

MALNUTRITION AND SUPPLY CHAIN IN SOUTHEAST ASIA: A SCOPING REVIEW

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Abstract

A significant impact of food supply chain disruptions on the populace is malnutrition. We investigated supply chain issues and malnutrition in Southeast Asia (SEA). A scoping search of the SCOPUS database was conducted to identify and extract information on interventions addressing malnutrition and strengthening supply chains. Eight studies were included in the final scoping review. These interventions cut across the school feeding program for school children, fortified foods for under-five, harmonization of stakeholders, conservation of aquatic life and curbing waste. Based on the analysis, we provide insights into a suite of strategies to help address the issue of malnutrition, especially in hard-to-reach areas informing SEA policymakers of the possibility of reducing malnutrition through improved supply chains.

Keywords: COVID-19, supply chain resilience, malnutrition, Southeast Asia.

1. Introduction

Prior to the emergence of the COVID-19 pandemic, there was already a danger to global food and nutrition security where it has been reported that almost 700 million people worldwide go to bed hungry every night, and another two billion people have "hidden hunger" from not getting enough of certain micronutrients like vitamin A, iron, and zinc in their diets. More than 144 million children are stunted, putting them at risk for delayed development and chronic diseases, according to recent statistics from the World Health Organization (WHO) and the United Nations Children's Fund (UNICEF) [1]. In Asia and the Pacific, it was predicted that 77.2 million children under the age of five were stunted in 2018, and 32.5 million suffered from food. To reach the goal "zero hunger" by 2030, more than 3 million people would need to be pulled out of hunger each month [1].

The flip side is that over two billion individuals worldwide are overweight or obese owing to excessive calorie intake, putting them at higher risk for developing diet-related disorders such type 2 diabetes, cardiovascular disease, and certain malignancies. Southeast Asia (SEA), a

region that includes countries like Thailand, Vietnam, Malaysia, Indonesia, the Philippines, Singapore, Myanmar, Cambodia, Laos, Brunei, and Timor-Leste. It is known for its cultural diversity, economic growth, and strategic geographic location. Many Asian nations have also seen dramatic increases in the prevalence of health disorders directly associated to overweight. We note that the frequency of overweight and obesity has increased across Southeast Asia, particularly in Indonesia, Malaysia, the Philippines, and Thailand. For example, both overweight and obesity were quite prevalent in Indonesia in 2013 where the rates were 13.5% and 15.4%, respectively. Further the number of overweight people saw a rise of 0.1% during a five-year period, whereas obese people saw a rise of 6.4%. (Indonesian Government [2]. From a gender perspective, males in Malaysia are less likely to be overweight than women, with the prevalence of overweight dropping from 30.8 percent in 2015 to 30.8 percent in 2019, whereas the prevalence of obesity rose from 15.3 percent to 15.3 percent during the same time period [3]. In the same time frame, the proportion of overweight Malaysian women rose from 29.7 to 30.0 percent, while the percentage of obese

women rose from 24.7 to 24.9 percent [3]. From 2015 to 2018, there was an increase in the rate of overweight, obesity, and diabetes in the Philippines [4]. There was a 4.1 percentage point rise in the prevalence of overweight individuals, and a 2.4 percentage point rise in the prevalence of obese individuals [4].

There was a rise in the percentage of adults in Thailand who are overweight or obese between 2008–9 and 2013–14. Within both time periods, a greater percentage of women than men were clinically overweight or obese [5]. Altogether, the health risks and economic costs associated with malnutrition, together with the associated productivity losses, cause a drop of 5-10% in global GDP [6]. Hence, this study investigates food supply chain resilience in SEA with a focus on malnutrition and provides insight into it.

BACKGROUND

Though the level of disruption has varied across regions (both internationally and in Asia), there have been effects of COVID-19 on the food and agricultural industry that showed weaknesses in the agri-food supply chain [7]. The Asian Development Bank predicted in 2021 that travel restrictions would prohibit local and migrant employees from reaching farming, processing, and packaging businesses that had been shuttered owing to quarantine regulations and ill workers [8]. As a result of quality degradation of fresh goods caused by the lack of cold chain infrastructure, there was a significant increase in food waste in the food systems. Moreover, the closure of businesses that relied on tourism and education, caused many farmers to see a drop in demand for their produce. In addition, congestion in port facilities caused difficulties for marine transit due to a shortage of staff and vehicles to remove goods. Mandatory crew health checks and more customs paperwork increased both these factors. The regional supply networks were already under stress before export restrictions were placed on essential food goods [8]. As a result of extended time required for

administrative processes and the lack of cold chain infrastructure, fresh food had to be thrown away when quality degraded there was a significant increase in food waste.

The agri-food supply chain links farmers with food consumers and involves all stages from growing crops to making finished products, from wholesale to retail to restaurants to government inspections to ensure food safety. In terms of public health, the agri-food system may be seen as a tool because of its potential to provide healthy meals that are also popular among consumers. Water and soil nutrient scarcity; arable land lost to urbanization and degradation; plant and animal biosecurity; erratic weather and climate change; dwindling public trust and social license are just some of the existential risks this system confronts [9]. The purpose of this analysis is to bring attention to critical weaknesses in SEA's supply chain resilience in the context of malnutrition. More recently gathered data on measures to fortify the supply chain while combating malnutrition will also be examined.

OVERVIEW OF SEA

SEA consists of three different groups of economies. Group 1 consists of countries with a GDP/capita of 53,000 to 10,000 (Singapore, Malaysia, Brunei); Group 2 consists of countries with a GDP/capita of 6,000 to 3,000 (Thailand, Indonesia, Philippines); and Group 3 consists of countries with a GDP/capita of 2,500 to 1,000 (Cambodia, Laos, Myanmar, Vietnam) [9]. These classifications represent the capacity to maintain import food supply networks that begin from elsewhere. Many elements, including arable land for self-production, GDP per capita, trading capacity, natural resources, infrastructure, and investments, contribute to the stability of supply chains and the resilience of food systems. The rising number of middle-class individuals in the ASEAN area, projected at 350 million [10], most of whom reside in metropolitan centers, is increasing demand for exotic food products from outside the region and for increased consumption

of animal protein. Urban populations in 2018 varied from 23% in Cambodia to 100% in Singapore, reflecting the overall trend of rising urbanization. Natural resource bases in ASEAN are diverse, particularly with regards to land, which is essential for sustaining robust agricultural systems. Singapore has the lowest proportion of agricultural land at 0.9%, while Thailand has the most at 43% of the country's total land area [11]. Though Southeast Asia is home to a population of 660 million as of the year 2019, the region has just around 0.12 hectares of arable land per person. This is one of the lowest rates of arable land per person anywhere in the globe [9].

FOOD SYSTEM RESILIENCE IN SEA

A food system is "the sum of actors and interactions along the food value chain—from input supply and production of crops, livestock, fish, and other agricultural commodities to transportation, processing, retailing, wholesaling, preparing, and consuming and disposing of foods," as defined by the International Food Policy Research Institute (IFPRI) [6]. Nutrition, health, environmental, and sustainability implications, as well as the enabling policy environment, must be considered [12] as shown in Fig 1. Consideration is given to the food system's ability to eliminate flaws and adapt to future uncertainties, including disruptive shocks, from a systems-level approach that acknowledges the system's inherent complexity [13].

It's vital to keep in mind that the agricultural sectors of ASEAN nations are experiencing fast structural transition while we talk about their food systems' resilience. According to the Asian Development Bank, the share of national GDP contributed by agriculture has been falling during the 1990s, with the share presently ranging from zero (Singapore) to twenty-three and a half percent (Cambodia) [11]. Additionally, the agricultural industry has seen a decrease in employment, which now stands at between 1% and 33% in Singapore and Cambodia,

respectively [11]. A more urban population and a decrease in agriculture's share of GDP both place stresses on the nation's food supply and highlight the significance of a reliable supply chain as shown in Fig 2.



Figure 1: Changing food systems

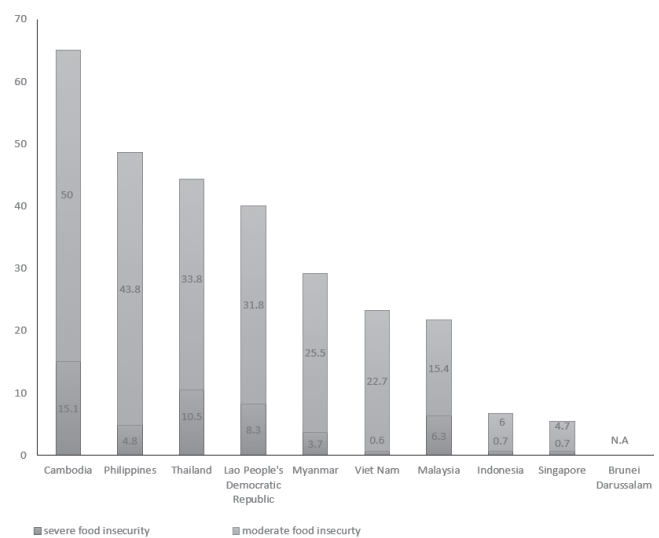


Figure 2: Significance of a reliable supply chain

Source: FAOSTAT [14]

The Association of Southeast Asian Nations (ASEAN) is a major exporter of agricultural goods despite its numerous weaknesses. Thailand and Vietnam, two ASEAN countries, are among the world's top three rice exporters. Other products in which ASEAN nations are global leaders in exporting include vegetable oil (Indonesia, Malaysia), coconuts (Philippines, Indonesia), sugar (Thailand), pineapple (Thailand, Philippines), coffee (Vietnam), pulse grains (Myanmar), and cassava (Indonesia) [9]. Many of

the supply networks for these and other goods are now managed by multinational corporations. However, the intertwining of a plethora of disjointed supply chains, which originate both inside and outside of the region and include numerous small and medium private firms (SMEs), is largely responsible for maintaining ASEAN food security [9]. Many ASEAN nations rely on commerce and imports from other countries to assist with their food security requirements, therefore these supply chains are crucial to their economies. Supply chains in Asia are more integrated because of trade liberalization, but they are still less efficient than their counterparts in North America and Europe.

Singapore, Brunei, the Philippines, Vietnam, Cambodia, and Laos are all net food importers in the ASEAN region, hence they rely on supply networks to ensure their populations always have access to nutritious food. For most countries, relying on foreign suppliers does not compromise food safety, according to the Economist Intelligence Unit's Global Food Security Index [15]. Moreover, food systems that produce surpluses are reflected in supply networks that facilitate export commerce. Even now, the primary food of ASEAN, rice, has a significant impact on agricultural output. Two of the world's three largest exporters of rice are in ASEAN, and the region's two largest importers of rice are also located there. Only around 25% of agri-food commerce occurs inside the ASEAN area, while the remaining 75% is exported [9].

Overall, the effects of COVID-19 disruption on system performance were found to be greatest in the irrigated wheat-based system and least in the hill mixed system, with the latter being associated with greater resilience and diversification as well as less dependence on external inputs and long market chains [16]. The recovery strategies and programs should consider the resilience and sustainability of farming and food systems, particularly in light of the fact that economic performance has recovered more slowly than productivity, the status of natural resources,

and social capital. Public policies that emphasized staple food production and distribution and complementing welfare programs also contributed to the robustness of Asian agricultural and food systems, as was observed by Dixon [16]. Efforts to strengthen resilience should be key to recovery programs considering the significant threats to plant and animal sourced food supply from future zoonoses and the institutional weaknesses identified by COVID-19.

MALNUTRITION IN SEA

It was reported by WHO in their 2021 study that COVID-19 has affected all six of the aforementioned facets of food security: availability, access, usage, stability, agency, and sustainability. This has a disproportionately negative impact on the ability of disadvantaged groups, including mothers and children, to get nutritious foods and ensure their own nutritional well-being [17]. Food security and nutrition have been impacted by the pandemic's resulting dynamics, including disruptions to food supply chains, loss of income and livelihood, rising inequality and poverty, interruptions to social protection programs, altered food environments, and irregular food prices in localized contexts [18]. Many low-income households in South and Southeast Asia lack the resources and knowledge to improve their nutrition and eating habits [18]. Due to financial restrictions, non-monetary constraints (such as access), and cultural norms, low-income households in South and Southeast Asia are more likely to make poor food choices and spend less in nutritional options. Other obstacles that make it hard to enhance nutrition and health-care results include dangerous, uneven, and difficult-to-access settings at these providing facilities [18]. Existing imbalances in geography, gender, caste, race, age, ethnicity, education, money, food, and health care systems all contribute to a vicious circle of inequality that makes malnutrition even more widespread. At-risk groups (poor socioeconomic groups, immunocompromised groups, handicapped

populations, health-risk groups) are already adversely impacted by the worldwide COVID-19 pandemic, and starvation exacerbates these effects.

The high price of nutritious food compared to cheap food is one of the biggest obstacles to proper nutrition in this area [18]. For over 1.9 billion people in Asia and the Pacific, a diet high in fruits, vegetables, and lean proteins is out of reach. The rising cost of living during the epidemic has led to a rise in food insecurity and a proliferation of different types of malnutrition. To address the many issues surrounding healthy eating, a sector-specific strategy is inadequate [18]. Adults in SEA tended to prefer traditional cuisines at the beginning of WHO's study, but this preference shifted over time as the region became more urbanized and Westernized. Unfortunately, there is a lack of accessible resources that discuss the importance of eating healthily and the risks associated with consuming too much processed food. Furthermore, this issue is exacerbated by the marketing and advertising of bad food.

SEA GOVERNMENTS AND MALNUTRITION

Several WHO member economies in SEA have accomplished some of the WHO's nutrition goals, according to the WHO [1]. There are nutrition policies, programs, strategies, and action plans in place in every Member State. Public policy documents in nearly every country outline specific, measurable, and time-bound goals for improving nutrition, with many of these goals directly inspired by the global nutrition targets and others relating to diet and noncommunicable diseases. Each WHO member State has either a fully operational plan or is in the process of formalizing/establishing a multi stakeholder coordination mechanism for nutrition because of the importance they place on multisectoral collaboration. Food-based dietary guidelines that promote healthy diets and are used for nutrition promotion have been developed in more than half of the countries in the SEA region [18].

Furthermore, data collection and monitoring of nutrition-related indicators has occurred because of at least one Member State conducting a demographic and health survey, a multiple indicator cluster survey, or a comparable national nutrition survey at least once in the past five years. Several nations have passed laws to discourage the marketing of breast milk substitutes and to levy taxes on sugar-sweetened beverages (SSB). With WHO's technical and advocacy support for promoting breastfeeding, the Region has seen a remarkable increase in the exclusive breastfeeding rate at six months. Recommitments from Member States to combat childhood stunting have been reaffirmed thanks to persistent advocacy at the highest levels. In addition, seven countries have established population-wide mean salt intake levels, and all Member States have incorporated salt reduction targets into their respective national plans [18].

Although progress has been made in reducing the double burden of malnutrition, the Southeast Asia Region is still behind in meeting global and local nutrition objectives. Prevalence of malnutrition remains significantly high in countries such as Thailand (8.8%), Indonesia (6.5%), and Cambodia (6.3%) as shown in Fig 3. Progress has also been slow toward the goal of reducing stunting in children under the age of five. Fig 4 shows about 32% prevalence of under-five stunting in Indonesia. This makes Indonesia the country with the highest prevalence of stunting in the SEA. Additionally, when it comes to low birth weight and anemia in women of reproductive age (15 to 49), not a single nation in the Region is on track to fulfill the objectives [18]. When it comes to fulfilling global goals, the area falls short, both in terms of wasting and obesity among children under the age of five. As shown in Fig 5, children who are overweight remains high in Indonesia with Myanmar showing the lowest level of under-five overweight at less than 2% prevalence. It's also worth noting that no Region member state is on track to achieve its goals for women's overweight and obesity [18].

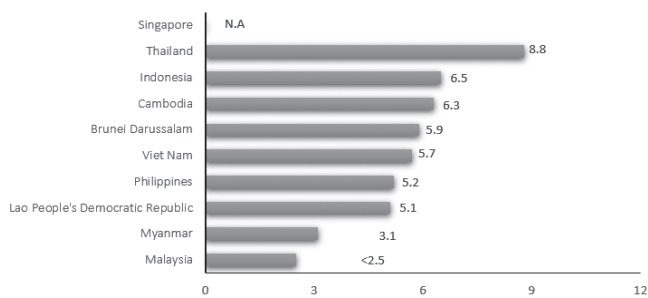


Figure 3: Prevalence of undernourishment in SEA states 2019-2021

Source: FAOSTAT [14]

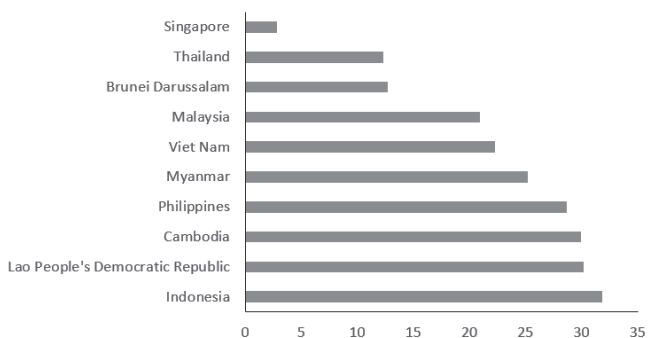


Figure 4: Percentage of children under 5 years of age who are stunted (2020)

Source: FAOSTAT [14]

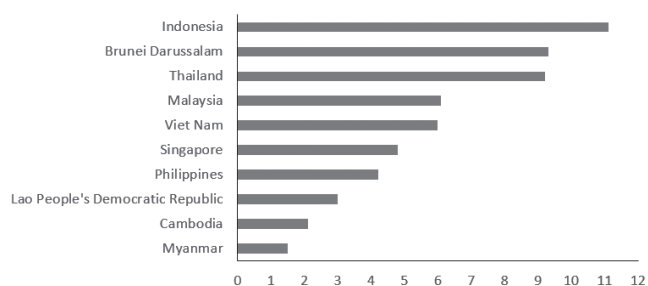


Figure 5: Percentage of children under 5 years of age who are overweight 2020

Source: FAOSTAT [14]

These issues stress the significance of developing strategies that can help curb malnutrition, and at the same time strengthen the supply chain of SEA.

2. Materials and Methods

We undertook a scoping review based on the SCOPUS database for English-language publications from 2015 till date. Using the terms “nutrit*” (where the ‘*’ indicates all forms of words beginning with the indicated characters) AND “supply chain,” AND interventions. The

search string was: (TITLE-ABS-KEY (nutrit*) AND TITLE-ABS-KEY (“Supply chain”) AND TITLE-ABS-KEY (intervention*)) AND PUBYEAR > 2014 AND PUBYEAR > 2014.

Our search returned 78 documents. Title screening was carried out to identify studies addressing interventions that addressed both supply chain and malnutrition. This was done in order to recommend strategies that SEA can apply to boost supply chain resilience whilst addressing the growing issue of malnutrition. After title screening, the researcher transferred included publications to Endnote software for analysis. From this point forward, the abstracts were screened followed by reading full texts by researchers. Consequently, 70 studies were excluded while 8 studies were included for the final scoping review of interventions.

3. Results

Eight studies were found to address interventions to tackle malnutrition and inform policy changes especially during periods of supply chain disruptions [19–26].

Two studies analyzed school feeding programs where Singh and Fernandez [21] analyzed the impact of the school feeding program in Ghana on diversified food production and consumption and Chote et al [23] analyzed the school feeding program in deprived communities in New Zealand. Singh and Fernandez [21] noted that the school feeding program led small farmers in North and South of Ghana to produce these foods. Thus, more inter-food group diversity for tubers and dark, leafy green vegetables in the South Island was reflected in a higher share of households producing these foods in this region as compared to the North Island of New Zealand. Conversely, the greater diversity of cereals in menus from the North was reflected in the higher production levels of this food group in the region. Chote et al [23] highlighted the importance of teacher support in engendering school children to try new and healthier foods.

Two studies analyzed interventions focusing on fortification of foods for under five and preschool children [22,25]. Le Port et al., [25] in a randomized controlled trial analyzed the possibility of leveraging the dairy value chain to supply micronutrient fortified yoghurt to curb anaemia. The study confirmed that this strategy was successful in reducing Haemoglobin levels for under-five children. With respect to Leyvraz et al., [22] the study analyzed the acceptance of the free fortified complementary food product, Bal Amrutham, in India. The authors observed that Bal Amrutham was widely accepted and consumed by the Indian populace and highlighted the need to improve the food supply chain.

Two studies noted the importance of curbing waste [19,24]. Van Doren et al. [19] analyzed the impact of the Eetmaatje cups in curbing waste in Dutch households. The study observed that the cups were found useful by 85–89% of the study population 77–87% of participants were convinced that the Eetmaatje helps them waste less pasta and rice. Thus, the study highlighted the impact of measurement cups in curbing losses. Shepon et al., [24] quantitatively examined the extent to which the final supply of omega-3 can be increased from present baseline using the current wild harvest base and without aquaculture expansion. This was done using material flow analysis. The results suggested that the omega-3 supply chain can be optimized through structural changes in aquaculture, utilization of byproducts, and reduction in losses

such that the overall final supply of omega-3 will grow by up to 50%, nearly closing the present nutrient gap. The study further recommended shifting consumption patterns towards specific fish groups (e.g. carps, catfish and cyprinids) and marine wild caught seafood to improve resource use efficiency.

Verwaart et al., [20] applied a Value Chain Lab that supports the measurement of behavioral change in vertically structured supply-chain relationships. This was done through a participative gaming approach that helps identify changes in mutual trust, transaction costs and risk behavior that result from value chain support and co-operation. The study noted the importance of trust and loyalty in value chain relationships, especially in the context of local small holder farmers.

5. Conclusions

Supply chains play a crucial role in ensuring food security and alleviating malnutrition in Southeast Asia (SEA). The disruptions caused by COVID-19 and other structural challenges have underscored the need for resilience and efficiency within the food supply network. In this section, we outline strategies leveraging supply chain improvements to mitigate food insecurity and malnutrition in the region.

5.1 Supply Chain Optimization for Nutrient-Rich Food Distribution

A well-structured supply chain can enhance the accessibility and affordability of nutritious food, particularly in remote or impoverished regions. Table 1 highlights key areas where supply chain interventions can have the greatest impact.

5.2 Role of Technology in Strengthening Food Supply Chains

Technological innovations, such as blockchain, AI-powered logistics, and 3D food printing, can improve food safety and distribution efficiency. Blockchain technology ensures traceability,

Table 1: Key Supply Chain Interventions for Food Security

Intervention	Impact
Strengthening cold chain logistics	Reduces food waste, ensures nutrient retention
Decentralized food storage hubs	Increases access to fresh produce in rural areas
Digital supply chain tracking	Enhance transparency and efficiency
Farm-to-school programs	Supports local farmers, improves child nutrition
Reduction of food loss	Optimizes resource utilization, reduces costs

reducing the risk of fraud and contamination, while AI-driven forecasting helps optimize inventory levels.

5.3 Enhancing Cross-Sector Collaboration

Collaboration between governments, private enterprises, and NGOs is vital for a resilient supply chain. Policymakers should prioritize infrastructure development, incentivize sustainable farming, and establish strategic reserves for staple foods.

5.4 Future Outlook and Suggestions

To achieve long-term food security in SEA, policymakers must embrace a data-driven, multi-stakeholder approach that integrates supply chain efficiency with public health initiatives. Encouraging local food production, reducing waste, and investing in resilient logistics systems will be critical steps toward reducing malnutrition and strengthening regional food security.

By leveraging supply chains strategically, SEA nations can combat malnutrition, reduce food waste, and ensure a more sustainable food ecosystem. The adoption of digital tracking systems, enhanced logistics, and coordinated policy frameworks will pave the way for a more resilient and equitable food supply chain across the region.

Recommendation

Future studies should utilize systematic review methods using more databases to be able to identify an extended list of interventions that addresses the issue of malnutrition. Further empirical studies to investigate how the benefits of the proposed strategies benefit the population living in areas that are difficult to reach due to the lack of transport infrastructure. SEA policymakers can consider the key findings in terms of strategies for reducing malnutrition through supply chain improvements.

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