ORIGINAL ARTICLE

Career Advice for Young Allergy Patients

A Systematic Review

Katja Radon, Dennis Nowak, Christian Vogelberg, Franziska Ruëff

SUMMARY

Background: One-third of all young persons entering the work force have a history of atopic disease. Occupationally induced allergy and asthma generally arise in the first few months on the job, while pre-existing symptoms tend to worsen. Young persons with a history of an atopic disease should receive evidence-based advice before choosing a career.

Methods: We systematically searched PubMed for cohort studies investigating the new onset of asthma, rhinitis, or hand eczema among job trainees from before the start of training and onward into the first few years on the job. The search revealed 514 articles; we read their abstracts and selected 85 full-text articles for further analysis. 24 of these met the inclusion criteria.

Results: According to present evidence, atopy and a history of allergic disease (allergic rhinitis, atopic dermatitis) are the main risk factors for occupationally induced disease. The predictive value of a personal history of allergic diseases for the later development of an occupationally induced disease varies from 9% to 64% in the studies we analyzed. It follows that only young people with severe asthma or severe atopic eczema should be advised against choosing a job that is associated with a high risk of allergy, e.g., hairdressing or working with laboratory animals. Young people with a history of other atopic diseases should be counseled about their individual risk profile.

Conclusion: In view of the relatively poor predictive value of pre-existing atopic disease, secondary prevention is particularly important. This includes frequent medical follow-up of the course of symptoms over the first few years on the job. If sensitization or allergic symptoms arise, it should be carefully considered whether exposure reduction will enable the apprentice to stay on the job.

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Approximately one-third of adolescents aged between 14 and 17 years suffer from at least one atopic disease. The most common such diagnosis is allergic rhinitis (20%), followed by atopic dermatitis (16%), bronchial asthma (8%), and allergic contact eczema (6%) (1). As a result, every year in Germany approximately 170 000 young people with a history of atopic disease start an apprenticeship (1, e1). In many workplaces, they are exposed to allergens and irritants.

Due to the high prevalence of atopic diseases (history of IgE-mediated sensitization or manifest disease) and the common exposure to allergens and irritants at the workplace, asthma and dermatitis are among the most common occupational diseases in many industrialized countries (e2). Internationally, occupational exposure is responsible for approximately 16% of asthma cases (e3) and probably a high percentage of hand eczema cases in adults. There are more cases of disease exacerbated by exposure at work than new cases caused by the workplace (e4–e8). In Europe the incidence of occupational asthma has remained constant since 2007 (2). In 2014, a total of 26 058 cases of occupational skin or airway disease caused by chemicals or allergens were reported in Germany (e9). That year they were the third-most common type of recognized occupational disease, with 1161 cases, exceeded only by noise-induced hearing loss and asbestos-related diseases (e9). Part of the reason for the large difference between the numbers of reported and recognized cases is that in Germany an individual must cease the harmful work in order for such diseases to be recognized as occupational.

The incidence of diseases triggered by work is highest in the first 6 to 12 months of employment (3–10, e10–e18) and is correlated with the level and frequency of exposure. In addition, recent evidence suggests that work-related stress is also associated with asthma and allergies (e19).

Although individual, risk-related career advice would be an important step in preventing both early cessation of training and the development of occupational diseases, various studies show that few young people with prior atopic diseases take them into consideration when choosing an occupation, and that only 10% of these receive advice from a physician (11–13, e20–e23). Individual, risk-related career advice leads to better use of personal protective equipment (PPE) at work (12). This shows how important it is for young

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people with atopic diseases to receive evidence-based advice from a physician.

This article therefore aims to summarize the published data on risk factors for and the course of occupational asthma, rhinitis, and hand eczema in the first years of work and to use this data to develop strategies for evidence-based career advice.

Methods

A systematic search of the literature was performed in the PubMed database for the period from the beginning of 2011 onwards. The procedure followed is described in detail in the *eBox*.

For rhinitis and asthma, the position paper of the European Academy of Allergy and Clinical Immunology (EAACI) was used as the basis for selecting studies published before 2011 (14). It should be mentioned that this method entails the limitation that due to poor data quality (in particular, there were no unexposed groups) the authors of the position paper were able to make only expert-based recommendations, not evidence-based ones. For skin disorders, the literature search was expanded to cover the period from 1965 onwards.

This search strategy identified 908 articles, of which the authors viewed the titles. On this basis, 514 were selected for their abstracts to be viewed. Of these articles, 85 potentially suitable fulltexts were identified, of which 24 were considered relevant to this review.

Results

Airway disorders

Only 5 of the 15 publications concerning the airways presented the findings of prospective cohort studies in which individuals at the beginning of their careers had been observed before or from the beginning of exposure (6–10). These 5 also contained data on risk factors before the beginning of training (*eBox*, *eTable 1*). Two studies were conducted in the general population (6, 9); an additional study included a small, unexposed comparison group (8). A study by Acouetey et al. followed 251 bakery/pastry and hairdressing apprentices prospectively over 2 years, taking genetic predictors of occupational asthma into account (10). One additional study was very small, with only 37 participants, and had a very short follow-up period, lasting only one year (7).

The other prospective cohort studies either examined the first years following the end of training (15) or did not exclusively recruit individuals at the beginning of their careers (16, 17). There were also 2 publications on a retrospective cohort (18, 19) and 5 case-control studies (20–24); some of the latter were part of the cohort studies already mentioned (20–22).

Asthma/airway symptoms

The findings of the EAACI position paper (14) and more recent studies can be summarized as follows: in 8 of these studies a history of atopy was a risk factor for asthma or respiratory symptoms (*eTable 2*). In 5 studies, a pre-existing sensitization to occupational al-

lergens was identified as risk factor for respiratory symptoms (rhinitis and asthma). Three studies provided evidence that pre-existing bronchial hyper-responsiveness was associated in particular with subsequent onset of asthma or airway symptoms.

Only a few studies investigated further potential risk factors for the development of occupational asthma or exacerbation of existing asthma in the first years of work. These found that women were more frequently affected than men; active smoking and exposure to passive smoking at an early age were described as unfavorable prognostic factors.

Allergic rhinitis and typical occupational sensitization

As with asthma, pre-existing sensitization to ubiquitous allergens is the principal risk factor for occupational sensitization and new-onset allergic rhinitis (*eTable 2*). Occupational sensitization can either remain asymptomatic or lead to allergic rhinitis or to airway symptoms at work and subsequently to occupational asthma. The atopic march (from atopic eczema to allergic rhinitis and asthma) could not be confirmed in all cohort studies (25).

Skin disorders

The 9 included publications on occupational skin diseases (*eBox*, *eTable 3*) showed history of atopic eczema (26, *e24*), a positive atopy score according to Diepgen et al. (27, 28, *e17*, *e25*), and wet work (4, 5, 27, 28, *e26*) to be the principal risk factors for occupational hand eczema (*eTable 4*). Various other indicators of atopic skin diathesis, such as history of flexural eczema or dry skin, were also risk factors for occupational hand eczema (27, *e17*, *e27*) (*eTable 4*). Only one study investigated evidence in clinical history of pre-existing contact allergies; it was associated with a significantly increased risk of onset of hand eczema (*e17*).

Diagnostic procedures were also investigated as predictors of occupational hand eczema. These included various skin function tests, some of which were found to be very sensitive (94%) regarding subsequent onset of hand eczema. However, these tests were judged unsuitable for clinical practice due to their poor specificity (24%) (*e17*).

In a few studies, the positive predictive values of individual risk factors for the development of occupational asthma, rhinitis, and hand eczema were calculated. They were found to be between 9 and 64% (*Table 1*).

Discussion

Due to the high prevalence of atopic diseases and their possible consequences for patients and indirectly for society as a whole, career advice for young people predisposed to atopy is very important. The available literature gives only a small number of confirmed predictive factors; these include prior atopic diseases and asymptomatic sensitization to ubiquitous allergens.

Intuitively, one might conclude that all atopy and asthma patients should be excluded from occupations

TABLE 1

Positive predictive value* (%) of various risk factors for occupational sensitization, rhinitis, airway symptoms, and occupational hand eczema

Risk factor	Occupation	Immediate-type occupational sensitization	Rhinitis/rhinoconjunctivitis	Airway symptoms/asthma	Hand eczema
Parents with allergy/atopy	Animal laboratory worker	17% (e6)	25% (e29)	13% (e29)	
Clinical history of:					
– Atopy/rhinitis	Animal laboratory worker	40% (e6)	26% (e29)	23% (e29)	
– Atopic eczema	Hairdresser				64% (26)
– Flexural eczema	Automobile industry worker				63% (27)
Total IgE >100 kU/L	Animal laboratory worker	33% (e6)		44% (e6)	
	Baker	21% (e13)			
Positive prick test	Baker	33% (e13)			
	Animal laboratory worker		23% (e29)	34% (e29)	
	Animal laboratory worker		30% (29)	9% (29)	
Positive atopy score according to (e25)	Automobile industry worker				29% (27)

* Positive predictive value indicates the percentage of individuals with positive test results who will develop the disorder in question. For example, 64% of hairdressers with atopic eczema on initial examination will develop hand eczema over time, whereas only 33% of bakers with positive prick test results on initial examination will acquire occupational immediate-type sensitization over time

that entail relevant exposures. However, this can only be clearly recommended for patients with severe asthma or severe atopic eczema (e28). For other prior conditions, various studies show that this measure—quite apart from its ethical implications—would not be effective, because most individuals with atopy will not develop occupational asthma or rhinitis. For example, to prevent one case of occupational asthma, 3 to 10 atopy patients would have to be advised against work that entailed a risk (29, e29). In view of the high proportion of individuals with atopy in the general population, this is not useful as the sole basis for decisions in individual career advice. However, individuals who are specifically sensitized, before the beginning of training, to a substance found at the workplace that cannot reliably be avoided, and who develop specific symptoms (rhinitis, asthma, eczema) on contact with that substance, should be advised against pursuing the occupation in question.

In a German study (6), models for predicting an individual patient's overall risk in the first years of employment were developed on the basis of epidemiological studies and made available online as a risk calculator (www.allergierisiko.de). The risk calculator shows clearly how strongly the individual risk of developing asthma in the first months of a high-risk occupation depends on other cofactors: in the absence of other risk factors for asthma, the risk factor atopy increases the risk of new-onset asthma by only 1.8 percentage points,

from 0.5% to 2.3%. The risk calculator also indicates the following other risk factors for asthma:

- Female sex
- Higher socioeconomic status
- At least one parent with asthma or atopic dermatitis
- Exposure to passive smoking during puberty
- Not breastfed
- No siblings.

If a patient has all these other risk factors, the risk of new-onset asthma is 32% for individuals without atopy and 70% for those with atopy. Additional studies should investigate whether these predictions are reliable.

The available research indicates that rhinitis (e10, e30, e31) and hand eczema (26) are particularly likely to lead individuals to cease their occupation and avoid exposure. It is therefore advisable to examine young people with a risk profile for these conditions closely at the beginning of training in high-risk occupations, in order to begin appropriate secondary prevention such as early treatment and use of PPE promptly. This can prevent cessation of training and damage to health. Occupational physicians, and possibly also pulmonologists and dermatologists, are important partners in this. Young people with a risk profile in occupations such as those shown in *Table 2* should be examined every 6 to 12 months during the first 2 years of training (14, e10, e32).

TABLE 2

Occupations or jobs entailing an elevated risk of asthma, rhinitis, or occupational hand eczema and the exposures occurring during these activities that trigger asthma, eczema, or allergies*

Occupation/work	Substances that trigger asthma or immediate-type allergies	Eczema triggers, delayed-type allergens
Baker	Flour and grain dust	
Construction worker	Isocyanates	Cement, wet concrete (potassium dichromate, cobalt compounds), glues, paints (epoxy resins, isocyanates)
Painter, varnisher, limer	Isocyanates	Paints, synthetic resins, turpentine and turpentine substitutes, paint pigments (see <i>Construction worker</i>)
Carpenter and other woodwork occupations	Wood dust	Woods
Agriculture	Animal particles, storage mites	Disinfectants, rubber auxiliary materials (see <i>Health care professions</i>)
Health care professions	Natural latex particles (nowadays uncommon in industrialized countries) Cleaning/disinfecting products	Rubber auxiliary materials (antioxidants or accelerants, e.g. thiurame, thiocarbamate, mercaptobenzothiazole, diphenyl guanidine); disinfectants (e.g. formaldehyde, glutaraldehyde, fragrances, mercury compounds); medications (e.g. antibiotics, local anesthetics, essential oils); tools, stainless steel surfaces (e.g. nickel)
Zookeeper, animal laboratory worker, veterinary doctor	Animal particles (also see <i>Health care professions</i>)	(See <i>Health care professions</i>)
Cleaning employee	Cleaning products, particularly disinfectants/spray products	Rubber auxiliary materials, disinfectants (see <i>Health care professions</i>)
Paint sprayer	Isocyanates	
Soldering and other work/occupations in the electrical industry	Resin	
Technical occupations (e.g. mechatronics technician)	Resin	
Hairdresser	Bleaches (persulfate)	Hair dyes (e.g. p-phenylenediamine, p-toluenediamine), perm products, hairwash products/haircare products, protective gloves (see <i>Health care professions</i>), stainless steel surfaces (e.g. nickel)

* A continually updated list of the substances relevant to asthma and type I sensitization can be found on the website of the UK Government Health and Safety Executive (www.hse.gov.uk/asthma/substances.htm)

Recent studies indicate that monitoring programs and training measures can reduce the risk of occupational asthma (e2, e33–e36) and hand eczema (6–10). School-based interventions among high school-age students have shown that the use of virtual patients in the classroom can improve young people's knowledge of occupational asthma and allergies in the long term (e37) (www.volle-puste.de). Training regarding skin protection and basic therapy in new workforce entrants has also been shown to be effective (e38). Without such measures, only around one-third of employees take preventive measures (e39). Secondary preventive measures, in contrast, do not seem to be as effective as complete avoidance of allergens (e40–e43). However, a recent study by Muñoz et al. was unable to confirm this (e44). It is important that thorough diagnostics be performed by a specialized physician before an individual is dismissed or hastily gives up his or her work. If occupational asthma is suspected, diagnostics should always also include patient self-monitoring of lung

function for at least 3 weeks with and without occupational exposure (30). If allergic contact sensitization is suspected, epicutaneous tests should also be performed (e45).

Limitations

The studies systematically summarized here show that the available data is rather scarce. In particular, there is a lack of long-term observational studies conducted in the general population and observing individuals from their choice of occupation through their first years of work. The studies conducted to date investigating high-risk occupations focused mainly on those working in occupations traditionally considered hazardous, such as nurses, hairdressers, animal laboratory employees, and bakers/pastry chefs. Very few studies included an unexposed comparison group. In addition, there is almost no research into non-occupational factors. Many of the available studies have methodological shortcomings such as excessively short follow-up periods, low

participant numbers, or no appropriate statistical modeling.

The literature search was performed in the PubMed database only, as one would expect that being purely medical this subject would be addressed in publications listed in PubMed. Literature not published in journals was not viewed. It was only possible to include references in 4 languages. A few relevant studies may, therefore, not have been included. However, this would not have affected the outcome of the literature search significantly, as the findings of the available papers were generally consistent.

Summary

Approximately one-third of apprentices in Germany have an elevated risk of occupational asthma, allergies, and dermatitis. The individual predictive value of specific parameters is too low to advise all young atopy patients against entering particular occupations. Those with severe asthma or atopic eczema and clinically manifest sensitization that is relevant to certain occupations should avoid the occupations that entail a risk. All young atopy patients wishing to begin an occupation that entails a risk should be informed of the risk and of preventive measures beforehand and should be monitored every 6 to 12 months for the first 2 to 3 years after the beginning of exposure. In addition to allergy-specific history taking and general physical examinations, those with a history of allergies should receive skin prick tests for general and job-specific allergens, spirometry, and—in case of work-related respiratory symptoms—unspecific bronchial challenge tests (methacholine) (14). However, diagnostic testing for occupational allergy in patients without a history of allergic diseases (“prophetic testing”) is not indicated (e46).

KEY MESSAGES

- Reducing exposure is a key step in preventing occupational allergic and asthmatic diseases.
- Patients with severe asthma or severe atopic eczema should be advised against occupations associated with an elevated risk of exacerbating their illness.
- Individuals who are already sensitized to an allergen that is relevant to their work and cannot be avoided and who react to it with specific symptoms should not perform such work.
- A positive prick test to widespread airborne allergens and bronchial hyperresponsiveness increase the probability of new-onset asthma. However, the individual predictive value of these 2 factors is too low for decisions to be based on them alone.
- Individuals whose clinical history indicates an elevated risk of developing an occupational respiratory allergy or atopic eczema should be monitored closely (every 6 months to 1 year) for their first 2 years of work. Should they develop an occupational disease, secondary preventive measures should be taken immediately.

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Conflict of interest statement

Prof. Vogelberg was a member of various ALK-Abelló advisory boards.

Prof. Radon, Prof. Nowak, and Prof. Ruëff declare that no conflict of interest exists.

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Supplementary material

For eReferences please refer to:
www.aerzteblatt-international.de/ref3116

eBox, eTables, eFigure:
www.aerzteblatt-international.de/16m0519

Erratum

Regarding the article “Obstructive Sleep Apnea — A Perioperative Risk Factor” by Fassbender et al. in issue 27/28 of *Deutsches Ärzteblatt International* published on 25 July 2016:

In the Results section of the Summary on page 463, the term “bronchodilator muscles” is incorrect. The correct wording is “airway dilator muscles”. **MWR**

Supplementary material to:

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eBOX

Methods

Two search strategies were developed according to the PICO (population, intervention, control, outcome) process (e48). These are shown in detail in *eTable 5*.

- 1.) Of 908 identified publications (*eTable 5*), 514 were incorporated into an Endnote database (Version X7.4; Thomson Reuters) for further analysis on the basis of their titles.
- 2.) The abstracts of these 514 articles were analyzed, and 85 publications were selected so that their fulltexts could be examined for relevance (DN, KR, FR). Of these, 15 were considered relevant to airway disorders, and 9 to hand eczema.

The 61 excluded publications were as follows (*eFigure*):

- Methodological studies ($n = 12$) (e18, e49–e59)
- Cross-sectional, intervention, or registry-based studies ($n = 13$) (e38, e60–e71)
- Cohort studies not started at the beginning of careers ($n = 10$) (e72–e81)
- Studies with methodological shortcomings or which used out-of-date procedures ($n = 8$) (e82–e89)
- Publications with no information on risk factors ($n = 7$) (e90–e96)
- Publications excluded for other reasons ($n = 7$). These included research into the following:
 - Genetic polymorphisms (e97, e98)
 - The “healthy worker” effect (e99, e100)
 - The effects of short-term exposure (e101)
 - The effects of environmental exposure (e102)
 - Exposure estimate (e103)

Flowchart showing study selection

*short-term effects (n = 3), “healthy-worker” effect (n = 3)

eTABLE 1

Description of included studies on airway disorders and occupational sensitization

First author	Year	Study type	Duration	No. of participants	Response rate (%)	Exposure	Occupations
Kellberger et al. (6)	2014	Prosp. cohorts	1996 to 2009	2051	32% (since initial study in 1996)	Asthma/JEM	General population, aged 9 to 11 years on initial examination
Saab et al. (16)	2014	Prosp. cohorts	4 to 9 years after the end of training	202	53%	Isocyanates	Car painters
Gui et al. (7)	2014	Prosp. cohorts	1 year	37	76%	TDI	Polyurethane foam production employees
Larese Filon et al. (17)	2014	Prosp. cohorts	2000 to 2009	1013 new employees 1040 existing employees	N/A	Unpowdered latex gloves	Hospital employees
Elholm et al. (8)	2013	Prosp. cohorts	1994 to 2008	994 agricultural apprentices 172 unexposed participants	N/A	Agriculture	Farmers, general rural population
Acouetey et al. (10)	2013	Prosp. cohorts	2 years	209 bakers/pastry chefs 142 hairdressers	80%	Training in baking and hairdressing companies	
Barakat-Haddad et al. (9)	2012	Prosp. cohorts	1978 to 2006	395	43%	Self-reported exposure	General population, aged 6 to 8 years on initial examination
Mouchetrou et al. (17)	2012	Prosp. cohorts	1993 to 2006	202 with at least 1 of 2 follow-ups	76%	Agriculture	
Dong et al. (18)	2013	Prosp. cohorts	2001 to 2006	128 bakers/pastry chefs 108 hairdressers 379 unexposed participants	N/A	Completion of training: bakers, pastry chefs, hairdressers Unexposed (butchers, chefs, etc.)	
Remen et al. (19)	2013	Prosp. cohorts	2001 to 2006	866	38%	Apprentices in bakeries, patisseries, and hairdressing companies	
Florentin et al. (22)	2014	Case-control study	2001 to 2006	19 OA cases 159 control participants	61% of cases 63% of control participants	Apprentices in bakeries, patisseries, and hairdressing companies	
Remen et al. (21)	2012	Case-control study	2001 to 2006	31 cases with incident occupational complaints of the lower or upper airways 196 control participants matched for training establishment, sector, and year training completed	N/A	Apprentices in bakeries, patisseries, and hairdressing companies	
Omland et al. (20)	2011	Case-control study	1994 to 1998	122 cases 116 control participants	100% of cases 95% of control participants	Agriculture, welding	Agricultural apprentices, non-agricultural apprentices
Fernández et al. (24)	2011	Case-control study	2009	247 cases 671 control participants	N/A	Self-reported (patient records)	General population, aged 12 to 40 years
Graff et al. (23)	2011	Case-control study	2000 to 2004	192 cases 323 control participants	72% of cases 74% of control participants	JEM, self-reported	General population, aged 20 to 65 years

Prosp. cohorts: prospective cohort study; Retro. cohorts: retrospective cohort study; JEM: job-exposure matrix; TDI: toluene diisocyanate; N/A: not available; OA: occupational asthma

eTABLE 2
Identified risk factors for occupational immediate-type sensitization, rhinitis, and airway symptoms in those starting employment^{*1}

	Immediate-type sensitization (prick/IgE)	Rhinitis/ rhinoconjunctivitis	Airway symptoms/ asthma
General factors			
Parents with asthma/rhinitis/atopy	(3, 31)		(6, 16)
Genetics			(18) ^{*2}
Female sex		(6, e15)	(e15)
Active smoker	(3)		(20)
Exposure to passive smoking at an early age			(6)
Findings on preliminary examination			
Bronchial hyperresponsiveness	(32, e47)	(3, 33)	(3, 20, 32, 34, 35)
Cutaneous symptoms	(25)		
Airway symptoms/asthma	(36, 37)		(32)
Rhinitis/rhinoconjunctivitis	(32, 37)	(3, 33, 38)	(3, 9)
Positive prick test/IgE/atopy	(25, 31, 32, 36, 37, e11, e47)	(25, 38, e14)	(6, 18, 21, 24, 25, 34, e11, e15)
Immediate-type sensitization to occupational allergens	(37)	(3, 33, 38, e14)	(3, 18, 25, 34, 35)

^{*1} For each risk factor, the studies that showed an association in the adjusted end model are included. Only the findings of each final regression model, where available, were used. Up to 2010, only studies also included by de Zotti et al. (e14) are shown. From 2011 onwards, all studies shown in the table are included.

^{*2} bronchial hyperresponsiveness

eTABLE 3

Description of included studies on skin diseases

Main author	Year	Study type	Duration	No. of participants	Response rate (%)	Exposure	Occupations
Visser et al. (5)	2014	Prosp. cohorts	2008 to 2011, individual follow-up ≤3 years	721	77% after 12 to max. 36 months	Wet work	Trainee nurses
Bregnhøj et al. (26)	2012	Prosp. cohorts	2008 to 2010, individual follow-up 8 to 18 months	301 in intervention group 201 in control group	65% after 8 months, 57% after 18 months	Wet work, hairdressing chemicals, gloves	Apprentice hairdressers
Apfelbacher et al. (27)	2008	Prosp. cohorts	1990 to 2006	1170	78%	Coolants, metals	Automobile industry employees
Bauer et al. (28)	2001	Prosp. cohorts	1996 to 1999	91	87% after 6 months, 69% after 12 months, 76% after 36 months	Wet work, skin contact with fruit, flour	Food industry apprentices (bakers, pastry chefs, baking salespeople)
Funke et al. (4)	2001	Prosp. cohorts	1990 to 1994, individual follow-up ≤3 years	1910	97% after 12 months, 92% after 36 months	Coolants, metals	Automobile industry apprentices (metalwork, other production work, office)
Berndt et al. (e17)	1999	Prosp. cohorts	1994 to 1997, follow-up every 6 months, individual follow-up ≤30 months	205	N/A	Coolants, metals	Metal industry apprentices
Uter et al. (e26)	1999	Prosp. cohorts	Individual follow-up max. 3 years	2352 apprentices	48% after 3 years	Wet work, hairdressing chemicals, gloves	Apprentice hairdressers
Brisman et al. (e24)	1998	Retro. cohorts	1961 to 1989	2923 bakers 1258 apprentices in same college with no wet work 1258 participants from general population	56% of bakers	Wet work	Bakery industry apprentices
Smit et al. (e27)	1994	Retro. cohorts	1990 to 1992, individual follow-up ≤2 years	74 hairdressers 111 trainee nurses	95% of hairdressers, 89% of nurses (after 1 year)	Wet work, gloves, hairdressing chemicals, disinfectants	Trainee nurses, apprentice hairdressers

Prosp. cohorts: prospective cohort study; Retro. cohorts: retrospective cohort study; N/A: not available

eTABLE 4

Risk factors identified in the included studies for occupational hand eczema in those starting employment^{*1}

Risk factor	Source
Preliminary examination findings	
History of atopic eczema	(26, e24)
History of dry skin	(e27)
History of flexural eczema	(27, e17)
History of hand eczema	(28)
Positive atopy score (according to Diepgen [e25])	(27, 28, e17)
History of allergic rhinoconjunctivitis	(e27)
Evidence in clinical history of contact sensitization to substances found at work	(e17)
Findings during training	
Wet work, exposure to irritants	(4, 27, 28)
Frequent handwashing at work	(5)
Wet work >2 hours/day, gloves worn >2 hours/day	(e26)

* For each risk factor, the studies that showed an association in the adjusted end model are included

eTABLE 5

Search strategies to identify relevant articles in PubMed

	Search strategy 1	Search strategy 2
Population	Adolescents, young adults, adults	Apprentices, those beginning a career
Intervention/exposure	Prior atopic disease, occupational exposure	Prior atopic disease
Control	–	–
Outcome	Asthma, rhinitis, hand eczema	
Study type	Cohort studies, case-control studies	
Languages	German, English, Spanish, Portuguese	
Time period	Rhinitis and asthma: January 1, 2011 to August 31, 2015 Skin diseases: January 1, 1965 to August 31, 2015	
Search terms	(asthma OR rhinitis) ^{*1} /(atopic dermatitis OR dermatitis OR hand eczema) ^{*2} AND (adolescent OR adult OR young adult) AND (occupational exposure OR occupational exposure/adverse effects) AND (incidence OR case-control studies OR cohort studies)	(asthma OR rhinitis) ^{*1} /(dermatitis OR atopic dermatitis OR dermatitis OR hand eczema) ^{*2} AND (apprentice ^{*1} OR young worker* OR first job OR first employment)
Limitation	Humans	
Hits	455	453 (excluding duplicates)
Included on basis of title	300	214

^{*1} for asthma and rhinitis

^{*2} for hand eczema