

REVIEW ARTICLE

Fisheries Traceability, Drivers, and Barriers to its Adoption: A Review

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ABSTRACT

Traceability has been applied in fisheries, for example, in tuna, as a means of verification and validation of the quality of fish meat and its origin. Traceability as a platform in the fisheries remains elusive in many parts of the country due to slow adoption. This study reviewed the existing literature in relation to “agri-fishery traceability system,” “fishery traceability,” and “food safety” from the years 2000–2023. It aimed to elucidate the common drivers and barriers to the adoption of fisheries traceability systems. The authors used PRISMA to analyze articles obtained from SCOPUS and WOS (Web of Science), DOAJ (Directory of Open Access Journal), Academia, and PubMed central databases. The results showed that 125 articles were included after the inclusion and exclusion process. There were nine articles included in the years 2000–2005, followed by 19 in 2006–2010, and 26 from the years 2011–2015. A total of 40 articles were recorded from the year 2016 to 2020 and 31 from the year 2021 to 2023. In terms of text data from the authors, “fish,” “supply chain,” “traceability system,” and “food safety” have the highest total link strength. Moreover, food safety, market compliance, consumer protection, product origin, quality, and seafood fraud are driving factors in the implementation of a traceability system. Costs, inadequate practices, lack of support from the government, infrastructure, information, and laws and regulations are foreseen barriers to the adoption of a traceability system. Leading countries in fisheries traceability studies include China, USA, Italy, Indonesia, UK, and Taiwan, where the first and corresponding authors originated. While this review endeavored to find fish traceability studies in the Philippines, the lack of comprehensive and relevant literature published on this topic shifted our focus to finding barriers and drivers to adopting a traceability system. We recommend that government agencies that oversee various commodities should link up with academics and non-government organizations in implementing and monitoring their traceability systems.

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1. INTRODUCTION

Traceability is widely understood as a practical technique of perceiving, communicating, and directing the relations of production and commerce in the global food system (Djelantik and Bush 2020). Olsen et al. (2013) define traceability as “the ability to obtain any or all information relevant to that which is under consideration, across its full life cycle, through recorded identifications. Moreover, Riviere and Buckley (2012) stated that 60 food traceability systems have been subject to obligatory

regulation in numerous nations over the past few years, and 61 particular rules or policies to be established at the national level for domestic goods (Schroeder and Tonsor 2012). The term “traceability” is frequently used interchangeably with “tracking and tracing” in many literary works (Van Dorp 2002). According to Petersen and Green (2005), tracking is a forward procedure that uses location in the supply chain to identify end users and trading partners. Tracing is a backward approach that uses history or records in the supply chain to determine the origin.

Providing details on the complete food chain, from farm to table, regarding quality and safety, the traceability system has been implemented in many countries to eliminate the uncertainties arising in the food purchasing process (Choe et al. 2009). Traceability data can give necessary information and will address the concerns of numerous stakeholders (manufacturers, buyers, regulators) of the food system (El Sheikha 2014). Food chain integrity now involves issues with quality, origin fraud, and safety because of the globalization of the food sector. Consumers also scrutinize evidence of traceability as a crucial factor in determining the quality and safety of food. A traceability system that details the origin, processing, retailing, and destination of foods is required to meet these standards (Bertolini et al. 2006; Peres et al. 2007). In addition, modern agricultural supply chains now include traceability as a mandatory requirement. Higher precision traceability increases the possibility of improving information retrieval so manufacturers receive better feedback, enhancing the supply system's efficiency (Lou et al. 2017). Furthermore, a traceability system is essential for guaranteeing food safety and generating advantages for various elements of the food supply chain (Kshetri and Loukoianova 2019). Fish traceability is important. Apart from giving quality assurance and providing reliable records for the fishers and suppliers, this can ensure food safety assurance for all consumers. Given that 30% of the protein requirement of Filipinos comes from fish and other seafood products, a traceable product would assure consumers of safe and sustainably sourced fish (Macusi et al. 2011 and 2023). Moreover, fish is one of the cheapest sources of protein, especially for most lower-income households in the Philippines (Sarmiento et al. 2021). In terms of fish production, the Philippines produced 4.34 million tons valued at PHP 326.57 billion and exported fresh, frozen, and preserved tuna of 107,000 tons valued at PHP 22 billion to the world market, e.g., Japan, Canada, Belgium, UK and Northern Ireland, Spain, Germany and the United States (BFAR 2023). Thus, tuna consistently ranks as the top export commodity, which is why a previous study that investigated traceability proposed that it is now possible to determine how, where, and why practices concerning tuna traceability can be accepted, rejected, or modified by examining how they are carried out and connected to other practices (Doddema et al. 2020; Macusi et al. 2023). The development and implementation of entire chain traceability from farm to end-user have become a substantial component of the overall food quality

assurance system to provide high-quality, safe, and nutrient-dense foods and restore public confidence in the food chain (Opara 2003). Moreover, enhancing traceability at the supply chain level has the potential to lower the costs to downstream players (such as merchants or processors) of observing the actions of upstream processes (e.g., raw material supply) (Hobbs 2003; Canada 2007). The food sector's laws, regulations, and standards for food safety and quality management were developed in response to the expanding challenges of food safety. In order to promote the adoption of food traceability systems, the European Union and other advanced countries have implemented a range of laws and regulations, including the introduction of credit systems. Over two years of progress, the food traceability system has played an important role in mitigating food safety risks in several advanced economies (Filho and Andrade 2007). For example, China introduced the idea of a traceability system and officially designated the promotion of this system as a top national priority. Nevertheless, producers and suppliers' adoption of food traceability in China is still limited due to inadequate incentives (Yuan et al. 2020). In the food industry, which began implementing integrated quality and food safety management systems, quality assurance has emerged to support food safety policy (Pinto et al. 2006; Trienekens and Zuurbier 2008). However, Tyedmers et al. (2008) specified that a traceability system is required to guarantee high-quality seafood products on the market; Becker (2000) also stated the need to ensure both the quality of the production process and the final product. Olsson and Skjöldebrand (2008) stated that recall reduction, maintaining market share, protecting trademarks, and enhancing reputation could be the driving motivations for implementing traceability throughout the complete chain of actors. He also pointed out that in the food supply chain, the producers typically bore the brunt of consumer complaints. Food traceability is the primary tool producers and consumers can rely on to boost confidence and effectively address food safety problems (Regattieri et al. 2007; Costa et al. 2013a). This paper offered an overview of recent advancements in the practice of traceability and is a helpful resource for further study (Vikaliana et al. 2020). Thus, our paper reviewed the existing literature on traceability systems, both in the Philippines and in other countries, and dealt with fisheries supply chain, agri-fishery, and food safety to provide information on the importance of adoption of traceability which may lead to the implementation of policies related to

this matter. It aimed to elucidate the common drivers and barriers to the adoption of a fish traceability system. The analysis made use of various journals mainly published and curated in the reliable scientific databases of SCOPUS and Web of Science (WOS).

2. MATERIALS AND METHODS

This review paper applied the use of Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) to review the existing literature in relation to traceability by using the following keywords in the searched databases: “agri-fishery traceability system”, “fishery traceability,” and “food safety” from the year 2000 up to the present year. PRISMA was used to perform systematic literature reviews and emphasize review reports for various types of research (Moher et al. 2009). This study made use of four databases: SCOPUS/WOS (as the most comprehensive data sources for various purposes) and supplemented with DOAJ (Directory of Open Access Journals), Academia (from Academia.edu), and PubMed Central (selected due to their unique and extensive index of various open-access journals worldwide and provided free and unlimited access). Relevant publications were chosen using the following keywords to search the literature: “agri-fishery traceability system,” “fishery traceability,” and “food safety.” As an initial step, the literature was identified through data searching and was encoded in Microsoft Excel 2019, and then duplicates were removed. The literature that did not meet the eligibility conditions were eliminated during the subsequent screening and data extraction phase. The eligibility criteria involved assessing the articles to determine their relevance to the subject of interest by examining their titles, abstracts, keywords, and contents based on the three chosen keywords. The reviewed studies were chosen

for inclusion in the review as the final phase based on the publications that passed the eligibility evaluation (Moher et al. 2009; Macusi et al. 2022).

The articles utilized in this study were screened using inclusion and exclusion criteria. There were 895 articles that were identified in the SCOPUS and WOS (Web of Science) databases using the three keywords (see Figure 1) and then reduced to 382 during screening using the criteria of inclusion after the 513 duplicates were removed from the databases. Then, 41 of the literature was assessed based on their title that met the eligibility criteria, while those that did not were excluded. Finally, 34 works of literature remained, which were included based on their abstracts, keywords, and content. A similar method was applied to the three open-access databases: Academia, DOAJ, and PubMed Central. About 488 works of the literature were identified in the three databases (see Figure 1) and then reduced to 388 during screening using the criteria of inclusion after the 100 duplicates were removed from the databases. Then, 213 of the literature was assessed based on their title, which met eligibility after screening, and excluded based on criteria. Finally, 91 works of literature remained and were included that met the criteria, meaning they contained either or all of the keywords: “agri-fishery traceability system,” “fishery traceability,” and “food safety” based on their abstracts, keywords, and content. A total of 125 articles from the four databases that passed the eligibility assessment were included in the review. In this paper, VOSviewer was then used to show the bibliographic map (van Eck and Waltman 2010) to create visual representations of how the author’s keywords and indexes are connected and to analyze the text data in titles and abstracts. This type of analysis helps identify the terms used most frequently and closely connected in the network (Macusi et al. 2022).

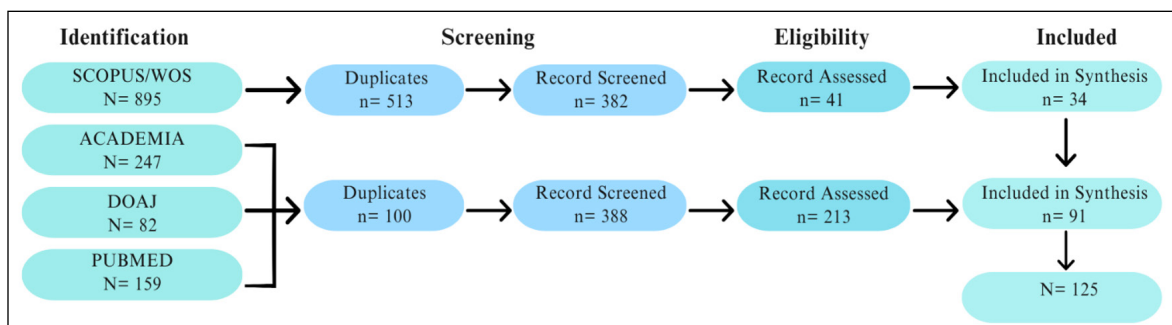


Figure 1. The literature was identified using PRISMA, which has been previously applied in shrimp aquaculture and small-scale fisheries management reviews (Macusi et al. 2022; 2024).

3. RESULTS

Results from the literature search using the keywords “agri-fishery traceability system,” “fishery traceability,” and “food safety” yielded most studies coming from China (18%), followed by the USA (12%), Italy (7%), and from Indonesia (5%). There were also data from Taiwan, Romania, Spain, and Canada, which comprised 4%, then those from Korea and the Netherlands were 3%. (Unfortunately, we were not able to locate more Filipino-published literature in SCOPUS and WOS-indexed journals during this time of scouring and selection regarding this topic; this could be due to many reasons that this paper does not cover). Figure 2 below shows countries where different authors originate and where predominant studies on various traceability systems were conducted. Moreover, about 15% of co-authors were also from China, and another 15% were from the USA. This was followed by Italy and Indonesia with 8% and followed by the UK and Taiwan with 5%. In the case of Romania, Spain, and Canada, these co-authors comprised about 4%, and in Korea and the Netherlands, about 3%. Figures 3 and 4 below present the most frequently used words in abstracts, titles, and keywords of publications from 2000 to 2023 were examined. The figures showed that three loosely connected clusters were apparent in the author’s keywords, titles, and abstracts. For example,

Figure 5 shows that the key terms in abstracts and titles linked to food traceability were *price, fish, producer, risk, benefit, opportunity, incentive, order, response, use, transparency, and application*. Key terms from the keywords linked to traceability were then shown in Figure 6, which were *food safety, food supply chain, sustainability, aquaculture, seafood, food supply, supply chains, fish, smart contract, blockchain, and traceability systems*. The difference between food traceability and traceability is that food traceability involves tracking a food product and its components as they move through the supply chain, whereas traceability is meant, in general, to keep records and link those records in the production, processing, and distribution of food products..

The cluster analysis of abstracts and titles revealed three clusters, as shown in Table 1, with their corresponding links, total link strengths, and occurrences (this analysis was an output from the VOSViewer). The link implies how two terms co-occur, while the total link strength indicates the frequency of occurrences where the two terms have been mentioned together in the publications. The co-occurrence analysis of abstracts and titles resulted in three clusters or communities. Cluster 1 contains terms such as application, practice, risk, and seafood, with ‘risk’ as having the highest total link strength. Cluster 2 contains terms such as consumer preference, fish,

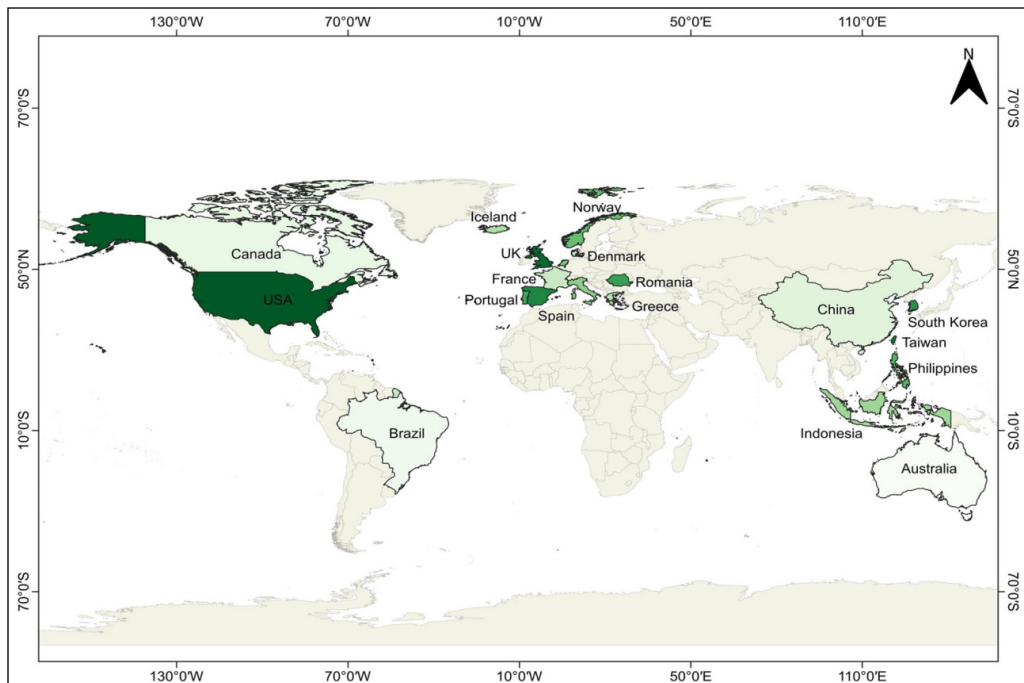


Figure 2. Countries in the map represent those with existing published studies on traceability systems and the origin of primary authors and co-authors. (Darker green colors represent more authors are writing about traceability systems)

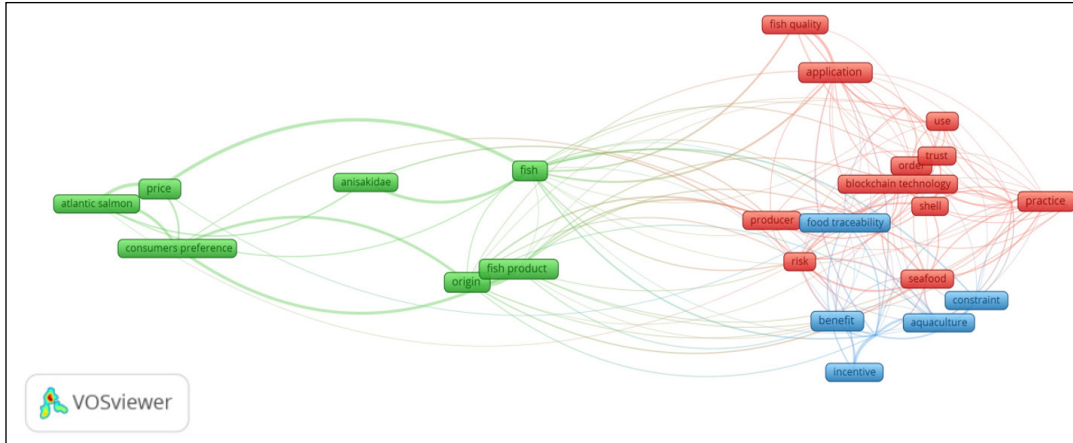


Figure 3. Co-occurrence map based on titles and abstracts of published articles. (Longer links represent farther connections while shorter links between boxes mean they are more related together and thicker lines also mean stronger connections; blurred texts indicate overlaps).

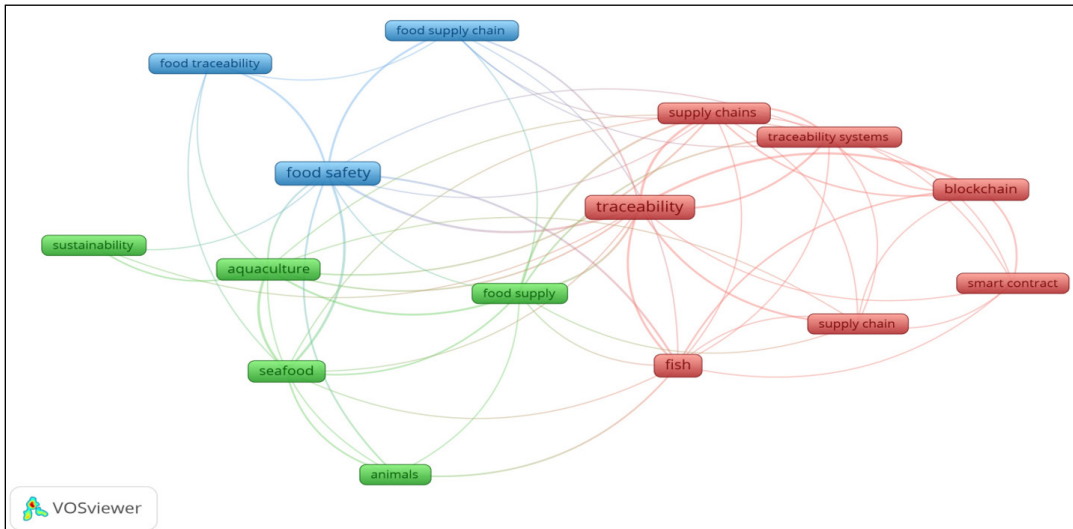


Figure 4. Co-occurrence map based on keywords of published articles. (Longer links represent farther connections while shorter links between boxes mean they are more related together).

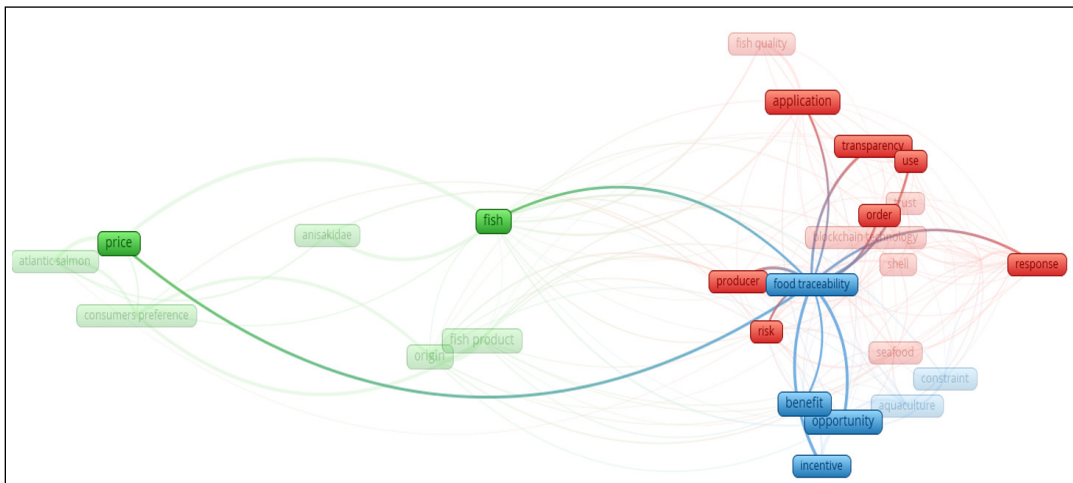


Figure 5. Co-occurrence map of key terms from titles and abstracts linked with 'food traceability' in the published articles.

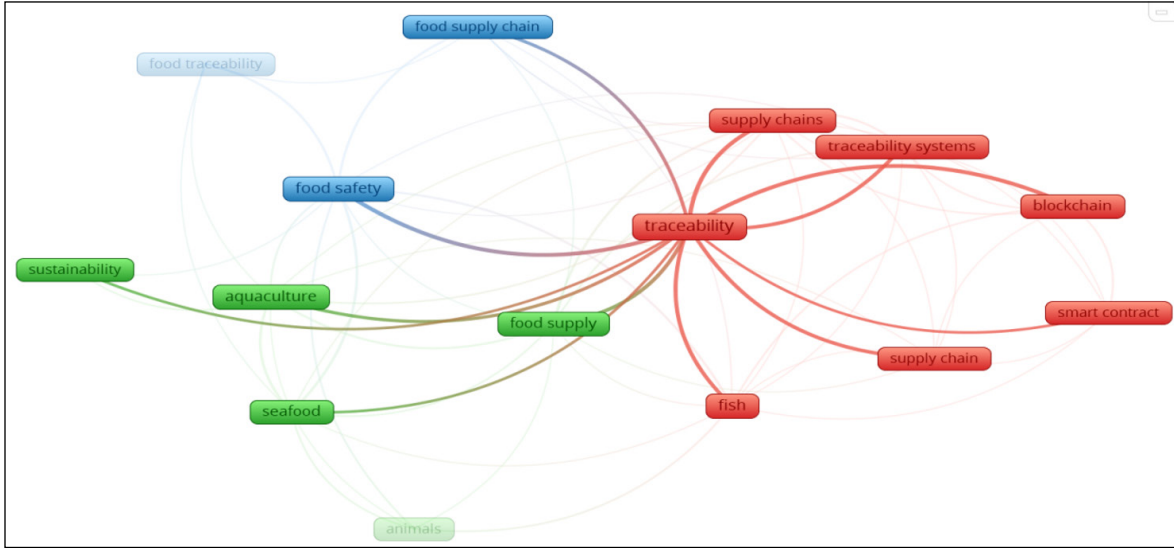


Figure 6. Co-occurrence map of key terms from keywords linked with 'traceability' in the published articles.

Table 1. Occurrence classification of text from authors' abstracts and titles.

	Links	Total Link Strength	Occurrences
Cluster 1			
Application	17	74	12
Blockchain technology	13	30	7
Fish quality	6	44	6
Order	13	32	6
Practice	14	70	12
Producer	16	53	6
Production	16	52	12
Response	8	41	6
Retailer	15	41	5
Risk	17	75	8
Seafood	16	66	8
Shell	5	35	5
Transparency	10	26	6
Trust	14	40	8
Use	10	31	8
Cluster 2			
Anisakidae	3	42	7
Atlantic salmon	5	75	10
Consumer preference	5	93	6
Fish	21	134	19
Fish product	12	129	13
Origin	12	128	12
Price	4	86	14
Cluster 3			
Aquaculture	13	66	9
Benefit	13	29	16

Continuation of Table 1. Occurrence classification of text from authors' abstracts and titles.

	Links	Total Link Strength	Occurrences
Constraint	8	38	5
Food Traceability	12	28	6
Incentive	4	54	7
Opportunity	14	114	14

fish product, and origin, with 'fish product' having the highest total link strength. Cluster 3 contains terms such as aquaculture, incentive, and opportunity, with 'opportunity' taking the first position in terms of total link strength.

Table 2 presents the cluster analysis results for author/index keywords and their occurrences and total link strengths. The co-occurrence analysis resulted in three clusters. Cluster 1 contains terms such as fish, supply chains, traceability systems, traceability, supply chain, and smart contract, with supply chains having the highest total link strength. Cluster 2 contains terms such as animals, aquaculture, food supply, seafood, and sustainability, with 'aquaculture' having the highest total link strength. Cluster 3 contains terms such as food safety, food supply chain, and food traceability, with 'food safety' having the highest total link strength.

Figure 7 shows the number of articles published every five (5) years from 2000 to 2023 using the three keywords: food safety, fishery traceability, and agri-fishery traceability system from the four databases. There were nine (9) articles in the years 2000 to 2005, followed by (19) articles in the years 2006 to 2010, and twenty-six (26) articles from the years 2011 to 2015. A total of forty (40) papers were recorded from the year 2016 to 2020. Moreover, thirty-one (31) articles were gathered from the year 2021 up to the present.

Figures 8 and 9 present the overlay visualization of the frequently used terms from 2000 to 2023 in abstracts, titles, and authors/index keywords. From there, it can be observed that the focus on traceability and safety has just emerged recently.

Table 2. Occurrence classification of text from author/index keywords.

	Links	Total Link Strength	Occurrences
Cluster 1			
Block chain	6	13	6
Fish	11	17	8
Smart contract	6	7	3
Supply chain	8	10	3
Supply chains	11	20	5
Traceability	12	13	14
Traceability systems	10	16	4
Cluster 2			
animals	5	8	3
aquaculture	10	19	7
Food supply	10	18	4
seafood	8	16	6
sustainability	3	4	3
Cluster 3			
Food safety	11	25	11
Food supply chain	7	10	3
Food traceability	4	6	3

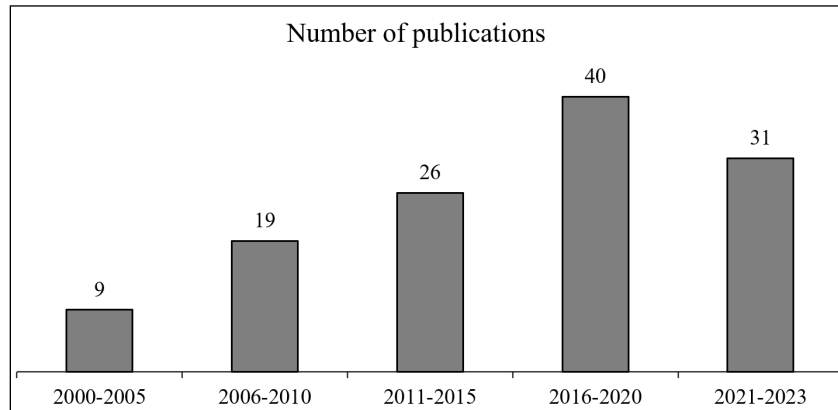


Figure 7. Number of articles published in every five years from 2000–2023 based on 125 articles included in the study.

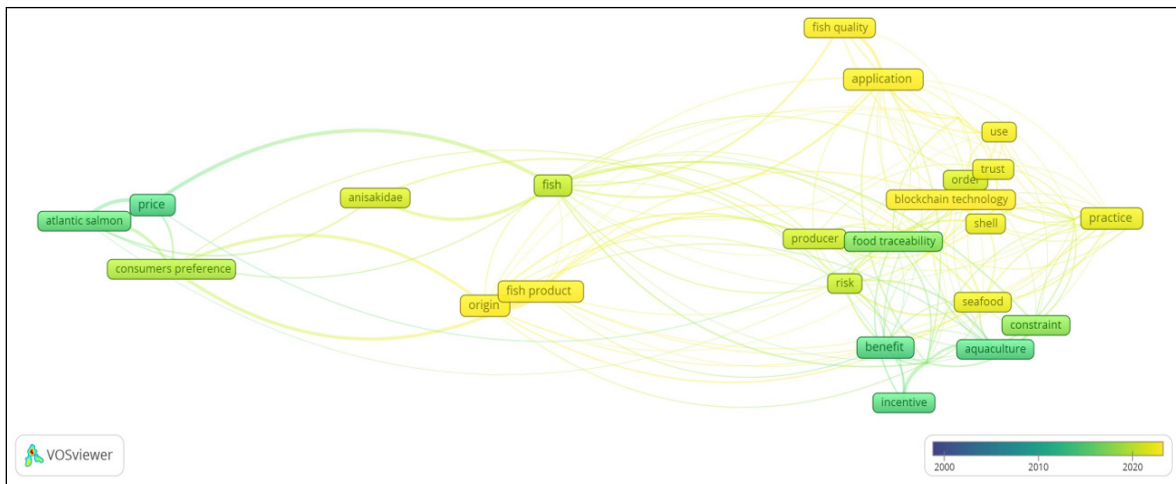


Figure 8. Overlay visualization of most frequently-used terms in titles/abstracts from 2000-2023 studies.

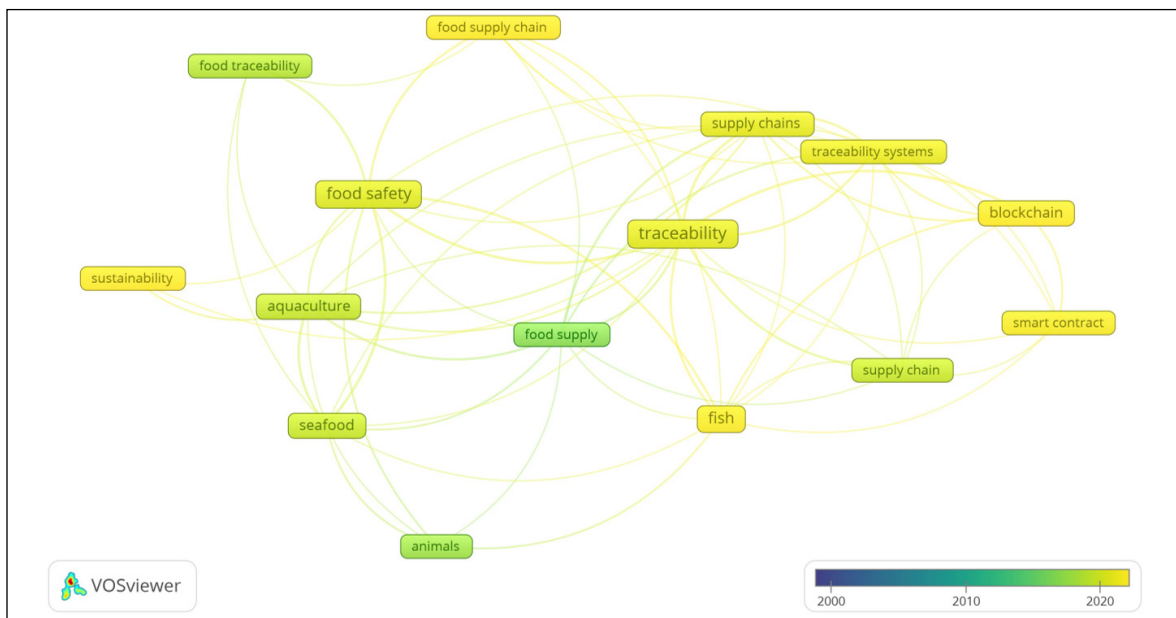


Figure 9. Overlay visualization of most frequently-used terms in authors/index keywords from 2000-2023 studies.

Figure 10 presents the principal drivers for adopting a traceability system, which include food safety, product origin, market compliance, consumer protection, quality concern, and seafood fraud risk. Identifying the drivers helps the food industry to value its capability to implement a traceability system (Singh Sandhu et al. 2011). While Figure 11 presents the different barriers to implementing of traceability system in the supply chain, such as the high cost of traceability implementation, lack of support from the government, lack of infrastructure, laws and regulations, information, and inadequate practices of the technology.

4. DISCUSSION

4.1 Traceability system in the agri-fishery and fishery supply chain

Based on the review result, from authors' abstracts and titles, "fish" takes a top position in terms of the total link strength and occurrences, and it is followed by "fish product," "origin," and "consumer preference" in cluster 2 (see Table 1). In the text from author/index keywords, "supply chain" has the highest total link strength in cluster 1, followed by "fish" and "traceability system" (see Table 2). Traceability in the fish food industry is becoming increasingly important in consumer safety and building confidence (Jérôme et al. 2008). According to Martinez and Jakobsen Friis (2004) and Mazzeo et al. (2008), consumers have had an increasing demand for fish in recent years, underlining the need to guarantee such products' safety, traceability, authenticity, and health benefits. Over the past ten years, various

factors within the seafood industry have encouraged the use of traceability for the issue of food safety and inventory control (Lewis and Boyle 2017). The General Food Law of the European Union mandates that the food industry have an accurate traceability system that enables timely and precise recall targets and information distribution to consumers (Kuo et al. 2017). In addition, due to the high frequency of food-borne illnesses, the agricultural food business has paid much more attention to social sustainability factors, including consumer health and safety (Farooq et al. 2016). Many countries have begun to give importance to agricultural product supply chain traceability and implemented rules and regulations to enhance the management of agricultural product traceability (Underwood 2016). Traceability is now an essential component in agricultural supply chain traceability. It is a technique for tracing every link in the supply chain for agricultural products (Prashar et al. 2020). Hence, finding the product's origin in the agricultural supply chain promotes food safety, helps uncover the underlying cause of food hazards, connects participating parties, and builds consumer trust (Saranya and Maheswari 2023).

In the Philippines, the lack of existing literature on the status of traceability systems for fishery products is attributed to the limited traceability systems implemented in the country. Most of these traceability systems are in their pilot testing stages or have undergone issues regarding the completeness of the records necessary to complete catch-to-plate traceability. A few studies have raised challenges, such as the diverse standards and requirements for fishery products per importing country (Shamsuzzoha et al. 2023), restrictive policies inhibiting the use of

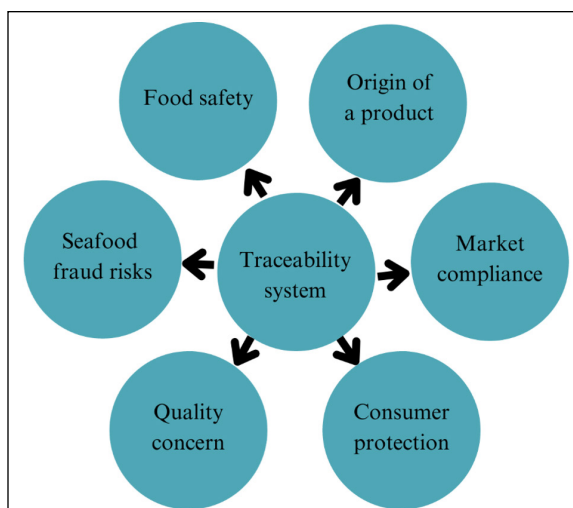


Figure 10. Drivers for the adoption of traceability system.

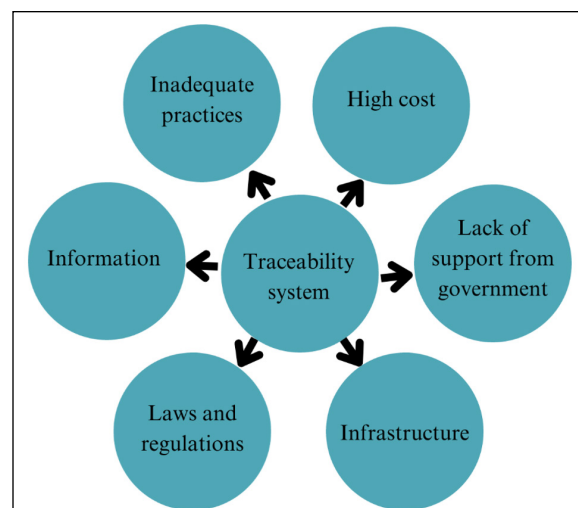


Figure 11. Barriers to implementing a traceability system.

the catch documentation and traceability systems, limited capacity of intended users both on the skills and technology, and lack of commitment from stakeholders resulting in distrust among companies to participate in the implementation of traceability systems (Saraphaivanich et al. 2022).

4.2 Drivers for the adoption of a traceability system

Traceability has been the subject of several types of research that have examined its features, advantages, potential implementation, and drivers to adopt the subject (Preziosi et al. 2014; Macusi et al. 2023)—according to Faisal & Talib (2016), implementation of a traceability system required to identify the drivers and their interactions that affect traceability in the value chain. The driving factors for adopting a traceability system are summarized in Figure 10 above. Six (6) motivating factors for the implementation of traceability were discussed.

4.2.1 Food safety

Yu et al. (2020) reviewed smart food traceability, which could significantly increase food safety and ensure food security while reducing foodborne outbreaks in the global food supply chain. Starbird and Boadu (2006) stated that one motivation for using traceability systems is ensuring food safety, specifically in suppliers, and distributing safe food. The study implied that suppliers are accountable for the unsafe food that might enter the supply chain without a traceability system. Meanwhile, Adam et al. (2016) used a whole-chain traceability system in the beef industry to have information on the product along the supply chain and to produce safe food. Due to safety concerns, consumers are willing to pay more for food with proper tracking mechanisms (Lu et al. 2016). Traceability also encourages liability among suppliers to provide safe food. As consumers gain appreciation towards traceability, exhibited by their willingness to pay a small premium (Hobbs et al. 2005), producers are more likely to improve the food safety reputation of their industry. However, this behavior is only true for a finite number of firms (Pouliot and Sumner 2008). In China, pork is a significant meat among the Chinese consumers. Thus, the traceability system is receiving attention as an effective technique to ensure the meat's safety for consumption. Another study confirmed that improving pork safety is possible by establishing a pork tracking system (Liu et al. 2022). To regulate

the production practices of pig farmers, the Chinese government has implemented several food safety laws (Ramzy 2009). A food traceability system is a potent remedy for food safety issues and has taken over as the primary instrument and foundation for guaranteeing meat quality and avoiding food safety risks (Sun and Wang 2019; Feng et al. 2020).

4.2.2 Origin of a product

Due to market globalization, more fish species are sold globally, which confuses consumers when they see various species sold under the same brand name (Pappalardo and Ferrito 2015) or from the sale of fish harvested illegally and from polluted areas (Kusche and Hanel 2021). One application of traceability is identity preservation through ensuring authenticity, particularly on the product's origin. Some consumers may view the country of origin as a safety signal (Hoffman 2000), and despite not having full chain information, traceability provides basic information on the origin of the product (Hobbs 2003). Consumers demand traceability and more detailed information on the food they purchase, including the place of origin, the inputs used in production, and its safety to enhance consumer awareness (Gates et al. 2015; Tripoli and Schmidhuber 2020). Critically aware consumers are typically concerned about the product's information and anxious about their food's origin (Zhu 2017).

4.2.3 Market compliance

Market compliance is one of the drivers for adopting the traceability system, and all export agriculture enterprises must implement traceability to comply with regulatory rules and market demands (Helyar et al. 2014). Traceability protocols are beneficial in agribusiness firms to enhance and streamline their manufacturing procedures. As a result, they enhance the transparency and management of food safety and quality in the food supply chain (Jones et al. 2004). The supply chain must adopt traceability systems to lower the cost of non-compliance and ensure adherence to the law (Hammoudi et al. 2009; Banterle and Stranieri 2008). Examples of stricter market compliance in terms of foodfish include Europe, the US, Japan, and China. Along fish supply chains, the adoption of traceability systems is positively influenced by the firms' drive to improve product quality for value adding and as a branding and marketing strategy of the company, while adoption is negatively driven by

the stringent traceability requirements that companies need to comply with in accordance to specific laws and standards (Borit and Olsen 2020).

4.2.4 Consumer protection

Due to the high frequency of foodborne illness incidents, the agricultural food business has paid much more attention to social sustainability factors, including consumer health and safety (Farooq et al. 2016). Industry and consumers have given attention to implementing traceability and becoming essential tools to verify the quality of food products they purchase (Dima et al. 2022). Moreover, traceability can also assist the sector in ensuring other quality certifications, such as halal products for non-pork consumption, and reducing risk until the product is in the hands of the consumer (Khan et al. 2018). Traceability can be used as a tool to trace the products to increase the consumer's confidence and help ensure the food safety and quality of the products they purchase (Aung and Chang 2014; Rodriguez-Salvador and Dopico 2020).

4.2.5 Quality concern

Recently, there has been an increasing concern about the reliability and quality of fish products. Describing the quality of fishery products has always been challenging because it is usually determined by how the consumer evaluates the product. Usually, consumers depend on the expiration date as their guide when purchasing a product. However, a fish product's sensory appeal typically determines whether a product is acceptable or not to the consumers (Zugravu and Soare 2012). Customers typically consider texture, color, flavor, and odor while assessing fishery products (Brockmann et al. 2006). Systems for quality control will help as a facilitating element (Behnke and Janssen 2020). The issue with the quality and safety of fish products in China is that people are more aware of the fish products they purchase which leads to a decrease in consumption. As a result, Chinese consumers currently emphasize quality over price when deciding to buy fish products (Zhang 2002). Typically, consumers are willing to pay a premium for fish products that are safe and traceable compared to the cost of products without clear safety information (Wang et al. 2009).

4.2.6 Seafood fraud risk

Due to the supply chain for fisheries goods being one of the most complex and globalized nowadays, it is challenging to trace fish and other seafood and uncover purposeful and inadvertent fraud (Warner et al. 2016). The expansion of the global food surveillance program is insufficient to prevent fraud, safeguard producers and consumers, and promote high-quality fish products. In order to confidently determine whether a product is authentic or counterfeit and to guarantee the integrity of the entire production chain, control measures must be applied in conjunction with the implementation of suitable vulnerability assessment systems and the development of quick analytical tools (Varrà et al. 2021). The resulting study by Rombe et al. (2018) implies that a traceability system will help to reduce and identify illegal fishing.

4.3 Barriers to the adoption of a traceability system

From the literature included in the study, some researchers highlighted the different barriers affecting the implementation of a traceability system. Six (6) main barriers were summarized above (Figure 11) and described below.

4.3.1 High cost

Certain disadvantages are reflected by the expenses and additional time and effort in adopting and using technology. However, most aquaculture farm managers and retailers agree that traceability information might add value to the goods (Karlsen et al. 2013). The findings of the study of Rombe et al. (2018) were that different actors in the fishery supply chain had foreseen barriers to adopting a traceability system, such as the new technology is costly, third-party involvement is required, it costs more because the seafood chain is too complicated, the entire cost should be agreed upon by the parties involved or provided by the government. Moreover, in Romania's fish farm, about 83% responses of respondents strongly agreed that high cost is one of the barriers to adopting a traceability system (Dediu et al. 2016).

4.3.2 Lack of support from the government

Lack of support from the government in external and internal parties is one of the significant

barriers to adopting a traceability system in the supply chain. From the external perspective, laws and regulations are essential in supporting the seafood chain regarding high-quality standards and safety for the consumer's needs. As a result, the government must set standards that entities must adhere to ensure sustainability chains (Rombe et al. 2018). To encourage the adoption of a traceability system, the government should provide a policy to guarantee the adoption of the traceability system. Likewise, the government should also offer training and foster capability building on traceability requirements to encourage the application and implementation of traceability (Dediu et al. 2016).

4.3.3 Infrastructure

Another barrier was found in a recent study (Rombe et al. 2018). Where the system needs appropriate infrastructure and information technology (IT) resources, there are no IT services at several fisheries, so all parties in the fish supply chain should use the same infrastructure, and cooperation should be encouraged. Investing more in strengthening market infrastructure and services can only help reduce food safety hazards to a greater extent (World Bank 2008)..

4.3.4 Laws and regulation

In terms of barriers, laws and regulations harm value-chain actors, which limit the fish operation of the fishers, and the lack of information and implementation of this from the government. The government controls making laws and regulations concerning fish processing, and the existing fish supply chain policy only focuses on the first stage. When there is a lack of laws and regulations regarding fish processing and only focus on the first stage, the available standards do not guarantee the safety of the products (Rombe et al. 2018). In addition, Romania still lacks the necessary rules and regulations to support the implementation of the traceability system in the fishing industry (Dediu et al. 2016).

4.3.5 Inadequate practices

Different agricultural products in India are sold for the domestic market or export trade and need better agricultural, manufacturing, hygiene practices, and traceability. However, they need proper development and traceability practices to provide high-quality, safe products. Furthermore, the Agricultural and Processed Food Products

Export Development Authority (APEDA) is working continuously to improve food safety for domestic and export markets, with an emphasis on the adoption of Hazard Analysis Critical Control Point (HACCP) and International Organization for Standardization (ISO) certification among food manufacturers (Umali-Deininger and Sur 2007). With a traceability system and good practices, farmers frequently complain about exorbitant marketing costs, lengthy travel times to the market, and dishonest traders (World Bank 2008).

4.3.6 Information

However, traceability could negatively impact all entities' performance if data flows from upstream to downstream will be inaccurate (Golan et al. 2004). In general, effective means of informing customers and other stakeholders about food traceability should be used in conjunction with implementing food traceability (Bosona and Gebresenbet 2013). The need for an origin label on fish products now prevents end customers from being able to identify the product before making a purchase. The sustainability of the fish supply chain is supported by the information flow from the point of origin to the final consumers. Also, the information on the label may increase the product's value, broadening the market (Rombe et al. 2018). Many buyers in Romanian supermarkets purchase fishery and aquaculture products based solely on their appearance but should pay more attention to the specifics of their quality information. A traceability system is a particularly effective method for attaching production information to the information consumers need about the quality of fish products before purchasing. It increases consumer confidence in quality goods (Dediu et al. 2016).

4.4 Traceability as a component of food safety

Based on the visualization result, “food safety” and “traceability” are some of the most frequently used terms in authors/index keywords from 2000–2023 studies (Figure 9). Traceability systems have become the primary techniques used to ensure food safety, while the safety of food is a fundamental component of food quality (El Sheikha 2015). According to Dzwolak (2009), traceability is essential for ensuring food safety and public health. Traceability aims to provide consumers with wholesome and safe foods that are produced in an economical manner (El Sheikha and Montet 2016), while Bailey et al. (2016) mentioned the importance of advocating against illegal, unreported,

and unregulated fishing (IUU fishing) to downstream actors in global tuna value chains. Moreover, all contributors engage in food production. Food safety is now recognized as a critical concern. Consumers and other stakeholders are becoming increasingly concerned due to the recent food incidents (Van Dorp 2004). Furthermore, in 2005, the EU General Food Law established a legal necessity for a traceability system for agricultural products to maintain food safety (Engelseth 2009). Food safety is a crucial aspect of food security and food traceability across the supply chain (Yu et al. 2020). At every point of the food supply chain, traceability is essential for maintaining the safety and quality of the food, especially for tracking the sources of contamination in meat, poultry, and seafood (McMillin et al. 2012).

4.5 Implications to policymaking bodies in the Philippines

In international trade, the European Commission (EC) Regulation No. 178/2002 or the General Food Law requires traceability to be implemented at all stages of the food supply chain. Developing countries, explicitly importing and exporting countries, have urged traceability implementation to comply with the market standard (EC 178/2002; PNS/BAFPS 2013). In the Philippines, the Republic Act No. 10611, or the Food Safety Act of 2013, mandates the Department of Agriculture (DA) through the Bureau of Fisheries and Aquatic Resources (BFAR) to amend the traceability system for fish and fishery products to create and implement guidelines for food safety and traceability at the post-harvest and primary production stages of the food supply chain (BFAR 2019). In addition, Executive Order 154 and Republic Act 10654 are more legislative reforms in the Philippines to drive the implementation of a better traceability system by the demand to maintain access to a foreign market (Oceana 2017).

5. CONCLUSION

The review reveals that the implementation of traceability in the fisheries sector varies significantly across regions and types of producers. Higher adoption rates are observed in certain regions and among large-scale producers, driven by regulatory requirements and market demands. In contrast, smaller-scale and artisanal producers often face significant challenges in implementing traceability. Key drivers promoting the adoption of traceability include regulatory compliance, market access, consumer demand for transparency,

and the need to combat illegal, unreported, and unregulated (IUU) fishing. However, several significant barriers hinder the widespread adoption of traceability systems, such as high implementation costs, lack of technical expertise, resistance to change among stakeholders, and insufficient infrastructure. In conclusion, although traceability in the fisheries sector is progressing, considerable gaps and challenges remain. The drivers and barriers identified in this review provide a clear roadmap for policymakers, industry stakeholders, and researchers to enhance the adoption and effectiveness of traceability systems. The fisheries sector can advance towards more sustainable and transparent practices by addressing these barriers and leveraging the identified drivers. Overall, this review can provide insights that can be considered in agriculture, business, governance, and the fisheries sector to implement a traceability system in every supply chain to provide safe and healthy food for consumers.

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AUTHOR CONTRIBUTIONS

Macusi ED: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Data curation, Writing - review and editing, Supervision, Project administration. **Nallos IM:** Validation, Investigation, Writing—original draft preparation, Visualization. **Borazon EQ:** Methodology, Validation, Formal analysis, Investigation, Data curation. **Castro MC:** Methodology, Validation, Investigation, Resources, Data curation, Supervision, Project administration. Funding acquisition. **Peralez CP:** Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Data curation, Writing - original draft preparation, Writing - review and editing, Supervision, Project administration, Visualization.

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DATA AVAILABILITY

Data are available upon request.

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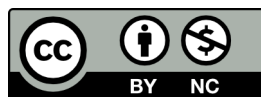
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