

Prevalence and Cutaneous Comorbidity of Acne Vulgaris in the Working Population

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Purpose: Although acne vulgaris (AV) is a common disease and can persist into adulthood, there are few large-scale epidemiological studies on the prevalence of acne vulgaris in adults. The aim of our study was to characterise the epidemiology and comorbidity of acne vulgaris in working adults in Germany.

Patients and Methods: Within the framework of a cross-sectional study, a total of 161,269 employees underwent dermatological whole-body examinations in more than 500 German companies between 2001 and 2016. Point prevalence rates for acne vulgaris and further skin diseases and their 95% confidence intervals were calculated and differences between participants with and without acne vulgaris were tested with chi-squared tests.

Results: Mean age was 43.2 years \pm 10.9, 55.5% were male. In total, $n = 5311$ people (3.3%) with acne vulgaris were identified. Prevalence decreased by age. Controlling for age and gender, acne was significantly associated with folliculitis (OR = 1.91; CI: 1.76–2.07), contact dermatitis (OR = 1.74; CI: 1.08–2.81), rosacea (OR = 1.74; CI: 1.40–2.15), pyoderma (OR = 1.58; CI: 1.22–2.06), seborrheic dermatitis (OR = 1.47; CI: 1.27–1.71), hand eczema (OR = 1.34; CI: 1.00–1.76), verruca vulgaris plantaris (OR = 1.29; CI: 1.09–1.51), tinea pedis (OR = 1.27; CI: 1.10–1.47), spider veins (OR = 1.26; CI: 1.16–1.38) and telangiectasia (OR = 1.15; CI: 1.02–1.30).

Conclusion: These data underline the importance of acne vulgaris in the adult population. Further studies to better understand the pathophysiology of AV and its comorbidity in different phases of adulthood would be desirable to develop appropriate guidelines and therapy concepts.

Keywords: acne vulgaris, comorbidities, epidemiology, inflammation

Introduction

Acne vulgaris (AV) is a chronic inflammatory skin disease arising from the pilosebaceous unit¹ with a prevalence of up to 85% of all young people aged 12–24 years.² 15–20% of cases are classified as moderate to severe.³ AV can also persist into adulthood. The published prevalence of AV in adulthood varies between 3 and 43% depending on the study.^{4,5}

Acne lesions are divided into inflammatory and non-inflammatory lesions. Inflammatory lesions include papules, pustules and nodules, while non-inflammatory lesions include comedones. The skin symptoms are particularly rich in sebaceous glands, such as the face, neck, chest, shoulder or back.⁶ Health-related quality of life in acne is particularly impaired by the visibility of lesions and consecutive psychosocial strain.^{7,8}

Three factors play an important role in the pathogenesis of AV: seborrhea, abnormal follicular keratinisation and dysbiosis, which is associated on the one

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hand with the predominance of phylotype IA1 of *Cutibacterium acnes* and on the other hand by overrepresentation of Proteobacteria and Firmicutes.^{9,10} Interestingly, a study by Dreno et al showed that Staphylococci also seem to be involved in the pathogenesis of acne when they colonised acne lesions such as comedones, papules or pustules more frequently than non-lesional skin.¹⁰ Perifollicular hyperkeratosis initially leads to the formation of microcomedones. Aggravated by the frequently increased sebum production during puberty, a microenvironment is formed which favours colonisation with *Propionibacterium acnes*.^{1,11} In addition, the inflammatory reaction results in the blocking of receptors such as histamine receptor, hormonal dihydrotestosterone (DHT) receptor, neuromodulatory receptors and corticotropin-releasing hormone (CRH) receptor.^{12,13} Recent studies show that different dietary substances can also lead to increased sebum production by activating specific receptors, such as peroxisome proliferator-activated receptors stimulated by free fatty acids and cholesterol, insulin-like growth factor (IGF)-1 receptor stimulated by sugar and leptin receptor activated by fat.^{14,15} Leptin, a hormone secreted by adipocytes, not only regulates body weight, but also activates pro-inflammatory enzymes and cytokines such as Interleukin-6/8, thus providing a link between fat metabolism and inflammatory response in other tissues.¹⁶ Some studies suggest that the prevalence of acne correlates with the glycemic index.^{17,18} It has been shown that a carbohydrate-rich diet correlates with the severity of the disease and that diet and lifestyle play an important role in the pathogenesis of the disease.

Publications have associated AV with a variety of comorbidities including depression and anxiety,¹⁹ upper respiratory tract infections, increased upper gastrointestinal diseases²⁰ and increased risk of endometriosis.²¹ In addition, AV is frequently associated with syndromes such as polycystic ovary syndrome²² or PASH (Pyoderma gangrenosum, acne and suppurative hidradenitis) syndrome.²³

The prevalence of AV also seems to vary according to skin type and ethnic group. The few comparative studies report that people with fair skin suffer more frequently from acne than people with black skin.^{24–26}

It has been shown several times that AV is more common in men during adolescence,⁴ but more common in women in adulthood.²⁷

The impact of socio-economic factors on the prevalence of AV remains unclear. In 1986, Cunliffe et al found a markedly higher unemployment rate in people with AV

compared to the control group.²⁸ Among 896 employees of a German city, no difference in prevalence was observed between the individual social classes in the study by Schäfer et al in 2001.⁴ However, a high socio-economic status was identified as a risk factor for the development of AV in the 0–17 age group in Bettoli's study in 2014.²⁰

Although AV is a common disease and can persist into adulthood, there are few large-scale population-based epidemiological studies on the prevalence of AV in adults. The aim of our study was to characterise the epidemiology and comorbidity of AV in working adults in Germany.

Materials and Methods

People and Centres

Within the framework of a cross-sectional study, a total of 161,269 employees underwent dermatological whole-body examinations as part of voluntary company-based skin screenings in more than 500 German companies between 2001 and 2016. All employees were invited to participate regardless of age, sex or social status.

The participating companies belonged to different branches of industry and commerce and varied in size (150–65,000 employees). Most of the companies belonged to the following fields: car industry, insurance companies, banking, energy companies, chemical industry and printing houses. Smaller companies with less than 200 employees included banks and postal services. The screenings were carried out on behalf of the companies or company health insurers by HSH GmbH, which has been active in the field of secondary prevention in the dermatological, phlebological and cardiovascular field since 1989.

A positive ethics vote has been obtained from the responsible ethics committee for the conduct of the study. Only patients aged 16 years and older with AD who had signed an informed consent form were included.

Assessments

To reduce selection bias, the screenings were conducted within the working hours. For each participant a standardised whole-body examination was carried out by experienced and trained dermatologists. The average duration of the examination was 15 minutes. The diagnoses were based on the clinical examination exclusively. AV was considered prevalent if at least IGA (Investigator Global Assessment) grade 2 was present, what is a mild form with less than half of the face infested with a few open or closed comedones, papules and pustules. In

addition to the documentation of acne, all other dermatological findings were also documented in a standardised PC-based case report form by an assisting person.

Statistics

Statistical analyses were conducted using SPSS 23.0 (IBM, Armonk, NY) for Windows. Point prevalence rates for AV and further skin diseases and their 95% confidence intervals (95% CI) were calculated and differences between participants with and without acne were tested with chi-squared tests. Logistic regression analysis was applied to test, whether further skin diseases are associated with AV when controlling for age and gender. Bonferroni correction of p-values was applied to account for inflation of nominal α -level due to multiple significance testing in the logistic regression analysis.

Results

People and Centres

In this study the mean age of $N = 161,269$ was 43.2 years ± 10.9 , 55.5% were male. The largest proportion of the population had skin phototype II with 101,455 people (65.5%) followed by skin phototype III with 37,695 people

(24.3%), skin phototype I with 13,696 people (8.8%) and skin phototype IV to VI with 2149 people (1.4%). With 32.7% ($n = 52,700$ people) the age group between 40 and 49 years was most frequently represented. The following distribution was found for other age groups: age group 30–39 years $n = 41,332$ (25.6%), age group 50–59 years $n = 37,419$ (23.2%), age group 16–29 years $n = 19,661$ (12.2%) and age group 60–70 years $n = 10,157$ (6.3%).

In total, $N = 5311$ people (3.3%) with AV were identified. The mean age in this group was 33.9 years, 55.9% ($n = 2970$) were male.

Prevalence decreased by age (Figure 1). There were no statistically significant gender differences in the prevalence of acne. However, when classified by age group, men were significantly more affected in people under 30 years (13.2% vs 7.5%), but AV was significantly more prevalent in women at the age of 30 to 39 (5.2% vs 4.7%).

Prevalence of Acne and Skin Phototype

The prevalence of acne was highest in people with phototype I ($n = 511$; 3.6%) and phototype IV ($n = 80$; 3.6%). Individuals with phototype III ($n = 1141$; 2.9%) had the lowest prevalence, followed by phototype II ($n = 3556$; 3.4%).

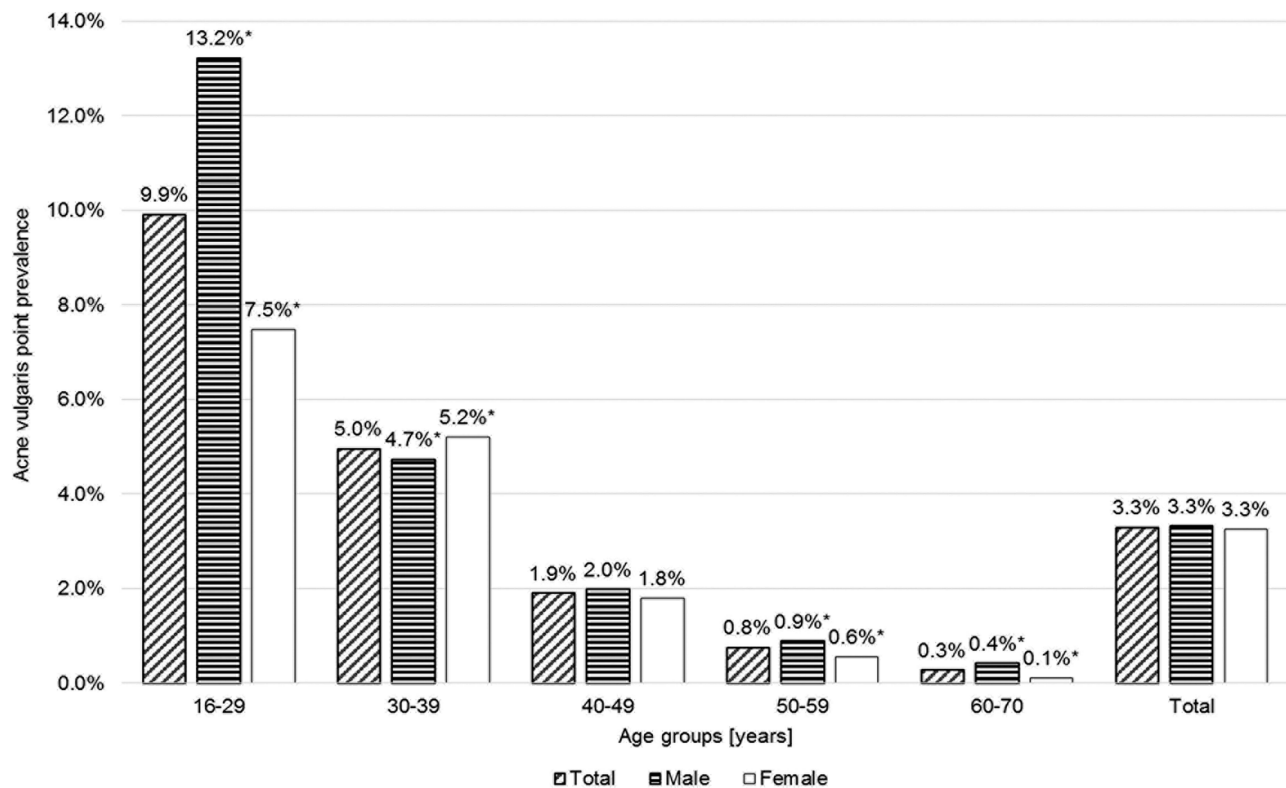


Figure 1 Prevalence of acne vulgaris by age group and gender. * significant difference between men and women, $p \leq 0.05$.

Table 1 Frequency of Skin Conditions in People with Acne Vulgaris (AV) in Total and by Gender, N = 161,269; 95% Confidence Intervals Permit Comparison with People Showing No Signs of Acne

	Total with AV (n = 5311)			Male with AV (n = 2970)			Female with AV (n = 2341)			Total without AV (n = 155,958)		
	n	%	95% CI	n	%	95% CI	n	%	95% CI	n	%	95% CI
Inflammatory skin diseases												
Atopic dermatitis	82	1.5	(1.23-1.92)	45	1.5	(1.11-2.03)	37	1.6	(1.11-2.18)	2,173	1.4	(1.34-1.45)
Contact dermatitis	19	0.4	(0.22-0.56)	9	0.3	(0.14-0.58)	10	0.4	(0.20-0.79)	330	0.2	(0.19-0.24)
Exsiccation dermatosis	31	0.6	(0.40-0.83)	16	0.5	(0.31-0.87)	15	0.6	(0.36-1.06)	1,526	1.0	(0.93-1.03)
Hand eczema	51	1.0	(0.71-1.26)	38	1.3	(0.91-1.76)	13	0.6	(0.30-0.95)	1,218	0.8	(0.74-0.83)
Intertriginous dermatitis	37	0.7	(0.49-0.96)	18	0.6	(0.36-0.96)	19	0.8	(0.49-1.27)	1,008	0.7	(0.61-0.69)
Psoriasis	66	1.2	(0.96-1.58)	43	1.5	(1.05-1.95)	23	1.0	(0.62-1.47)	3,209	2.1	(1.99-2.13)
Rosacea	94	1.8	(1.43-2.17)	61	2.1	(1.57-2.64)	33	1.4	(0.97-1.98)	3,292	2.1	(2.04-2.18)
Seborrheic dermatitis	204	3.8	(3.33-4.41)	165	5.6	(4.74-6.47)	39	1.7	(1.18-2.28)	4,962	3.2	(3.09-3.27)
Viral diseases of the skin												
Verruca vulgaris feet	167	3.1	(2.69-3.66)	84	2.8	(2.26-3.50)	83	3.6	(2.82-4.40)	3,613	2.3	(2.24-2.39)
Verruca vulgaris hands	26	0.5	(0.32-0.72)	21	0.7	(0.44-1.08)	5	0.2	(0.07-0.50)	820	0.5	(0.49-0.56)
Fungal diseases of the skin												
Onychomycosis	222	4.2	(3.65-4.77)	170	5.7	(4.90-6.65)	52	2.2	(1.66-2.91)	9,773	6.3	(6.14-6.39)
Pityriasis versicolor	37	0.7	(0.49-0.96)	25	0.8	(0.54-1.24)	12	0.5	(0.26-0.90)	1,549	1.0	(0.94-1.04)
Tinea corporis	17	0.3	(0.19-0.51)	14	0.5	(0.26-0.79)	3	0.1	(0.03-0.37)	676	0.4	(0.40-0.47)
Tinea pedis	223	4.2	(3.67-4.79)	180	6.1	(5.21-7.01)	43	1.8	(1.33-2.47)	7,115	4.6	(4.46-4.67)
Bacterial diseases of the skin												
Folliculitis	865	16.3	(15.22-17.41)	577	19.4	(17.87-21.08)	288	12.3	(10.92-13.81)	11,819	7.6	(7.44-7.72)
Pyoderma	70	1.3	(1.03-1.67)	51	1.7	(1.28-2.26)	19	0.8	(0.49-1.27)	778	0.5	(0.46-0.54)
Vascular lesions of the skin												
Haemangioma	1521	28.6	(27.22-30.11)	886	29.8	(27.90-31.86)	635	27.1	(25.06-29.32)	65,954	42.3	(41.97-42.61)
Naevus flammeus	220	4.1	(3.61-4.73)	101	3.4	(2.77-4.13)	119	5.1	(4.21-6.08)	7,765	5.0	(4.87-5.09)
Spider veins	752	14.2	(13.17-15.21)	203	6.8	(5.93-7.84)	549	23.5	(21.53-25.50)	30,086	19.3	(19.07-19.51)
Telangiectasia	298	5.6	(4.99-6.29)	136	4.6	(3.84-5.42)	162	6.9	(5.90-8.07)	12,198	7.8	(7.68-7.96)

Abbreviations: AV, acne vulgaris; CI, confidence interval.

Table 2 Odds Ratio of the Occurrence of Different Skin Conditions Among People with Acne Vulgaris, Logistic Regression Analysis Controlling for Age and Gender, N = 161,269

Skin Disease	OR	95% CI of OR	p ≤
Atopic dermatitis	0.92	0.73–1.15	0.464
Contact dermatitis	1.74	1.08–2.81	0.024
Exsiccation dermatosis	0.64	0.45–0.92	0.017
Folliculitis	1.91	1.76–2.07	0.001*
Haemangioma	0.93	0.88–1.00	0.040
Hand eczema	1.34	1.00–1.79	0.049
Intertriginous dermatitis	1.00	0.71–1.40	0.986
Naevus flammeus	1.10	0.95–1.26	0.201
Onychomycosis	1.14	0.99–1.32	0.068
Pityriasis versicolor	0.66	0.47–0.92	0.013
Psoriasis	0.80	0.62–1.03	0.078
Pyoderma	1.58	1.22–2.06	0.001*
Rosacea	1.74	1.40–2.15	0.001*
Seborrheic dermatitis	1.47	1.27–1.71	0.000*
Spider veins	1.26	1.16–1.38	0.001*
Telangiectasia	1.15	1.02–1.30	0.025
Tinea corporis	0.90	0.55–1.48	0.682
Tinea pedis	1.27	1.10–1.47	0.001*
Verruca vulgaris (feet)	1.28	1.09–1.51	0.003
Verruca vulgaris (hands)	1.03	0.69–1.53	0.897

Notes: *Remains significant at nominal $\alpha \leq 0.05$ level after Bonferroni correction for 22 significance tests.

Abbreviations: CI, confidence interval; OR, odds ratio.

Cutaneous Comorbidities in People with Acne

In groupwise comparisons, the following skin diseases showed a significantly higher prevalence in people with acne compared to people without acne (Table 1): folliculitis, seborrheic dermatitis, plantar verruca vulgaris and pyoderma. A significantly lower prevalence was found for exsiccation dermatitis, onychomycosis, psoriasis and vascular lesions of the skin.

Seborrheic dermatitis, onychomycosis, tinea pedis, folliculitis and pyoderma affected significantly more often men than women. Vascular lesions of the skin were more frequent in women (Table 1).

Logistic regression showed that the probability of having acne vulgaris was lower with increasing age (OR = 0.91; CI: 0.91–0.91) and in women (OR = 0.81; CI: 0.76–0.85). Controlling for age and gender, acne was a significantly associated with: folliculitis (OR = 1.91; CI: 1.76–2.07), contact dermatitis (OR = 1.74; CI: 1.08–2.81), rosacea (OR = 1.74; CI: 1.40–2.15), pyoderma (OR = 1.58; CI: 1.22–2.06), seborrheic dermatitis (OR = 1.47; CI: 1.27–

1.71), hand eczema (OR = 1.34; CI: 1.00–1.76), verruca vulgaris plantaris (OR = 1.29; CI: 1.09–1.51), tinea pedis (OR = 1.27; CI: 1.10–1.47), spider veins (OR = 1.26; CI: 1.16–1.38) and telangiectasia (OR = 1.15; CI: 1.02–1.30) (Table 2). Less commonly associated with AV were the following diseases: exsiccation dermatosis (OR = 0.64; CI: 0.45–0.92), pityriasis versicolor (OR = 0.66; CI: 0.47–0.92) and haemangioma (OR = 0.93; CI: 0.88–1.00). After Bonferroni correction, folliculitis, pyoderma, rosacea, seborrheic dermatitis, spider veins and tinea pedis remained statistically significant. Figure 2 shows crude OR and OR controlled for age and gender. Significant difference between the crude OR and OR controlled for age and sex shows up only for co-morbidity rosacea. Without control for age and sex, rosacea is not more frequent, but is significantly more often associated with AV in terms of age and gender.

Discussion

The aim of this study was to determine the prevalence of acne vulgaris (AV) and common cutaneous comorbidity in the adult working population in Germany. In the cohort of 161,269 employees, the total prevalence of AV was 3.3%. These data correspond with the published data where the prevalence of each degree of AV was described for people aged over 25 years between 3% for men and 12% for women.^{4,29} In consensus with previous publications, we also found gender differences in the prevalence of AV being significantly more prevalent in adolescent men and in women aged 30–39. While AV in adolescents is mainly due to the physiologically increased production of sebum and follicular hyperkeratinisation by pubertal maturation, pathological hormonal fluctuations or hypersensitivity to normal androgen level were described in adults.^{30–32} In women, however, the use of cosmetic products, diets and comorbidities such as polycystic ovary syndrome also play an important role.³³ Premenstrual flare of AV has been described with up to 78% of cases.^{34,35} In women, the influence of cycle-dependent hormone level fluctuations on the flares seems to be significant.

In our study, AV prevalence was highest in people with skin type I and IV with 3.6%. However, due to less frequent occurrences, people with skin types V and VI after Fitzpatrick were also grouped under skin type IV. The ethnic origin seems to be related to the frequency of AV. Several studies have shown that AV is more common in people of Caucasian descent than in black subjects.^{24,36}

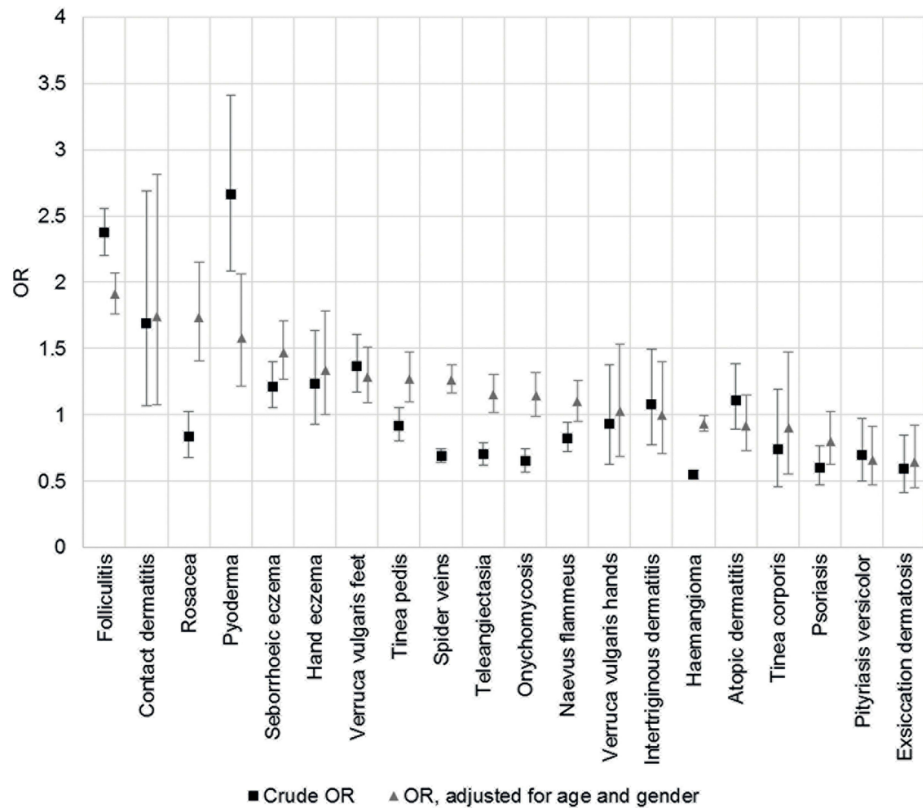


Figure 2 Odds ratios (crude and adjusted for age and gender) and their 95% confidence intervals to develop further skin diseases when acne vulgaris is present. **Abbreviation:** OR, odds ratio.

Further studies on larger patient groups with different ethnic origins would be desirable.

We were able to show that people with AV suffer more frequently from pustular and/or infectious skin diseases such as folliculitis or pyoderma. One reason could be the cutaneous dysbiosis due to increased androgen-induced sebum production. Moreover, hormonal imbalances, psychosocial stressors and genetic factors may also contribute to the association between these conditions.

Interestingly, our study showed gender-specific differences in comorbidities related to the skin. Men with AV were more frequently affected by tinea pedis. One explanation might be that men were more likely to engage in physically strenuous activities associated with increased exposure to dirt, wearing protective footwear and sweating. Gender differences in personal hygiene could be another reason.

One limitation of this study is the focus on the working population. However, though data on the prevalence of AV in the unemployed population group are missing, a strong “healthy worker effect” is not expected in this condition.

Nevertheless, it has been shown that socio-economic differences exist in the prevalence of AV and that unemployed people suffer more frequently from AV.²⁸ This may have led to an underestimation of prevalence in our study.

Another limitation is the voluntary nature of the study. People rejecting skin examinations might potentially show altered frequencies of skin affections. AV is associated with a severe reduction in quality of life and social isolation.³⁷ It is possible that especially people with a severe AV did not dare to participate in the screenings. Even if the current data cannot be directly transferred to the overall general population, they show robust results due to the size of the cohort of 161,269 people and the standardised kind of whole-body examinations by trained dermatologists.

Conclusion

Overall, the current data underline the importance of AV in the adult population. Furthermore, the associations of AV with other inflammatory and infectious skin diseases show the need for adapted counselling and skin care and

treatment for these people. Further studies to better understand the pathophysiology of AV and its comorbidity in different phases of adulthood would be desirable to develop appropriate guidelines and therapy concepts.

Compliance with Ethical Standards

All procedures performed in studies involving human participants were in accordance with the standards of the ethics committee of the Medical Association of Hamburg and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The UKE clinical ethics approved this study. Informed consent was obtained from all individual participants included in the study.

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Disclosure

The authors report no conflicts of interest in this work.

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