

Food Insecurity, Population Health and Food Supply Chain: A Framework Integrating Three Constructs*

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Abstract

Design/methodology/approach: food insecurity is discussed within population health and food supply chain framework. Research shows that food insecurity is one of the three main causes in impacting population health. After exploring the relationship between food insecurity and population health, this study explores possible solutions to address food insecurity through food supply chain management framework. Food supply chain is different from commercial supply chain in many important attributes. Literature does not provide research framework linking these three attributes (food insecurity, population health and food supply chain). Therefore, we use an exploratory map to build roadmap to a successful integration of these three attributes. *Purpose:* social determinants of health are considered as a precondition for population health. Food security forms basis for catalyst in population health. Food security touches human dignity. Many people face starvation while tons of foods are wasted globally. There is a mismatch between supply and demand for food production and consumption. Distributions of foods from producers to consumers become a focal point in managing starvation and waste/glut of foods. The purpose of this paper is to investigate how food supply chain mitigates food insecurity and provides sustainable food supply. *Findings:* this paper reveals mismatch between supply and consumption of food at a global scale. Inadequate supply chain assets -technologies, storages, distribution networks, etc. - at the producer's ends causes lower return on investments for producers. Unique characteristics of food supply chain compared with commercial supply chain raises challenges to the imbalance between supply and demand. Oligopolistic market structure may solve the chronic mismatch. *Originality/value:* literature addresses these three constructs – food security, population health and food supply chain – separately and independently from each other. This paper argues these three constructs should be addressed together in order to solve global food insecurity and waste. As far as we know, this is the first attempt to unify these three constructs.

Keywords: population health, food insecurity, social determinant of health, food supply chain, digital supply chain.

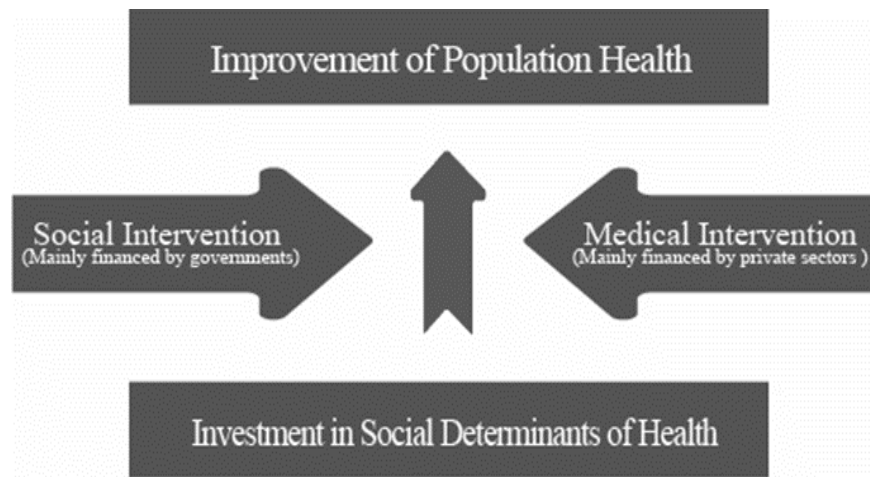
Section 1: Introduction

Recently discussions of health management have shifted from medical intervention to a comprehensive population health concept (Kim and Kwon, 2020). Such a shift is a result from less than satisfactory health outcomes based on medical intervention in the United States. No credible relationship has been reported between population health and investment in healthcare. Search for possible reasons for such weak relationship between these two constructs (health status and the amount of investment in health care system) compels us to look into other areas that we may have neglected.

One of the new approaches that have been actively discussed in academics and adopted in policy arena is population health concept. This concept is not a new. Kindig and Stoddart (2003, italic added) suggested that the nation's health should be measured by population health; "the health outcome of a *group of individuals*, including the distribution of such outcomes *within the group*. The concept of population health implies that the nation's health is depending on collective health of different groups in the society who have a wide different background in health, wealth, food security, social networks, and other important attributes that shape the people's health. The basket of such attributes defines community and nation's health. Medical intervention is only a part of intervention that improves nation's health.

World Health Organization recognizes importance of such "basket (population health)" called social determinant of health (SDOH). Recognizing importance of SDOH as a main driver of population health, WHO formally defined SDOH as "The conditions in which people are born, grow, live, work and age" and the fundamental drivers of these conditions (WHO, 2008; Marmot and Allen, 2014). The fundamental drivers in SDOH, therefore, precede any medical intervention. "The purpose of medical intervention is to cure illnesses that have already occurred and progressed while social intervention through SDOH prevents such health issues from occurring (Kim and Kwon, 2020, P. 2). It follows then when an adequate investment in social environment is made, there will be less need for medical intervention. This line of argument in improving the nation's health through SDOH appears to have made a track in the United States by health care leaders and clinicians (Eisenenson and Mohta, 2020). For example, it is reported that SDOH was estimated to account for 70% of avoidable mortality (McGinnis, Williams-Russo and Knickman, 2002).

Based on studies of population health through SDOH, Kim and Kwon (2020) propose a road map on how to improve population health as shown in **Figure 1**.

Figure 1: Formation of Population Health

Adopted from Kim and Kwon (2020) with permission

It is apparent from Figure 1 that social determinants become the most critical area in improving population health. Without adequate investment in the areas of social determinant, the population health may not be improved irrespective of investments in medical areas. The purpose of this paper, therefore, is to investigate how food supply chain improves population health, mitigates food insecurity, and provides sustainable food supply. This paper consists of 6 sections. A brief description of social determinants of health is introduced in Section 2 in the context of population health. A role of food supply chain in population health will be introduced in Section 3 to set a stage of contrasting food supply chain with commercial supply chain in Section 4 which is followed by a framework of building sustainable food supply chain in Section 5. Conclusions of this paper are presented in Section 6.

Section 2: Social Determinants of Health and Food Insecurity

Literature indicates that the fundamental drivers of social determinants of population health include broadly three categories; healthy housing/community, accessible transportation systems (Nichols and Taylor, 2018) and food security; nutritious food supply (Oss, 2014). This paper addresses only food insecurity in conjunction with the population health and food supply chain.

Food insecurity, a lack of resources to purchase and consume nutritious foods, is a leading health issue in the United States (Gundersen and Ziliak, 2015). For example, the food insecurity is associated with an increased risk of birth defects, anemia, lower nutrient intakes, cognitive problems, and aggression and anxiety. It is also associated with higher risks of being hospitalized and poorer general health and with having

asthma, behavioral problems, depression, suicide ideation, and worse oral health. It is also reported that children in food-insecure households had 2.0~3.0 times higher odds of having anemia compared with their counterpart, 2.0 times higher odds of being in fair or poor health, and 1.4-2.6 times higher odds of having asthma. It is also reported that for those who enrolled in their nutrition study, the mean monthly ER visit decreased for three consecutive months compared with the control group (0.2. vs. 0.4) and the total monthly costs associated care decreased from \$40,9 06 to \$28,268 ($P < 0.01$) (Gurvey, 2013).

Disconnected food supply chain causes diametrical imbalance in food production and consumption leading to global health issues. While over 800 million people do not have enough food and 3 million children die each year due to malnutrition, 650 million were obese in the world (FAO, 2017)wasting 1.6 billion tons of food, worth about \$1.2 trillion. In 2030, such waste will go up to 2.1 billion tons worth \$1.5 trillion (Hegnsholt *et al.*, 2018). On the other hand, in developing countries, the poor spend 60~80% of their income on food leaving not much for other areas including healthcare, while in developed countries, only 10% spending on food. Three billion people around the world survive on \$2.50 a day or less. It has been reported that on a per-capita basis, much more food is wasted in the industrialized world than developing countries. We estimate that the per capita food waste by consumers in Europe and North America is 209 ~ 253 pounds per year, while this figure in sub-Saharan Africa and South/Southeast Asia is only 13.2 ~ 24.2 pounds/year (6-11 kg). (Meybecket *al.*, 2011).

It appears that the food system has to deal with diametrical challenges; food insecurity primarily in developing countries while glut and waste at the consumer side mainly in developed countries.

Section 3: Food Supply Chain in Population Health

It is estimated that two-thirds of food wasted (about 1 billion tons) has occurred in the food supply chain (FSC) domain (Fritz and Schiefer, 2008). FSC is lengthy (sourcing, planting/production, processing, packaging, storage, transportation, distribution, wholesales, retail stores and to consumers), complex (many regulations and compliances under local, regional and country jurisdictions), sensitive to climate change (unpredictable outside interference where players have little or no control) and is loaded with requirements on safety and traceability (Department of trade and Industry, 1995).

Introduction of genetically modified seeds to the farming communities presents another challenge as farmers have many choices in selecting inputs (seeds). There are multiple combinations in seeding crops. Producers especially in Africa and Southeast Asia are rarely equipped with knowledge of using the right seeds in the right place at

the right time. Failure using modern technologies may result in less-than-optimal yields.

Once harvested, it takes time to process the crops and many producers (farmers) are lacking facilities (storage). Much yields either are wasted (rotten) or dumped to oligopolistic buyers' market with lower than market prices. Farmers/producers, therefore, face an endless cycle of waste and low returns from their investment. Such vicious cycles are exacerbated by outside uncontrollable interference such as weather, unrest (e.g., war in Ukraine), epidemic, etc.

In addition, food supply chain requires special and unique transportation and storage and distribution facilities in order to preserve the original contents. In many instances, local ordinances, regulations and compliances require special storage facilities (e.g., cold chain) suitable for perishable products. Cold chain requires a heavy investment that producers (farmers) rarely can afford. Packaging becomes an important requirement for quality and traceability. Consumers often purchase food items based on its content on the labels, and, therefore, packaging has to be in such a way to be easily visible, identifiable and informative. In addition, packaging in food distribution serves as an important role in the sustainability process.

Almost every player in FSC is aware of sustainability issues; and packaging is one of the most effective and important communication medium informing consumers where and how they can contribute toward sustainability efforts along the FSC. Consumers are increasingly paying attention to products they are consuming from the labels on the packages. They pay attention where, how, and who produce the products; whether producers and processors are employing forced labor, using underage labor, abuse of animals during the production processes, etc.

Section 4: Food Supply Chain vs. Commercial Supply Chain

As discussed above, food supply chain has unique characteristics compared with the commercial supply chain. However, we argue that *fundamentals* of food supply chain are identical to those in commercial supply chain; product design to consumption. Yet, due to unique requirements, characteristics and circumstances described in the previous section, food supply chain is operating under different sets of circumstances. Some of the characteristics between food supply chain and commercial supply chain are summarized in Table 1 below.

Table 1: Comparative Attributes between Food Supply Chain and Commercial Supply Chain

Attributes	Food Supply Chain	Commercial Supply Chain
Production facilities	Unmovable and local	Flexible and global
Environments	Vulnerable	Controllable
Safety, quality and traceability	Critical and essential	Manageable
Transportation modes	Mainly cold chain	Multiple choices
Inventory management	JIT mode in disconnected chain	Optimum inventory strategy throughout chain
Product life cycle	Short	Long
Regulations and compliances	Numerous. (Local/Country specifics)	Simple and universal
Sustainability effort	Production area	Consumption area
Market structure	Oligopoly	Competitive

Safety, quality and traceability are core requirements in food supply chain as products in the food supply chain directly affects health and environments. Regulations and compliances in food supply chain, therefore, are extensive and global in nature compared with other supply chain operations. Most of products from food supply chain are targeted to local and regional markets as opposed to global markets for commercial supply chain. Food supply chain mainly deals with products with short life cycles compared with those in commercial supply chain. As such, just-in-time inventory management is a predominant tool in inventory management as opposed to optimum inventory management used in commercial supply chain. Just-in-time inventory management requires unique set of transportation modes such as less-than-truckload (LTL) modes.

Food supply chain has to deal with uncertain environments such as unpredictable weather, floods, threat of earth quacks and political unrest as their production facilities are unmovable. Since most waste occurs at production sites due to insufficient investments in technologies and logistics facilities, sustainability effort in food supply chain has to start at production areas as opposed to consumption sites in commercial supply chain. Market structure in food supply chain is characterized as oligopolistic nature where few buyers exercise their buying powers over producers.

Section 5: Building Sustainable Food Supply Chain

The food supply chain has two fundamental goals; to improve producer's yield by managing better food distribution in order to reduce global waste and meet consumer's demand. Research indicates that enough food is produced to feed the entire population if distribution is coordinated on a global scale. Producers should be rewarded sufficiently enough to reinvest their earnings into a technology-based production platform. Machine

learning would assist producers in managing better environmental forecasting, market fluctuation, consumption patterns and subsequently reduce waste at production sites. Distributors, on the other hand, can play an important role by working closely with producers. Distributors have first-hand knowledge on consumer preferences. In addition, distributors have assets in logistics (warehousing, transportation, and technologies) which facilitates production flows from producers to consumers. Perhaps it may be easier and simpler if producers form semi-monopolistic seller's markets where they deal with distributors in one coherent voice. Such an approach may also improve information flow which, in turn, improves food supply chain operations.

Producers and distributors together need to build a supply chain that is sustainable to the vulnerable external environment. Sustainable supply chain requires more than investment in technologies. Technologies are tools and not ultimate goals. Supply chain is a journey from sourcing to the final destination, along which each player exercises its best intention to improve the partners to achieve the ultimate goal (profit). We embark such journey based on unwritten assumption that their partners act based on relational trust (Ellram and Cooper, 2014). Supply chain should be built on a strong foundation; trust-led-commitment. Trust is built based on information sharing and collaboration (Kwon and Suh, 2004). Once trust is broken, commitment cannot be expected. It is safe to say that supply chain survives or dies based on commitment by players in the chain. Of the three critical components in a supply chain management strategy, the relationship management based on collaboration and trust is perhaps the most fragile and tenuous. This is because of the high importance placed on trusting relationships where each party in the supply chain has mutual confidence in the other members' expectations, capabilities and commitments (Handfield and Nichols, 1999). Zak's study (2017) shows that compared with people at low-trust companies, people at high-trust companies report 74% less stress and 29% more satisfaction with their lives, 106% more energy at work and 50% higher productivity, and 13% fewer sick days and 40% less burnout. Supply chain built on "sand" is incapable of sustaining external "shocks" and highly vulnerable to internal discord. Assis, Lucas and Rainho (2022, P. 1) argue that "trust is one of the most prominent and critical aspect for not only the effectiveness of collaboration, but also for improving sustainability performance. In this sense, the understanding of how trust works in agrifood supply chains is essential to find better paths to improve the functioning of those structures."

Developing and fostering the intended partner's trust is an important first step in managing the relationship (Tejpal, Garg and Sachdeva, 2013). Trust is considered the single most important variable influencing interpersonal and inter-organizational behavior (Kiessling, Harvey and Garrison, 2004). Maintaining a mutual relationship between partner companies based on trust contributes to enhanced supply chain management performance (Park, Chang and Jung, 2017). Loss of trust with suppliers, on the other hand, costs Chrysler \$24 billion in profit over the past 12 years (Henke,

Stallkamp and Yeniyurt, 2014). Trust led commitment is even more critical during the digital transformation in supply chain (Kwon *et al.*, 2021).

Section 6: Conclusion

Food supply chain faces diametrical challenges; unstable production creating food insecurity on one hand and waste of tons of valuable foods at the consumption level. It has been reported that we produce enough food to feed the entire population. The issue is distribution networks along the food supply chain. Global food distribution network would be an ideal forum in managing food distribution and would play an intermediating role between producers, buyers, and consumers in different regions around the world where food insecurity is severe enough to raise fear of starvation. Food logistics professionals could use the Global Food Security Index (consisting of such variables as from nutritional standards to food safety) as a baseline to place logistics assets where needed the most. Securing food by Food and Agriculture Organization (FAO) is only half of the solution. In order to solve world food insecurity and improve population health, food has to be distributed to areas needing it the most. Logistics assets (warehousing, packaging, transportations etc.) are very expensive. Countries where such assets are needed the most are unable to afford it. Global public and private investments partnership could be one of the solutions. Partnerships with private investment require adequate and reasonable return on investment. The World Bank, IMF etc., may be good sources to explore possible partnership.

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