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## REVIEWED BY

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Agriculture, Slovakia  
Gülsün Ozyurt,  
Çukurova University, Turkey

## \*CORRESPONDENCE

Sandra Pavičić Žeželj  
sandrapz@medri.uniri.hr

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# The influence on fish and seafood consumption, and the attitudes and reasons for its consumption in the Croatian population

Sandra Marinac Pupavac<sup>1</sup>, Gordana Kenđel Jovanović<sup>1</sup>,  
Željko Linšak<sup>1,2</sup>, Marin Glad<sup>1</sup>, Luka Traven<sup>1,2</sup> and  
Sandra Pavičić Žeželj<sup>2\*</sup>

<sup>1</sup>Department of Health Ecology, Teaching Institute of Public Health of Primorsko-Goranska County, Rijeka, Croatia, <sup>2</sup>Department of Health Ecology, Faculty of Medicine, University of Rijeka, Rijeka, Croatia

Fish makes an important part of the Mediterranean diet, which has been scientifically proven to help preserve human health by protecting against major chronic and inflammatory diseases. Eating fish and seafood is very important, not only for its proven health benefits but also for its positive impact on the environment. Due to many fish and seafood significant positive effects on human health, this study aimed to investigate the socio-demographic factors associated with the consumption of fish and seafood in the population of Primorsko-goranska County in Croatia. Another aim was to determine people's attitudes, choices, and reasons for the consumption of fish and seafood. Self-reported data from 2,910 participants were used. According to the European dietary recommendations for fish consumption, the participants were divided into two groups; the very low to low fish consumption group and the moderate to high fish consumption group, in order to examine the differences in socio-demographic and lifestyle variables, and their attitudes, opinions, and reasons for fish and seafood consumption. More fish and seafood were consumed by women, the elderly, the more educated, non-smokers, and more physically active participants. Age, the highest level of education, and a diet even moderately adherent to the Mediterranean diet was found to significantly increase the likelihood of recommended fish consumption. Participants considered the best reasons to consume more fish lower prices, buy much more locally produced fishery products, and prefer to eat wild-caught fish rather than farmed fish. The study has found a slight increase in fish consumption, although still lower than the European average. It also showed significant socio-demographic associations, also the reasons and attitudes toward higher fish and seafood consumption of the Croatian population. The

obtained research data are valuable for planning future public health programs in Croatia aimed at greater consumption of fish and seafood, as well as their promotion as an important part of a sustainable diet.

#### KEYWORDS

fish and seafood consumption, attitudes, choices, reasons, sustainable diet, consumers, Mediterranean diet (MD)

## Introduction

Fish and seafood are foods of high nutritional value, rich in essential amino acids, high-quality proteins, many vitamins (A, B, and D) and minerals (iron, calcium, zinc, selenium), and especially omega-3 polyunsaturated fatty acids (Cardoso et al., 2013; Nesheim et al., 2015; Chen et al., 2022). Strong scientific evidence is confirming the beneficial effects of fish consumption on human health, including cognitive development, mental health, immune system, prevention of anemia, cardiovascular disease, and dementia (Béné et al., 2015; Golden et al., 2016). Fish consumption is an important part of the Mediterranean diet (MD), which has been scientifically proven to help preserve human health by protecting against major chronic and inflammatory diseases (Mazzocchi et al., 2019). In addition, there is a strong evidence suggesting a protective effect of the MD mostly on the risk of cardiovascular disease and certain types of cancer (Mazzocchi et al., 2019; Serra-Majem et al., 2019). The Mediterranean diet is not only considered as “the role model” of a healthy diet but also as a sustainable diet (Burlingame and Dernini, 2012; Portugal-Nunes et al., 2021) providing economic and socio-cultural benefits (Berry, 2019). However, regarding fish quality which is consumed as a part of the diet, its environmental effects can vary greatly between caught and farmed fish since the nutrient content depends on the fish's diet. The recommended weekly fish intake is often not reached due to insufficient supply (Berry, 2019).

Although the beneficial effects of MD on health are well known, the diet of many Mediterranean countries' residents is moving away from traditional MD. At the same time, those countries record a rise in overweight people, obesity, and chronic non-communicable diseases (FAO, 2015; Vilarnau et al., 2019).

As part of a healthy diet, it is usually recommended to consume at least two servings of different types of fish (~240 g) each week, including one serving of oily fish. This consumption provides an average intake of 250 mg EPA + DHA, especially when fish replaces the consumption of less healthy foods (McGuire, 2016; Piepoli et al., 2016). The consumption of fish and seafood varies in all European countries, although according to the Food and Agriculture Organization (FAO),

consumption of fish and seafood has increased over the last 60 years (FAO, 2020). A trend toward increasing consumption of fish and seafood can also be observed in Croatia. In 2000, per capita consumption was 7.26 kg and in 2013 it was 19.06 kg, which is an increase of 162.5% (EUMOFA, 2019). The average consumption of fish and seafood in 2017 in the European Union was 24.35 kg per capita, whereas, in Croatia, the consumption in 2017 was 18.7 kg per capita (EUMOFA, 2019). Although the consumption increased by 6% (19.19 kg on average) in 2018, it still remained below the European average consumption (EUMOFA, 2020).

Various factors, such as place of residence (coast or continent), socio-demographic factors, tradition, habits, age, gender, etc. have been shown to influence seafood consumption (Almeida et al., 2015; Murray et al., 2017; Govzman et al., 2021). Moreover, fish and seafood consumption is also influenced by modern lifestyles, urbanization, and consumer preferences (Crona et al., 2020) likewise consumer attitudes toward food and nutrition all have been shown to be important factors influencing seafood consumption (Hearty et al., 2007).

Some of the main factors of insufficient consumption of fish and seafood include price or preferences, but it is worth mentioning that consumer habits and lifestyle can be influenced in the long term (Ministarstvo poljoprivrede, Uprava ribarstva, ožujak, 2021). Public health activities should be undertaken to influence changes in consumers eating habits toward increasing the consumption of fish and seafood. This paper aims to study the socio-demographic factors related to the consumption of fish and seafood among the population of the Primorsko-goranska County in Croatia. Another aim is to determine people's attitudes, choices, and reasons for the consumption of fish and seafood.

## Materials and methods

### Participants

This is a quantitative cross-sectional study conducted in the population of Primorsko-Goranska County, Croatia. The study has been carried out under the project “Population exposure to traditional and emerging contaminants due to the consumption

TABLE 1 Socio-demographic characteristics and mean consumption of fish and fishery products among Croatian adults from Primorsko-goranska County ( $N = 2,910$ ).

	<i>N</i> (%)	<i>p</i> -value*	Mean (g/week)	SD	<i>p</i> -value**
<b>Gender</b>					
Male	427 (14.7)	<0.001	406.24	349.76	0.363
Female	2,483 (85.3)		412.79	367.90	
<b>Age group (years)</b>					
20–30	328 (11.3)	<0.001	457.04	419.19	<0.001
31–40	1,717 (59.0)		392.14	345.03	
41–50	698 (24.0)		409.68	346.85	
51 +	167 (5.7)		526.98	465.50	
<b>Highest level of education</b>					
Postgraduate degree/Graduate diploma/Bachelor degree	1,731 (59.5)	<0.001	424.55	378.29	0.013
High school/Elementary school diploma	1,179 (40.5)		393.95	346.93	
<b>Employment status</b>					
Employed	2,489 (85.5)	<0.001	415.88	374.63	0.328
Unemployed	402 (13.8)		381.24	296.88	
Retired	19 (0.7)		391.32	166.62	
<b>Income (Croatian average salary)</b>					
≤1–2	1,661 (57.1)	<0.001	412.26	372.51	0.630
>2–3	671 (23.1)		399.72	356.12	
>3	271 (9.3)		434.86	324.54	
Don't want to respond	307 (10.5)		415.57	399.57	
<b>Physical activity level</b>					
Low	561 (19.3)	<0.001	409.30	388.77	0.049
Moderate	1,720 (59.1)		401.86	358.51	
High	629 (21.6)		443.48	359.59	
<b>Smoking habits</b>					
Non-smoker	1,965 (67.5)	<0.001	400.96	347.20	0.025
Smoker	945 (32.5)		430.13	381.61	
<b>Nutrition status</b>					
Underweight	81 (2.8)	<0.001	437.07	364.91	0.887
Normal weight	1,984 (68.2)		411.75	364.48	
Overweight	797 (27.4)		414.64	398.23	
Obese	48 (1.7)		442.73	305.19	
<b>Mediterranean diet score (points)</b>					
Not adherent (≤5)	1,132 (38.9)	<0.001	357.60	344.02	<0.001
Moderately adherent (6–9)	1,661 (57.1)		430.76	358.27	
Adherent (≥10)	117 (4.0)		679.40	494.63	

\*Chi squared test (categorical variables).

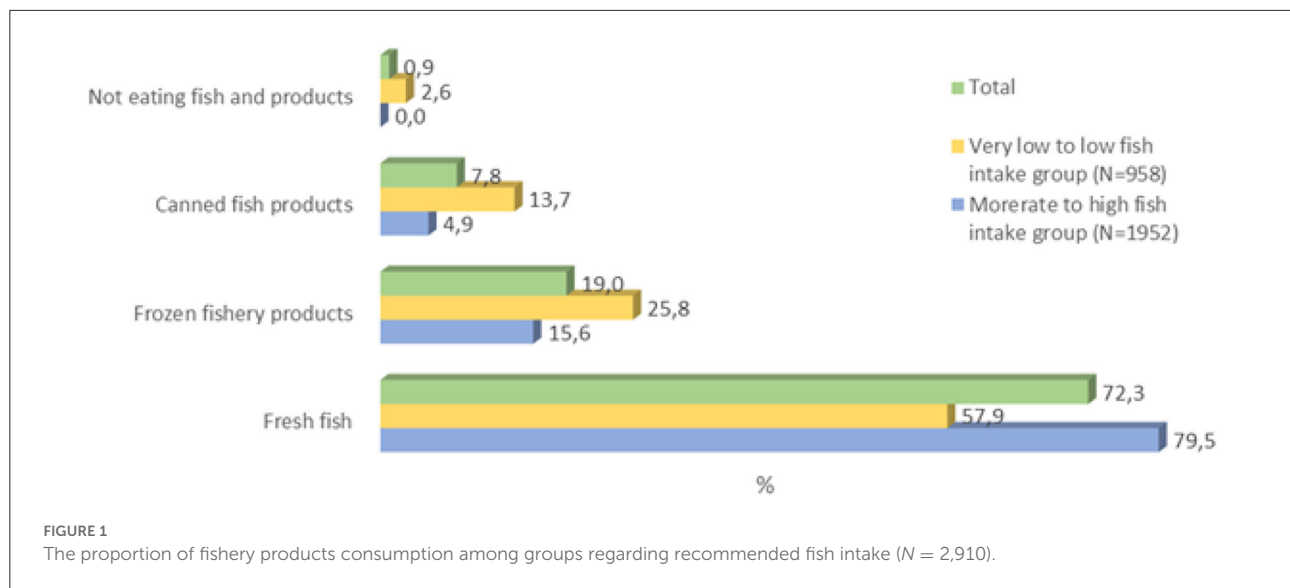
\*\*One-way ANOVA test (continuous variables).

of seafood and the characterization of health risks". The study was conducted in the period from October 2019 to February 2020 and approved by the Ethical Committee of the Teaching Institute of Public Health of Primorsko-Goranska County. Based on a number of residents of Primorsko-goranska county ( $N = 296,195$ ) (Health Statistical Yearbook of Primorsko-Goranska County for 2020, 2022) a total of 7,745 questionnaires were sent to the residents older than 18 years of Primorsko-goranska County, out of which 5,542 (71.6%) have been returned. For the purposes of this study, only those questionnaires that were

completed were further analyzed. Therefore, this study included questionnaires of 2,910 participants (37.6%).

## The questionnaire

The questionnaire was anonymous and consisted of three sections. The first section included data on fish and seafood consumption (type of fish and seafood consumed), general



habits, preferences and frequency of buying fish, locations and reasons of buying, reasons for consumption, attitudes, and opinions about fish preferences based on its origin (i.e., marine and farmed), and about sources of information on the positive health effects of fish consumption. Participants graded the statements about farmed fish using the Likert scale with five ratings ranging from “strongly disagree” (1) to “strongly agree” (5). The second part was related to sociodemographic characteristics and lifestyle of the study participants and included data on age, gender, geographical region, education level, income, occupation, body weight and height, physical activity, and smoking habits. The third part of the questionnaire evaluated dietary habits. Participants noted their habitual fish intake in offered intervals from once per month or less than to every day, separately for eating at home and for eating in restaurants and/or at work. They also noted their average fish consumption portion in kilograms per household member (estimate based on the mean value of portion consumption and number of household members). Since the Primorsko-goranska County resides by the Mediterranean Sea where the traditional Mediterranean diet is a hereditary diet, the adherence to the MD was assessed with the 14-Item Mediterranean Diet Assessment Tool (Martínez-González et al., 2012). The adherence to MD has categorized into three levels;  $\leq 5$  points which meant low adherence, from 6 to 9 points which meant moderate adherence and  $\geq 10$  points which meant high adherence to MD. To explore differences in attitudes, opinions, and reasons toward fish and seafood consumption regarding habits of fish consumption, the participants were divided into two groups: the very low to low fish intake group (VLF; i.e., <1 serving/month to 1 serving/week) and to moderate to high fish intake group (MHFI; i.e., 2–5 servings/week),

based on the European dietary recommendations for fish consumption (Lofstedt et al., 2021), where one serving of fish is 130 g.

## Statistical analysis

To describe habits of fish and seafood consumption among sociodemographic subgroups of participants, the proportion and means of fish and seafood consumption were calculated and tested for differences with one-way ANOVA test for continuous variables, or with the Chi-Square test for sociodemographic subgroups. The Chi-square test was used for differences between subgroups of participants based on their habitual fish consumption regarding recommended fish intake (Lofstedt et al., 2021) for their attitudes, choices and reasons for consuming fish and seafood and farmed fish. The quantification of the influence of the individual factors is expressed by the odds ratio calculated with the logistic regression method. All tests were performed using Statistica 12.7 for Windows (Statsoft Inc., Tulsa, OK, USA). Results with a  $P$ -value of  $<0.05$  were considered statistically significant.

## Results

### Socio-demographic characteristic and consumption of fish and seafood

The study consisted of 2,910 residents of the Primorsko-goranska County older than 18 years of which over four-fifths (85.3%) were females ( $p < 0.001$ ; Table 1). Their

average age was  $38.00 \pm 7.14$  years, and the most of participants were in the 31–40 years age group (59.0%,  $p < 0.001$ ). There were statistically more participants with higher education ( $p < 0.001$ ), employed ( $p < 0.001$ ), with two average Croatian salaries ( $p < 0.001$ ), moderately physically active ( $p < 0.001$ ), non-smokers ( $p < 0.001$ ), with normal weight ( $p < 0.001$ ) and diet that moderately adhered to the Mediterranean diet ( $p < 0.001$ ). On average, participants' fish and fisheries product consumption per week was  $412.28 \pm 365.01$  g (data not shown). Mostly consumed was fresh fish (72.3%), followed by frozen fisheries products (19.0%) and canned fish products (7.8%) (Figure 1). When choosing their most consumed types of fish and fisheries products, participants consumed mainly white fish (56.5%), followed by cephalopods (52.3%), fatty fish (43.9%), and crabs (27.1%) (Figure 2). In Table 1 there are presented the participants' mean fish intake according to their characteristics. Participants in the 51+ age group ate statistically significantly more fish than other age groups ( $p < 0.001$ ). Participants with higher education ( $p = 0.013$ ), those who were highly physically active ( $p = 0.049$ ), smokers ( $p = 0.025$ ) and those with high adherence to MD ( $p < 0.001$ ) ate statistically more fish than their related groups. Average weekly consumption of fish didn't significantly differ according to employment, income, and nutrition status (Table 1).

Based on European dietary recommendations for fish consumption (Lofstedt et al., 2021), the moderate to high fish consumption group (MHFI) consumed statistically 2.5 more fish per week ( $511.12 \pm 410.77$  g) than the very low to low fish consumption group (VLFI) group ( $206.05 \pm 172.95$  g,  $p < 0.001$ ) (data not shown). The MHFI group consumed statistically significantly more fresh fish than the VLFI group (79.5 vs. 57.9%,  $p < 0.001$ ). The VLFI group had significantly higher consumption of frozen fisheries products (28.8 vs. 15.6%,  $p <$

0.013) and canned fish (13.7 vs. 4.9%,  $p < 0.020$ ) than the MHFI group (Figure 1).

Regarding the fish and fishery products, the MHFI group consumed significantly more fatty fish (47.6%), crabs (30.0%), cephalopods (54.7%), and molluscs (9.7%) than the VLFI group (36.4, 21.2, 47.3, and 5.5%,  $p < 0.001$ ). The VLFI group consumed significantly more white fish and freshwater fish than MHFI group (62.4 vs. 60.9%,  $p < 0.001$ ; 9.1 vs. 8.6%,  $p < 0.001$ ) (Figure 2).

## Socio-demographic and lifestyle factors influencing consumption of fish and seafood

The socio-demographic and lifestyle factors influencing recommended fish and fishery product consumption were assessed by logistic regression (Table 2). It was shown that age was an important influencing factor, the probability of recommended fish intake significantly increases by 1.38 times in older than 40 years, or about 40% ( $p = 0.001$ ), while among younger people that probability reduces by 18% ( $p = 0.035$ ) to 35% ( $p = 0.001$ ). The highest education level significantly increases that probability by 1.72 times, or about 70% ( $p = 0.001$ ) while the lower one reduces the probability by 19% ( $p = 0.033$ ).

Non-smoking and smoking a smaller number of cigarettes had no statistically significant effect while smoking a larger number of cigarettes reduces the probability by 1.43 times ( $p = 0.004$ ). Also, having a normal weight significantly increases the probability by 1.24 times ( $p = 0.008$ ) while having obesity significantly reduces that chance by 1.32 times ( $p = 0.025$ ). So, if the person smokes more or has obesity,

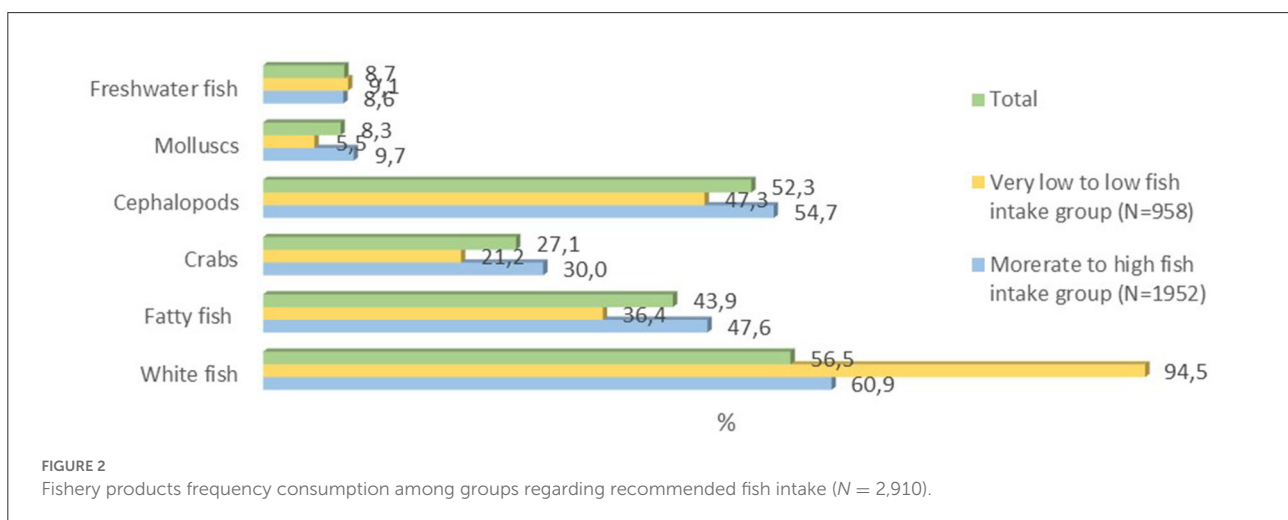


TABLE 2 The association of participants' socio-demographic characteristics and lifestyle habits with recommended fish intake.

Variable	OR	95% CI	P-value
<b>Age group</b>			
<30 years	0.74	0.58–0.94	0.014
31–40 years	0.85	0.72–0.99	0.035
41–50+ years	1.38	1.17–1.63	0.001
<b>Highest level of education</b>			
Elementary school	1.18	0.70–2.00	0.538
High school	0.84	0.72–0.99	0.033
Graduated/Bachelor degree	0.99	0.85–1.16	0.945
Postgraduate degree	1.72	1.27–2.34	0.001
<b>Smoking habits</b>			
No	1.16	0.99–1.37	0.071
1–10 cigarettes	1.11	0.91–1.35	0.320
11–20 cigarettes	0.70	0.55–0.89	0.004
<b>Physical activity level</b>			
Low	1.11	0.92–1.34	0.284
Moderate	0.94	0.81–1.10	0.471
High	0.98	0.80–1.19	0.827
<b>Nutrition status</b>			
Underweight	1.19	0.72–1.96	0.507
Normal weight	1.24	1.06–1.45	0.008
Overweight	0.86	0.72–1.03	0.109
Obese	0.76	0.60–0.97	0.025
<b>Mediterranean diet score</b>			
Not adherent	0.49	0.42–0.58	<0.001
Moderately adherent	1.66	1.42–1.95	<0.001
Adherent	5.43	2.83–10.44	<0.001

the likelihood to consume fish as recommended decreases by about 30–40%.

On the other hand, a diet even moderate adherent to the Mediterranean diet compared to a diet that is not adherent to MD significantly increases the probability of recommended fish intake by 1.66 times, or about 70% ( $p < 0.001$ ) while a diet that is completely adherent MD increases that probability five times ( $p < 0.001$ ).

The participants also reported the most important information available on fishery products (Figure 3). Expiration dates were the most important information about fishery products for participants in both groups, slightly more important for the VLFI group (44.5% MHFI and 48.4% VLFI, respectively,  $p = 0.046$ ) as well as fishing area or country of origin (21.6% MHFI and 19.3% VLFI, respectively,  $p = 0.150$ ). Whether fishery products were previously frozen was significantly more important for the MHFI group than for the VLFI group (13.5 and 10.4%, respectively,  $p = 0.016$ ).

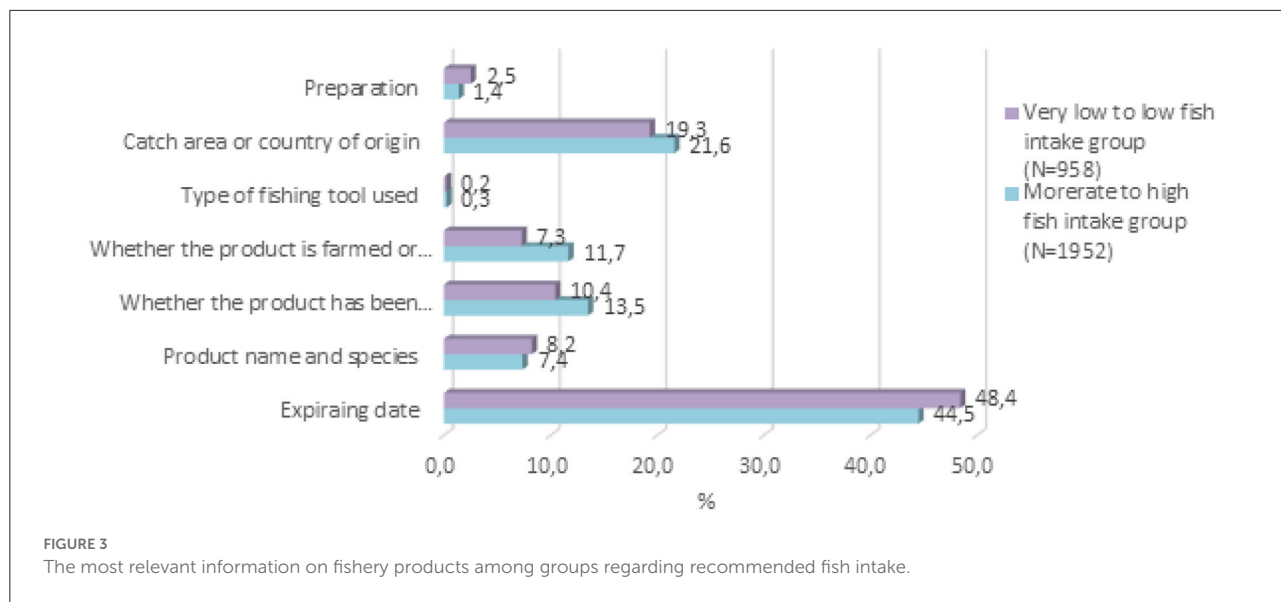
## Attitudes, choices, and reasons for the consumption of fish and seafood

In Table 3 are presented reasons for encouraging to consume more fish and fishery products according to recommended fish intake group. In both groups, participants considered that the best reasons for promoting the higher fish consumption were lower prices (56.8 and 56.2%, respectively,  $p = 0.758$ ) and better availability in stores (47.2 and 44.2%, respectively,  $p = 0.117$ ). With a significant difference, participants in the MHFI group placed more importance on highlighted labels of quality or origin (31.1 and 25.3%, respectively,  $p = 0.001$ ), while participants in the VLFI group provided more the information about fish preparation recipes (14.5 and 9.2%, respectively,  $p < 0.001$ ). Other reasons weren't statistically different according to recommended fish intake.

When choosing their main reasons for consumption of fish and fishery products, participants in the MHFI group chosen as the most important reasons the taste (69.5 vs. 58.4%,  $p < 0.001$ ), health consideration (84.6 vs. 72.3%,  $p < 0.001$ ), availability (9.7 vs. 5.3%,  $p < 0.001$ ), good quality (15.1 vs. 5.1,  $p < 0.001$ ) and a habit to eat (42.4 vs. 18.8%,  $p < 0.001$ ) significantly more than participants in the VLFI group (Figure 4). Participants were asked to declare from which information sources they learn about the importance of consuming fishery products. All declared that they the most got the information from their friends, relatives and families, significantly more the MHFI group (60.2% of the MHFI and 51.3% of the VLFI,  $p < 0.001$ ), while the VLFI group significantly more stated to get it online (47.8 MHFI and 51.3 VLFI,  $p = 0.080$ ). Only a fifth of participants (22.7% of MHFI and 19.5% of VLFI,  $p = 0.051$ ) declared that information has been provided by health workers, including physicians, nutritionists, etc. (Figure 5).

Regarding the choices and reasons for purchasing fishery products by its origin, the MHFI group was statistically significantly more likely to purchase fishery products from Croatia, i.e., locally (49.1, 39.7%, respectively,  $p < 0.001$ ) or from all Croatia regions (40.1, 36.0%, respectively,  $p = 0.035$ ) when compared to the VLFI group. Significantly 2.5 times more the VLFI group said that the origin doesn't matter to them and/or didn't know the origin than the MHFI group ( $p < 0.001$ ; Table 3). More precisely, the main reasons of buying the fishery product by its origin for both studied groups were first of all better quality and taste (58.7 and 42.3%, respectively,  $p < 0.001$ ), then availability (41.1 and 39.5%, respectively,  $p = 0.400$ ), habit (29.3 and 26.0%, respectively,  $p < 0.062$ ), and support to local fishermen, farmers and for job preservation reasons (28.3 and 19.4%, respectively,  $p < 0.001$ ) (Table 4).

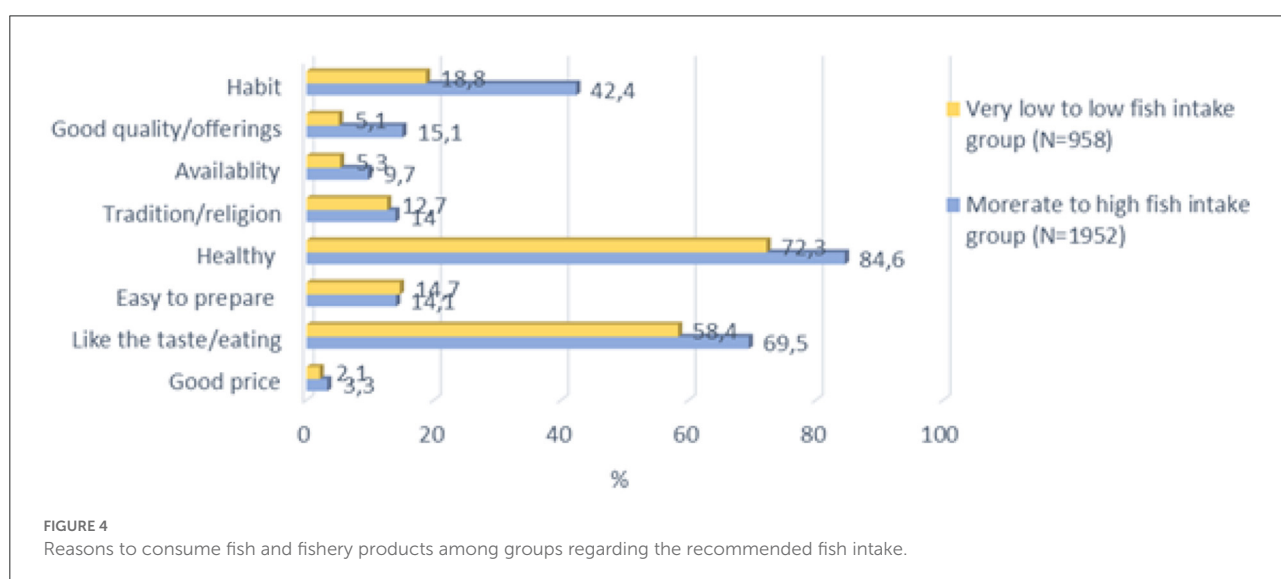
Regarding the wild caught or farmed fish consumption preference, both studied groups of participants preferred more



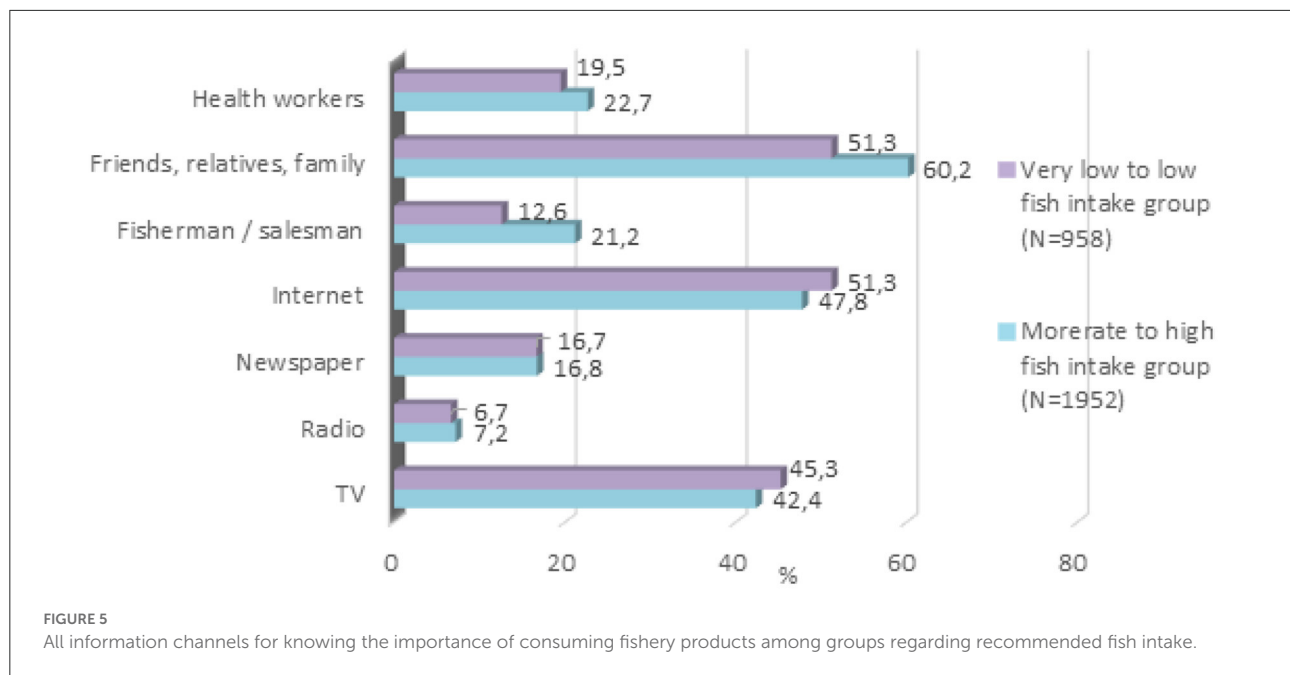
**TABLE 3** Reasons for encouraging to consume more fish and fishery products among groups regarding the recommended fish intake (N = 2,910).

	MHFI (N = 1,952)	VLFI (N = 958)	p-value*
Better availability in stores	922 (47.2)	423 (44.2)	0.117
Better availability in restaurants	36 (1.8)	23 (2.4)	0.317
Lower prices	1,108 (56.8)	538 (56.2)	0.758
Better availability of information on the impact of fish diet on health	155 (7.9)	73 (7.6)	0.763
Highlighted marks of quality or origin	607 (31.1)	242 (25.3)	0.001
More information on recipes to prepare fish	180 (9.2)	139 (14.5)	<0.001
Introduction of special educational courses on preparing fish for eating	66 (3.4)	46 (4.8)	0.061
Nothing/I don't need to consume it more often	299 (15.3)	139 (14.5)	0.567

MHFI, moderate to high fish intake group; VLFI, very low to low fish intake group.  
\*Chi square test between the observed groups.







**TABLE 4** Choices and reasons to buy fishery products by its origin ( $N = 2,910$ ) among groups regarding the recommended fish intake.

	MHFI ( $N = 1,952$ )	VLFI ( $N = 958$ )	$p$ -value*
<b>The most common origin of bought fishery products</b>			
Croatia—local region	959 (49.1)	380 (39.7)	<0.001
Croatia—all regions	782 (40.1)	345 (36.0)	0.035
Imports from EU countries	84 (4.3)	61 (6.4)	0.016
Imports from non-EU countries	15 (0.8)	12 (1.3)	0.200
It doesn't matter to me/I don't know the origin	113 (5.8)	136 (14.2)	<0.001
<b>Reasons to make that choice of buying the fishery product by its origin</b>			
Better price	128 (6.6)	83 (8.7)	0.039
Better quality and taste	1,146 (58.7)	405 (42.3)	<0.001
A better relationship between price and what I get for that price	269 (13.8)	132 (13.8)	<0.001
Better choice/greater products offer	290 (14.9)	80 (8.4)	<0.001
Availability	802 (41.1)	378 (39.5)	0.400
Habit/previous experience	572 (29.3)	249 (26.0)	0.062
Support to local fishermen/farmers/ob preservation	552 (28.3)	186 (19.4)	<0.001

MHFI, moderate to high fish intake group; VLFI, very low to low fish intake group.

\*Chi square test between MHFI and VLFI group.

eating a wild caught fish over a farmed fish, significantly more the MHFI group than the VLFI group (68.4 and 51.6%, respectively,  $p < 0.001$ ) (data not shown).

Table 5 shows the respondents' attitudes toward farmed fish and its quality. The MHFI group mostly agreed that farmed fish are fatter than wild fish and of a poorer quality ( $p < 0.001$ ), while the VLFI group was mostly uncertain about that ( $p < 0.001$ ;  $p < 0.001$ ). Both groups mostly were uncertain about that the farmed fish is too expensive ( $p < 0.001$ ). The MHFI group the group was undivided about the knowledge about farmed fish, in

almost equal shares the participants agreed that they know and that they do not know and that they agree and disagree, while the VLFI group significant mostly agreed that they don't know enough about farmed fish ( $p < 0.001$ ).

## Discussion

This study is one of the very few conducted in Croatia that investigated factors influencing fish and seafood consumption

TABLE 5 Attitudes toward farmed fish and its quality ( $N = 2,910$ ) among groups according to recommended fish intake.

Statement	I disagree	I neither agree nor disagree	I agree	$p$ -value*	$p$ -value**
<b>Farmed fish is fatter than wild</b>					
MHFI ( $N = 1,952$ )	378 (19.4)	692 (35.5)	882 (45.2)	<0.001	<0.001
VLFI ( $N = 958$ )	200 (20.9)	398 (41.5)	360 (37.6)	<0.001	
<b>Farmed fish is of poorer quality than wild</b>					
MHFI	437 (22.4)	712 (36.5)	803 (41.1)	<0.001	<0.001
VLFI	250 (26.1)	382 (39.9)	326 (34.0)	<0.001	
<b>Farmed fish has an unnatural shape, color, and taste</b>					
MHFI	863 (44.2)	683 (35.0)	406 (20.8)	<0.001	0.119
VLFI	452 (47.2)	335 (35.0)	171 (17.8)	<0.001	
<b>Farmed fish is too expensive</b>					
MHFI	732 (37.5)	760 (38.9)	460 (23.6)	<0.001	0.041
VLFI	317 (33.1)	414 (43.2)	227 (23.7)	<0.001	
<b>I don't know enough about farmed fish</b>					
MHFI	651 (33.4)	668 (34.2)	633 (32.4)	0.641	<0.001
VLFI	264 (27.6)	296 (30.9)	398 (41.5)	<0.001	

MHFI, moderate to high fish intake group; VLFI, very low to low fish intake group.

\*Chi square test within a particular group (MHFI and VLFI group).

\*\*Chi square test between MHFI and VLFI group.

and examined the reasons for their consumption. Regarding available similar studies (Tomić et al., 2016; Thong and Solgaard, 2017; Sacchetti et al., 2021), this study also assessed the average fish intake regarding socio-demographic characteristics of participants, and the proportion of particular seafood in the coastal part of Croatia regarding recommended fish intake (Lofstedt et al., 2021).

## Fish and seafood consumption of croatian participants

Although there's a trend of increasing consumption of fish and seafood in Croatia (EUMOFA, 2019), it has remained below the European average consumption (EUMOFA, 2020), and this study confirmed that. On average, study participants consumed fish and aquatic products 13% less than the EU weekly average and 12% more than the Croatian (EUMOFA, 2020). Those participants who consumed fish two to five servings per week consumed 28% more than the Croatian average consumption, while those who consumed fish less than one serving per month to one serving per week consumed slightly more than half of the Croatian average consumption (EUMOFA, 2020). Of all aquatic food, participants mostly consumed fresh fish, preferably white over fatty fish. These results are consistent with consumption in Portugal and Spain, which also reported the highest consumption of fresh fish, followed by frozen and canned fish (Cardoso et al., 2010, 2013; MARM, 2010).

Interestingly, cephalopods have been consumed more than fatty fish which is consistent with the results from Norway (Trondsen et al., 2003), and opposite to Portugal, where more fatty fish was consumed (Cardoso et al., 2013). In Norway salmon, as the most common fatty fish, is traditionally an expensive food, so, understandably, more white fish is eaten there. In Croatia, on the other hand, anchovy and sardines, as the most common fatty fish, are cheaper than white fish, so the data that participants ate less fatty than white fish is worrying, considering that fatty fish over white have as beneficial content of omega—3 fatty acids (McManus and Merga, 2011; Abdelhamid et al., 2018). Cephalopods were slightly more consumed than fatty fish. Compared with sardines and salmon, cephalopods such as squid, octopus, and cuttlefish contain lower energy due to lower content of total fat, and omega—3 fatty acids, but contain a higher quantity of cholesterol, vitamin A and most of the minerals, especially calcium (Food data, 2019).

An increasing interest is arising for more diverse and sustainable use of cephalopods, not only for culinary, but for novel uses to compensate for the declining fisheries of bonefish, and to identify them as additional protein sources to replace meat from land-animal production (Mouritsen and Styrbaek, 2018). In addition, it was shown that cephalopod species may be classified as potentially healthy food due to their ideal atherogenic/thrombogenic and hypocholesterolemic/hypercholesterolemic ratios based on fatty acid/amino acid ratios (Chakraborty et al., 2016). Although many studies have confirmed the beneficial effects

of fish consumption on cardiovascular health, mainly due to the content of omega-3 fatty acids, also high-quality proteins, vitamins, and minerals (de Roos et al., 2017; Abdelhamid et al., 2018; Chen et al., 2022), recently it was concluded that fish consumption possesses also antioxidative, anti-inflammatory, immune-protective, wound healing, neuroprotective, cardioprotective, and hepatoprotective properties, not only for the content of omega-3 fatty acids but for substantial content of vitamin D, proteins, such as immunoglobins and amino-acids such as arginine (Chen et al., 2022). This study found that two-thirds of participants consumed fish and seafood two or more times a week, and three-fifths of participants had a diet that moderately and highly adhered to the Mediterranean diet, which represents important information and a prospective beneficial foundation for good health. The results showing a substantial proportion of participants with a diet moderately to highly adhering to MD is affirmative, since previous Croatian studies showed the MD diminishing, especially among younger populations (Kolčić et al., 2016; Kendel Jovanović et al., 2020; Šarac et al., 2021). Despite the well-known health benefits of fish and seafood consumption, mainly due to the content of omega-3 fatty acids, there is a potential health risk of fish and seafood consumption. Recent studies have pointed to them as a potential dietary source of exposure to various environmental pollutants with well-known potential adverse effects on human health (Domingo, 2016; Vilavert et al., 2017). The most pronounced contaminants investigated in fish and seafood are methylmercury and polychlorinated biphenyls, heavy metals and organohalogenated compounds, and also polycyclic aromatic hydrocarbons. It was shown that the exposure to the abovementioned environmental contaminants can be managed by the frequency and amount of consumption as well as controlled consumption of particular seafood species, such as predatory fish regarding their potential risk for pregnant and nursing women and also children (EFSA, 2012). Regarding this potential health risk, it is worthy to examine the potential health risk for Croatian fish and seafood consumers assessed according to the average consumption of various species of fish and seafood provided by this study.

## Factors influencing fish and seafood consumption

Regarding fish and seafood consumption, many factors affect its consumption such as place of residence (coast or continent), socio-demographic factors, tradition, habits, age, gender, and many others (Murray et al., 2017; Govzman et al., 2021; Sacchetti et al., 2021). The study results confirmed that older age, higher education level, non-smoking, normal weight and adherence to the Mediterranean diet were significant and

strongest determinants for higher fish and seafood consumption. It was shown that age is one of the most important factors influencing fish and seafood consumption (Akbaraly and Brunner, 2008; Jahns et al., 2014; Marushka et al., 2018). Study results are also consistent with the findings of studies showing a positive association between older age and fish consumption (Akbaraly and Brunner, 2008; Buscemi et al., 2014; Jahns et al., 2014). A small number of studies noted a positive association between fish consumption and younger people (Mozaffarian et al., 2008; van Woudenberg et al., 2009; Anderson et al., 2010; Virtanen et al., 2010; Belin et al., 2011; Bonaccio et al., 2017), which represents an important public health task for promoting fish consumption among the younger population. A previously established positive association between educational level and fish and seafood consumption (van Woudenberg et al., 2009; Anderson et al., 2010; Levitan et al., 2010; Heppel et al., 2011; Larsson et al., 2011; Giuli et al., 2012; Nordgren et al., 2017) was also confirmed in this study. Non-smoking presented to be positively associated with fish consumption (He et al., 2009; van Woudenberg et al., 2009; Sala-Vila et al., 2011; Giuli et al., 2012; Langlois and Ratnayake, 2015), and this study found that smokers were significantly less likely to consume fish compared to non-smokers. No clear association between body weight and fish and seafood consumption was shown in this study, although participants with obesity were significantly less likely to consume fish and seafood than other sub-groups. Mixed results are available about this association, some studies have shown a positive association (He et al., 2009; Hostenkamp and Sørensen, 2010; Belin et al., 2011; Heppel et al., 2011; Belle et al., 2017) and others did not (van Woudenberg et al., 2009; Meier et al., 2010; Kossioni and Bellou, 2011; Nesheim et al., 2015; Wallin et al., 2017). The results of this study showed that a diet that is even moderately adherent to the Mediterranean diet significantly increases the probability of recommended fish intake while high adherence increases that probability by five-fold. Fish and seafood, recognized as foods of high nutritional value (Cardoso et al., 2013; Nesheim et al., 2015; Chen et al., 2022), are represented as an important part of the Mediterranean diet, highly abundant in plant-based foods, which are considered as a model for a healthy and sustainable diet (Burlingame and Dernini, 2012; Portugal-Nunes et al., 2021). Dietary guidelines for sustainable diets generally recommend diets that are based on plant-based foods, because the majority of them tend to have some of the lowest environmental impacts given their nutrient content (Willett et al., 2019). Still, some fish, such as small pelagic fishes, were shown to be among the most healthful and sustainable foods (Springmann et al., 2020; Koehn et al., 2022), likewise some wild-caught fisheries and farmed shellfish, which showed to have low environmental impacts similar to many plant-based foods, and lower than most animal-source proteins (Koehn et al., 2022). Therefore, by including more fish in a diet, and making it more adherent to the MD, a diet that is proven to sustain

human health by protecting it against the main chronic and inflammatory diseases (Mazzocchi et al., 2019), represents a significant step toward a more sustainable and healthier diet and way of living. Therefore, promoting a Mediterranean diet style with sustainable fish consumption through education is a very important way to transfer knowledge to every population group, especially the younger ones. Also, teaching families could be of greater importance because parenteral dietary habits have a strong influence on children's eating habits (Sotos-Prieto et al., 2015).

When choosing fish, for this study participants the most important information about fishery products was the expiration date of the country of origin. More frequent fish and seafood consumers were significantly more likely to buy fish and seafood from Croatia, i.e., locally, while those less frequent fish and seafood consumers indicated the origin as less important. It can be supposed that participants who more frequently consumed fish and seafood believed that fish and seafood from Croatia have better quality and taste, is more accessible, and when buying, they did it as a support local fishermen and to help the local economy. Those participants also consumed significantly more fatty fish than those who were less frequent consumers, which is supported by the information that more frequent consumers chose health as the most important reason for fish consumption, which is in line with other studies (Govzman et al., 2021; Sacchetti et al., 2021).

The frequency of consuming fish within recommendation didn't influence the consumption of wild-caught or farmed fish, since both study groups consumed more wild-caught fish than farmed fish, which is similar to results obtained in Portugal (Cardoso et al., 2013) and other European countries (Verbeke et al., 2005). The consumption of more wild-caught fish by study participants is consistent with their attitudes toward farmed fish and its quality. More frequent fish and seafood consumers significantly agreed that farmed fish is fatter than wild-caught, and thus has poorer quality. They reported farmed fish to have an unnatural shape, color, and taste. Participants who were less frequent consumers were significantly uncertain about that issue. Those results represent an area that should be further examined for a better insight on the results.

This study looked at what measures would be the most appropriate to promote the consumption of fish and seafood. Participants from both groups agreed that this would be a lower price and better availability in stores. Many studies also mention that the price of fish is a barrier to its consumption (Altintzoglou et al., 2010; Grieger et al., 2012; Lawley et al., 2012; Dijkstra et al., 2014; Bishop and Leblanc, 2017). Sotos-Prieto et al. in their study mentioned that people with lower income eat less fish, and although in this study the participants with higher income ate slightly more fish, this difference was not significant (Sotos-Prieto et al., 2015). As the main

reason for consuming fish and seafood, more frequent fish and seafood consumers from this study significantly chose taste and health. Many studies confirmed that the taste of fish influenced its higher consumption (Sveinsdottir et al., 2009; Appleton, 2016; Bostic et al., 2017; Christenson et al., 2017). The belief that fish contains nutrients that have a positive effect on health also leads to higher fish and seafood consumption (Altintzoglou et al., 2010; Birch et al., 2012; Rahmawaty et al., 2013; Jacobs et al., 2018), which this study also confirmed. Interestingly, both groups in this study reported that they get the most information about the importance of fish consumption from friends, relatives, family, then the Internet and TV, and only a fifth from health workers. Rahmawaty et al. (2013) mentioned in their study that those family members who often do not eat fish negatively influence the fish consumption of other family members. This study showed that the frequency of consuming fish and seafood products wasn't related to the source of information about the health benefits of consuming fish, but it is suggesting that the role of health workers should be stronger in promoting the health benefits of fish consumption.

In this study participated a significant number of participants from Primorsko-goranska County in Croatia (81%) which makes the study results relevant and reliable. It found a significant proportion of participants that consumed fish and seafood products within recommendations and a higher proportion of those having a diet that moderately to highly adhered to the MD. This study provided the data on the average consumption of various fish and seafood regarding socio-demographic variables. Those data could serve for further analytical research regarding environmental pollutants in seafood and assessing the potential health risk for population groups. However, this study is limited to the fact that the consumption was assessed by a self-report measure that may be biased. Also, the data were collected from inhabitants of the coastal part of Croatia and they cannot be related to the habits and reasons of the inhabitants of other parts of Croatia. Another limitation is related to the data collection method applied. The study was processed by a self-fulfilling paper-type questionnaire, with an estimated participant's effort of 15–20 min, which represents a strong barrier to complete for people with low motivations. That limitation was controlled since this study included the data only from those questionnaires that were entirely responded to. However, future similar research should be directed toward a more objective measurement of fish and seafood consumption. Also, further detailed analysis of the nutritional profile of fish and seafood consumed could consider a comprehensive participants' nutrient profile originating from fish and seafood. This is important because there is a highlighted relationship between healthy and sustainable food, meals and diets (Hallström et al., 2018) which has not been investigated in Croatia so far.

## Conclusion

The data obtained from this study showed an average consumption of fish and seafood according to different socio-demographic subgroups. More fish is consumed by women, the elderly, the more educated, non-smokers, and the more physically active participants. Given the recommended weekly intake of fish, a significantly larger proportion of participants reached these recommendations. That subgroup highlighted fish health benefits as the main reason for choosing to consume fish, but also the liking of its taste and the tradition of its consumption. Participants preferred the most wild-caught fish originating locally, regardless of the frequency of fish and seafood consumption. The obtained data are valuable because they cover the habits and reasons for fish and seafood consumption, which is valuable in terms of directing the sustainable diet promotion program, in which fish and seafood consumption have a significant part, not only for its proven health benefits but also for its beneficial environmental impact.

## Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

## Ethics statement

The studies involving human participants were reviewed and approved by Ethics Committee of Teaching Institute of Public Health of Primorsko-Goranska County, Croatia. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

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## Author contributions

SM, SP, LT, and MG designed the research. SM, GK, and ŽL analyzed the data. SM, GK, ŽL, MG, LT, and SP wrote the paper. All authors contributed to the article and approved the submitted version.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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