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Fish consumption associated with reduction of fish allergy

A comparative study between children and adults in Fez-Meknes region

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Abstract

Purpose – This paper aims to examine the differences in the self-reported allergies to food, especially fish and shellfish, between children and adults, and to study the association between fish consumption and self-reported fish and shellfish allergy (FSA) according to age.

Design/methodology/approach – This study is based on a survey conducted between April 2014 and December 2016 where children and adults were recruited from the general population of the Fez-Meknes region. The total studied population was 4,046 people.

Findings – The results show that the self-reported food allergy (FA) of the general population was more frequent among children (28.2 per cent) than adults (16.8 per cent), in which eggs, fish/shellfish, milk and cereals were the most common food cited. With regard to the self-reported FSA, the authors found a prevalence of 9.5 per cent in both children and adults, whereas fish species allergies were more frequent among adults than children. The most common clinical manifestations observed in this population were cutaneous reactions. The study of the association between fish consumption and FSA shows that people who consumed fish had a lower rate of FSA, especially in adults ($p < 0.001$).

Originality/value – The self-reported FA of the general population was more pronounced in children than adults. Regarding the self-reported FSA, the authors have shown a prevalence of 9.5 per cent in both children and adults, indicating an important sensitivity of their population to fish and shellfish. The authors have shown that consumption of fish was associated significantly with a lower rate of FSA, especially in adults.

Keywords Children, Adults, Fish consumption, Fish/shellfish, Self-reported allergy

Paper type Research paper

Introduction

Food allergy (FA) is a large and growing public health problem in the world. It affects all age groups and its prevalence worldwide has increased in recent years (Ben-Shoshan *et al.*, 2012; Venter *et al.*, 2010; Gray *et al.*, 2014; Soller *et al.*, 2012; Ho *et al.*, 2012; Obeng *et al.*, 2010). In Morocco, 9.5 per cent of adults reported allergy to foods (Ouahidi *et al.*, 2011). In atopic children, a sensitization to food was observed in 45 per cent of the cases (Ghadi *et al.*, 2007).

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No potential conflict of interest was reported by the authors.



Fish and shellfish are important foods in the world including Morocco. While their consumption varies notably between coastal and inland regions, they are essential sources of animal protein for the Moroccan population. According to the Food and Agriculture Organization of the United Nations, estimated per capita seafood consumption in Morocco was 16.6 kg in 2015. In addition, Morocco has an important stock of fish living along the 3,500 km of Mediterranean and Atlantic coasts, with sardine as the most abundant species (Mohamed Lamlili *et al.*, 2015). This latter specie is the most widely consumed fish species in Moroccan population and is characterized by its richness in omega-3.

However, fish and shellfish are identified as the main allergenic foods in the world (Aas, 1987; Sampson, 2004). The estimated prevalence of fish and shellfish allergy (FSA) has been reported in numerous countries and is less than 2 per cent for fish (Soller *et al.*, 2012; Gupta *et al.*, 2011; Rona *et al.*, 2007) and 18 per cent for shellfish (Rona *et al.*, 2007; Sánchez and Sánchez, 2013; Kim *et al.*, 2008). The prevalence of FSA in the population depends on factors, such as age, gender, eating habits, cultural influences as well as methodologies applied. However, in Morocco, no study focused on fish sensitivity except Ghadi *et al.*'s (2007) study that showed that 4 per cent of 160 atopic children in Marrakech city have a sensitization to fish.

This work aims to examine the differences in the prevalence of the self-reported allergy to fish and shellfish between children and adults, and to study the association between fish consumption and self-reported FSA. The study is based on a survey conducted between April 2014 and December 2016 among the general population of the Fez-Meknes region.

Methods

Selection of study population

We conducted a cross-sectional survey between 2014 and December 2016, where children (12-18 years old) and adults (19-60 years old) were recruited from the general population of the Fez-Meknes region. Children were selected from public and private schools of Fez city and surroundings. The target schools comprised eight high schools (six in Fez and two in territories of Fez) and eight middle schools (six in Fez and two in territories of Fez). The survey was conducted after approval by the Ethic Committee of the local authorities of the Ministry of Education.

The general population was surveyed using a questionnaire that was completed by adults and children in the presence of research teams. This questionnaire was distributed from different areas of the Fez-Meknes region targeting a total of 4,046 people.

Questionnaire

Questions regarding FA, FSA, allergic clinical manifestations and dietary habits were used in the present study, as well as questions on demographic and social factors, including sex, age and education level. Subjects were asked if they were allergic to food (yes or no). If yes, they were asked to tick one or more of the following foods: fish, milk, egg, cereals, peanuts, white bean, haricot, sesame, meat, chicken, almond, chocolate and strawberry. If any current adverse reaction to fish/shellfish was reported, subjects were asked to provide information on the species causing them allergy (sardine, horse mackerel, mackerel, shrimp, common Pandora, whiting, squid, etc.), types of fish allergic to (fried fish, cooked fish and canned fish) and the presence of allergic clinical manifestations which are defined as cutaneous reactions (urticaria, atopic dermatitis or rash), respiratory reactions (asthma, rhinitis, wheezing or nasal congestion) and gastrointestinal reactions (nausea, vomiting, diarrhea or oral pruritus). The dietary questionnaire contained questions about their consumption of fish and consumption frequency (more than once per week, once per week, three times

per month and once per month). The questionnaire was carried out in Arabic language (native language). For children subjects, all questionnaires were filled out in class with the presence of research and educational teams.

Statistical analysis

Descriptive statistics were presented as numbers with percentages or as average values. Comparisons of the prevalence of FA or FSA by population age (children and adults), sex (male and female) and fish consumption (with consumption and without consumption) were performed with χ^2 test. Associated factors were identified by odds ratio (OR), with confidence intervals set at 95 per cent (95 per cent CI). Any value of $p < 0.05$ was considered statistically significant. All statistical analyses were performed using the Epi InfoTM version 7.2.0.1.

Results

Description of the study sample

From the 6,000 questionnaires distributed, 4,046 were completed (response rate, 67.4 per cent) and included in the analysis. Among them, 2,810 persons were represented by children and 1,236 were represented by adults. The child population composed of 1,405 boys and 1,405 girls, who were 57.7 per cent students aged between 12 and 15 years and 42.3 per cent students aged between 15 and 18 years. Adults composed of 618 men and 618 women. A total of 76.7 per cent were aged between 19 and 40 years and 23.3 per cent aged between 40 and 60 years.

Self-reported food allergy among children and adults

The prevalence of the self-reported FA was 28.2 per cent ($n = 792$) in children and 16.8 per cent ($n = 208$) in adults with statistically significant difference (OR, 1.9; 95 per cent CI, 1.6-2.3; $p < 0.00001$). According to sex, the prevalence was significantly higher in girls than in boys (Table I, $p < 0.0001$), with equivalent prevalence in women (16.3 per cent) and in men (17.3 per cent). By age groups, the highest prevalence was 31 per cent in young children aged 12-15 years and decreased gradually with advancing age to 14 per cent in adults >40 years of age (Table I).

Regarding the food category, food allergies were markedly different between children and adults groups. Among the 792 children reporting allergy, the foods most frequently

Demographic variables	FA n (%)	Children OR (95% CI)	p -value	FA n (%)	Adults OR (95% CI)	p -value
Sex						
Male	336 (23.9)	0.7 (0.6-0.8)	<0.0001	107 (17.3)	1.1 (0.8-1.4)	0.6
Female	456 (32.5)			101 (16.3)		
Age						
12-15 years	497 (30.6)	1.3 (1.1-1.6)	<0.001	—	—	—
15-18 years	295 (24.8)			—	—	—
19-40 years	—	—	—	167 (17.6)	1.3 (0.9-1.8)	0.2
40-60 years	—	—	—	41 (14.2)		

Table I.
Frequency of
self-reported FA
according to sex and
age

Notes: OR, odds ratio; 95% CI, confidence intervals set at 95%; p -value corresponds to differences in the prevalence of FA by sex and age in both children and adults; χ^2 test, any value of $p < 0.05$ was considered statistically significant

reported were eggs (38 per cent), fish/shellfish (33.8 per cent), milk (26.5 per cent) and cereals (18.4 per cent). For adults ($n = 208$), FA was mostly associated with fish/shellfish (56.7 per cent) and milk (32.7 per cent), followed by eggs (16.8 per cent) and cereals (10.6 per cent). Estimated prevalence rates for all foods causing allergy in children and adults are shown in Table II.

Referring to the general population, the prevalence of FA decreased in both children and adults for all foods categories and indicated that children were more sensitive to eggs with 10.7 per cent and fish/shellfish with 9.5 per cent, followed by milk (7.5 per cent), cereals (5.2 per cent), chocolate (4.2 per cent) and white bean (4.2 per cent). Accordingly, adults were more sensitive to fish/shellfish with 9.5 per cent, followed by milk (5.5 per cent), eggs (2.8 per cent) and cereals (1.8 per cent). Concerning the four most common foods, children, compared to adults, were significantly more allergic to eggs (10.7 vs. 2.8 per cent; OR, 4.1; 95 per cent CI, 2.9-5.9; $p < 0.0001$), milk (7.5 vs 5.5 per cent; OR, 1.4; 95 per cent CI, 1-1.8; $p = 0.02$) and cereals (5.2 vs 1.8 per cent; OR, 3; 95 per cent CI, 1.9-4.7; $p < 0.0001$). While no significant difference was observed in the prevalence of FSA between children and adults (9.5 vs 9.5 per cent, $p = 0.9$).

Self-reported fish and shellfish allergy among children and adults

Regarding the results of FSA, we noticed a strong sensitivity of the general population to the fish products with equal frequency in children and adults (9.5 vs 9.5 per cent; $p = 0.9$). Prevalence according to sex was significantly higher in girls than in boys (12 vs 7 per cent; OR, 0.6; 95 per cent CI, 0.4-0.7; $p < 0.0001$) and higher in women than in men subjects (11.7 vs 7.4 per cent; OR, 0.6; 95 per cent CI, 0.4-0.9; $p < 0.02$).

The most frequent clinical signs of FSA, observed in children and adults, were cutaneous reactions, followed by gastrointestinal reactions and respiratory symptoms (Table III). Children had more clinical reactions because of fish allergy, but there was no significant difference in the prevalence of clinical manifestations of FSA by age population. Regarding the types of fish allergic to, fried fish was reported to be the most allergenic, in the studied population, followed by cooked and canned fish. The analysis of the three types of fish according to population age (children and adults) showed that the adult population reported

Food category	Children FA n (%)	Adults FA n (%)	p -value
Fish and shellfish	268 (33.8)	118 (56.7)	0.9
Egg	301 (38)	35 (16.8)	<0.0001
Milk	210 (26.5)	68 (32.7)	0.02
Cereals	146 (18.4)	22 (10.6)	<0.0001
Chocolate	118 (14.9)	16 (7.7)	<0.0001
White bean	117 (14.8)	11 (5.3)	<0.0001
Red meat	73 (9.2)	8 (3.8)	<0.0001
Peanut	61 (7.7)	10 (4.8)	<0.01
Green bean	58 (7.3)	4 (1.9)	<0.0001
Strawberry	51 (6.4)	6 (2.9)	<0.001
Sesame	45 (5.7)	5 (2.4)	<0.01
Chicken	41 (5.2)	3 (1.4)	<0.001
Almond	27 (3.4)	6 (2.9)	0.1

Notes: p -value corresponds to differences in the prevalence of FA to each category between children and adults; χ^2 test, any value of $p < 0.05$ was considered statistically significant

Table II.
Distribution of FA
according to food
category in children
and adults

Table III.
The prevalence of
FSA, clinical
manifestations of
FSA and types of
fish allergic
according to
population age

more cooked and canned fish allergy than the children, with statistically significant difference ($p < 0.001$) (Table III).

According to fish species, the three leading causes of the self-reported FSA in children and adults were sardine, horse mackerel and mackerel. Compared to children, adults were significantly more allergic to horse mackerel (OR, 0.6; 95 per cent CI, 0.4-0.8; $p < 0.01$) and mackerel (OR, 0.5; 95 per cent CI, 0.4-0.8; $p < 0.001$). For other species of fish, there was no significant difference in the prevalence of FSA between children and adults (Table IV).

By age groups, FSA was more frequent in young children (12-15 years) and in older adults (40-60 years; 12-15 years, 10.5 per cent; 40-60 years, 10.1 per cent). Results showed that there was a significant decrease in the prevalence of FSA from 10.5 per cent in the age group of 12-15 years to 8.2 per cent in the group of 15-18 years (OR, 1.3; 95 per cent CI, 1-1.7; $p = 0.03$), this was followed by an increase in the prevalence with advancing age, lowest in children 15-18 years of age and highest in adults >40 years of age. The prevalence of sardine (10.1 per cent) and horse mackerel (5.6 per cent) sensitization was highest in older adults aged 40-60 years. While mackerel (4.5 per cent), shrimp (2.2 per cent), whiting (2.2 per cent) and common pandora (2.1 per cent) sensitizations were most common in young adults aged 20-40 years.

Fish/shellfish allergies	Children <i>N</i> (%) <i>N</i> = 2,810	Adults <i>N</i> (%) <i>N</i> = 1,236	OR (95% CI)	<i>p</i> -value
FSA	268 (9.5)	118 (9.5)	1 (0.8-1.3)	0.9
<i>Allergic clinical manifestations</i>				
Digestive manifestations	78 (2.8)	32 (2.6)	1.1 (0.7-1.6)	0.7
Cutaneous manifestations	212 (7.5)	80 (6.5)	1.2 (0.9-1.5)	0.2
Respiratory manifestations	39 (1.4)	14 (1.1)	1.2 (0.7-2.3)	0.5
<i>Type of fish allergic</i>				
Fried fish	216 (7.7)	99 (8)	0.9 (0.7-1.2)	0.7
Canned fish	63 (2.2)	51 (4.1)	0.5 (0.4-0.8)	<0.001
Cooked fish	84 (3)	63 (5.1)	0.6 (0.4-0.8)	<0.001

Notes: OR, odds ratio; 95% CI, confidence intervals set at 95%; *p*-value corresponds to differences between children and adults, χ^2 test, any value of $p < 0.05$ was considered statistically significant

Table IV.
The prevalence of
FSA to each species
among children and
adults

Fish/shellfish allergies	Children <i>N</i> (%) <i>N</i> = 2,810			Adults <i>N</i> (%) <i>N</i> = 1,236			<i>p</i> -value
	Total	Boys	Girls	Total	Men	Women	
Fish/Shellfish	268 (9.5)	99 (37)	169 (63)	118 (9.5)	46 (39)	72 (61)	0.9
Sardine	199 (74.3)	65 (24.3)	134 (50)	99 (83.9)	36 (30.5)	63 (53.4)	0.2
Horse mackerel	81 (30.2)	24 (9)	57 (21.3)	60 (50.8)	16 (13.6)	44 (37.3)	<0.01
Mackerel	70 (26.1)	26 (9.7)	44 (16.4)	55 (46.6)	17 (14.4)	38 (32.2)	<0.001
Whiting	49 (18.3)	18 (6.7)	31 (11.6)	25 (21.2)	9 (7.6)	16 (13.6)	0.5
Common pandora	36 (13.4)	12 (4.5)	24 (9)	25 (21.2)	10 (8.5)	15 (12.7)	0.07
Shrimp	55 (20.5)	27 (10.1)	28 (10.4)	25 (21.2)	10 (8.5)	15 (12.7)	0.8
Other	30 (11.2)	10 (3.7)	20 (7.5)	22 (18.6)	9 (7.6)	13 (11)	0.06

Notes: *p*-value corresponds to differences in the prevalence of fish and shellfish allergy between children and adults; χ^2 test, any value of $p < 0.05$ was considered statistically significant

Multiple fish allergies rates in children and adults

A total of 268 children reported allergy to fish and several foods, 36.2 per cent of these subjects had allergy to fish only (single food), 23.5 per cent had allergy to two foods (fish + another food) and 40.3 per cent had multiple food allergies (fish + 2 foods or more). Of the 118 adults, 57.6 per cent reported allergy to fish only, 23.7 per cent reported allergy to two foods and 18.7 per cent reported allergy to multiple foods. In the whole population, adults were significantly more allergic to single food than children (5.5 vs 3.5 per cent; OR, 0.6; 95 per cent CI, 0.5-0.8; $p = 0.002$), and they were significantly less allergic to multiple foods (1.8 vs 3.8 per cent; OR, 2.2; 95 per cent CI, 1.4-3.5; $p < 0.001$).

According to fish species, we showed (Table V) that subjects who had multiple fish allergies had almost higher rates when compared to subjects with single allergies for different species of fish. Furthermore, the proportion with single fish allergies was higher in children than adults, especially for sardine and shrimp species (52.3 vs 36.4 per cent and 36.4 vs 16 per cent, respectively). However, these differences between children and adults subjects were not statistically significant.

Frequency of fish consumption among children and adults

In our population, most children (94.5 per cent) and adults (95.5 per cent) consumed fish and shellfish. Among children, the fish species consumed the most was sardine, with a rate of 88.6 per cent, compared to 55 per cent for horse mackerel, 46.9 per cent for whiting and 39.5 per cent for mackerel. For the adult population, the consumption of fish was strongly associated with sardine (92 per cent), followed by horse mackerel (76 per cent), common pandora (69.9 per cent) and whiting (68.4 per cent). Table VI shows the rate of fish consumption for each species among children and adults. Fish consumption did not differ between adults and children ($p = 0.1$), but the latter were significantly less likely to eat fish species than adults with statistically significant difference for all fish species ($p < 0.0001$).

Correlation between fish consumption and fish and shellfish allergy in children and adults

Table VII shows the prevalence of FSA according to fish consumption. Among adults population, results showed that the FSA rate was significantly lower in adults who consumed fish than those who did not (OR, 0.1; 95 per cent CI, 0.1-0.2; $p < 0.0001$). The correlation between FSA and fish consumption was most significant with sardine and horse mackerel ($p < 0.0001$), followed by whiting, mackerel, common pandora and shrimp ($p < 0.05$). However, this correlation was not observed in children, except for mackerel species for which the frequency of mackerel allergy was significantly higher in children who consumed it than those who did not (OR, 2; 95 per cent CI, 1.3-3.2; $p < 0.01$). No significant association was found for other types of fish.

The prevalence of FSA by consumption frequencies of fish is shown in Table VIII. The relation between FSA and consumption frequency in children showed that those with

Fish/shellfish species	Children <i>N</i> (%)		Adults <i>N</i> (%)	
	Single allergies	Multiple allergies	Single allergies	Multiple allergies
Sardine	104 (52.3)	95 (47.7)	36 (36.4)	63 (63.6)
Horse mackerel	4 (4.9)	77 (95.1)	1 (1.7)	59 (98.3)
Whiting	5 (10.2)	44 (89.8)	0	25 (100)
Common pandora	1 (2.8)	35 (97.2)	0	25 (100)
Mackerel	10 (14.3)	60 (85.7)	4 (7.3)	51 (92.7)
Shrimps	20 (36.4)	35 (63.6)	4 (16)	21 (84)

Table V.
Multiple fish
allergies rates
according to fish
species

NFS
48,1

142

Table VI.Estimated rates of
fish consumption
among children and
adults

Fish/shellfish consumption	Children <i>N</i> (%) <i>N</i> = 2,810			Adults <i>N</i> (%) <i>N</i> = 1,236			<i>p</i> -value
	Total	Boys	Girls	Total	Men	Women	
Fish/Shellfish	2,656 (94.5)	1,335 (50.3)	1,321 (49.7)	1,181 (95.5)	587 (49.7)	594 (50.3)	0.1
Sardine	2,353 (88.6)	1,207 (45.4)	1,146 (43.1)	1,086 (92)	559 (47.3)	527 (44.6)	<0.001
Horse mackerel	1,464 (55.1)	751 (28.3)	713 (26.8)	899 (76.1)	460 (39)	439 (37.2)	<0.0001
Whiting	1,245 (46.9)	600 (22.6)	645 (24.3)	808 (68.4)	424 (35.9)	380 (32.2)	<0.0001
Mackerel	1,048 (39.5)	540 (20.3)	506 (19.1)	679 (57.5)	373 (31.6)	306 (25.9)	<0.0001
common pandora	934 (35.2)	467 (17.6)	467 (17.6)	826 (69.9)	407 (34.5)	419 (35.5)	<0.0001
Shrimp	800 (30.1)	370 (13.9)	428 (16.1)	625 (52.9)	316 (26.8)	309 (26.2)	<0.0001
Other	931 (35.1)	459 (17.3)	472 (17.8)	598 (50.6)	323 (27.3)	275 (23.3)	<0.0001

Notes: *N*, number of people who consumed fish species; *p*-value corresponds to differences in the prevalence of fish/shellfish consumption between children and adults; χ^2 test, any value of $p < 0.05$ was considered statistically significant

Table VII.Frequency of
self-reported FSA
according to fish
consumption

Fish consumption	Children (C)		Adults (A)	
	FSA <i>n</i> (%)	OR (95% CI) <i>p</i> -value	FSA <i>n</i> (%)	OR (95% CI) <i>p</i> -value
<i>Fish/Shellfish</i>				
Yes NC = 2,656; NA = 1,181	254 (9.6)	1.1 (0.6-1.8)	96 (8.1)	0.1 (0.1-0.2)
No NC = 154; NA = 55	14 (9.1)	$p = 0.8$	22 (40)	$p < 0.0001$
<i>Sardine</i>				
Yes NC = 2,353; NA = 1,086	161 (6.8)	0.8 (0.5-1.2)	36 (3.3)	0.1 (0.03-0.1)
No NC = 457; NA = 150	38 (8.3)	$p = 0.2$	63 (42)	$p < 0.0001$
<i>Horse mackerel</i>				
Yes NC = 1,464; NA = 899	42 (2.9)	0.9 (0.6-1.5)	17 (1.9)	0.1 (0.1-0.1)
No NC = 1,346; NA = 337	39 (2.9)	$p = 0.9$	43 (12.7)	$p < 0.0001$
<i>Whiting</i>				
Yes NC = 1,245; NA = 808	18 (1.4)	0.7 (0.4-1.3)	8 (1)	0.2 (0.1-0.6)
No NC = 1,565; NA = 428	31 (2)	$p = 0.2$	17 (3.9)	$p < 0.001$
<i>Mackerel</i>				
Yes NC = 1,048; NA = 679	38 (3.6)	2 (1.3-3.2)	17 (2.5)	0.4 (0.2-0.6)
No NC = 1,762; NA = 557	32 (1.8)	$P < 0.01$	38 (6.8)	$p < 0.001$
<i>Common pandora</i>				
Yes NC = 934; NA = 826	13 (1.4)	1.1 (0.6-2.3)	9 (1.1)	0.3 (0.1-0.6)
No NC = 1,876; NA = 410	23 (1.2)	$p = 0.7$	16 (3.9)	$p < 0.01$
<i>Shrimps</i>				
Yes NC = 800; NA = 625	13 (1.6)	0.8 (0.4-1.4)	6 (1)	0.3 (0.1-0.8)
No NC = 2,010; NA = 611	42 (2)	$p = 0.4$	19 (3)	$p < 0.01$

Notes: OR, odds ratio; 95% CI, confidence intervals set at 95%; NC, number of children; NA, number of adults; *p*-value corresponds to differences in the prevalence of self-reported FSA between persons who consumed fish and those who did not, in both children and adults; χ^2 test, any value of $p < 0.05$ was considered statistically significant

Table VIII.
Frequency of
self-reported FSA
according to
consumption
frequency of fish

Fish consumption frequency	Children (C)		Adults (A)	
	FSA <i>n</i> (%)	OR (95% CI) <i>p</i> -value	FSA <i>n</i> (%)	OR (95% CI) <i>p</i> -value
<i>More than once per week</i>				
Yes NC = 861; NA = 440	81 (9.4)	1 (0.7-1.3)	24 (5.5)	0.4 (0.3-0.7)
No NC = 1,949; NA = 796	187 (9.6)	<i>p</i> = 0.8	94 (11.8)	<i>p</i> < 0.001
<i>Once per week</i>				
Yes NC = 1,133; NA = 534	106 (9.4)	1 (0.7-1.2)	40 (7.5)	0.6 (0.4-1)
No NC = 1,677; NA = 702	162 (9.7)	<i>p</i> = 0.7	78 (11.1)	<i>p</i> = 0.03
<i>3 times per month</i>				
Yes NC = 455; NA = 171	38 (8.4)	0.8 (0.6-1.2)	25 (14.6)	1.8 (1.1-2.9)
No NC = 2,355; NA = 1,065	230 (9.8)	<i>p</i> = 0.3	93 (8.7)	<i>p</i> = 0.01
<i>Once per month</i>				
Yes NC = 207; NA = 36	29 (14)	1.6 (1.1-2.4)	7 (19.4)	2.4 (1-5.5)
No NC = 2,603; NA = 1,200	239 (9.2)	<i>p</i> = 0.02	111 (9.3)	<i>p</i> = 0.04

Notes: OR, odds ratio; 95% CI, confidence intervals set at 95%; NC, number of children; NA, number of adults; *p*-value corresponds to differences in the prevalence of self-reported FSA according to fish consumption frequency in both children and adults; χ^2 test, any value of *p* < 0.05 was considered statistically significant

consumption once per month had a significantly higher FSA rate than those with consumption more than once (*p* = 0.02). Children eating fish ≥ 3 times per month was not significantly associated with FSA. For the adult population, consumption ≥ 1 time per week was significantly associated with low rates of FSA. However, adults with consumption ≤ 3 times per month had a significantly higher FSA rate than those with consumption ≥ 3 times per month (*p* < 0.05).

Discussion

This work aimed to examine the differences in the prevalence of the self-reported allergy to food, especially to fish and shellfish, between children and adults, and to study the association between fish consumption and self-reported FSA. On the basis of a survey, this study was conducted between April 2014 and December 2016, where children (12-18 years old) and adults (19-60 years old) were recruited from the general population of the Fez-Meknes region.

The prevalence of the self-reported FA, in the present study, was 16.8 per cent in adults and 28.2 per cent in children with statistically significant difference (OR, 1.9; 95 per cent CI, 1.6-2.3; *p* < 0.00001). The FA prevalence decreased progressively with advancing age, which moved from 31 per cent in the youngest group (12-15 years of age) to 14 per cent in older persons >40 years of age. As in a previous survey in the USA, [Liu et al. \(2010\)](#) found that the highest prevalence of food sensitization was 28.1 per cent in children aged 1-5 years and declined steadily with increasing age to 13.0 per cent in adults aged 60 years. This conclusion is supported by [Sampson's study \(2004\)](#) which found that the prevalence of FA in the USA was greatest in young children (6 per cent) and decreasing over the years to 3.7 per cent in adults. In other countries, authors have observed a decline of FA with age in Taiwan, where the FA reduced from 7.7 per cent in 4-18 years of age group to 6.4 per cent in adults >19 years of age ([Wu et al., 2012](#)). In China, the results were similar where children

aged 11-17 years had a higher rate of FA than the adults ≥ 18 years of age (Kim *et al.*, 2008). Recently, studies performed in New York and South Africa with children showed a higher frequency of FA among young children than the older ones (Mehta *et al.*, 2014; Gray *et al.*, 2014). Furthermore, a study that only included adult Portuguese aged between 40 and 70 years showed that the food hypersensitivity prevalence decreased with age in females (from 7.9 per cent in the age group of 40-49 years to 5.3 per cent in the age group of 70 years) and in males (from 4.4 per cent in the age group of 40-49 years to 0 per cent in the age group of 70 years) (Falcao *et al.*, 2004). These findings indicated that FA was more frequent among younger age population than the older ones and decreased in prevalence with advancing age, which support our study.

Regarding the food categories involved in allergic adverse reactions in our study, eggs, fish/shellfish, milk and cereals were the most common self-reported allergies in both children and adults, which was similar to the results of several studies (Gray *et al.*, 2014; Nwaru *et al.*, 2014; Ontiveros *et al.*, 2016; Ho *et al.*, 2012; Aba-Alkhalil and El-Gamal, 2000; Gupta *et al.*, 2011; Rance *et al.*, 2005; McGowan and Keet, 2013). The frequency of milk, eggs and cereals, in our study, was significantly higher in children compared to adults ($p < 0.0001$). This result was consistent with those obtained in Spain, where eggs and milk were the main elicitors of FA in children (≤ 14 years) with a significant difference between the age groups (≤ 14 years group: 32.3 per cent and 31 per cent, respectively; > 14 years group: 2.8 per cent and 1.3 per cent, respectively; $p < 0.001$) (Sánchez-López *et al.*, 2017). A meta-analysis, in Europe, showed that allergy to cow's milk and eggs were more common among younger children, whereas allergy to peanuts, tree nuts, fish and shellfish were more common among the older ones (Nwaru *et al.*, 2014). In Canada and Taiwan, the results were similar where milk and eggs were the most common allergies in children compared to adults (Wu *et al.*, 2012; Soller *et al.*, 2012). As well as a survey study, by Flokstra-de Blok *et al.* (2010), showed that the prevalence of eggs, milk and peanut allergy was more prevalent in children aged 8-12 years than in adults aged ≥ 18 years (children: 37, 28 and 74 per cent, respectively; adults: 22, 26 and 58 per cent, respectively). Moreover, Sampson (2004) showed that a prevalence of allergy to milk and eggs was more common in young children (2.5 and 1.3 per cent, respectively) than in adults (0.3 and 0.1 per cent, respectively). Other studies performed among Hong Kong and France children (0-14 years) showed a decrease in the relative frequency for eggs and milk allergies with advancing age (Ho *et al.*, 2012; Rance *et al.*, 2005). These conclusions were in agreement with our observations and showed that children were more sensitive than adults, especially to milk and eggs. This finding can be related to immunologic tolerance that is established in adults.

According to sex, the prevalence of FA in adults was equivalent in both females and males but in children, it was significantly higher in females than in males (32.5 vs 23.9 per cent), which was consistent with other studies. In Colombia, the prevalence was 16.4 per cent in female and 12.8 per cent in male, and Sweden girls were more likely to have FA than Sweden boys (Marrugo *et al.*, 2008; Strinnholm *et al.*, 2014). In contrast, studies in Hong Kong and United Kingdom reported a higher prevalence in boys (Ho *et al.*, 2012; Pereira *et al.*, 2005).

Regarding FSA, we found a prevalence of 9.5 per cent in both children and adults, which was close to the prevalence reported in Asian and African countries, such as Singapore, Philippines, Turkey, South Africa, Mozambique, Tunisia and Saudi Arabia (Shek *et al.*, 2010; Orhan *et al.*, 2009; Gray and Kung, 2012; Lunet *et al.*, 2005; ben Ameer *et al.*, 2014; Aba-Alkhalil and El-Gamal, 2000). However, the percentages were seen to be decreasing in developed countries worldwide, such as as Denmark, USA, Canada, Japan and UK, which were less than 2 per cent (Osterballe *et al.*, 2009; Gupta *et al.*, 2011; Soller *et al.*, 2012; Noda, 2010; Pereira *et al.*, 2005). The high prevalence obtained in our study is thought to be related

to the quality of fish products and their freshness related to histamine content (data not reported). Thus, higher self-reported FSA prevalence in emerging and less developed countries could be explained by the effect of histamine content in those products which can induce false allergic reactions. Notably, the frequency of FSA in our study was close to double in females when compared with males (children: 12 vs 7 per cent; adults: 11.7 vs 7.4 per cent). Interestingly in this regard, other studies also found that FSA was more common in females when compared with males (Ho *et al.*, 2012; Sicherer *et al.*, 2004; Schäfer *et al.*, 2001).

Regarding the fish species involved in allergic reactions in our study, sardine, horse mackerel and mackerel were the main causes of FSA, and the adults were significantly more allergic to horse mackerel and mackerel than children ($p < 0.01$). With regard to clinical manifestations of FSA, the most frequently described in the literature were cutaneous reactions, followed by digestive reactions, respiratory symptoms and anaphylactic shock (Marrugo *et al.*, 2008; Rance *et al.*, 2005). Similar results were found in our population, in which cutaneous reactions were the most frequently reported manifestation, followed by digestive reactions and respiratory symptoms. No significant difference was found between children and adults.

By age groups, the highest prevalence of FSA was found in young children (12-15 years: 10.5 per cent) and in older adults (40-60 years: 10.1 per cent). According to fish species, the prevalence of sardine and horse mackerel sensitization was highest in older adults aged 40-60 years, whereas mackerel, shrimp, whiting and common pandora sensitizations were most common in young adults aged 20-40 years. An interesting finding in Colombia considering the prevalence of FA according to age showed that the relative frequency of seafood allergies was higher among older adults aged 40-80 years than among others group (Marrugo *et al.*, 2008). Another study released in Spain found that the frequency of seafood allergies was higher in the >14 years group than the ≤ 14 years group (Sánchez-López *et al.*, 2017). These data are similar to those obtained in other epidemiological studies, in which the prevalence of FSA was higher in the older age groups than in the younger age groups (Sampson, 2004; Soller *et al.*, 2012; Nwaru *et al.*, 2014; Sicherer *et al.*, 2004; Ben-Shoshan *et al.*, 2010). With specific regard to shrimp allergy, Liu *et al.* (2010) found that the prevalence estimated in the USA by age was more prevalent among young adults aged 20-39 years than among other group, which is similar to our study. These findings confirmed that FSA was more common in older age groups than in younger age groups, in which the prevalence of FSA varies according to age and region.

In our dietary questionnaire, the majority of children and adults consumed fish and shellfish, whereas children were significantly less likely to eat fish species than adults ($p < 0.0001$). Consumption of fish once per week was very common in our population (children, 40.3 per cent; adults, 43.2 per cent). Moreover, there was strong inverse relationship ($p < 0.0001$) between FSA and fish consumption in adults population, in which FSA was less pronounced among those who consumed fish. However, no significant association was found for children, except for mackerel species, as those eating it reported more allergy. According to fish consumption frequency, we found that those consuming fish more often had significantly less FSA; thus, those consuming fish rarely had significantly more FSA.

The observed inverse association between fish consumption and FSA can be explained by two hypotheses: First, the emergence of fish allergy symptoms may cause people to change their regular consumption of fish and to avoid their consumption, which may therefore explain the higher rate of self-reported FSA among people who did not or rarely consumed fish. Second, early and regular fish consumption for a long time may reduce the risk of developing an allergy to fish, which may contribute to explaining the lower rate of self-reported FSA among people who consumed fish or with daily fish consumption.

Interestingly, several studies in infancy and childhood have shown that high and regular fish consumption in early life may reduce the overall risk of allergic disease, possibly because of its high content of omega-3 polyunsaturated fatty acid (Kull *et al.*, 2006; Magnusson *et al.*, 2013; Nafstad *et al.*, 2003; Øien *et al.*, 2010; Alm *et al.*, 2011; Virtanen *et al.*, 2010; Nagel *et al.*, 2010). One further study on the association between fish consumption and allergic sensitization in adults, conducted by Schnappinger *et al.* (2009), suggested that adults with a high fish intake have a lower rate of allergic sensitization, which is similar to our study. Moreover, the effect of omega-3 polyunsaturated fatty acid on allergic diseases has been investigated in a number of studies, suggesting a high consumption of omega-3 polyunsaturated fatty acid in early life has been associated with a decreased risk of allergy and its symptoms, as a result of their capacity to inhibit the production of inflammatory mediators (Øien *et al.*, 2010; Willemsen, 2016; Magnusson *et al.*, 2015; Søyland *et al.*, 1994; Kremmyda *et al.*, 2011; Klemens *et al.*, 2011; Prescott and Calder, 2004).

In conclusion, our results have shown that the self-reported allergy of the general population to foods was more frequent among children than adults, which decreased in prevalence with age. Regarding the self-reported FSA, we have shown a prevalence of 9.5 per cent in both children and adults, whereas fish species allergies were more frequent among adults than children. As for the relation between fish consumption and FSA, we found that consumption of fish was associated significantly with a lower rate of FSA, especially in adults.

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