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A 21-Year Perspective on Occupational Skin and Respiratory Diseases Among Food Handlers

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Abstract

Background: *Food handlers may have an increased risk of developing occupational skin and respiratory diseases.* **Methods:** *This retrospective study was based on examinations, skin prick testing, and patch testing performed at the Unit of Occupational Medicine at the University of Trieste (N-E Italy) between 2002 and 2022 in food-handler workers referred to the unit for suspected occupational allergic diseases.* **Results:** *More than half of the population (58.1%) experienced occupational skin diseases, with a higher prevalence among women (OR 3.3, 95% CI 1.5-7.6). Irritant contact dermatitis was the most prevalent skin condition (22.9%), followed by allergic contact dermatitis (20%) and protein contact dermatitis (15.1%). Pastry makers and bakers exhibited a high rate of protein contact dermatitis (20.6 and 17.7%, respectively), which was primarily attributed to wheat flour. Of the participants, 47.8% reported having rhinitis, and 17.6% reported having asthma. Positive SPT results were observed in 34.4% of workers with rhinitis and 58.3% of those with asthma, with bakers and pastry makers being more frequently sensitized to wheat flour (22.8% and 20.6%, respectively). Cooks reported rhinitis (43.2%) and asthma (12.3%) with sensitization to soy, scampi, peanuts, and other foods. Atopy determined by prick test was significantly linked to respiratory symptoms. Bakers and pastry makers showed significantly higher sensitivity to wheat flour (OR 3.3, 95% CI 1.3-7.8).* **Conclusions:** *Food handlers can experience occupational skin and respiratory diseases, and more efforts are needed to prevent such diseases by improving preventive habits and avoiding exposure to allergens.*

1. Introduction

Skin and respiratory diseases are common in food workers due to exposure to irritants and sensitizing agents. In terms of numbers, this occupational group ranked third after hairdressers and healthcare workers for occupational skin diseases [1] in patients who underwent patch testing. Considering epidemiological data on the incidence of occupational skin diseases (OSD), Dickel et al. reported in 2002 that there were 37.7 cases per 100,000 workers among bakers and pastry makers, and 8.5 cases per 100,000 workers among all food handlers in Germany [2].

The main cause of irritant contact dermatitis (ICD) in these workers is repeated water exposure, followed by the use of soaps and detergents during cleaning, as well as contact with food [3]. Besides wet work, these workers are also exposed to heat and thermal burns, which damage the skin's barrier

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and raise the risk of skin diseases [4]. Additionally, bakers, cooks, and pastry makers can develop allergic contact dermatitis (ACD) due to sensitization to rubber additives like thiuram mix [5]. A potential role of nickel sulfate in handled pans and pots has been suggested [6]. However, an extensive database of 1,297 food handlers with suspected ACD investigated in the North East of Italy did not find any increased risk of sensitization compared with clerks [5].

A specific type of contact dermatitis is Protein Contact Dermatitis (PCD), which is characterized by an allergic skin reaction mainly triggered by proteins of animal or plant origin. [7]. Bakers, pastry chefs, and cooks can all be affected. Nieto et al. [8] showed that common allergens causing dermatitis include peanuts, scampi fish, tomatoes, onions, garlic, milk, grains, and meat, with a positive prick test for the offending allergen.

Work-related allergic respiratory disorders are common in bakers, with approximately 15-20% of workers experiencing rhinitis and 5-10% developing asthma, making it a common occupational health concern [9]. Baker's asthma ranks as the second leading cause of occupational asthma in Norway and England and the primary cause in France, Germany, and Italy [10] with sensitization to flours or enzymes [11]. A study conducted among bakers in the Veneto region [12] reported a prevalence of occupational asthma of 7% and upper respiratory symptoms of 22%, with 37.1% of participants sensitized to occupational allergens. The age of symptom onset varies, but the highest risk occurs within the first two years of exposure [13].

Exposure to flour dust has been recognized as a trigger for allergic sensitization and respiratory diseases; however, other causative agents, such as different flours, enzymes (alpha-amylase), egg proteins, and organic contaminants, including storage mites, molds, and insects, have also been identified [14-16]. Cross-reactivity among different flours is common, with lupine proteins emerging as antigens. Fungal enzymes, such as *Aspergillus*-derived α-amylase, are significant triggers for OA, as are other enzymes [17]. Soya flour, used as a baking additive, can cause sensitization to components like lipoxygenase and soybean trypsin inhibitors, leading to asthma and rhinitis [18, 19]. Gluten-free and vegan baking ingredients, such as psyllium derived from Plantago ovata, have also been linked to occupational rhinitis and dermatitis [20]. Additionally, kitchen workers exposed to cooking fumes may develop rhinitis and asthma due to inhaling food allergens like seafood. A recent systematic review on occupational asthma analyzed only five studies dealing with occupational exposure to wheat flour, crabs, and spices [21], though more data are needed on these professional groups.

Despite major changes in food production methods, skin and respiratory symptoms related to work stay high, especially in the artisan sector, where work conditions are the worst and exposure to allergens can be greater. Our study aimed to investigate skin and respiratory symptoms in food handlers who underwent a medical examination for a suspected occupational disease at the Unit of Occupational Disease at Trieste University from 2002 to 2022.

2. METHODS

This retrospective study analyzed 205 food workers examined at the Occupational Health Clinic (University of Trieste) for suspected allergic occupational diseases from 2002 to 2022. The group was composed of 81 kitchen workers (19 men and 62 women), 79 bakers (48 men and 31 women), 34 pastry workers (14 men and 20 women), and 11 food industry workers (six men and five women).

Each participant underwent a thorough medical assessment, including skin prick tests (SPTs) for common and occupational allergens, as well as patch tests if allergic contact dermatitis was suspected. Additionally, all subjects were required to complete a standardized questionnaire based on the Nordic Occupational Skin Questionnaire (NOSQ-2002) [22] to gather information on their symptoms, occupational exposure, smoking habits, atopy or familial allergies, and personal history of dermatitis and respiratory symptoms. ICD was defined in cases of local inflammatory reactions characterized by erythema, fissures, edema, vesicles, and blisters after exposure to irritant agents and water [3]. The patch test results were usually negative or irrelevant. ACD was defined as a local inflammatory reaction

characterized by erythema, edema, vesicles, blisters, and itching, with positive and relevant patch tests.

PCD was defined as acute flares of symptoms, such as pruritus (itching), urticaria (hives), edema (swelling), or vesiculation, occurring within minutes of contact with the causative substance. Moreover, the patch test was typically negative, while the prick test with food was positive [7]. Contact urticaria (CU) was defined as a wheal-and-flare reaction that occurs immediately after external contact with a specific food, clearing completely within hours without residual signs of irritation or the presentation of eczema [23].

Diagnosis of asthma was supported by spirometry and, when needed, a methacholine challenge. In patients with asthma, work-related asthma was defined as recurrent cough, wheezing, and dyspnea that occurred exclusively during work or significantly worsened at the workplace. Allergic occupational asthma was diagnosed by a specialist in occupational medicine in patients with work-related asthma that occurred only during work, with a positive result for the suspected occupational allergen. Irritative occupational asthma was diagnosed by a specialist in occupational medicine in patients with work-related asthma that occurred only during work, with no positive result for any occupational allergen, but with exposure to irritants at work. Occupational rhinitis was described as symptoms such as sneezing or an itchy, runny nose that occurred solely during working hours and were attributed to workplace conditions.

Before conducting SPTs, a comprehensive interview with a trained physician was undertaken to identify and exclude individuals at risk for severe adverse reactions to SPTs. Individuals who had experienced a severe asthma attack within the past year or had a history of anaphylactic shock or severe reactions to allergens being tested were excluded. Workers taking antihistamine medications during testing were also exempted from SPTs. Skin prick tests were performed with a panel of common inhalant allergens, including perennial allergens such as *Dermatophagoides farinae, Dermatophagoides pteronyssinus*, dog and cat dander, pollens, foods like soy, yeast, white eggs, yolks, milk, peanut, scampi fish, and specific occupational allergens like latex, wheat, rye, barley, rice flours, green coffee bean, and α-amylase. Lofarma Allergeni (Milan, Italy) provided allergen extracts for testing, and SPT was performed using standardized lancets (Hollister Stier Laboratory, Spokane, Washington). After a 15-minute wait, all tests were read and recorded, with a wheal of at least 3 mm considered a positive result. A single positive response to an inhalant allergen was the defining criterion for atopy, as determined by the SPT. No adverse reactions to SPTs were reported in this study.

Patch testing was performed using the European baseline series, with Finn® Chambers applied on aluminum on Scampor® tape (Epitest Ltd, Tuusula, Finland). Additionally, specific allergens, including the flours they worked with, were tested by bakers and pastry makers. The substances used and the clinical protocols remained consistent throughout the study period. Substances were applied to the upper back and removed after 48 hours (day 2). Examination of the test sites was performed upon removal and again after either 24 h (day 3) or 48 h (day 4), following the guidelines established by the International Contact Dermatitis Research Group [24].

Data analysis was performed using STATA 13.0 (STATA Corp, College Station, Texas, USA). Continuous data are summarized as median and 25°-75° percentiles. Differences between the mean values were assessed using the Mann-Whitney test. Categorical data were analyzed using the appropriate likelihood chi-square test with Yates' correction. Univariate logistic regression analysis assessed factors associated with occupational skin diseases or respiratory symptoms (asthma and/or rhinitis). Factors that were significantly associated were included in the multivariate logistic regression analysis. Results are reported as odds ratios (ORs) and 95% confidence intervals (CIs). A sensitivity analysis was performed to verify factors associated to only skin or respiratory symptoms.

3. Results

Table 1 summarizes the general characteristics of the study population. There were 87 males and 118 females, with a median age of 34 and 25th-75th percentiles of 27-45 years. The median

Table 1. Characteristics and workers studied according to gender.

	Men N (%) 87 (42.4)	**Women N (%) 118 (57.6)**	**Total N (%) 205 (100)**	**P**
Age, years, median (25°-75° percentiles)	32 (25-75)	37 (27-45)	34 (27-45)	0.264
Seniority of work, years, mean (CI 95%)	9 (1-23)	6 (2-12)	7 (2-15)	0.155
Job tasks, N (%)				
Food industry-workers	5 (5.7)	1 (0.85)	6 (2.9)	<0.001
Bakers	48 (55.2)	31 (26.3)	79 (38.5)	
Pastry-makers	14 (16.1)	20 (17.0)	34 (16.6)	
Cooks	19 (21.8)	62 (52.5)	81 (39.5)	
Trainees	1 (1.2)	4 (3.4)	5 (2.4)	
Smoke habits, N (%)				
Smokers	25 (28.74)	42 (35.6)	67 (32.7)	0.324
Ex smokers	18 (20.7)	16 (13.6)	34 (16.6)	
Familiar Allergy N (%)	33 (37.9)	51 (43.2)	84 (41.0)	0.447
Atopic eczema N (%)	23 (26.4)	32 (27.1)	55 (26.8)	0.913
Diseases N (%)				
Contact dermatitis	39 (44.8)	80 (67.8)	119 (58.1)	0.001
Urticaria	8 (9.2)	13 (11.0)	21 (10.2)	0.671
Oculorhinitis	49 (56.3)	49 (41.2)	98 (47.8)	0.053
Asthma	18 (20.7)	18 (15.3)	36 (17.6)	0.288
Symptoms duration, years (SD) CI 95%	1 (0.66-4)	1 (1-3)	1 (1-3)	0.753

latency period before symptom onset was 7 years (25th-75th percentiles: 2-15 years).

An analysis of smoking habits revealed that nearly 50% of the study population was either smokers or ex-smokers, with no statistically significant difference between the sexes (p=0.324). Furthermore, regarding individual allergic susceptibility, 84 (41%) workers reported having at least one family member with allergies. Additionally, 55 (26.8%) individuals had a history of atopic dermatitis, with no significant differences between the sexes.

Skin-related conditions were the most common work-related diseases, including ACD, ICD, PCD, and urticaria (Table 2). Women had a higher prevalence of skin disease than men (67.8% *vs.* 44.8%, respectively, p=0.001). ACD and PCD affected 72 (35.1%) workers (23 men and 49 women), with a statistically significant difference between the two groups (p=0.008). ICD was observed in 16 men and 31 women, with no significant difference between sexes (p=0.185).

Ninety-eight workers had oculorhinitis (47.8%) and 36 (17.6%) reported asthma during their work. The median duration of symptoms was 1 year (25°-75° percentiles 1-3 years), similar in both sexes. Cooks were the most represented professional group (n. 81, 39.5%), and 60.5% of them reported occupational contact dermatitis (29.6% ACD, 11.1% PCD, 19.8% ICD, 11.1% urticaria) with sensitization to various allergens (Table 3).

Patch tests were positive for nickel sulfate (30.6%), thiuram mix (2%), benzoyl peroxide

Table 2. Characteristic of workers and distribution of work-related diseases in 205 workers from the food industry.

	Food industry(%)	Bakers (%)	Pastry-makers (%)	Cooks (%)	Total (%)
Study subjects N (%)	11 (5.4)	79 (38.5)	34 (16.6)	81 (39.5)	205 (100)
Age median years (25^{th}-75^{th} percentile)	38 (32-43)	33 (28-47)	31 (24-42)	37 (28-45)	34 (27-45)
Seniority, years (25^{th}-75^{th} percentile)	2 (1-3)	10 (2-20)	7 (2-12)	6 (2-13)	7 (2-15)
Smoking habits N (%)					
Smokers	4 (36.4)	23 (29.0)	12 (35.3)	28 (34.6)	67 (32.7)
Ex smokers	1 (9.1)	16 (20.2)	7 (20.6)	10 (12.35)	34 (16.6)
Familiar Allergy N (%)	4 (36.4)	30 (38)	16 (47.0)	34 (42.0)	84 (41.0)
Atopic eczema N (%)	3 (27.3)	22 (27.9)	8 (23.5)	22 (27.2)	55 (26.8)
Work-related symptoms N (%)					
Contact dermatitis	7 (72.7)	38 (48.1)	25 (73.5)	49 (60.5)	119 (58.1)
ACD	1 (9.1)	10 (12.6)	8 (23.5)	24 (29.6)	41 (20.0)
PCD	1 (9.1)	14 (17.7)	7 (20.6)	9 (11.1)	31 (15.1)
ICD	5 (45.4)	14 (17.7)	10 (29.4)	16 (19.8)	47 (22.9)
Urticaria	0	7 (8.9)	5 (14.8)	9 (11.1)	21 (10.2)
Oculorhinitis	5 (45.4)	43 (54.4)	15 (44.1)	35 (43.2)	98 (47.8)
Asthma	4 (36.4)	18 (22.8)	4 (11.8)	10 (12.3)	36 (17.6)
• Occ. Allergic N (% on asthma)	2 (50)	8 (44.4)	4 (100)	4 (40)	19 (52.8)
• Occ. Irritative N (% on asthma)		6 (30)			6 (16.7)
• Work exacerbated asthma N (% on asthma)	2 (50)	4 (22.2)		6 (60)	12 (33.3)
Symptom duration, median y (25^{th}-75^{th} percentile)	1 (1-1)	1 (0.66-3)	1 (1-2)	1.25 (1-6)	1 (1-3)

ACD = allergic contact dermatitis. ICD=irritant contact dermatitis. PCD=protein contact dermatitis.

(4.1%), and diallyl disulfide (4.1%). Oculorhinitis and asthma were reported by 43.2% and 12.3% of cooks, respectively. Five of 54 tested (9.3%) were sensitized to wheat flour, 5 of 52 (9.6%) to soy, 4 of 81 (4.9%) to scampi with symptoms cooking them, 3 of 81 (3.7) to peanut, one of 81 to fish (1.2%), one to latex, and few of them were sensitized to other allergens (Table 3).

The number of bakers was 79 (38.5%); more than half reported work-related rhinitis (54.4%), 22.8% had asthma, 8.9% had urticaria, and 48.1% had skin symptoms. Allergy to wheat flour was demonstrated in 22.8% of workers, 8.9% were sensitized to soy, 7% to alpha-amylase from *Aspergillus oryzae,* and a few subjects were sensitized to other potential professional allergens such as yeast, eggs, and other flours. Two workers reported symptoms with latex gloves that were positive for the skin prick test. In bakers with skin diseases, 9 of the 34 patches tested (26.5%) were positive for standard allergens (nickel sulfate, palladium chloride, balsam of Peru, and potassium dichromate). Furthermore, 5.9% of the samples were positive for sodium metabisulfite, a common reducing agent used in dough preparation. Fourteen (17.7%) had PCD with sensitization to wheat, soy, yeast, rye, barley, and white eggs (Table 2 and Table 3).

Pastry makers reported work-related oculorhinitis, asthma, and urticaria in 44.1%, 11.8%, and 14.8%

Table 3. Results of skin prick test and patch test in different occupations. Patch test concentration is reported in percent.

Skin prick test	Food industry N. 11 N/tested (%)	Bakers N. 79 N/tested (%)	Pastry- makers N. 34 N/tested (%)	Cooks N. 81 N/tested (%)	Total N. 205 N/tested (%)
Wheat/whole wheat flours	0/2	18/79 (22.8)	7/34 (20.6)	5/54 (9.3)	30/169 (17.8)
α-amylase from *Aspergillus Oryzae* (IgE)	-	3/43 (7.0)	-	-	3/43 (7.0)
Rye flour	-	1/79 (1.3)	0/34	-	1/113 (0.9)
Barley flour	-	2/79 (2.6)	0/34	-	2/113 (1.8)
Rice flour	-	0/79	0/34	-	0/113
Soy	2/11 (18.2)	7/79 (8.9)	2/34 (5.9)	5/52 (9.6)	16/167 (9.6)
Yeast	-	2/79 (2.5)	1/34 (2.9)	0/50	3/163 (1.8)
White eggs	-	2/79 (2.5)	1/34 (2.9)	1/81 (1.2)	4/194 (2.1)
Yolks	-	2/79 (2.5)	2/34 (5.9)	1/81 (1.2)	4/194 (2.1)
Milk	-	0/79	0/34	2/81 (2.4)	2/194 (1.0)
Peanut	-	1/10 (1.3)	-	3/81 (3.7)	4/91 (4.4)
Scampi	-	1/10 (1.3)	1/34 (2.9)	4/81 (4.9)	6/125 (4.8)
Fish	-	1/10 (1.3)	-	1/81 (1.2)	2/91 (2.2)
Latex	-	2/2 (100)	1/1 (100)	1/1 (100)	4/4 (100)
Green coffee bean	1/1 (100)	-	-	-	1/1 (100)
Dermatophagoides farina	3/10 (30.0)	27/71 (38.0)	6/27(22.2)	18/53 (34.0)	54/161 (33.5)
Dermatophagoides pteronyssinus	2/10 (20.0)	24/71 (33.8)	5/27 (18.5)	19/53 (35.8)	50/161 (31.0)
Dog dander	1/10 (10.0)	8/71 (11.3)	4/27 (14.8)	11/53 (20.7)	24/161 (14.9)
Cat dander	1/10 (10.0)	7/71 (10.8)	4/27 (14.8)	7/53 (13.2)	19/161 (11.8)
Alternaria alternata	1/10 (10.0)	4/71 (5.6)	0/27	5/53 (9.4)	10/161 (6.2)
Graminae	4/10 (40.0)	21/71 (29.6)	5/27 (18.5)	16/53 (30.2)	46/161 (28.6)
Compositeae	1/10 (10.0)	7/71 (9.9)	1/27 (3.7)	5/54 (9.3)	15/162 (9.2)
Cupressaceae	1/10 (10.0)	11/71 (15.5)	3/27 (11.1)	6/53 (11.3)	21/161 (13.0)
Betulaceae	2/10 (20.0)	15/71 (21.1)	1/27 (3.7)	11/53 (20.7)	29/161 (18.0)
Oleaceae	2/10 (20.0)	13/71 (18.1)	2/27 (7.4)	10/53 (18.9)	27/161 (16.8)
Patch test (occupational)					
Nickel sulphate 5%	1/7 (14.3)	5/34 (14.7)	2/20 (10.0)	15/49 (30.6)	24/110 (21.8)
Thiurams mix 1%	0/7	0/34	0/20	1/49 (2.0)	1/110 (0.9)
Benzoyl peroxide 2%	0/7	0/34	1/20 (5.0)	2/49 (4.1)	3/110 (2.7)
Ammonium persulfate 1%	0/7	0/34	0/20	0/49	0/110
Sodium metabisulfite 5%	0/49	2/34 (5.9)	2/20 (10)	0/49	4/110 (3.6)
Sorbic acid 5%	0/7	0/34	0/20	0/49	0/110
Butylated hydroxyanisole 2%	0/7	0/34	0/20	0/49	0/110
Butylated hydroxytoluene 2%	0/7	0/34	0/20	0/49	0/110
Propylgallate 0.1%	0/7	0/34	0/20	0/49	0/110
Diallyl disulphide 1%	-	-	-	2/49 (4.1)	2/49 (4.1)
Patch test with flours in water	-	0/34	0/20	0/49	0/103

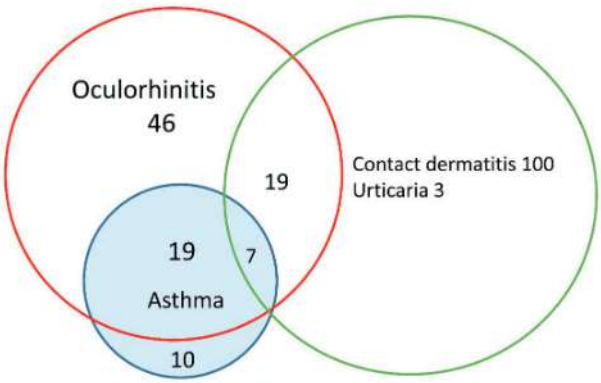

Figure 1. Symptoms and co-morbidities in workers involved in the study.

of the cases, respectively. The prevalence of skin symptoms was higher than that in bakers (73.5% vs. 48.1%, p<0.02). The prevalence of sensitization to wheat flour was over 20%, whereas sensitization to other flours was less relevant. Positive results were also observed for yeast, legumes, soy, and eggs. In patch tests, 2/20 (10%) individuals tested positive for nickel sulfate, 2/20 (10%) for sodium metabisulfite, and 1/20 (5%) for benzoyl peroxide, a possible oxidizer used in flour. Seven pastry makers had PCD (20.6%), with sensitization to wheat (n = 3), soy (n = 2), egg yolk (n = 1), yeast (n = 1), and white eggs (n = 1).

Among the 11 food industry workers investigated, most reported skin diseases (72.7%), primarily ICD (45.4%). One subject was sensitized to nickel sulfate. Four (36.4%) patients reported asthma with oculorhinitis. In two cases, we found sensitization to soy and, in one case, to green coffee beans in a worker occupied in a coffee roasting facility. In one case, we did not find any specific occupational allergens.

Figure 1 reports the relationship between symptoms: 26 subjects with skin diseases also had oculorhinitis (26/119=21.8%). Twenty-six subjects with asthma also had oculorhinitis (26/36=72.2%).

Factors associated with skin and respiratory diseases were investigated using univariate and multivariable logistic regression analyses. Results showed an increased risk of occupational skin diseases among women (OR 3.3; 95% CI 1.5-7.6) and an increased risk for bakers and pastry makers to be sensitized to wheat (OR 3.3; 95% CI 1.30-7.81) and common allergens. Differences were found between the different work tasks analyzed (Supplementary Table 1). When considering only subjects with respiratory diseases, women are underrepresented compared to men (OR 0.3; 95% CI 0.1-0.8).

4. Discussion

Our study reports occupational symptoms in a large group of food handlers in the Trieste Province from 2002 to 2022. Skin or respiratory work-related symptoms began at a median age of 34 years (25th-75th percentiles 27-45 years), a value higher than that reported in other studies [25-26], where the median age was lower and around the twenties. Symptoms appeared in the median after 7 years of work (25th-75th percentiles 2-15 years), which aligns with previous reports [25-26], and the median symptom duration was 1 year. Women had a higher prevalence of skin diseases than men (67.8% vs. 44.8%). It is well known that women are more exposed to detergents and irritants, and their skin is thinner, increasing their risk of being affected by irritants and allowing greater permeation of allergens [27]. About half of the workers were smokers or ex-smokers, a rate higher than that reported in similar workplace studies (24% of current smokers in a survey of bakers in Verona province, reported by Olivieri et al. 2021 [28]). Additionally, smoking raises the risk of skin and respiratory allergic diseases due to its effects on skin microcirculation and the irritant effects on airways [29, 30]. Familial allergy was reported by 41% of workers. In comparison, 26.8% had a personal history of atopic eczema, which is a well-known risk factor for respiratory allergic diseases [31].

4.1 Skin Diseases

Fifty-eight percent of workers presented with skin diseases involving the hands and fingers, with pastry makers having the highest prevalence (73.5%). This value was expected because of wet work, protective gloves, and contact with irritants and allergens. In a recent paper on subjects who underwent

patch tests for suspected allergic contact dermatitis in the North East of Italy, food handlers ranked 3rd after healthcare workers and metal workers regarding the number of workers tested [5]. Compared to clerks, they presented a higher risk of hand dermatitis (odds ratio [OR] 2.15; 95% confidence interval [CI] 1.89–2.45) and occupational irritant or allergic contact dermatitis (OR: 7.7; 95% CI 6.37–9.54).

ICD prevalence was 22.9% of the workers tested, with vast differences between professional groups: 45.4% in food industry workers, 29.4% in pastry makers, 19.8% in cooks, and 17.7% in bakers. The variability in ICD prevalence can be attributed to work environment, hygiene practices, and individual susceptibility factors. Work in wet or humid environments, contact with irritant foods, exposure to various food additives, and thermal burns have been identified as the potential causes of ICD. Moreover, bakers, cooks, and pastry makers are at higher risk of developing allergic respiratory and skin diseases due to exposure to wheat flour and other allergens [11,29], which means that it is easier to find a sensitization to flour in these groups compared to food industry workers, for whom the diagnosis of ICD is sometimes derived from the lack of sensitization to common and occupational allergens.

ACD was diagnosed in 20% of workers, higher in cooks (29.6%) and pastry makers (23.5%). The relevant allergens were rubber additives in cooks (thiurams 2%), benzoyl-peroxide (potentially used in flours as oxidizer in the past) in cooks (4.1%) and pastry-makers (5%), sodium metabisulfite, used as preservatives in food, positive in pastry-makers (10%) and bakers (5.9%), diallyl disulfide found in garlic, and onions positive in cooks (4.1%). The prevalence of sensitization to nickel sulfate was 21.8%, which is within the expected range for the non-occupational population in our region [32]. Only one baker was sensitized to Balsam of Peru, a resin that can cross-react with some flavors used in foods and bakery goods [33].

PCD was demonstrated in 15.1% of the subjects studied with prick test sensitization mainly to wheat flour, soy, yeast, and other food allergens. There is limited data on the prevalence of PCD [34,35], and our results align with those obtained in a Danish study, which found a prevalence of 22% in patients with occupational food-related skin diseases [23]. This result highlights the need to perform a prick test for food in workers to verify this allergy. Moreover, patch tests performed with flours handled during work were negative in all tested subjects, confirming a role for IgE-mediated allergy.

Contact urticaria was more prevalent among pastry makers (14.8%), with wheat flour being the primary allergen. Legumes and soy are the main allergens responsible for cooking. The prevalence of contact urticaria was higher than that reported in a similar study [23]; however, data in the literature are limited [36].

4.2 Respiratory Diseases

Bakers had the higher prevalence of occupational oculorhinitis (54.4%) while asthma was diagnosed in 4/11 (36.4%) of the food processing workers. In bakers and pastry makers, sensitization to wheat flour was found in 22.8% and 20.8%, respectively. In our study, wheat flour was identified as the primary occupational allergen in both occupational groups, which aligns with the literature. A survey conducted in Verona province on bakers [28] found a higher prevalence of wheat sensitization (44.6%) among 174 bakers tested. However, considering wheat sensitization only in subjects with asthma, wheat sensitization was confirmed in 30% of the workers. Wheat sensitization was significantly increased in bakers and pastry makers, as well as in workers with respiratory symptoms, in multivariable logistic regression analysis. This finding aligns with the extensive literature on baker's asthma, which is strongly related to wheat sensitization (9-17, 37-39). Olivieri et al. noted the potential for cross-reactivity between cereals [28]. Still, in our case, sensitization to other flours was zero for pastry makers and very low for bakers (2.6% for barley flour and 1.3% for rye flour), likely due to the higher use of wheat flour compared to other flours. More importantly, sensitization to alpha-amylase from *Aspergillus Oryzae* resulted in 7% positivity, whereas Olivieri et al. (2021) [28] reported a higher prevalence of sensitization (20.7%). Possible risk factors for oculorhinitis and asthma include personal atopy to common inhaled allergens. Due to their similarities, grass allergens and wheat sensitization are strongly associated [28].

Among the cooks, 43.2% had oculorhinitis, and 12.3% had asthma with sensitization mainly to common inhalant allergens and, in some cases, foods, with symptoms occurring when cooking them (one case with fish, four cases with scampi, and one case with eggs). Five patients were sensitized to wheat flour. One patient was sensitized to latex with respiratory symptoms that disappeared using alternative gloves. Overall, occupational asthma and oculorhinitis in cooks were observed in 8 cases. The literature on cook respiratory allergy data is limited to a few case reports; however, it is a well-known asthma among food-processing workers [40]. In our study, only 11 patients were included from the food industry, as there are few such industries in our region. In four cases, the workers had asthma and oculorhinits: one was exposed and sensitized to green coffee beans and two to soy. In one case, we failed to identify the causative occupational allergen.

4.3 Strengths and Limitations of the Study

This study presents data on various skin and respiratory diseases among food handlers, spanning a prolonged timeframe in our region and utilizing a consistent protocol, which includes a skin prick test for subjects with contact dermatitis. All workers underwent a comprehensive allergic evaluation to identify the allergen responsible, which should be avoided in the workplace. Additionally, our study has limitations, including its cross-sectional design, which does not provide follow-up information or data on symptom persistence after diagnosis and the implementation of preventive measures. Another limitation is the lack of data on some prick and patch tests for workers who refused to undergo additional testing. There is also a shortage of data on critical diagnostic tools for occupational asthma, according to the most recent reviews on this topic [41], such as serial PEF measurements and specific inhalation challenge.

5. Conclusion

This study offers valuable insights into the prevalence of work-related diseases, risk factors, and allergen sensitization among various occupational groups within the food industry. The findings underscore the importance of understanding these factors to enhance the occupational health and safety of food handlers.

Moreover, there is a need to improve the diagnosis of occupational allergic diseases in food handlers using skin-prick tests to diagnose protein contact dermatitis and to identify culprit allergens that sensitized workers must avoid. Most workers who came to our attention had mild symptoms (oculorhinits, mild asthma, and mild contact dermatitis), meaning that therapy and prevention of new symptoms were easier if the culprit allergen could be identified.

Supplementary Materials: The following are available online: Supplemental material table S1 includes the univariate and multivariate logistic regression analysis examining factors associated with occupational skin and respiratory symptoms. Data are reported as OR (Odds Ratios) and 95% CI (Confidence Intervals).

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Institutional Review Board Statement: The study was conducted following the guidelines of the Declaration of Helsinki and approved by the Institutional Ethics Committee (CEUR) of the Friuli Venezia Giulia Region (protocol number: 709/2018).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

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Declaration of Interest: The authors declare no conflict of interest.

Author Contribution Statement: F.L.F. and I.L. contributed to the design and implementation of the research, J.G. C.D. and L. C. contributed to the analysis of the results, and J.C. and F.L.F. contributed to the writing of the manuscript.

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APPENDIX

SUPPLEMENTARY MATERIAL

Table S1. The univariate and multivariate logistic regression analysis investigated factors associated with occupational skin and respiratory symptoms. Data are reported as OR (Odds ratios) and 95% CI (Confidence Intervals).

Factors associated with skin symptoms	**Univariate analysis**	**Multivariable analysis symptoms**	**OR (95%CI) Skin Only skin symptoms**
Women	**2.55 (1.5-4.6)**	**3.3 (1.5-7.6)**	**1.2** (0.4-3.1)
Age (years)	1.0 (0.9-1.0)	1.0 (0.9-1.0)	1.0 (0.95-1.1)
Work seniority (years)	1.0 (0.9-1.0)	1.0 (0.9-1.0)	0.96 (0.9-4.7)
Atopic dermatitis	0.82 (0.5-1.5)	-	-
Job tasks			
• Food industry (ref)	1		
• Bakers	0.5 (0.1-1.9)		
• Pastry makers	1.6 (0.4-6.7)		
• Cooks	0.9 (0.2-3.2)		
Sensitization to wheat flour	0.9 (0.4-2.0)		
Sensitization to house dust mites	0.6 (03-1.2)		
Atopy by prick test	**0.5 (0.3-1.0)**	0.7 (0.2-1.4)	0.5 (0.2-1.4)
Factors associated with respiratory symptoms	Univariate analysis	Multivariable analysis	
		Respiratory symptoms	Only respiratory symptoms
Women	**0.6 (0.3-1.0)**	0.7 (0.3-2.1)	**0.3 (0.1-0.8)**
Age (years)	0.9 (1.0-1.1)	1.0 (1.0-1.1)	1.0 (0.9-1.1)
Work seniority (years)	**1.1 (1.0-1.1)**	1.1 (1-1.1)	1.0 (1.0-1.1)
Atopic dermatitis	1.9 (0.9-4.1)	-	-
Smoke habit	1.1 (0.7-1.8)	-	-
Job tasks			
• Food industry (ref)	1		
• Bakers	2.1 (0.6-7.4)		
• Pastry makers	1.2 (0.3-4.7)		
• Cooks	1.0 (0.3-3.4)		
Sensitization to wheat flour	**2.3 (1-5.3)**	1.5 (0.5-5.2)	0.8 (0.32.5)
Sensitization to house dust mites	**2.0 (1.0-4.0)**		
Atopy by prick test	**2.3 (1.2-4.5)**	2.1 (0.8-5.7)	2.0 (0.3-2.5)