

Smoking does not Alter the Therapy Response to Systemic Anti-psoriatic Therapies: A Two-country, Multi-centre, Prospective, Non-interventional Study

Florian ANZENGRUBER^{1,2}, Matthias AUGUSTIN³, Marc A. RADTKE⁴, Diamant THACI⁵, Nikhil YAWALKAR⁶, Markus STREIT⁷, Kristian REICH⁸, Mathias DRACH^{1,2}, Christina SORBE³, Lars E. FRENCH^{1,2}, Ulrich MROWIETZ⁹, Julia-Tatjana MAUL^{1,2}, Peter ITIN¹⁰, and Alexander A. NAVARINI^{1,2}; for the investigators of PsoBest and SDNTT

¹Department of Dermatology, University Hospital Zurich, ²Faculty of Medicine, University of Zurich, Zurich, Switzerland, ³Department of Dermatology, German Center for Health Services Research in Dermatology (CVderm), University Clinics of Hamburg, ⁴Institute for Health Services Research in Dermatology and Nursing, University Medical Center of Hamburg-Eppendorf, Hamburg, ⁵Comprehensive Center for Inflammation Medicine, University Hospital Schleswig-Holstein, Lübeck, Germany, ⁶Department of Dermatology, Inselspital, Bern University Hospital, University of Bern, Bern, ⁷Department of Dermatology, Kantonsspital Aarau, Aarau, Switzerland, ⁸Dermatologikum Hamburg, Hamburg, ⁹Psoriasis Center, Department of Dermatology, University Medical Center Schleswig-Holstein, Campus Kiel, Kiel, Germany, and ¹⁰Department of Dermatology, University Hospital Basel, Basel, Switzerland

Psoriasis can involve the skin, joints, nails and cardiovascular system and result in a significant impairment in quality of life. Studies have shown a lower response rate to systemic anti-psoriatic therapies in smokers, and smoking is a trigger factor for psoriasis. The aim of this study was therefore to analyse the response to systemic therapies for psoriasis, with a focus on smoking. Prospectively collected data from patients with moderate to severe psoriasis included in the national psoriasis registries for Germany and Switzerland (PsoBest and SDNTT) were analysed. Therapy response was defined as reaching a Psoriasis Area and Severity Index (PASI) reduction of 75%, PASI ≤ 3 or Dermatology Life Quality Index (DLQI) ≤ 1. Out of 5,346 patients included in these registries, 1,264 met the inclusion criteria for this study. In the smoking group, 715 (60.6%) reached therapy response at month 3, compared with 358 (63.7%) in the non-smoking group ($p \leq 0.269$), 659 (74.1%) vs. 330 (77%) reached therapy response at month 6 ($p \leq 0.097$), and 504 (76.6%) vs. 272 (79.0%) at month 12 ($p \leq 0.611$). Therefore, these data do not show that smoking affects the response rate of anti-psoriatic therapy after 3, 6 and 12 months.

Key words: tobacco; nicotine; psoriasis; fumaric acid esters; methotrexate; acitretin; ciclosporin; apremilast; adalimumab; etanercept; infliximab; ustekinumab; secukinumab; treatment response.

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Corr: Alexander Navarini, Department of Dermatology, University Hospital Zurich, Gloriastrasse 31, CH-8091 Zurich, Switzerland. E-mail: alexander.navarini@usz.ch

Smoking has been reported as a trigger factor for psoriasis (1) and smokers are at higher risk than non-smokers of developing psoriasis (2). Among patients with psoriasis, the prevalence of cigarette smoking exceeds that of the general public (odds ratio (OR) 1.78) (2–5). Besides genetic factors, cigarette smoking and exposure to tobacco smoke in early childhood are associated with psoriasis, as shown in a retrospective study (6).

SIGNIFICANCE

The German (PsoBest) and Swiss (SDNTT) Psoriasis Registries collect data on the efficacy of anti-psoriatic treatments among smokers and non-smokers. Out of 5,346 patients included in these registries, 1,264 met the inclusion criteria for this study. In the smoking group, 715 (60.6%) reached therapy response at month 3, compared with 358 (63.7%) in the non-smoking group. At month 6, 659 (74.1%) vs. 330 (77%), and at month 12, 504 (76.6%) vs. 272 (79.0%) reached therapy response. Therefore, these data do not show that smoking affects the response rate of anti-psoriatic therapy after 3, 6 and 12 months.

Triggering the onset of psoriasis can be mediated by genetic, inflammatory, or oxidative mechanisms (7). Smoking induces an elevated level of free radicals and thus causes oxidative damage (8). Several signalling pathways can be stimulated by tobacco use. Released cytokines activate T lymphocytes, which cause chronic inflammation (7). In addition, other triggering factors, such as obesity, oxidative stress and even insulin-resistance, are aggravated by tobacco consumption (9). Both smoking and increased fat mass are associated with increased serum tumour necrosis factor (TNF)- α levels (10, 11). Furthermore, due to the persistent inflammation, the risk of cardiovascular events is increased (12). Psoriasis can involve the skin, joints, nails and cardiovascular system, and causes a significant impairment in quality of life amongst patients and cohabitants (13).

Several studies have investigated the overall effects of psoriasis on patient's health, as well as the overall efficacy of treatment. The causality of smoking and negative influence on health is better established in diseases other than psoriasis. In rheumatoid arthritis, negative associations have been shown between smoking and treatment response (14) and continuation of TNF blockers (15, 16). Worse responses have been shown for methotrexate (MTX) treatment (17). It could therefore be assumed that increased TNF- α due to smoking aggravates psoriasis and impairs treatment response. This has been investigated

RESULTS

Out of 5,346 patients included in the psoriasis registries, 1,264 met the inclusion criteria and their data were analysed. Of these, 423 patients were assigned to the subgroup “non-smokers” and 841 to the subgroup “smokers”, with a mean of 18.5 ± 14.0 pack years (Fig. 2).

On average, non-smokers were older than active smokers (44.6 vs. 47.7 , $p \leq 0.001$). At baseline, the average patient was overweight (mean BMI 28.4 ± 5.9 kg/m²). There was no significant difference between smokers (27.8 ± 5.8 kg/m²) and non-smokers (28.3 ± 5.7 kg/m²; $p \leq 0.197$) regarding BMI. Among smokers 43.5% were female, of all non-smokers 44.0% ($p \leq 0.879$). The waist-hip ratio was significantly lower among non-smokers (0.921 vs. 0.933 ; $p \leq 0.048$). There was no difference in burden of therapy ($p \leq 0.214$), meaning patients did not experience the application of treatment as a reduction in quality of life. The family medical history was positive for psoriasis in 37.8% of smokers and 37.1% of non-smokers, yielding no significant difference ($p \leq 0.560$).

At baseline, the PASI in the active smoker cohort was slightly higher than in non-smokers (14.8 vs. 13.4 , $p \leq 0.021$). BSA was, however, no different ($p \leq 0.610$). When patients self-assessed their disease severity on a 0–10 VAS, active smokers classify their severity slightly but significantly higher than non-smokers (6.6 vs. 6.3 , $p \leq 0.017$). Nail psoriasis (58.4 vs. 43.7 , $p \leq 0.001$) occurred more often in the group consuming tobacco and the

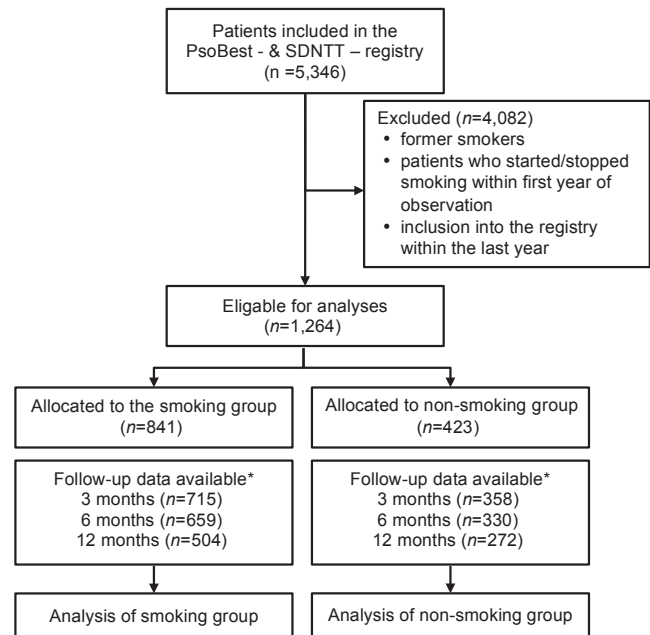


Fig. 2. Study enrolment. Patient inclusion and exclusion flow diagram. *The number of patients decreased over time, since patients were not yet observed at the time of database cut-off or due to treatment cessation (as-observed analyses). PsoBest: German Psoriasis Register; SDNTT: Swiss Dermatology Network for Targeted Therapies.

number of involved nails in patients with nail psoriasis was higher (7.4 vs. 5.3 , $p \leq 0.001$). Nevertheless, PsA was found more frequently in non-smokers (24.1%) than in

Table I. Baseline characteristics. Baseline demographic and clinical characteristics of smokers and non-smokers (German Psoriasis Register (PsoBest) and Swiss Dermatology Network for Targeted Therapies (SDNTT)) and comparison statistics using a one-way analysis of variance (ANOVA)/ χ^2 test

Baseline characteristics	Smokers			Non-smokers			p-value
	n	Mean \pm SD	%	n	Mean \pm SD	%	
Age, years	841	44.6 \pm 12.3		423	47.7 \pm 16.0		0.001
Weight, kg	840	83.6 \pm 19.6		420	84.0 \pm 19.1		0.720
Body mass index, kg/m ²	840	27.8 \pm 5.8		420	28.3 \pm 5.7		0.197
Sex (female)	841		43.5	423		44.0	0.879
Waist-hip ratio	770	0.9 \pm 0.1		394	0.9 \pm 0.1		0.048
Smoking, pack-years	771	18.5 \pm 14.0		NA	NA		
Burden of therapy							0.214
Not at all	217		25.8	81		19.1	
Somewhat	154		18.3	101		23.9	
Moderately	139		16.5	79		18.7	
Quite	153		18.2	87		20.6	
Very	129		15.3	64		15.1	
No information	49		5.8	11		2.6	
Family medical history	812		37.8	410		36.1	0.560
Psoriasis Area and Severity Index (PASI)	825	14.8 \pm 10.1		418	13.4 \pm 9.4		0.021
Body surface area (BSA)	828	22.4 \pm 19.7		416	21.8 \pm 20.2		0.610
Severity of psoriasis (patient assessment)	817	6.6 \pm 2.4		421	6.3 \pm 2.4		0.017
Nail psoriasis	841		58	423		44	0.001
Number of involved nails	464	7.4 \pm 3.2		174	5.3 \pm 3.3		0.001
Psoriatic arthritis (PsA)	841		18	423		24.1	0.010
Activity PsA (physician assessment)	138	4.7 \pm 2.9		98	4.1 \pm 2.8		0.125
Pain PsA (patient assessment)	137	5.0 \pm 2.7		93	4.3 \pm 2.7		0.087
Activity PsA (patient assessment)	104	4.9 \pm 2.7		79	4.2 \pm 2.5		0.080
Clinical type of psoriasis							
Plaque type	841		11.1	423		21.3	0.101
Small spot	841		0.6	423		1.4	0.352
Erythrodermic psoriasis	841		0.1	423		0.2	0.266
Psoriasis inversa	841		0.0	423		0.0	0.996
Psoriasis pustulosa	841		0.0	423		0.2	0.756

SD: standard deviation. Significant values are shown in bold.

smokers (18%; $p \leq 0.010$). Physician assessments showed no differences between smokers and non-smokers. This was true for activity of PsA ($p \leq 0.125$) and pain in PsA ($p \leq 0.087$). Also, patients did not assess a difference in PsA when they had to rate the activity ($p \leq 0.080$). There was no difference in psoriasis type (Table I).

The majority of registered patients had received fumaric acid esters at baseline ($n = 1,832, 48.9\%$), followed by methotrexate ($n = 1,467, 34.3\%$). The most frequently used biological agent was adalimumab ($n = 564, 10.5\%$) (Fig. 3).

Response to treatment was considered to be achieved when PASI 75, or PASI ≤ 3 or DLQI ≤ 1 was reached. Overall, there was no significant difference observed in treatment response of skin lesions in active smokers compared with non-smokers when comparing for each individual systemic therapy after 3, 6 or 12 months (Fig. 4A). In the smoking group, 60.6% of patients ($n = 715$) reached therapy response at month 3 compared with 63.7% ($n = 358$) in the non-smoking group ($p \leq 0.269$) (Fig. 4B). At month 6, 74.1% ($n = 659$) compared with 77% ($n = 330$) reached PASI 75, or PASI ≤ 3 or DLQI ≤ 1 ($p \leq 0.097$) (Fig. 4C). After one year of treatment 76.6% ($n = 504$) in the smoking cohort and 79.0% ($n = 272$) of non-smokers reached treatment response (Fig. 4D). Also, at this time-point, this was not significant ($p \leq 0.611$).

Regarding adalimumab, out of all patients it was possible to obtain valid data on response in 159 cases at month 3. Out of these, 116 patients responded to treatment at that time. While the current smoker group showed a treatment response in 72.3% ($n = 101$) of cases, in the

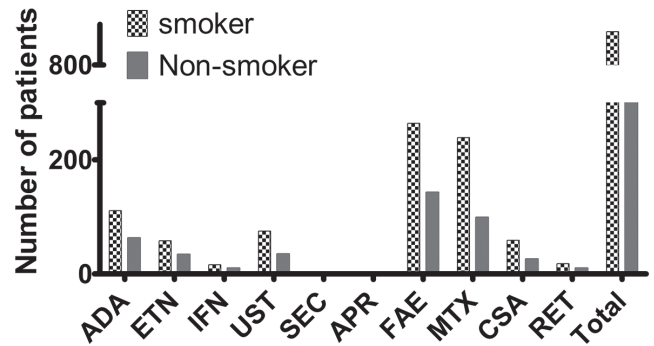


Fig. 3. Number of patients included in the registry by baseline treatment, subgrouped as current smokers and non-smokers. ADA: adalimumab; ETN: etanercept; IFN: infliximab; UST: ustekinumab; SEC: secukinumab; APR: apremilast; FAE: fumaric acid esters; MTX: methotrexate; CSA: ciclosporin; RET: retinoids.

non-smoking group 74.1% ($n = 58$) of patient reached this goal ($p \leq 0.799$) after 3 months. Neither was there any difference in treatment response at month 6 (data for 156 patients were analysed, of which a response was seen in 78.0% ($n = 100$) vs. 76.8% ($n = 56$) ($p \leq 0.862$)) or month 12 (data for 111 participants were analysed, 78.6% ($n = 70$) vs. 87.8% ($n = 41$) ($p \leq 0.222$)) between the 2 groups of patients receiving adalimumab.

For etanercept, valid data on response were received for 77 patients at month 3. In the smoking group 50.0% ($n = 50$) were considered to have achieved either PASI 75 or PASI ≤ 3 or DLQI ≤ 1 . In comparison, 70.4% ($n = 27$) of non-smokers had a therapy response after 3 months of treatment. However, this difference was not significant ($p \leq 0.085$). Also, after 6 (70.5% ($n = 54$) vs.

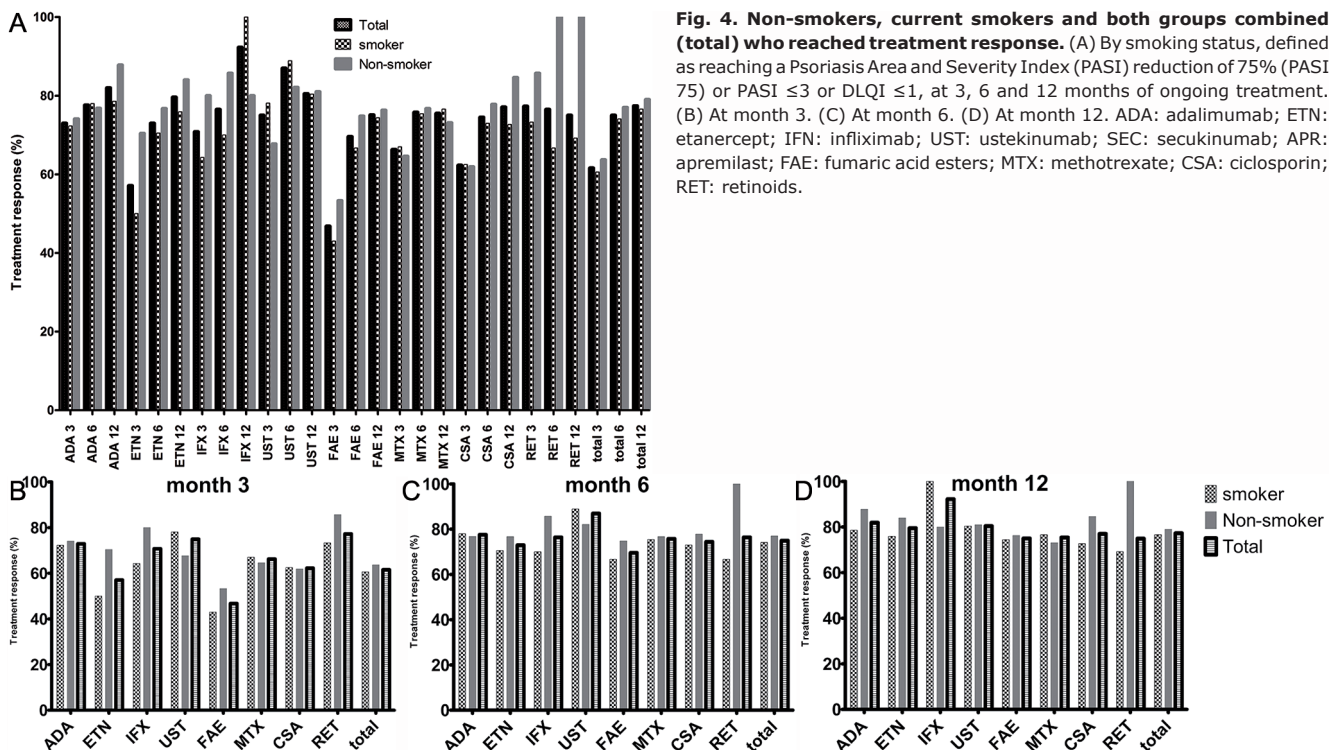


Fig. 4. Non-smokers, current smokers and both groups combined (total) who reached treatment response. (A) By smoking status, defined as reaching a Psoriasis Area and Severity Index (PASI) reduction of 75% (PASI 75) or PASI ≤ 3 or DLQI ≤ 1 , at 3, 6 and 12 months of ongoing treatment. (B) At month 3. (C) At month 6. (D) At month 12. ADA: adalimumab; ETN: etanercept; IFN: infliximab; UST: ustekinumab; SEC: secukinumab; APR: apremilast; FAE: fumaric acid esters; MTX: methotrexate; CSA: ciclosporin; RET: retinoids.

76.7% ($n=30$), $p \leq 0.555$) and 12 months (75.9% ($n=29$) vs. 84.0% ($n=25$), $p \leq 0.459$) there was no significant difference between the 2 groups.

In 24 cases, valid data on response were obtained for patients on infliximab (64.3% ($n=14$) vs. 80.0% ($n=10$), $p \leq 0.404$) at month 3. Also, at later time-points (months 6 and 12), no difference was found in achieving response to treatment between the smoking group vs. the non-smokers (70.0% ($n=10$) vs. 85.7% ($n=7$), $p \leq 0.452$; 100.0% ($n=8$) vs. 80.0% ($n=5$), $p \leq 0.188$).

For ustekinumab, the data for 104 patients were valid for response evaluation at month 3. Of these patients 78.1% ($n=73$) (smokers) vs. 67.7% ($n=31$) (non-smokers) ($p \leq 0.265$) responded to treatment. Also, at month 6 (88.9% ($n=72$) vs. 82.1% ($n=28$), $p \leq 0.368$) and month 12 (80.4% ($n=56$) vs. 81.0% ($n=21$), $p \leq 0.953$), one year after initiation of treatment, no statistical difference in response rate was seen between the 2 groups.

Regarding secukinumab and apremilast, which, at the time of data cut-off, were the newer drugs in anti-psoriatic treatment, not enough valid response data could be obtained for any statistical comparison of smokers (valid $n=0$ and $n=1$, respectively) and non-smokers (valid $n=2$ and $n=0$, respectively).

For fumaric acid esters, data for 327 patients at month 3 were obtained. 43.0% ($n=207$) of smokers responded to treatment, while 53.3% ($n=120$) of non-smokers did ($p \leq 0.071$). At month 6 (66.7% ($n=192$) vs. 74.8% ($n=111$), $p \leq 0.139$) and month 12 (74.4% ($n=160$) vs. 76.3% ($n=97$), $p \leq 0.731$) there was also no difference between smokers and non-smokers.

The data on methotrexate did not yield any significant differences between smokers and non-smokers at month 3 (67.0% ($n=206$) vs. 64.6% ($n=82$), $p \leq 0.703$), 6 (75.4% ($n=191$) vs. 76.7% ($n=73$), $p \leq 0.823$) or 12 (76.6% ($n=145$) vs. 73.1% ($n=67$), $p \leq 0.963$).

For ciclosporin there was no statistical difference between treatments group at month 3 (62.5% ($n=48$) vs. 61.9% ($n=21$), $p \leq 0.963$), 6 (73.0% ($n=37$) vs. 77.8% ($n=18$), $p \leq 0.701$) or 12 (72.7% ($n=22$) vs. 84.6% ($n=13$), $p \leq 0.418$).

Data for only 22 patients were valid concerning the response to retinoids at month 3. While 73.3% ($n=15$) of the smoking group responded to treatment, 85.7% ($n=7$) ($p \leq 0.519$) of the non-smokers did. No statistically different results between the groups were seen at month 6 (66.7% ($n=12$) vs. 100.0% ($n=5$), $p \leq 0.140$) or at month 12 (69.2% ($n=13$) vs. 100.0% ($n=3$), $p \leq 0.267$).

After 12 months the number of patients continuing their treatment was 111 (70 smokers and 41 non-smokers) for adalimumab, 54 (29/25) for etanercept, 12 (8/4) for infliximab, 77 (56/21) for ustekinumab, 0 for secukinumab, 1 smoker for apremilast, 257 (160/97) for fumaric acid esters, 212 (145/67) for methotrexate, 35 (22/13) for ciclosporin A, 16 (13/3) for retinoids, an overall total of 776 (504/272).

Overall, there was no significant difference between smokers and non-smokers regarding any treatment at any time-point.

DISCUSSION

The data from the cohort of patients with psoriasis for Germany and Switzerland analysed prospectively in this study confirms the results of previous prospective (35–37) and retrospective (38–40) studies, in demonstrating that active smoking does not significantly affect the treatment response of skin lesions in psoriasis to systemic therapies. Menter et al. reported the absence of a correlation between active tobacco use and PASI 75 response in a prospective study with 814 patients treated with adalimumab (35). Similar results were reported in a prospective study with 2,368 patients, where smoking was shown not to affect treatment response, whereas BMI significantly decreased the response to systemic anti-psoriatic treatment (36). In contrast, a retrospective report by Rakkhit et al. (40) detected a minimally superior response of psoriasis to etanercept in non-smokers compared with active smokers. No difference between smoking status and efficacy of TNF- α blockers and ustekinumab was, however, found in a retrospective Italian study of 350 patients (39). A smaller retrospective study yielded similar results; however, only 36 non-smokers and 20 smokers met the inclusion criteria (38).

Interestingly, in a prospective study with 434 inflammatory bowel disease patients treated with TNF-antagonists, almost 5% developed a paradoxical psoriasis. Smoking was shown to be an important risk factor, and all of these patients had cutaneous infiltrates with increased numbers of IL-17A/IL-22-secreting T helper cells (37).

The published data to date is thus not homogeneous. In a retrospective study with 110 patients with psoriasis treated with TNF antagonists, 13 non-responders were assessed in detail, and a history of active smoking at the onset of therapy appeared to be associated with non-response. The majority (61.5%, $n=8$; OR: 2.71 (0.82–8.92) of non-responders were smokers (41). No data on p -values were published.

There was a difference in age between our 2 cohorts. Smokers tended to be younger than non-smokers, leading to speculation about how much this affects treatment outcome. Our data also indicated that PsA was significantly less frequent in active smokers compared with non-smokers. In a published large study consisting of 1,388 patients it was reported that active smokers not only had a poorer treatment response, but also had worse treatment adherence. Interestingly, active smokers were less affected by obesity, had a shorter duration of disease, and the affected joint count was lower than in non-smokers. However, they scored more points on the visual analogue scale (VAS) than the comparison group at baseline. Once treated, the reduction in pain was not

statistically different between smokers and non-smokers (42).

In total, non-smokers had better starting conditions, as their PASI was lower (13.4) compared with that of smokers (14.8). Also, self-assessed severity and nail psoriasis were more severe in the cohort of smokers. This has been reported previously and was also true in our study.

In certain other diseases, such as axial spondylarthritis, the effect of tobacco consumption on therapy response has also been analysed. A decreased response to TNF-antagonist treatment was reported in smokers with axial spondylarthritis (18). This was especially true for active smokers compared with non-smokers.

Recently, a multicentre, observational, prospective pharmacovigilance study (BADBIR), identified factors associated with a higher likelihood of achieving PASI 90 in biologic-naïve patients. Among other factors, smoking, or even only having a history of smoking, was associated with a reduced probability of treatment response in patients on biologic therapy (43). The study included more patients ($n=3,079$ at 6 months and $n=3,110$ at 12 months), which might be an explanation for the difference in results.

Since only 1,264 patients could be selected for analysis there is a potential selection bias in our study, which may be a weakness. Possible differences in the resonance rates in the treatment groups may not have been detected due to the small number of cases in the subgroups and the resulting insufficient power. However, a power calculation (90% power, 5% alpha, 10% equivalence limit, 50% response rate) was performed and, assuming there was no difference between the smokers and non-smokers regarding treatment response, 1,084 patients would be required. There were some differences at baseline such as age, PASI, psoriasis severity (patient assessment), nail psoriasis, number of involved nails and the presence of PsA. This could be a potential bias, but it is expected to be small, since we considered absolute and relative measures for treatment response. Also, PsA was not evaluated by a rheumatologist, and none of the usual scores were utilized. In registry studies there is no control for confounding, which poses a limitation to this work. Comparisons of the effect of smoking on response by treatment are not powered sufficiently to detect differences, and therefore the results should be interpreted in the light of this knowledge. One important limitation of this study was that difference in response given smoking status was contingent on the patient remaining on treatment until the relevant time-period. The high number of smokers in our cohort can be explained by the fact that former smokers (and current non-smokers) were excluded from the analysis.

In conclusion, this prospectively collected registry-based data analysis of 1,264 patients did not show that smoking affects the response of psoriasis skin lesions to systemic therapy.

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