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Covid-19 pandemic in the lens of food safety and security

Nyuk Ling Ma[a,b,*], Wanxi Peng[a], Chin Fhong Soon[c], Muhamad Fairus Noor Hassim[b], Suzana Misbah[b], Zaidah Rahmat[d,e], Wilson Thau Lym Yong[f], Christian Sonne[g,a,**]

[a] Henan Province Engineering Research Center for Biomass Value-added Products, School of Forestry, Henan Agricultural University, Zhengzhou, 450002, China
[b] Biological Security and Sustainability Research Group (BIOSES), Faculty of Science and Marine Environment, Universiti Malaysia Terengganu, 21030, Kuala Nerus, Terengganu, Malaysia
[c] Biosensor and Bioengineering Laboratory, Microelectronics and Nanotechnology-Shamsuddin Research Centre, Universiti Tun Hussein Onn Malaysia, 86400, Parit Raja, Batu Pahat, Johor, Malaysia
[d] Faculty of Science, Universiti Teknologi Malaysia, 81310, Johor Bahru, Johor, Malaysia
[e] Institute of Bioproduct Development (IBD), Universiti Teknologi Malaysia, 81310 Johor Bahru, Johor, Malaysia
[f] Biotechnology Research Institute, Universiti Malaysia Sabah, Jalan UMS, 88400 Kota Kinabalu, Sabah, Malaysia
[g] Aarhus University, Faculty of Science and Technology, Department of Bioscience, Arctic Research Centre (ARC), Danish Centre for Environment and Energy (DCE), Frederiksborgvej 399, POBox 358, DK-4000, Roskilde, Denmark

A R T I C L E I N F O

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A B S T R A C T

The recently emerged coronavirus disease (COVID-19), which has been characterised as a pandemic by the World Health Organization (WHO), is impacting all parts of human society including agriculture, manufacturing, and tertiary sectors involving all service provision industries. This paper aims to give an overview of potential host reservoirs that could cause pandemic outbreak caused by zoonotic transmission. Amongst all, continues surveillance in slaughterhouse for possible pathogens transmission is needed to prevent next pandemic outbreak. This paper also summarizes the potential threats of pandemic to agriculture and aquaculture sector that control almost the total food supply chain and market. The history lesson from the past, emerging and reemerging infectious disease including the Severe Acute Respiratory Syndrome (SARS) in 2002, Influenza A H1N1 (swine flu) in 2009, Middle East Respiratory Syndrome (MERS) in 2012 and the recent COVID-19 should give us some clue to improve especially the governance to be more ready for next coming pandemic.

1. Introduction

The human population is estimated to reach 10 billion by the year 2050 which raises a significant concern on the safety and continuous food supply. The demand for meat, dairy, and highly processed food has increased particularly in the higher urban areas (FAO, 2017). This scenario has greatly escalated the process of industrialisation of animal-derived products and agricultural activities to meet the global food demand. While the demand is projected to remarkably increase, the emergence of zoonotic diseases has also occurred at an accelerating rate. The World Health Organization (WHO) has estimated that zoonotic transmission from animals to humans contributes to 75% of new emerging infectious diseases (WHO, 2014). Agricultural drivers are reported to be associated with more than 50% of zoonotic infectious diseases (Rohr et al., 2019). These are due to substantial increase in crop and animal production that expand agricultural use of water, fertiliser, and antibiotics, including frequent contact between humans and animals, which allows the emergence of infectious pathogens. Production of animal livestock has shown to increase the risk of zoonotic infections due to frequent animal-human close interactions (Lowenstein et al., 2016). Such transmission occurs via direct contact with infected animal during handling and slaughtering, or consumption of the undercooked meat and animal products. Livestock producers are also exposed to the pathogens when using the animal waste as a fertiliser on their crops and during handling sick or dead animals (Goodwin et al., 2012). Animals raised in sub-urban agriculture have a higher risk for zoonotic disease

* Corresponding author. Henan Province Engineering Research Center for Biomass Value-added Products, School of Forestry, Henan Agricultural University, Zhengzhou, 450002, China.
** Corresponding author. Henan Province Engineering Research Center for Biomass Value-added Products, School of Forestry, Henan Agricultural University, Zhengzhou, 450002, China.
E-mail addresses: nyukling@umt.edu.my (N.L. Ma), zaidahrahmat@utm.my (Z. Rahmat), wilsonyg@ums.edu.my (W.T.L. Yong), cs@bios.au.dk (C. Sonne).

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transmission due to poor living conditions, and competition for space and food (Slingenbergh et al., 2004). Furthermore, higher transmission occurs in 90% study of households living with dogs, as they carry parasitic flatworms *Echinococcus* sp. that can be transmitted to livestock and humans by ingestion of food and water contaminated with the dog faeces (Sack et al., 2018).

Zoonotic diseases also include those caused by enteric bacteria such as *Campylobacter* sp., *Salmonella* sp. and *Escherichia coli* associated with poultry or livestock farms (Fischer et al., 2012; Hermans et al., 2012; Singh et al., 2013). These animals are commonly treated with antimicrobials, however inappropriate use of the antimicrobials may lead to the development of antimicrobial-resistant bacteria (Shallcross and Davies, 2014). Other important zoonotic diseases include those caused by viruses such as the highly pathogenic avian influenza viruses that have ravaged the poultry industry in many countries (Yang et al., 2019; Zhu et al., 2017). The avian influenza was evolved from avian influenza (subtype H5N1) originary from wild birds and domestic duck (Lee et al., 2005; Tumpey et al., 2002). In Malaysia, the outbreak of Nipah infection in 1998, affecting pig industry has resulted in the culling of over 1 million pigs and 40% of human death cases who directly contact with infected pigs (Lam and Chua, 2002; Parashar et al., 2000). Re-emergence of Nipah virus infection occurs in Meherpur and Naogaon, Bangladesh, demonstrated a total of 17 death, most have exposure to the common infectious source (Hsu et al., 2004). Apart from that, sporadic hepatitis E viral infection has been reported in 90% of patients in Hokkaido, Japan, due to consumption of inadequately cooked pig liver (Yazaki et al., 2003). Hepatitis E virus is known to be able to shed into the environment through faeces containing high levels of virus and spreads into the human population via faecal-oral route.

Amongst all well known viral zoonosis disease, the largest viral zoonosis is the severe acute respiratory syndrome (SARS) coronavirus, which contributes to the high mortality rates in humans and animals (Guan et al., 2003). Previous outbreaks of human severe acute respiratory syndrome (SARS-CoV) in Guangdong, China, followed by the Middle East respiratory syndrome coronavirus (MERS-CoV) in Saudi Arabia have shown viral transmission from masked palm civets and dromedary camels to humans, respectively (Peiris et al., 2003; Zaki et al., 2012). Both SARS-CoV and MERS-CoV are highly fatal and found to be originated from bats (Su et al., 2016). Additionally, an outbreak of a fatal swine acute diarrhoea syndrome coronavirus (SADS-CoV) infecting pigs in Guangdong, China is caused by a novel coronavirus associated with horseshoe bats (Zhou et al., 2018). The current coronavirus disease 2019 (COVID-19) pandemic is a severe respiratory illness caused by SARS-CoV-2 virus, first reported in Wuhan, China. The virus is transmitted through direct exposure to respiratory droplets of an infected person or by direct contact to virus-contaminated surfaces (Wu et al., 2020). COVID-19 transmission has not been shown caused by food consumption, however it was suggested that the emergence of SARS-CoV-2 virus could be due to human exposure to domestic animals or wild captive animals such as bats, snakes, marmots and civets at the Huanan Seafood Wholesale Market in Wuhan (Ahmad et al., 2020; Hui et al., 2020; Ji et al., 2020). These observations are derived from previous findings that coronaviruses are zoonotic basis circulating between various animal species and humans (Cui et al., 2019). Similar to the current COVID-19, bats are most likely the ecological reservoir of the SARS-CoV-2, due to the high sequence similarity (96%) of the virus with a bat coronavirus (Zhou et al., 2020). Identification of bats as the reservoir for most viral zoonoses highlights the importance of bats as a source of other lethal viruses, such as Ebola and Marburg viruses (Leroy et al., 2005; Towner et al., 2007). While humans do not usually encounter bats, it is suggested that the virus transmission occurs through an intermediate host. The role of intermediate hosts is suggested to drive virus adaptation prior to transmission into another susceptible animals (Chan et al., 2013. This is possible particularly in captive spaces such as in wet markets, by which overcrowding of various wildlife may facilitate the viral transmission into different animal species.

With the current expansion of human population, increased intrusion of humans into wildlife habitats due to and migration into new localities particularly near deforested areas, brings human closer into animal populations carrying infectious pathogens (Michelotti et al., 2018). This increases the risk of viruses being able to infect humans through transcutaneous, mucosal routes or via virus-contaminated materials (Cantlay et al., 2017). Besides that, hunting of wild animals obtained from the wild increased the risk of zoonotic disease transmission. For example, bushmeat trade in the Cross-Sanaga Rivers, Nigeria has traded over 900, 000 kg every year (Fa et al., 2006). Thus, the bushmeat derived from wildlife animals have posed a significant threat associated with the global meat market (Cantlay et al., 2017).

Given the current demographical, sociological and economical changes due to the expansion of human population and advanced transportation of living animals, the potential emergence of new viruses, evolution of older viruses into new clades or transmission route from various host or reservoirs is currently uncertain. However, in the One Health approach, the health of humans, animals and the environment are inextricably linked that brings together interdisciplinary research to communicate and collaborate for better management of infectious diseases (Garcia et al., 2020). Clearly, there is a linear relationship of human dominated ecosystems with zoonotic diseases transmission (Gibb et al., 2020), based on the current developmental trend, it is impossible to reverse the urbanisation therefore a better understanding of the epidemiology and pathogenesis of these zoonotic diseases is essential in order to break further transmission into susceptible hosts (Cobey, 2020).

2. Economic impact of pandemics on the food and agricultural sector

In the recent COVID-19 outbreak, many countries have imposed lockdown and travel restriction to curb the infection. Although there is no evidence showing that the Sars-Cov-2 can be transmitted through food, COVID-19 have an economic impact on the food and agricultural sector. Affected countries were forced to re-examine and change their food and agriculture policies to ensure their food supplies remain available and affordable to the public. Moreover, at the time of COVID-19 outbreak, the food security in Central and East Africa is also threaten by locust infestation depleting food resources, forcing 20.2 million people from 8 countries into severe acute food insecurity (FAOa, 2020; Roussi, 2020). Countries that are under civil unrest, political isolation or underinvestment in public health worsen the pandemic impacts to the food supply chain. War-torn countries such as Yemen, Sudan and Syria are the most vulnerable states in term of food security. Prior to the pandemic, over 80% of Yemen's population dependent on food aid and facing acute food insecurity. In Syria, 9.3 million people are food insecure due to record-high food price inflation. Sudan currently facing strict curfew while the food price inflated to 82% in April compared to the previous month (Plecher, 2020). This would make achieving the Zero Hunger goal by 2030 to be less likely (UN, 2015). According to the report of United Nations, the food insecurity was already on the rise from 23.3% to 26.4% for 2014 to 2018; before the onset of COVID-19 at September 2019, around 821 million people i.e. more than 10% of the world's population are experiencing hunger (FAO; IFAD; UNICEF; WFP; WHO, 2019). The COVID-19 pandemic has affected the food supply to another 260 million people by the end of 2020 (Anthem, 2020; FAOb, 2020). Prior to the pandemic, 135 million people in 55 countries with low and middle income is already suffered from food security and this number is expected to double due to COVID-19, climate shocks, locust outbreaks and armed conflicts that all threat the food system (FSIN; GNAFC, 2020).

The aspects of food security during the COVID-19 pandemic need to be addressed including a) availability, b) access, c) utilisation and d) stability (Zurayk, 2020). Availability and access of food are most vulnerable during COVID-19 outbreak due to problems with transportation, distribution and delivery (Galanakis, 2020; Vallianatos et al.,

2010) (Fig. 1). As restrictions set in, availability of food stocks may be disrupted to a certain extent, hindering import and export. Countries need to ensure they have a sustainable food reserve to meet market demand. Even planting of crops for continuous supply will be delayed due to late harvesting caused by limited number of workers (Zurayk, 2020). These would further affect accessibility to food supply that could disrupt nutrition and dietary recommendations. Diet plays an important role and lack of protein and specific micronutrients have been associated with increased susceptibility to infection (Gleeson et al., 2004). In contrast, good gut microbial composition attributed from a healthy diet of well-balanced food may increase immune response (Wypych et al., 2017). In summary, the above raised issues could be categorised into five threats to global food security (Sova, 2020). First, pandemic threaten nations that are suffering from pervasive poverty and poor healthcare infrastructure. Second, pandemic threaten nation that lacking robust social safety nets. Third, pandemic has proved especially deadly for people suffering from chronic or acute hunger or malnourishment (Chen and Mao, 2020; Hobbs, 2020). Fourth, pandemic may cause breaks in the food supply chain, food shortages and food price spikes. Clearly, pandemic cause the global economy to slow or fall into recession, exacerbating extreme poverty and hunger (Sova, 2020). Moreover, the decision of one nation in their international trade policies

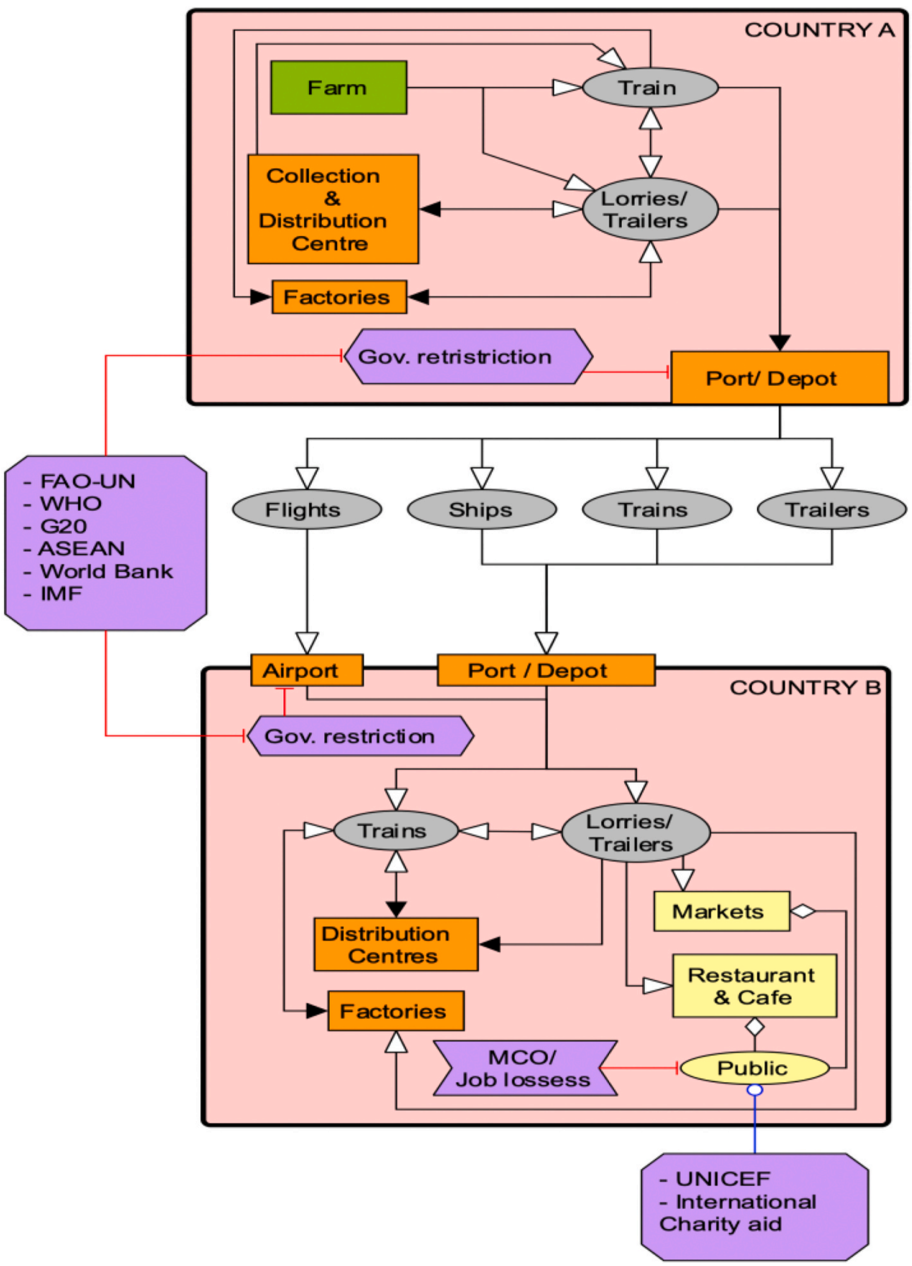

Fig. 1. Flow diagram of the international supply chain for agricultural and food sector during the pandemic. The diagram is drawn using process description languages of System Biology Graphical Notation edge: inhibition; production direction; stimulation; and catalysis. Nodes: location; phenotype (domestic situation); perturbing agent; complex (stimuli); and unspecific entity. MCO - movement control order; SME – small-medium enterprise. The construction method of the SBGN diagram is described in Mohd Khalim et al. (2017).

could have domino effect threatening food accessibility of other nation. Therefore, coordination and cooperation at the global level are critical during this period onward.

The G20 Trade and Investment Ministers meeting and G20 Extraordinary Agricultural Ministers meeting in March and April 2020 yield to fruitful agreement for global food trade stability and continuity (G20, 2020; G20, 2020). ASEAN ministers of Agriculture and Forestry (AMAF) also issued a Joint Statement to ensure the sustainable supply of sufficient, safe and nutritious food during and after the pandemic (AMAF, 2020). The global food supply is reported to mainly affected by the currency exchange rate and 13% declined in global GDP in the first half of 2020 due to export ban (Fernandes, 2020). The rapid spreading of COVID19 worldwide resulted to the closure of European Union external boarder for the first time in history and massive restriction of air travel to contain the spreading of COVID-19 (Linka et al., 2020). While the current restriction on air transportation would significantly reduce the outbreak, it has greatly affected the food of high valued commodities such as fruits, vegetables, meat, etc. Staple food supply chain such as grains are less likely affected which usually transported via ships or land freights (Fig. 1) (The World Bank, 2020).

The World Bank warned that immediate issues during Covid-19 pandemic disrupt the domestic supply chain while the global food supply remains uninterrupted (Fig. 2) (Malpass, 2020). In comparison with previous food crisis on 2007–2008 caused by the global financial crisis, current world food production is at low risk amid COVID-19 pandemic. For example, the global production of rice from 2002 to 2014 period recorded a 57% increment (Savary et al., 2020) but was only traded between 8% and 10% of total global production to secure local supply (The World Bank, 2020). Nevertheless, major disruption in domestic food supply are caused by labour shortage, logistic bottleneck and loss of income would immediately affect the domestic food supply and accessibility chain during pandemic (Savary et al., 2020; Singh et al., 2020). Domestic food supply also affected by massive wasting of agricultural products that couldn't be transport out during the enforcement of movement restriction control by government (Miwil, 2020; Torero, 2020). Taking Southeast Asia as an example, the disruptions of supply chains could translate into huge demand shocks, for the first quarters of year 2020 only, a 3% decline or 17.03 million tons reduction in aggregate volume of production that estimate affecting 100.77 million individuals were recorded. This economical lost is equivalence to 1.4% decrease of GDP or USD 3.76 billion (Gregorioa and Ancog, 2020). Shortage at the supermarkets is not caused by a disruption in the global supply chain but only a temporal shortage at retailer supply chains due to panic buying by the consumers (The World Bank, 2020) which is quickly resolved at almost all supermarkets across the globe with stabilised supply (OECD, 2020).

The World Bank, WTO, IMF, ASEAN and G20 leaders committed to global collaboration and solidarity during the pandemic (Candia, 2020; Malpass, 2020). The Pan American Health Organisation (PAHO) introduce three main components that the government has to consider in their policy during the pandemic, which is to sustain food availability, food access and food utilisation (Tim et al., 2020). Governments are encouraged to provide financial support to small-medium enterprise since the majority of them are involved in the food and agriculture sector or part of the food supply chain (Barrett, 2020; Malpass, 2020; The World Bank, 2020).

3. Impact on aquaculture industry and way forward

In a response to flatten the curve or slow the rate of new infections, governments in many countries have enforced border shutdowns, travel restrictions and quarantines making every sector bracing for the worst and the aquaculture industry is no exception (Pullano et al., 2020; Rodríguez-Morales et al., 2020). Albeit it is challenging to quantify the full economic impact of one global crisis to the aquaculture industry, the key causes have been identified mainly due to the restrictions on transport and closure of processing factories that connecting producers and consumers (Fleming et al., 2014; Jennings et al., 2016). Prior to the pandemic, aquaculture is one of the most promising sectors in the food industry due to rising demand for fish and aquatic products with the efford to reduce capture fisheries from nature (Fox et al., 2018; Jennings et al., 2016).

Fish and fishery products are the most heavily traded food commodity in the world and many seafood markets have expanded in the recent decades from strictly regional to global levels (Cao et al., 2015; FAO, 2018). Taking the United States as example, 68% of the seafood produce are for trade and estimates that only 4% of mollusks primary point of sales are direct to consumers (van Senten et al., 2020). Therefore, the worldwide lockdown during the COVID-19 pandemic could have major impact on the supply of these food caused by decline of fishing activities worldwide (Fig. 3). The global fishing activity on Mar–April 2020 was about 6.827 mil hours, which was 9.4% reduction as compared to 7.542 mil hours on Mar–April 2019 (Fig. 3). This huge reduction in fishing activities and the stocking of aquaculture products delayed to reach customers could ultimately translate to supply shortage. The subsequence increase in consumer demand and transaction costs will push the market price of fish and aquatic products up, making them unavailable or less affordable for the poor (Bostock et al., 2010). Reduction of sales in this sector is expected to cause millions of small- and medium-scale producers become unemployed worldwide (Fox et al., 2018).

These uncertainties create new challenges that the aquaculture farmers need to address, either by promoting and diversifying their products for wider domestic markets, or by reducing the overall operational and production costs, to protect and maximise the value of their products and maintain a sustainable business (Fernández-Polanco, 2016; Jennings et al., 2016; Kaminski et al., 2020). To reduce labor intensity, improve farming operations and win market trusts, new methods such as intelligent sensors, camera systems and automated or remotely controlled monitoring/feeding strategies may be introduced to create incremental and positive shifts in aquaculture practices (Føre et al., 2018). These computer-based technologies represent a leading-edge innovation in the current age of disruptive technologies and contribute to a new wave of "precision aquaculture" to prepare the industry for the next global pandemic.

In short, the important aspects that require attention for food security include 1) the importance of migrant workers as manpower to provide food supply that was previously invisible to the food system, 2) importance of local food system and 3) supports to local agriculture (Galanakis, 2020). The government needs to take initiative to work together with private sectors, international agencies and local communities to secure essential and nutritious food stocks during the pandemic. Effective communication between government and the public in ensuring sufficient food supply would be seen as a transparent way to convey messages and news while building trust and support at the same time (Gostin, 2006).

4. Advanced technologies offer food safety

Apart from food security supply, the safety of food supply is always being neglected in the food systems; before the onset of COVID-19, most of the consumers are assuming food that they consume is healthy and hygienically safe (Nagyová et al., 2019). Nevertheless, the outbreak of COVID-19 in Wuhan live animal market and later on the second wave of COVID-19 outbreak in China that closely related to contaminated salmon created concern in food safety issue (Huang, 2020). As SARS-CoV-2 is part of the *Coronaviridae* family and genus *Betacoronavirus* that only infect mammals (Lam et al., 2020), therefore salmon is unlikely to have epidemiological role in spreading COVID-19 to humans with proper handling and sanitation process (Bondad-Reantaso et al., 2020).

In food processing framework, slaughterhouse represent a very

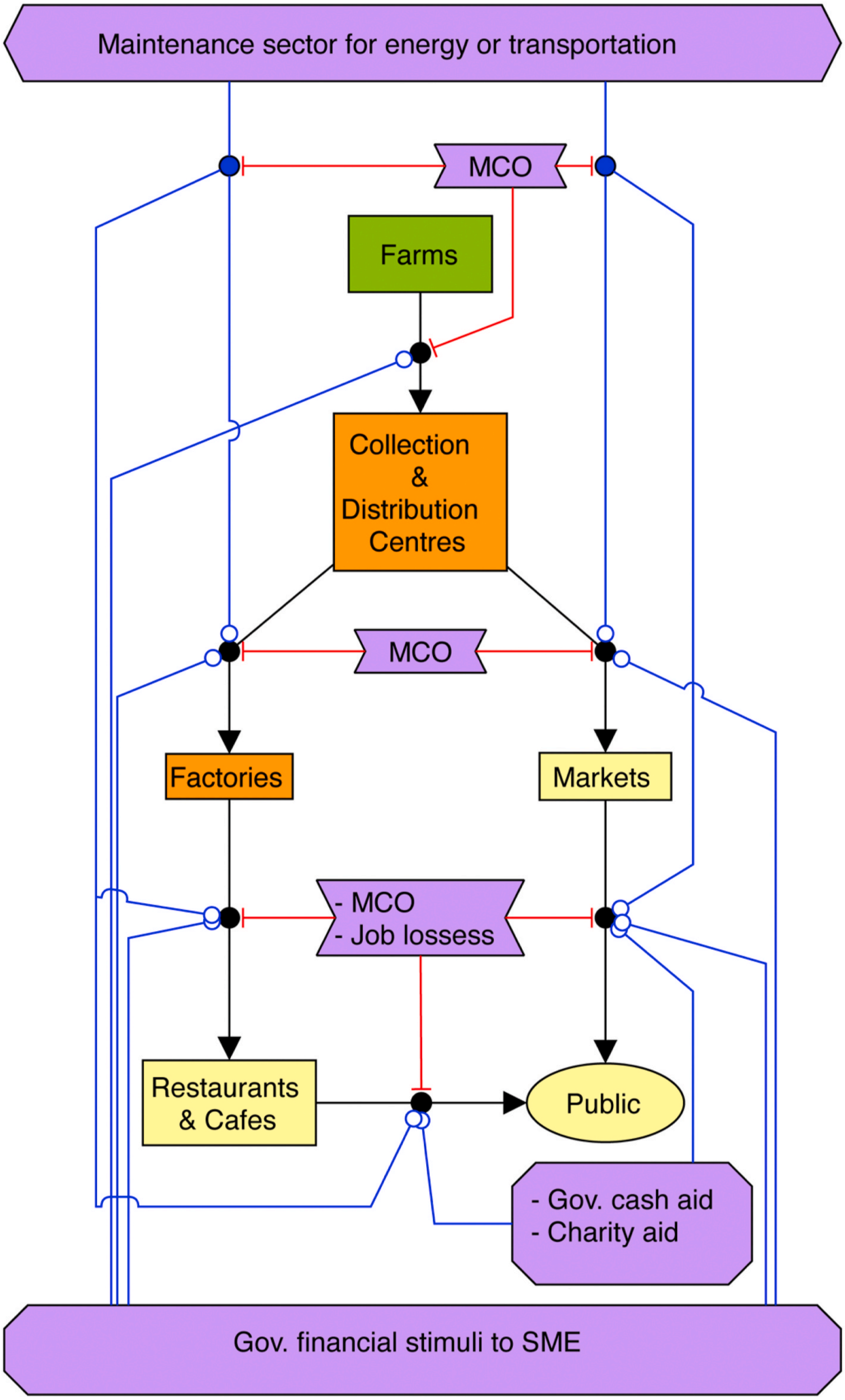

Fig. 2. Flow diagram of the domestic (local) supply chain for agricultural and food sector during the pandemic. The diagram was drawn using entity relationship languages of System Biology Graphical Notation edge: inhibition; production direction; stimulation; and catalysis. Nodes: location; phenotype (domestic situation); perturbing agent; complex (stimuli); and unspecific entity. MCO - movement control order; SME – small-medium enterprise. The construction method of the SBGN diagram is described in Mohd Khalim et al. (2017).

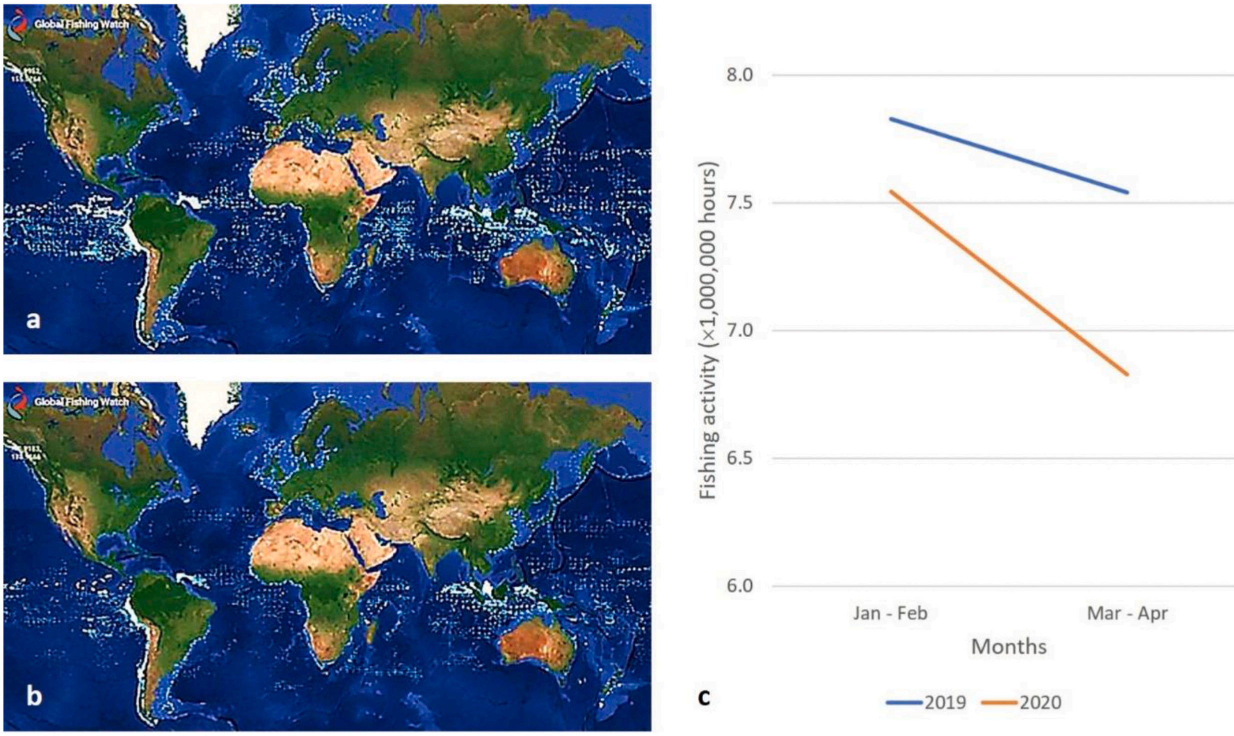

Fig. 3. Global fishing activity (hours, represented by the white dots) for the periods (a) before COVID-19 outbreak (Jan–Feb 2020), (b) after COVID-19 outbreak (Mar–Apr 2020), and (c) fishing activity relative to the year 2019 for the same periods. The data points of fishing activity in (a) and (b) were collected using the Automatic Identification System (AIS) broadcast signals in each vessel and analysed according to the Global Fishing Watch's fishing detection algorithm (Source: Global Fishing Watch, https://globalfishingwatch.org/).

important component but the policy and regulation for implementing slaughterhouse is lacking. To date, no clear regulation for biowaste management including waste water from the slaughterhouse (Bustillo-Lecompte and Mehrvar, 2015) and basic hygienic and food handling practise is also lacking (Adonu et al., 2017), the basic facility of slaughterhouse in some developing country is scarcity such as no roof top and basin for hand wash (Cook et al., 2017). Such condition, is undoubtedly become the reservoir for microbe breeding.

Nevertheless, the utilisation of recent technologies could reduce the transmission of diseases. Severe acute respiratory syndrome-related coronavirus (SARS-CoV) can be inactivated by heat treatments ranging between 56 °C and 75 °C for 60–90 min or, exposure to ultraviolet irradiation for 60 min (Duan et al., 2003). Increased scrutiny for food safety should be applied by ensuring the workers and vendors in the food processor had their temperature screened, hand washed before entering their facility and with proper personal protective equipment to mitigate diseases transmission. In addition to food handler control, Ultraviolet-C (UVC) is recommended to be applied to disinfect food manufacturing facilities (Welch et al., 2018) as it could warp the deoxyribonucleic acid (DNA) structure of the SARS and MERS coronavirus (Eickmann et al., 2018). During the pandemic, hygiene monitoring system in food manufacturers such as frequently wiping down the surface and swab test on food surface sample could reduce the food contamination (Danley, 2020; Sjerven, 2020). In addition to chemical and heat treatment, irradiation to treat food has been practised since 1958 to prevent foodborne pathogens; Ionising radiation could be applied to eliminate microbes in food while maintaining the nutrients (Kilonzo-Nthenge, 2012). The types of ionising radiation for sterilization of food including Gamma rays, X-rays, and electron beams ranging from 1 to 30 kgray (kGy) (Fellows, 2018). Ozone has been recognised as a powerful sanitiser for food, milling wine industries, water treatment, surface disinfection and packaging of food (Brodowska et al., 2018). Ultraviolet and Corona discharge methods are used for producing ozone (Brodowska et al., 2018). These techniques split oxygen molecules into single oxygen atoms (O) and combine with the oxygen molecules (O_2) into ozone (O_3) (Brodowska et al., 2018). Ozone disintegrates the enveloped membrane of the coronavirus and seemed to be effective and safe approach in the inactivation of coronavirus (Cannon et al., 2013; Elvis and Ekta, 2011; Rowen and Robins, 2020).

Apart from prevention, continue food safety surveillance, including pathogen detection, is paramount essential to track the spread of pathogens. Nevertheless, the reliable detection tools in foods remain a challenge due to viral particles distribution, low viral load and non-optimised isolation techniques and methodology that required expertise such as RT-PCR, Elisa, and immunosorbent assay (Rizou et al., 2020). Since the outbreak of COVID-19, many aspects of food safety, including delivery and dining etiquette, have been improved. Due to the lockdown, the use of information technology (IT) to track down information of customers, smartphone apps for food order and delivery using a drone and robotic technologies emerged as a new business opportunity in the food industry (Elavarasan and Pugazhendhi, 2020). The use of telecommunication efficiently data sharing especially the COVID-19 information and hotspots enable to significantly reduce the spread of the virus (Elavarasan and Pugazhendhi, 2020).

5. Governance in food security assurance

To prepare us from next pandemics and prevent future zoonotic outbreaks related to food consumption, the Meat Control Act 2012 integrated with One Health Policy demand immediate attention (Zheng et al., 2019). Hazard analysis critical control point (HACCP) programs should be reviewed with more tightened measures to ensure the safety of food production (Wilhelm et al., 2011). The terms and conditions involved in the safety of food production with technology advancement should be updated to fit into 21-century contexts. Lesson from COVID-19, more funds and best use of fund should put in affords for food safety monitoring against emerging of infectious diseases (Maxmen, 2019). Enhanced multi-sectional collaboration and data sharing between world health partners such as WHO, Centres for Disease Control and Prevention (CDC), and other public health organisation is envisaged to ensure refinement in the prediction of viral emergence for efficient pandemic prevention (Eisenstein, 2018). During the outbreak of a pandemic, initiative of food banks by non-government organisations to support the needy and prevention in food waste should get full support from the public (Deaton and Deaton, 2020). Policies at the community, national and global levels are essential in determining smooth food access to the public (Naja and Hamadeh, 2020).

6. Impact of COVID-19 to food supply chain

The food supply chain normally involves production, post-harvest handling, processing, distribution/retail and finally the dinner plates, which possess several risks for virus transmission. Therefore, managing secure food production, consumer and worker's health and efficient distribution of food have become a great challenge during the present crisis response which involve several stakeholders (Mollenkopf et al., 2020). The pandemic is affecting farmers and small to medium sized enterprises in developing countries, who often lack the necessary advanced IT and transport infrastructure (Reardon et al., 2020). The efforts from the governments to sustain the current situation by new regulations that keep the food production and associated supply chain in line with the demands. Hence it is important to help this sector to sail through the hardship and assure the continue supply of food (Mollenkopf et al., 2020). Some of the largest beef-packing and meat processing companies in the United States were forced to closed down when employees are suspected of COVID-19 infection but surprisingly no food products produced from these companies were recalled from the market and hence causing the concern of food safety (FDA, 2020). This shouldn't be a concern as acid stomach effectively inactivate the SARS-CoV coronavirus opposite of the mucous membranes in the respiratory airways while SARS-CoV-2 can also be killed by normal cooking ($>$70 °C) for 5 min (Chin et al., 2020; Darnell et al., 2004). Nevertheless, virus transmission is still possible through frozen food as the virus can retain up to 21 days in frozen chicken, pork and salmon (Chin et al., 2020). By knowing this, a shift in food supply chain notably at food processing premises to terminate the transmission, warrant extra attention. For example, strict standard operation procedures in the food industry needs to follow material and utensil sterilization, PPE usage, social distancing and worker hygiene should be enforced (virology, 2020). Investment in technology in the food production sector is needed to get ready for the next pandemic to include automation, robotics system and central palletized systems. These technologies not only improve food safety and minimize waste from production but they also minimize human food contact thereby ensuring a smooth operation during disease outbreaks (Neo Perly, 2020). However, not all sectors in the food chain decrease during the COVID-19 outbreak. In the distribution, online retail and take-away sector, there is a fast growing pattern reflect massive growth in home delivery during the pandemic as the effort to reduce social contact in order to reduce infection spike. This is seen as a +63% grow in brand value to $ 3.3 bn of the UK Top retail brand *Ocado* (Morrison, 2020). Moreover has the lock down and fear for COVID-19 caused a change in shopping behaviour that the demand for multi-serves or weekly storage are gaining traction. The action of panic buy resulted in increase of unnecessary £1 bn worth of food in UK homes (Jack, 2020). Therefore, to control the action of panic buy, some enforcements such as the restriction to the amount of product that an individual can buy, special shopping hour for elderly and vulnerable populations, and the shift to the manufacturing of products with greater need (Samantha, 2020). Despite these pressures on the food supply chain, the pandemic has resulted in almost 30,000 new sector jobs in order to restock food and utilities, including the beverage sector in UK (Morrison, 2020; Samantha Sault, 2020). Nevertheless, these increases in the food sector cannot offset the worldwide job lost and permanent closure of restaurants and cafes during lock downs which force restaurants to shift their business model (Jack, 2020).

7. Conclusions

The spread of COVID-19 has resulted in public health concern, economic and food crisis. During the pandemic lockdown, the food sector is hardly impacted and most affected vulnerable group such as the poor and in isolated ruler area. The economics of agriculture and aquaculture for the last quarter of the year 2020 has shown a significant decline, which affected the live hood for millions of people worldwide. As this pandemic started from a food market, it is envisaged that the governance and policy for food processing and manufacturing could be revised. If new ways of collaboration and actions between government, industries and individual are not taken, the world is even less prepared in the future for the next pandemic, which will delay vaccine development and pandemic mitigation.

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Credit author statement

Nyuk Ling Ma: Conceptualization, Editing. Wanxi Peng: Supervision. Chin Fhong Soon: Data curation, Writing - original draft, Visualization, Investigation. Muhamad Fairus Noor Hassim: Data curation, Writing - original draft, Visualization, Investigation. Suzana Misbah: Data curation, Writing - original draft, Visualization, Investigation. Zaidah Rahmat: Data curation, Writing - original draft, Visualization, Investigation. Wilson Thau Lym Yong: Data curation, Writing - original draft, Visualization, Investigation. Christian Sonne: Writing- Reviewing and Editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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