies. These support the progress over time that can be seen in this study's five figures (Figures 1 to 5). In our study's case, the main effect of time was observed. In other words, for all the countries in the sample, each outcome and the overall GHI score improved as time passed. Moreover, in this study's sample, the countries were classified according to the high or low use of hunger model criteria. It is noted that most countries with high GHI score have chosen a broader model with high hunger model criteria to fight their hunger problem. The change over time for under five mortality rate and general hunger score found to have significant improvement with programs using higher number of criteria in their hunger-management model, as can be seen in Figures 4 to 5. No significant interaction between high and low used of criteria was found for

undernourished people in population, prevalence of wasting in children under five and prevalence of stunting in children under five as seen in Figures 1 to 3.

The prevalence of undernourishment is used by the FAO as its main hunger indicator. This reflects the portion of the population that has a calorific intake below what is needed to meet individual needs. According to the FAO's data, the prevalence of undernourishment in regions with developing countries (i.e., those with the greatest proportions of undernourished people) has decreased significantly over the years. In 1991, 18.6% of the world's population was undernourished, but this dropped to 10.8% in 2015 [57]. In their study, Abegaz and Secur [1] also indicated a positive trend in the prevalence of undernourishment in East and sub-Saharan African countries between 1991 and 2015. Ambagna et al. [3] also support this decreasing trend in the prevalence of undernourishment in the population through estimates derived using two methods: The HCES (Household Consumption and Expenditure Surveys) and the FAO approach of Food Balance Sheets (i.e., the pattern of a country's food supply). For all the countries in this study's sample, regardless of how many hunger model criteria they used, the proportion of undernourished people in the population decreased significantly. In 1992, 25.37% of the population were undernourished, but this fell to 13.84% in 2016. This result supports the trend reported in the research literature, such as the works of Roser and Ritchie [57] and Abegaz and Secur [1].

Stunting and *wasting* are another two indicators that measure the effects of undernutrition. They are regarded as important indicators of nutritional status and health in a population. The proportion of under-fives across the world's regions who are defined as in a state of wasting (i.e., having a low weight for their height) has been recorded since 1990. Since then, there has been a steady decline in the global level of wasting in children under five, with it falling from around 25% in 1990 to 15% in 2015 [57]. However, wasting is often exemplified by rapid weight loss, which means that short-term disruptions in food supplies can dominate the long-term trends. This is particularly evident in politically unstable countries. For example, there was a large spike in childhood wasting in the Democratic Republic of Congo during the Second Congo War of the late 1990s and early 2000s [57]. What is more, de Onis et al. in 2012 [11] report estimates for the prevalence of wasting in the under-fives of different regions. For example, in Africa in 1990, 8.7% of under-fives were affected by wasting compared with 8.5% in 2011. In Asia, 11.4% of under-fives were affected by wasting in 1990, compared with 10.1% in 2011. In Latin America and the Caribbean, 2.6% of under-fives were affected by wasting in 1990, compared with 1.4% in 2011. Looking at all developing countries, 10.0% of under-fives were affected by wasting in 1990, compared with 8.8% in 2011. In general, small improvements have been made over time, but wasting continues to be a problem that requires more effort to overcome.

In our study, in childhood wasting, no main effect of time was found for this outcome, meaning that no significant change over time occurred for the countries. As shown in Figure 2, there were two spikes in childhood wasting for countries with both the high and low use of hunger model criteria, and these may be explained by the impact of different events on food supplies. This in turn leads us to speculate that these spikes in childhood wasting may warrant a longer follow-up. In other words, changes in the prevalence of wasting seem to be part of a longer-term process, so long-term monitoring is needed.

The stunting indicator expresses the percentage of children with a low height for their age, and this reflects poor environmental conditions having a detrimental long-term influence on a child's growth potential. Data for the prevalence of childhood stunting in under-fives is often not available on an annual basis. Despite this limitation, the FAO's data for different

countries shows significant differences across all years, with there being an overall decreasing trend. For example, in 1978, Kenya's rate of stunting was 41.6%, but this had dropped to 26% in 2014. What is more, in Bangladesh between 1990 and 2016, the prevalence of stunting in under-fives fell from 61.5% to 32.6%. During the same period, Nigeria reduced its rate of stunting from 35.10% to 32.60%. The same positive trend was seen in Bolivia (9.70% to 3.40%). Indeed, there has been a steady decline globally, with it falling from around 25% in 1990 to 15% in 2015 [57]. According to Prendergast and Humphrey [53] impressive progress has also been made in Asia between 1990 and 2010, with a decline in the proportion of stunted children from 49% to 28%. Prendergast et al. [53] point to a similar reduction in stunted children in Asia with a decline from 49% to 28% between 1990 and 2010. In Africa, however, the prevalence of stunting has remained stubbornly high at around 40%, and because of population growth, the absolute number of stunted children has increased. Webb et al. [68], meanwhile, point out policy actions aimed at reducing malnutrition in all its forms, and among them, reducing the prevalence of under-five stunting has shown positive results, and the evidence to support such actions is growing. For example, *Brazil* saw its prevalence of childhood stunting decline from 37% in 1974–1975 to 7% in 2006–2007. *Ethiopia* has faced famines many times from the 1980s to the early 2000s, yet it also reduced childhood stunting from 58% in 2000 to under 40% in 2014. *Bangladesh* also saw childhood stunting fall from almost 57% in 1997 to around 36% in 2014.

In our study model, for countries with both the high and low use of hunger model criteria, significant decreases were seen in the prevalence of stunting in under-fives. In 1992, the rate of stunting was 33.79%, but this dropped to 25.78% in 2016. This mirrors the trends reported by Roser and Ritchie [57], Webb [68], and Prendergast and Humphrey [53]. Moreover, Figure 3 shows that for countries that apply the high use of hunger model criteria, the downward trend has stalled. This could be a localized phenomenon, or there may be some barrier preventing further progress. In any case, this warrants further investigation.

The World Bank's 2019 [67] data gives under-five child mortality estimates for different countries, including developing countries. These show that the global under-five mortality rate (per 1,000 live births) is falling faster than at any other time in the past two decades. All regions have reduced their under-five mortality rates by 52% or more. For example, the global under-five mortality rate was 93% in 1990, but it dropped to 41.3% in 2016. More specifically, between 1960 and 2016, the mortality rate of different developing countries has dropped dramatically: Botswana (176.6% to 43.6%), Ethiopia (246% to 58.9%), and Kenya (198.1% to 47.8%). Angola's rate also dropped from 237% in 1980 to 84.2% in 2016. All this indicates the positive trend over time that is occurring in different developing countries.

For under five mortality rate, countries which used higher criteria model, a significant higher trend was observed between 1992 and 2016, which it dropping from 12.2% to 5.51% while countries which have used low criteria model during the same time have dropped from 6.62% to 2.93%.

Tracking progress in GHI scores over time also showed definite improvements in all regions, including developing countries. In 1992, most countries across sub-Saharan Africa and South Asia fell within the "extremely alarming" or "alarming" classification, but by 2016, no countries remained in the "extremely alarming" category, and most had been downgraded to the "serious" category. In other regions, countries have generally shifted from "moderate-to-serious" in 1992 to "low-to-moderate" in 2016. For example, in 1992, Pakistan's GHI score was 43.4%, but this dropped to 32.6% in 2017. Bangladesh, meanwhile, had a GHI score of 52.4% in 1992, but in 2017, it was just 26.5% [57]. In general, the level of hunger in developing

countries has decreased by 27% since 2000. During the 2000–2017 period, the GHI scores of 14 countries—including Senegal, Azerbaijan, Peru, Panama, and Brazil—improved by 50% or more. Angola, Ethiopia, and Rwanda, which have all experienced violent conflict in recent decades, were among the 72 countries that improved their GHI scores by between 25% and 49.9%, with them progressing from “extremely alarming” levels to “serious” levels [54].

For general hunger score in this study, countries using high use of hunger model criteria yield significantly higher improvement for their score between 1992 and 2016, with it dropping overall from 38.3% to 22.74%. Countries with low use of hunger model criteria have shown a drop from 27.25% to 17.43%. This noticeable improvement was also noted in Roser and Ritchie’s [57] and Ralte’s studies [54].

5.3 Summarizing the ANOVA four effects

Main effect of time (within-subject effect): There was a significant change over time with respect to the overall hunger outcome. With the exception of the prevalence of wasting in children under five, the examined outcomes, as well as the general hunger score, improved as time passed for all countries in the sample.

Main effect of group (between-subject effect): In general, there was a significant difference between the two groups’ performances. In this case, significant differences were found across all years, with those countries that applied four or more criteria in their hunger models experiencing higher outcomes and general GHI scores when compared to those countries that applied three or fewer criteria in their hunger models.

Interaction effect: This concerns whether there are different trends in the change over time for the two groups of countries. For most of the examined outcomes, no significant interactions were found between the use of different hunger models and time, with the exceptions being the under-five mortality rate and the General Hunger Score. In other words, the changes in outcomes over time did not differ substantially between the two groups of countries according to their use of criteria in their hunger models. An interaction effect would have emphasized the difference in the various hunger indices over time.

5.4 The regional development theory and public choice theory

Two economic theories, namely the regional development theory and the public choice theory, make a significant contribution to this study’s discussion by linking the decisions of government institutions with development, because such decisions can also play an important role in reducing poverty and hunger in developing countries. Both these theories therefore provide feasible explanations for a country’s level of hunger, as well as its various outcomes, as presented in Figures 1 to 5. They also lend support to this study’s proposed solution to the hunger problem of developing countries.

Regional development theory: This theory asserts that development occurs in different socioeconomic environments and takes various forms at both the national and regional levels, which in turn leads to different levels of regional and national development [59]. When performance is unsatisfactory, some kind of intervention is required at both the regional and community levels. It is therefore necessary to formulate policies for each region in order to ensure good performance for the whole national economy [61]. Such insights and understandings support this study’s basic concept of tailoring a hunger solution to a specific country’s level of development. This ensures that improvements in the various hunger indicators will be maximized, thus helping to achieve better progress in the overall GHI score. Moreover, regional development theories relate to change in a desirable direction and at an

appropriate and sustainable speed. This direction and rate of change depend upon the objectives of the proposed development [61]. This theory therefore helps explain the various tendencies presented in Figures 1 to 5. More specifically, it explains why countries that implement a greater number of hunger model criteria (i.e., they have broader goals for fighting hunger through development) show greater rates of change over time in their GHI scores and other indicators. In other words, countries that apply a greater number of hunger model criteria generally show better improvements in development while fighting hunger, and this indirectly reflects on their progress in improving their GHI scores over time.

Public choice theory: Advancing development ultimately depends on making political decisions that meet the needs of the public [4]. This is where the public choice theory comes in, because it recognizes that politicians are often motivated out of self-interest, so they sometimes do not seek to meet the real needs of a country and its people [15]. Thus, public choice theory highlights how government failures result in poor economic efficiency, specifically in terms of economic decisions and unfair income distribution. Poor levels of economic efficiency often result from government corruption in developing countries, and this hinders their socioeconomic performances and consequently their efforts to fight hunger [11]. Drazen's study in 2006 points out that policy failures can often be understood in the context of political choice. The failure of some developing countries to achieve growth can be attributed to poor political choices, both by those countries' governments and external bodies. Such policies may be designed to serve special interests and exclusively benefit a small elite group [13]. Public choice theory could therefore explain governments' preference for one of two political choices in their fight against hunger, namely the low use of hunger model criteria and the high use of hunger model criteria. Such a choice can have a significant influence on how GHI scores and other indicators are reduced over time, as can be clearly seen in Figures 1 to 5. When a government chooses to apply more criteria in its hunger-management model, the better its progress will be in terms of improving its GHIs score and other hunger indicators over time.

5.5 Conclusions

The above provides two important insights into the relationship between a country's profile and the number of criteria employed in a hunger model, and these are clear from the five figures presented in this paper.

First, two different behavioral approaches to fighting hunger are evident. More specifically, countries with an initially more problematic situation (i.e., higher values in the four indicators and general hunger score), tend to prefer a wider solution to their hunger problems, and this manifests in higher criteria being used in their hunger models. In contrast, countries facing a less severe situation, in terms of the indicators- opt for simple and focused programs (i.e., they use a lower number of criteria in their hunger models) to address their hunger problems.

Second, both approaches have a positive effect over time in terms of significant decreases in each examined indicator as well as the general hunger score.

Significant differences were observed across all years between the two groups of countries with those implementing hunger models with a greater number of criteria achieving more favorable hunger outcomes for under five mortality rate and general hunger score. This effect was stable over time, thus emphasizing the importance of implementing such interventions to bring about long-term benefits in term of reducing negative hunger outcomes and overall hunger scores.

Based on the data analysis and the insights presented above, we present a new working plan for countries facing decisions about hunger issues. This involves applying an effective and well-fitting hunger program based on a country's profile to achieve more effective and controlled results when addressing the hunger issue (Table 10). It is a tailored solution for hunger, one where countries with different developmental levels, choose between two basic hunger models: the "high use" and the "low use" criteria. This solution presents a dynamic program that seeks to maximize the positive effect over time in terms of GHI scores and other outcomes indicators.

Table 10. The hunger-solution program

Group	Country profile: Means (over time 1992-2016)		Recommendations				
	General Hunger Score	Prevalence of mortality	High -use hunger criter ia	Low- use hunger criter ia	Time effect	Next step	Expected time effect
Less problema tic countries	21.2	4.6		✓	Positi ve effect	To apply a more focuse d progra m in their hunger model criteria	Achieving MG2 hunger goals
More problema tic countries	36.5	8.7	✓		Positi ve effect	To move to a more focuse d format in hunger model criteria	A significant improveme nt in under five mortality rate and general hunger score

This is a new approach for addressing hunger, and it is based on an original hunger-management model. The working plan for countries at different of development levels comprises the following premises:

1. Countries facing a more severe, problematic initial situation (in terms of GHI score and the four indicators) are advised to adopt a wider approach when initially addressing their hunger problems. In other words, they should apply a higher number of criteria in their initial hunger model (i.e., use more criteria in their hunger models), because this will be more effective at reducing the under-five mortality rate and the general hunger score over time.
2. It is recommended that countries with a better initial situation (in terms of the four indicators and GHI score) formulate a simpler, more focused program to address their hunger problems (i.e., use fewer criteria in their hunger models).
3. For countries that have applied a high number of criteria in their hunger models for several years, they may want to consider simplifying their efforts (i.e., switching to using fewer criteria in their hunger models). This should help them benefit from continuing improvements in the four indicators and GHI score.

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