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Abstract

This study examines the impacts of Covid-19 pandemic and adaptive strategies to build resilience among stakeholders and actors in the aquaculture value chain in Kenya. Prior to the pandemic, Kenya's aquaculture sector had progressed from a minor player to a key component of the country's fish food system. Fish and fishery products have become the most heavily traded food commodity in Kenyan markets. The results indicate that the pandemic had major impacts on the access to aquaculture inputs, fish trade, and socio-economic livelihoods of the aquaculture value chain stakeholders and actors during the two whole years. Thus, initial and longer-term adaptive measures, in particular by private sector players and government agencies can contribute to building resilience to multiple shocks and stressors among stakeholders and actors in the aquaculture sector. Some of the measures include government incentive package to overcome the damage to the fisheries and aquaculture sector, improve farming operations and win market trusts and adoption of new methods such as intelligent sensors, camera systems and automated or remotely controlled monitoring/feeding strategies to reduce labour intensity. Such measures and policies can cushion the sector against future shocks occasioned by such pandemics.

Key words: Covid-19, lockdowns, movement restrictions, aquaculture value chain, adaptive measures

1.0 Introduction

Aquaculture represents the fastest-growing food production sector and is recognized worldwide as among the most sustainable options for improving food security and eradicating poverty (Munguti et al., 2021). More so, fish and fish products constitute an important part of a healthy diet. In Kenya, the fishery sector provides nutrient-rich food, jobs and income to a large population. Over 75% of supply comes from capture fisheries in Lake Victoria. Aquaculture is the fastest growing subsector in the country due to the enabling policy environment and the subsector has attracted substantial public funding for aquaculture development over the past two decades. For instance, the introduction of Fish Farming Enterprise Productivity Programme (FFEPP) in mid-2009 targeted the improvement of fish farming in the country (GoK, 2010). Similarly, the eight-year (2018–2025), USD 143.3 million Aquaculture Business Development Programme funded by the International Fund for Agricultural Development (IFAD) and Government of Kenya is supporting smallholder aquaculture fish production to accelerate and consolidate the expansion of aquaculture production and trade within the country by realizing the productive potential of smallholders (Obiero et al., 2019; Odende et al. 2022).

The outbreak of Covid-19 pandemic and the subsequent lockdowns caused significant disruptions in fish supply chains, market segments, companies, and small-scale actors both in the fisheries and aquaculture subsectors in Kenya. Many fish-related activities, including fishing, post-harvesting, trading and selling, were prohibited because of transportation restrictions and market closures. The Covid-19 virus was first identified in Wuhan, China in December 2019 and subsequently spread to many countries of the world. The World Health Organization (WHO) declared it a Public Health Emergency of International Concern on 30th January, and a pandemic on 11th March 2020 (UN News, 2020). By 1st June 2020, 6.22 million people worldwide had been infected with the virus and resulted in more than 373,032 deaths (JHU, 2020). In Kenya, the first case of COVID-19 was reported on 12th March 2020 (Anadolu Agency News, 2020). Subsequently, the number of COVID-19 cases in the country increased and by 9th June 2020 a total of 2,989 people had been infected (MoH News, 2020). In a response to flatten the curve by slowing the rate of new infections, governments in many countries enforced border shutdowns, travel restrictions and quarantines to contain the spread of the virus (Pullano et al., 2020; Rodríguez-Morales et al., 2020).

In Kenya, the government instituted several measures and restrictions to reduce the spread of COVID-19 and minimize casualties. These included restricting international travel, cessation of movement from some cities including the capital city of Nairobi, imposing curfews, social distancing and closure of areas of mass gathering such as schools and places of worship, and dusk to dawn curfews (Africa Press Office, 2020). These measures, and specifically the cessation of movement to cities that are the main fish markets, curfews and social distancing affected fish trading and duration, disrupted the fish value chain and affected the livelihoods of fish farmers', traders and consumers. Yet, in this period of global pandemic, fish remains an essential source of animal proteins, micronutrients and omega-3 fatty acids (FAO, 2020).

Although, quantification of the full economic impact of Covid-19 pandemic to the aquaculture industry is challenging, the key causes have been identified mainly due to the restrictions on transport and closure of processing factories that connect producers and consumers (Fleming et al., 2014; Jennings et al., 2016). Many producers were unable to sell their harvest and had to maintain large quantities of live fish. Others had to halt all necessary seasonal tasks such as fish breeding. These measures resulted in increased costs and risks, when the supply of inputs was disrupted, and massively delayed restocking and subsequent harvests (FAO, 2020). Prior to the pandemic, aquaculture was one of the most promising sectors in the food industry due to the rising demand for fish and aquatic products (Fox et al., 2018; Jennings et al., 2016; Love et al., 2021). Fish and fishery products are the most traded food commodity in the world and many fish food markets have expanded in recent decades from regional to global levels (Cao et al., 2015; FAO, 2018). Therefore, the worldwide lockdown during the COVID-19 pandemic, the social distancing practices, and additional COVID-19 restrictions that have been implemented had a major impact on the supply of these food caused by the decline of fishing and aquaculture activities worldwide (Ma et al., 2021). The subsequence increases in consumer demand and transaction costs pushed the market price of fish and aquatic products up, making them unavailable or less affordable for the poor (Bostock et al., 2010). Also, the reduction of sales in this sector caused millions of small- and medium-scale producers to become unemployed worldwide (Fox et al., 2018).

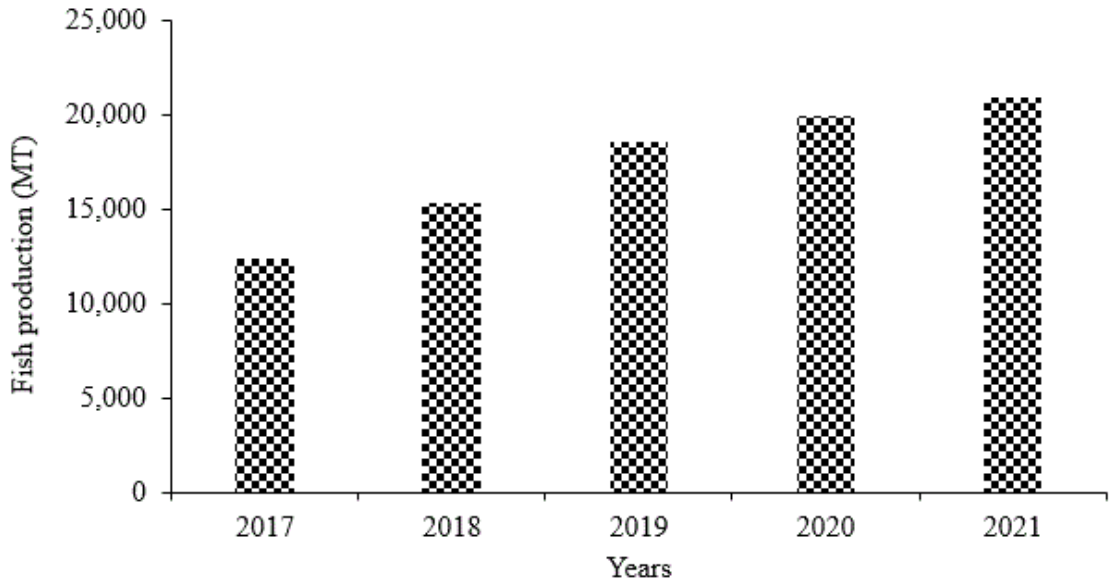
These uncertainties thus created new challenges that needed to be addressed by the aquaculture farmers and stakeholders, either by promoting and diversifying their products for wider domestic markets, or by reducing the overall operational and production costs, to protect and maximize the value of their products and maintain a sustainable business (Fernandez-Polanco, 2016; Jennings et al., 2016; Kaminski et al., 2020). Therefore, this paper reviews impacts of the Covid-19 pandemic in the aquaculture sector in Kenya and elucidates some adaptive strategies adopted in the country by the various stakeholders and actors in the aquaculture value chain.

1.1 Overview of the aquaculture sector in Kenya prior to COVID-19

In Kenya, aquaculture is predominantly small-scale; but significantly contributes to food security and nutrition, livelihoods, economic development, social capital, biodiversity conservation, and climate change resiliency (Obiero et al., 2021). Over the past two decades, Kenya's aquaculture sector has progressed from a minor player to a key component of the country's fish food system and has been recognized as one of the flagship projects capable of stirring the country’s economy (Nyonje et al., 2018; Githukia et al., 2020; Obiero et al., 2021). Aquaculture is recognized as a source of food security, poverty reduction, and job creation in Kenya's Vision 2030, as well as the continental aspiration of Agenda 2063, the United Nations 2030 Agenda for Sustainable Development, and the East African Community Vision 2050, in which member countries aspire to become middle-income countries (AUC-NEPAD, 2014). Through supportive government policies and substantial public investments, aquaculture production in Kenya increased rapidly from less

than 1,000 tonnes in 2006 to 24,000 tonnes in 2014 (Obiero et al., 2021) including in regions of the country with little history of fish production or consumption (Ole-Moiyoi, 2017).

In the past 5 years, the output from aquaculture nationally has increased steadily from the year 2017 to 2021 which currently stands at about 20,000 MT annually (Figure 1) (KNBS, 2022). Although capture fisheries presently remain the dominant supplier of fish in Kenya, the maximum sustainable yields (MSY) for most rivers and lakes in Kenya have been exceeded and fish output from these sources plateaued over the past 5 years. Therefore, aquaculture is viewed as an alternative to bridging the widening gap between fish demand and its supply in Kenya (Obiero et al., 2019a).



National aquaculture production trends in Kenya 2017-2021 (KNBS, 2022)

2.0 Review methodology

The scoping review methodology (Arksey and O'Malley, 2005) approach was adopted in the present study to generate a comprehensive literature review on the Covid-19 impacts on the aquaculture sector in Kenya and adaptive strategies. The literature review focused on covid-19 impacts on aquaculture production, access to aquaculture inputs, fish marketing, and socio-economic impacts on the livelihoods of stakeholders and actors in the aquaculture sector. To meet the set objectives, a wide range of keywords (closely related to Covid-19 impacts on aquaculture) were searched in online database tools and scientific domains of Science Direct, Research Gate, Google Scholar, and Web of Science. To further narrow and refine the search, Boolean operators (“OR”, “AND” and “NOT”) were appropriately used in the various databases and search engines. The

collected literature database was organized in excepts, copies, and notes according to topics. The current paper is a result of research publications that met the inclusion criteria for the review paper.

3.0 Why Fisheries and Aquaculture Food Systems were vulnerable to Covid-19 Related Shock

Consumer demand is growing across the fish value chains, and some fish stocks are becoming less sustainable (Pradeepkiran, 2019). It takes a complicated set of actions to get fish and fish products from fisheries and aquaculture production to final customers and the methods used to handle these value chains range from artisanal to highly industrial (Alam et al., 2022). The important steps in a supply chain for fisheries or aquaculture product include fishing, aquaculture production, processing, input transit, distribution, wholesale marketing and retail marketing. These operations are all equally crucial to the supply chain's performance. The effects of COVID-19 and associated procedures have the potential to interrupt or stop any point along the chain. In the event that one of these 'buyer- seller' relationships is broken by the disease, there will be a cascade chain of interruptions caused by the disease or containment efforts, which will have an impact on livelihoods and food security (Siswaningsih et al., 2021). Financially troubled households may reduce their spending. The decrease in household demand, which was also impacted by containment measures (such as the closing of restaurants and tourist attractions, etc.), has an impact on production, processing and distribution and disrupts both local and foreign supply chains. Additional logistical difficulties in the supply chain are caused by the fact that live, fresh or chilled products are very perishable. Additionally, the decline in domestic demand and extensive containment measures have a substantial impact on a sector that depends heavily on international trade by lowering imports and decreasing foreign income (Siswaningsih et al., 2021).

Regarding the private sector, a company's financial difficulties may result in a pay cut, fewer hours worked or a hiring freeze. Furthermore, many insurance companies do not cover commercial interruptions caused by conditions such as the COVID-19 condition. As a result, a slowdown anywhere in the supply chain is caused by a disruption in the flow. Human consumption of fish and fish products, and thus successful and ongoing completion, can only occur if buyer-seller ties are protected at every stage of the supply chain. As a result, it is critical to protect as many stages of the fisheries and aquaculture food chain as possible. Long-term changes that improve fish supply and demand sustainability, such as reducing food loss and waste, can be guided by bottlenecks observed during the pandemic and the obvious need to reduce some fish supply chains (Brown-Webb et al., 2022).

4.0 Impacts of Covid-19 on Aquaculture sector in Kenya

Published data across news, social media outlets, governments, and development partners provide an emergent picture of covid-19 disruptions or shocks to multiple stages of aquaculture value chain. These disruptions caused a generalizable range of impacts across different subsectors, product forms, markets, and consumer segments (Love et al., 2021). Impacts from the pandemic were felt first in China and among its trading partners, but quickly spread around the world. For instance, due to the significant drop in the market's demand for fish and the limited transportation options that were available during the lockdown, fish farms have had difficulty in collecting and selling their goods (FAO, 2021). As farmers were unable to sell their products there was an increase in live fish stock levels and a lengthening of the fish culture period, both of which negatively impacted the feed conversion ratios, the ability to restock and, ultimately, the farms' profitability (Alam et al., 2022). Accordingly, the risky of fish mortality and feeding expenditures grew (Fiorella et al., 2021; Alam et al., 2022). Moreover, due to the stringent restrictions on movement, aquaculture producers reported difficulties with access to production inputs, such as broodstock, fingerlings, feed, labour and limited access to extension services (Manlosa et al., 2021). Furthermore, the restrictions placed on foreign markets and the closure of restaurants and hotels hampered fish trade and consumption. These impacts caused a drop in aquaculture production (Ferrer et al., 2021) and impacted the livelihoods of various stakeholders and actors in the aquaculture value chain. Generally, COVID-19 posed numerous challenges to fish supply chain actors, including a shortage of inputs, a lack of technical assistance, an inability to sell the product, a lack of transportation for the fish supply, export restrictions on fish and fisheries products and a low fish price. These challenges lead to inadequate production, unanticipated stock retention, and a loss in returns as detailed below (Alam et al., 2022).

4.1 Covid-19 impact on Access to Extension services and Aquaculture Inputs

During the pandemic, gatherings were banned and thus trainings could not be organized to recruit more farmers into aquaculture as well as training existing fish farmers on sustainable aquaculture. Generally, the dissemination of information through training and educational visits was greatly hampered. Movement was disrupted through lockdowns and curfews and boundary blockades; the disruption of movement meant that the transport of fingerlings across counties was hampered. As a result, farmers and or traders could not send fingerlings through public and private transport means across county and country boundaries.

The fish feed industry in Kenya generally depends on imported feed ingredients for example maize, wheat, rice by-products, soybean and its derivatives, sunflower, cotton and, fishmeal, and micro-ingredients typically utilized as additives (chemical preservatives, vitamins, antibiotics, minerals, fermentation products among many others) acquired from the East African Community (EAC), regional market and other international markets (Munguti et al., 2021). The pandemic

considerably impacted the fish feed industries due to the crisis of raw materials and labour, lesser sale of feed, increased transportation cost (20–60%), and more operating cost to maintain health guidelines and social distancing, which have in turn forced the factories to increase the feed price (Islam et al., 2021).

The fish hatcheries have also been affected by the pandemic due to the decrease in the sale price of fry and shortages of labour, increase in transportation cost and increase in the cost of maintenance to follow health guidelines and social distancing (Islam et al., 2021). The demand for new fry/fingerling has decreased drastically as much of the farmer's fish are left in their culture ponds unsold. The unavailability of regular labour and increased labour cost has brought a crisis to the hatcheries and feed plants (Islam et al., 2021). These situations may worsen over time unless some recovery actions are taken in the sector to revamp easy access to these critical production inputs in the aquaculture value chain.

4.1 Covid-19 impacts on Fish Market systems

Most fish farmers in Kenya are small scale farmers, such farmers previously took their fish produce to nearby open-air markets. When the open-air markets were closed down, fish farmers did not have a place to sell their fish. Further, movement restrictions made it difficult to get fish to market as well as reluctance among traders and consumers to visit markets where crowding may put them at risk of COVID-19 transmission which potentially contributed to fish spoilage (Okronipa et al., 2021). The fisheries and aquaculture sector in particular have faced great difficulty, mainly due to the perishability of the product. Also due to the restrictions, restaurants and hotels are legally bound to close their doors. The demand for fish and fish products has decreased as a result of this.

However, news reports suggest that declines in Chinese imports of tilapia due to movement restrictions may have increased demand for Lake Victoria tilapia (Reuters Staff, 2020) and necessitate increasing local fish production to meet demand within Kenya (Business Daily Africa, 2020). Moreover, the ties between global small-scale fisheries and export markets, as is the case for Lake Victoria, have emerged as uniquely problematic for small-scale fisheries amid the COVID-19 pandemic (Love et al., 2020). Sharp declines in international fish demand have dramatically reduced prices and negatively impacted small-scale fisheries (Knight et al., 2020). Due to transport crisis, all stakeholders in the aquaculture sector suffered severe problem for transporting the finished products, raw materials, feed and other necessary required materials which is ultimately hampering the business not only for this time but also long term. Low prices of farm gate fish due unavailability of local buyers and foreign, leading to market instability and price reduction. Due to market disruptions, fish farmers have been unable to sell their fish.

4.2.1 Covid-19 impacts on Socio-Economic Livelihoods

Lockdowns due to covid-19 pandemic disrupted employment in the aquaculture value chain for workers, and access to labor for aquaculture businesses. In Kenya**,** fish farms and fish enterprises provide self-employment and casual work for many people. COVID-19 policy responses impacted the operation of such businesses which resulted in lowered incomes and caused substantial unemployment (Reardon et al., 2020). Most of the casual laborers were laid off due to lack of funds from the fish farmers to pay due to reduced sales and profits. Laying off meant lost livelihoods thus leading to social economic stresses. Loss of livelihoods lead to domestic problems and issues that affect the stability within families. Islam et al., (2021) noted that, all the stakeholders' financial capitals (e.g., reduced income, disruption of financial activities, etc.) were highly affected by the adverse impacts of COVID-19. Because of reducing income due to shortening of marketing hours, increasing cost for fish feed and transportation, and extra cost for buying covid-19 prevention materials (e.g., soap, hand sanitizer, masks and gloves), all stakeholders were affected miserably (Islam et al., 2021).

Fish consumption also decreased significantly among the households during the COVID-19 pandemic mainly due to increased food prices and reduced fish income (Fiorella et al., 2021). This finding suggests that many households in Kenya could be at risk of insufficient nutrient intake. Animal source foods like fish are particularly important in diets because they provide adequate nutrition for young children's growth and development (Headey et al., 2018). Alongside a decline in the frequency of fish consumption, changes in the fish species that households accessed were also noted (Fiorella et al., 2021). Higher-priced species (e.g. Tilapia) were consumed less often, while lower-priced species (e.g., dagaa and cichlids) were eaten more often (Fiorella et al., 2021). This dynamic alongside households**'** reports of food access being affected by higher prices and reduced income during covid-19 pandemic suggests a downgrading of fish access, in which even low-value species may have already become unaffordable for some households (Fiorella et al., 2021). While moderate dietary impacts have been noted at this stage of the pandemic, existing rates of poverty, malnutrition, and food insecurity prior to the COVID-19 pandemic makes the smallholder fish farmers and other stakeholders in the aquaculture value chain vulnerable (Kenya National Bureau of Statistics, 2018; Kenya National Bureau of Statistics and ICF Macro, 2015; Okronipa et al., 2021; Teh et al., 2020; Fiorella et al., 2021). Therefore, as suggested by Fiorella et al., (2021) continued monitoring of changes in consumption patterns, as well as analysis of food insecurity and malnutrition, will be critically important going forward to determine whether such changes are a result of the COVID-19 pandemic and attend to increases in vulnerability.

5.0 Adaptive strategies to build resilience in the aquaculture sector

The uncertainties and new challenges posed by the covid-19 pandemic in the aquaculture sector prompts the need for farmers and other actors in the value chain 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 maximize the value of their products and maintain a

sustainable business (Fernandez-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.

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 pandemics. 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). Initial coping responses, in particular by governments, could sought to maintain the sector's core functions through the period of wide-spread economic disruption, while protecting the most vulnerable. Longer-term adaptive measures, that often emerge outside of government, can contribute to building COVID-19-specific and generalized resilience to multiple shocks and stressors.

Some of the short-term strategic research needs to support learning from COVID-19 impacts and responses include: Using survey tools to document and better understand COVID-19 impacts on people working at all levels in aquaculture value chain in order to direct support to vulnerable actors in the value chain system as suggested by (Smith et al., 2020; Rosen, 2020; Kumaran et al., 2020; Campbell et al., 2020; Giannakis et al., 2020; Steenbergen et al., 2020; Sorensen et al., 2020); Document and share case-experiences of actors in the value chain that have adapted to shifts in supply and demand of fish so lessons from their strategies can be more widely adopted as proposed by (Stoll et al., 2020; Smith et al., 2020); Improve open data and data sharing platforms to facilitate the exchange of information about the societal impacts of COVID-19, to enable more rapid and coordinated responses to future shocks as recommended by (Moorthy et al., 2020; Oliver et al., 2020; Foraker et al., 2020).

The longer-term strategic research needs to support learning from COVID-19 impacts and responses in the aquaculture sector as suggested by Love et al., (2021) include: Design future response strategies in support of the aquaculture stakeholders, draw on lessons from social safety net programs in other food sectors, and experience with implementing the Human Right to Food; Improve information systems to track fish prices and trade volumes typically consumed by different types of consumers to reduce wasted fish and enable value chains to respond to consumers' nutrition needs and demand preferences; Focus resilience research on those parts of the aquaculture and fisheries system that supply populations most nutritionally dependent on fish and those which, through employment, support food security of low-income value chain actors; Develop and apply an evaluation framework and resilience indicators for aquaculture value chain,

that include social economic and environmental aspects, to identify and learn from resilience 'hot spots'; Study temporal effects of the shock on employment in the sector, on adoption of technologies for production and processing, to better design future crisis-coping strategies and recovery efforts; Study immediate and longer-term impacts on natural resource systems to identify means to sustain resources during and after future system shocks; Understand how the fisheries and aquaculture sectors may or may not be different from other food sectors from a resilience perspective for COVID-19 and other largescale disturbances.

6.0 Conclusion

Due to the continuous, restrictive measures imposed on travel, movement and transportation in the midst of the covid-19 pandemic, communities and stakeholders in the aquaculture sector have been negatively affected. The review shows that, various stakeholders and actors in the aquaculture sector have experienced several obstacles owing to COVID-19, such as input supply limitation, inability to market their products, export restrictions on fish and fishery products, and low fish prices. These obstacles have contributed to a significant gap between demand and supply in the aquaculture value chain, resulting in a decline of the aquaculture production. The pandemic has exposed pre-existing vulnerabilities and limited resilience by disrupting fish supply and demand, fish distribution, labor and production, therefore posing a threat to smallholder fish farmer households' well-being. Initial coping responses, in particular by governments, could sought to maintain the sector's core functions through the period of wide-spread economic disruption, while protecting the most vulnerable and the longer-term adaptive measures can contribute to building COVID-19-specific and generalized resilience to multiple shocks and stressors among stakeholder involved in the aquaculture sector. Also, the government can consider incentive package to overcome the damage to the fisheries and aquaculture sector. These mitigation packages help fish farmers, various other actors within the supply chain and the overall sector to enhance their resilience.

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Author contribution statement

Jonathan Munguti, Erick O. Ogello, Kevin Obiero: Initiation; Methodology; document review and formal analysis. Nicholas Outa and Jacob Iteba: Investigation; Methodology; Supervision; Validation. Domitila Kyule, James Kirimi: Formal analysis; Dan Mungai: Investigation; Visualization

Conflict of interest

The authors declare that there are no conflicts of interest that might arise as a result of the publication of this manuscript and the information therein.

Author's Ethical Statement

We certify that this is our original scientific research work, and it has not been submitted or published anywhere. The authors are responsible for all the content in the manuscript.

Animal Ethical Statement

The current study was a review and no animal or human subjects were used. Therefore, there were no ethical approvals needed.

Data Availability statement

We certify that the data used in this article was collected from the study and can only be availed through the request and permission of the third-party authors.

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