IMPACT OF MICROBIAL FLORA 0N SEAFOOD CONSUMPTION BY PREGNANT WOMAN

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Abstract
Infections induced by seafoods consumption during pregnancy can harm a developing fetus. These infections can be fatal to the mother, fetus, or newborn when it is untreated. Furthermore, it can lead to viral infections, potentially causing spontaneous abortions or organ disease(Van Oostdam, et al., 2005). However, pregnancy exposure to methylmercury is unlikely to be a significant risk factor for low neurodevelopmental functioning, especially in terms of cognitive performance (Huss, et al., 2000) in early childhood. Therefore, it is recommended that pregnant women consume a variety of low-mercury seafoods that provide essential nutrients without exposing them to excessive levels of contaminants. The US FDA and EPA advise a maximum intake of 8–12 ounces (2–3 servings) per week of cooked seafoods low in mercury, such as shrimp, salmon, canned light tuna, tilapia, and catfish (Clarkson, et al., 2003). According to FDA recommendation, pregnant women, women of childbearing age, and young children should also avoid high-mercury seafoods such as shark, swordfish, king mackerel, and tilefish (Lüth, et al., 2020) which can accumulate more toxins in their tissues due to their longer lifespan and higher trophic level in the food chain.

Introduction

Microbial flora found in seafood

It is generally agreed that the microbial flora of seafood found in temperate waters consist of Gram-negative psychrotolerant bacteria, whose growth is possible at 0°C but optimal around 25°C. Among these, the majority belong to the subclass γ of *proteobacteria: Pseudomonas, Shewanella, Acinetobacter, Aeromonas, Vibrio, Moraxella, Psychrobacter, Photobacterium,* etc. and to a lesser extent the CFB (CytophagaFlavobacter-Bacteroides) group (Huber, *et al.,* 2004; Wilson, *et al.,* 2008). Nevertheless, Gram-positive bacteria like *Micrococcus, Bacillus, Lactobacillus, Clostridium or Coryneforms,* may also be present in variable proportions (Shewan, 1971; 1977; Hobbs, 1983; Mudarris and Austin, 1988; Gram and Huss, 1996; Gennari,*et al.*, 1999; Wilson, *et al.*, 2008). Some genera, like *Vibrio, Photobacterium* and *Shewanella*, require the presence of salt to multiply and are thus typically found in seawater while Aeromonasis more common in fresh water even though it is often isolated from marine products (Hanninen,*et al.*, 1997). In tropical fish, the flora has the same composition overall (Al Harbi and Uddin,2005; Emborg, *et al.*, 2005), but often with a greater proportion of Gram-positive bacteria(Micrococcus, *Bacillus, Coryneforms*) and *enterobacteria* (Devaraju and Setty, 1985; Liston,1992; Huss, 1999).

The indigenous microflora of the gastro-intestinal tract of fish have been much more studied than those of the skin or the mucus due to their importance in digestion, nutrition and growth and in disease control in aquaculture (Ringo, *et al*., 1995; Spanggaard, *et al.*, 2000). Gram-negative bacteria dominate the intestinal flora. In general, Aeromonas, Pseudomonas and members of the Flavobacterium/Cytophaga group are most often found in the intestine of freshwater seafood while Vibrio, Acinetobacter, and Enterobacteriaceae are more common in marine seafood (Ringo, *et al.,* 1995; Ringo and Birkbeck, 1999). These are fermentative bacteria that develop rapidly in the gastrointestinal tract due to the low pH, the lack of oxygen and the abundance of nutrients. Staphylococci have also been found to be the dominant flora in the intestine of the Arctic char (Ringo and Olsen, 1999). Although not predominant, lactic acid bacteria (*Lactobacillus, Carnobacterium, Streptococcus, Leuconostoc, Lactococcus, Vagococcus)* have often been isolated from the gastro-intestinal tract of seafood (Ringo and Gatesoupe, 1998). (Pond, *et al.,* 2006) have identified a strict anaerobe *(Clostridium gasigenes*) in the intestinal flora of rainbow trout. Similarly, Kim, *et al*. (2007) have shown the presence of Clostridium in the intestinal mucus. Moreover, molecular methods have enabled a new species belonging to the genus Mycoplasma to be detected for the first time in fish. It was found in abundance in the intestine of wild and farmed salmon (Holben, *et al.,* 2002).

The worldwide shrimp market is mainly composed of the Nordic shrimp (*Pandalus borealis*), which is only fished, and the tropical shrimp (*Penaeus sp*.), which can be fished or farmed and whose production has expanded rapidly in recent years. The deep-water tropical shrimp (*Parapenaeuslongirostris*) is also found in Europe, particularly on the Spanish and Portuguese Markets (Sobriono, *et al*., 2005) As in fish, the bacterial flora of shrimps depends on several factors including the species considered, the geographic location and environment, the temperature and salinity of the water, etc. However, overall, the same species of microorganisms are found in shrimps and in fish from a given geographical zone. In fresh tropical shrimps, the initial bacterial flora consistsmainly of *Pseudomonas, Vibrio, Acinetobacter, Moraxella, Flavobacterium* and a high proportion of *Aeromonas* (Vanderzant, *et al.,* 1973; Jayaweera and Subasinghe, 1988;Jeyasekaran, *et al.,* 2006).

In India, Gopal, *et al.* (2005) have detected significant amounts of different species of *Vibrio*, including *V. parahaemolyticus*. Benner*, et al*. (2004), working on Nicaraguan shrimps, reported a predominance of Coryneforms and Moraxella followed by lower levels of *Bacillus, Lactobacillus, Micrococcus, Proteus, Shewanella, Acinetobacter* and Pseudomonas. These results confirm those previously obtained by Matches, (1982).Chinivasagam, *et al.,* (1996) have shown the influence of the fishing zone on the nature of theinitial flora: mostly Gram-positive bacteria on shrimps fished at low depths and Pseudomonas on those caught in deep water. The nature of this initial flora has an effect on sample.

Acinetobacter

Acinetobacteriwoffii, a serious human pathogen, has been identified as a cause of nosocomial infections such as bacteremia, pneumonia and meningitis (Bergogne-Bérézin, *et al.,*1996). There are only a few studies reporting A. iwoffii as a pathogen of fish. In 2016 and 2017, six bacterial strains, isolated from diseased fish of the Schizothorax genus, were identified as A. iwoffii by morphology, biochemical tests, 16S rDNA and gyrB gene sequencing analysis (Cao, *et al.,* 2018).

Aeromonas

As part of Singapore's National Strategic Action Plan towards AMR while incorporating a Health approach, the Antimicrobial Resistance Congress (AMR) surveillance program looked at the prevalence of *Aeromonasspp* from 1343 seafood samples since August 2021 (Koh, *et al.,* 2024). According to the research,1 69% (n=136/197) were *Aeromonashydrophila/caviae* and 23% (n=46/197) were Aeromonassobria . The highest prevalence of *Aeromonasspp*was found in fish (53% n=104/197) and oysters (26% n=52/197). A lower prevalence was found in prawn and mussel (6% n=12/197), feed (4%=7/197) with scallop, clam, squid, and cockle as (5% n=10/197). It was noted that oysters are often eaten raw and have a possibly higher risk of foodborne illness. Thus, antimicrobial profiles and genome analysis were performed on 30 Aeromonas spp. Isolates from oyster samples to delve more into AMR implications in aquatic environments and public health (Ramachandran and Teo, (2024).

Vibrio Species

Vibrio spp. are Gram-negative, facultatively anaerobic motile curved rods with a single polar flagellum. Among the members of the genus, 12 species have so far been reported to be pathogenic to humans, where eight of these may be associated with foodborne infections of the gastrointestinal tract. Most of these foodborne infections are caused by *V. parahaemolyticus* and *V. cholerae,* and to a lesser extent by *V. vulnificus*. (Roshini, *et al.,* 2023).

Vibrio cholerae

Among the *vibrios, V. cholerae* is of most concern because of its ability to cause cholera. *V. cholerae* can be divided into serogroups on the basis of the O antigen. Of the more than 200 *V. cholerae* serogroups that exist, only O1 and O139 are associated with the epidemiological features and clinical syndrome of cholera (Chowdhury, *et al*., 2023). However, organisms of *V. cholerae* serogroups other than O1 and O139 (non-O1 non-O139 serogroups) have been associated with sporadic cases of foodborne outbreaks of gastroenteritis, but have not spread in epidemic form. The most important virulence factor associated with *V. cholerae* O1 and O139 5 serogroups is the cholera toxin. Non-O1 non-O139 serogroups are generally nontoxigenic.

Vibrio parahaemolyticus

V. parahaemolyticus was first identified as a foodborne pathogen in Japan in the 1950s. By the late 1960s and early 1970s, *V. parahaemolyticus* was recognised as a cause of diarrhoeal disease worldwide, although most common in Asia and the United States (Wang, *et al*.,2023). In Hong Kong, *V. parahaemolyticus* continued to be the top causative agent among all the reported food poisoning outbreaks in recent years, Food and Environmental Hygiene Department. (2005).

Vibrio vulnificus

V. vulnificus is an opportunistic pathogen that can cause wound infections and primary septicaemia. This bacterium has less often been described as a cause of gastroenteritis, and its role as a primary cause of gastrointestinal disease remains to be determined.. Wound infections occur in connection with puncture wounds after handling of raw seafood or trauma and exposure to saline environments that harbour the organism (Daskalov, *et al.,* 2023).

Psychrobacter

The *genus Psychrobacter*belongs to the family of Moraxellaceae within the class of Gammaproteobacteria. The members of this genus are psychrophilic to psychrotolerant, halotolerant, aerobic, nonmotile, Gram-negative *coccobacilli. Psychrobacter* species have been mainly isolated from cold environments including Antarctic sea ice, seawater, deep sea, permafrost soil but also from other environments, such as pigeon feces, fish, poultry, dairy products, fermented seafood (Bowman,
2006).

Photobacterium

Photobacterium is a marine motile,*psychotrophic,* facultative Gram negative bacteria, and member of the Vibrionaceae family (Jérôme, *et al*., 2016). This genus comprises of P. phosphorus, *P. iliopiscarium, P. aquimaris, P. piscicola and P. kishitanii (*Figge, *et al.*, 2014). However, P. phosphoreum is more associated with seafood spoilage than others (Macé, et al., 2013). P. phosphoreum has been detected in several studies as spoilage bacterium in seafood such as fish, salmon, It is the main spoilage organism in lobster (Gornik, *et al.,* 2011), and shrimp (Hansen, et al., 2009; Macé, *et al.,* 2012b). It can survive high CO 2 (Gornik, *et al.,* 2013a), hence it plays significant role in packaged seafood (Pennacchia, *et al.*, 2011).

Health risks of seafood consumption for pregnant woman

Pregnant women are often advised to consume seafood due to its nutritional benefits, including omega-3 fatty acids that are important for fetal brain development (Mahaffey, *et al.,* 2009). However, seafood also contains a variety of contaminants that can pose a risk to both the mother and developing fetus(Jeffries, *et al.,* 2011).

Seafood contains harmful levels of environmental contaminants such as methylmercury, PCBs, dioxins (Mahaffey, *et al.,* 2009) and brominated flame retardants (BFRs) Oliver, 2015), which can pose significant risks to human health, especially for pregnant women and developing fetuses (Sani, *et al.,* 2017).. Exposure to these chemicals has been associated with adverse neurological, developmental, endocrine, reproductive, and immune effects in offspring, as well as increased risk of preterm birth, low birth weight, and cognitive deficits (Oliver, 2015). According to Misser, *et al.*,(2022), prenatal exposure to methylmercury has been linked to adverse developmental outcomes such as impaired cognitive function and behavioral problems. High levels of methylmercury in seafoods can also lead to fetal growth restriction and preterm birth (Choi, *et al.*, 2009).

In addition to methylmercury, PCBs, dioxins, and other persistent organic pollutants have been linked to negative effects on reproductive health and immune function, as well as increased cancer risk (Grandjean, *et al.,* 2014). Pregnant women are therefore advised to avoid consuming predatory seafoods such as shark, swordfish, tilefish, and king mackerel, which tend to havehigher levels of these contaminants (Meeker, *et al.,* 2009).

Infections induced by seafoods consumption during pregnancy can harm a developing fetus. These infections can be fatal to the mother, fetus, or newborn when it is untreated. Furthermore, it can lead to viral infections, potentially causing spontaneous abortions or organ disease(Van Oostdam, *et al.,* 2005). However, pregnancy exposure to methylmercury is unlikely to be a significant risk factor for low neurodevelopmental functioning, especially in terms of cognitive performance (Huss, *et al.,* 2000) in early childhood.

Therefore, it is recommended that pregnant women consume a variety of low-mercury seafoods that provide essential nutrients without exposing them to excessive levels of contaminants. The US FDA and EPA advise a maximum intake of 8–12 ounces (2–3 servings) per week of cooked seafoods low in mercury, such as shrimp, salmon, canned light tuna, tilapia, and catfish (Clarkson, *et al.*, 2003). According to FDA recommendation, pregnant women, women of childbearing age, and young children should also avoid high-mercury seafoods such as shark, swordfish, king mackerel, and tilefish (Lüth, *et al.,* 2020) which can accumulate more toxins in their tissues due to their longer lifespan and higher trophic level in the food chain.

In addition to contaminants, some species of microbes such as *E. coli, Aeromonashydrophila, Yersinia spp., Brucella spp., Shigella spp., Salmonella spp., Streptococcus iniae, Clostridium botulinum, Klebsiella spp.,* and Edwardsiellatarda are already isolated from fish (Gochfeld and Burger, (2005). Therefore, some fish species may harbor infectious agents such as *Listeria monocytogenes,Vibrio parahaemolyticus,* and *Salmonella spp.,* which can cause foodborne illnesses in pregnant women (Mahaffey, 2004).. These pathogens can cross the placenta and infect the fetus, leading to miscarriage, stillbirth, or severe neonatal infection. To minimize the risk of foodborne illness, pregnant women should avoid eating raw or undercooked seafood, refrigerated smoked seafood, and sushi made with seafood (Silk, *et al.*, 2012).

Pathogenic Microorganisms associated with seafood

Vibrio species.

Vibrio organisms are Gram-negative, halophilic bacteria that are widespread and naturally present in marine and estuarine environments. Environmental factors influence their growth, and their numbers are highest when the water is warm. The genus Vibrio includes 30 species, of which at least 14 are recognized as pathogenic in humans. Vibrio infections are acquired through ingestion of contaminated seafood or through exposure of an open wound to seawater(Baker- Austin, *et al.,* 2013) . *Vibrio parahaemolyticus* and *Vibrio vulnificus* are the species most commonly associated with reported infection. *V. parahaemolyticus* has been associated with sporadic infections and outbreaks of gastroenteritis, while *V. vulnificus* infections occur almost exclusively as sporadic cases in the United States.

Clinical features most often associated with *V. parahaemolyticus* infection include watery diarrhea, abdominal cramps, nausea, and vomiting; wound infections and septicemia occur less commonly (Abbott, *et al.,* 2017). *V. vulnificus* is particularly virulent, especially among patients with liver disease and iron storage disorders, who are at increased risk of invasive disease (Ayers, *et al.,* 2008). *V. vulnificus* infections can lead to sepsis and severe wound infections (Bialek, *et al.*, 2007). Cases of Vibrio infections have a marked seasonal distribution; most occur during summer and early fall, corresponding to the period of warmer temperatures. Almost all cases of food-borne Vibrio infection are associated with a recent history of seafood consumption, primarily raw oyster consumption. Like other organisms found in water, vibrios can be concentrated in the tissues of filter-feeding bivalve Mollusks.

Samonella

Salmonellae are Gram-negative bacilli. Approximately 2,500 *Salmonella* serotypes have been identified, causing a variety of clinical syndromes ranging from asymptomatic carriage to invasive disease (Brenner, *et al.,* 2000). *Salmonella* most commonly causes acute gastroenteritis, with symptoms including diarrhea, abdominal cramps, and fever. Other clinical manifestations can include enteric fever, urinary tract infections, bacteremia, and severe focal infections. Isolation of Salmonella organisms from cultures of stool, blood, or other clinical samples is diagnostic; isolates are referred to public health laboratories for serotype characterization.

Salmonella is a leading cause of food-borne illness, causing approximately 1.4 million illnesses annually in the United States (Mead, 2000). Incidence is highest among infants and the elderly, and infections are more likely to occur during summer and early fall (Olsen, *et al.*, 2001)). Seafood-associated outbreaks have been caused by fish, shrimp, oysters, and clams. Studies to determine the prevalence of Salmonella spp. in oysters from domestic bays and testing of sampled oysters from domestic seafood samples by the U.S. Food and Drug Administration (FDA) have demonstrated the presence of *Salmonellae* in a variety of fish and shellfish, including seafood intended for consumption without further preparation upon distribution, requiring minimal cooking, and shellfish eaten raw (Brands, *et al.,* 2005). Fish and shellfish can acquire *Salmonella* from polluted waters. Historically, sewage contamination of shellfish harvest beds led to large shellfish-associated outbreaks of *Salmonella* serotype Typhi infections. Control measures aimed at detecting contamination of harvest waters, such as monitoring fecal coliform counts in these waters, have been effective at reducing the risk of *Salmonella* contamination of seafood occurring before harvest. Additionally, seafood can become contaminated with*Salmonella* during storage and processing (Gangarosa*, et al.,* 2000). Salmonella infection can be prevented by adequate cooking, proper storage and processing after harvest, and avoidance of cross-contamination during seafood handling (FDA, 2006).

Shigella species.

Shigella species are Gram-negative bacilli. Four species have been identified, and clinical presentations vary by species.Clinical manifestations of *Shigella*infection range from watery, loose stools to more severe symptoms, including fever, abdominal pain, tenesmus, and bloody diarrhea (Potasman, *et al.,* 2001). With seafood, contamination can occur if seafood is harvested from sewage-contaminated water, as occurred in an outbreak caused by consumption of raw oysters harvested from waters where sewage was dumped overboard from the oyster harvest boat (Olsen, *et al.*, 2001). *Shigella* organisms can survive outside the host, but they are killed readily by cooking. Control strategies to prevent shigellosis associated with seafood have included monitoring of harvest water for fecal coliforms, prohibition of harvesting from sewage- contaminated areas, enforced control of dumping sewage overboard, and guidelines for seafood handling in restaurants.

Clostridium botulinum.

Clostridium botulinum is a spore-forming, anaerobic, Gram-positive bacillus that is widespread in the environment. The bacterium produces a potent neurotoxin under anaerobic, low-acid conditions. Seven types of botulism toxin have been identified; toxin types A, B, and E cause most human illnesses (McLaughlin, *et al.,* 2004). Food-borne botulism is caused by the ingestion of food contaminated with preformed toxin produced by spores of C. botulinum. Botulism is characterized by an acute, symmetric, descending flaccid paralysis. Early signs and symptoms of botulism often include cranial nerve palsies, with diplopia, ptosis, slurred speech, and difficulty swallowing progressing to descending weakness and paralysis.

Symptoms can progress to cause paralysis of the respiratory muscles, requiring ventilatory support (Mead, *et al.,* 2001). Cases of botulism are rare but serious; an estimated 60 food-borne cases occur each year in the United States. Most cases are sporadic, but food-borne botulism outbreaks are reported each year. Food-borne botulism cases are most often associated with home-canned foods. Other food vehicles identified in outbreak investigations have included fermented or salted seafood, potatoes baked in aluminum foil, garlic in oil, onions held under butter, and homemade salsa (Sobel,2005). Most seafood-associated cases are caused by toxin type E, which is associated most commonly with eating traditional Alaska Native foods, such as fermented salmon heads, salmon eggs, and blubber and skin from marine animals (muktuk) (CDC, 2009). *C. botulinum* type E spores are commonly found in fish and aquatic animals, and implicated seafood has been fermented under anaerobic conditions that favor the germination of *C. botulinum* (McLaughlin, *et al*., 2004). Measures to prevent seafood-borne botulism have included educational efforts to promote proper methods to ferment foods and to boil fermented foods before consumption, especially if they were stored in tightly sealed plastic or glass containers (CDC, 2000).

Conclusion

Infections induced by seafoods consumption during pregnancy can harm a developing fetus. These infections can be fatal to the mother, fetus, or newborn when it is untreated. Furthermore, it can lead to viral infections, potentially causing spontaneous abortions or organ disease(Van Oostdam, *et al.,* 2005). However, pregnancy exposure to methylmercury is unlikely to be a significant risk factor for low neurodevelopmental functioning, especially in terms of cognitive performance (Huss, *et al.,* 2000) in early childhood. Therefore, it is recommended that pregnant women consume a variety of low-mercury seafoods that provide essential nutrients without exposing them to excessive levels of contaminants. The US FDA and EPA advise a maximum intake of 8–12 ounces (2–3 servings) per week of cooked seafoods low in mercury, such as shrimp, salmon, canned light tuna, tilapia, and catfish (Clarkson, *et al.*, 2003). According to FDA recommendation, pregnant women, women of childbearing age, and young children should also avoid high-mercury seafoods such as shark, swordfish, king mackerel, and tilefish (Lüth, *et al.,* 2020) which can accumulate more toxins in their tissues due to their longer lifespan and higher trophic level in the food chain.

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