



Association of Air Pollution Exposure and Face-Washing Behavior with Acne Vulgaris Among Medical Students

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ABSTRACT

Introduction: Acne vulgaris (AV) is a chronic inflammatory disease of the pilosebaceous unit that is common among young adults. Air pollution exposure and face-washing behavior may be associated with AV. This study aimed to analyze the association of air pollution exposure and face-washing behavior with AV among medical students. **Methods:** This analytical cross-sectional study included 117 eligible students from the 2024 cohort of the Faculty of Medicine, Universitas Muhammadiyah Surakarta, using total sampling. Data were collected using questionnaires that underwent content and face validation, as well as clinical observation. We assessed the association between face-washing behavior and AV using the Chi-square test, and the association between air pollution exposure and AV using Fisher's exact test. **Results:** AV prevalence was 79.5%. Overall, 94.9% of respondents had heavy air pollution exposure, and 59.8% had positive face-washing behavior. Face-washing behavior was not significantly associated with AV (Chi-square = 1.521; $p = 0.217$; OR for negative vs positive behavior = 1.83; 95% CI 0.69–4.84). Air pollution exposure was also not significantly associated with AV (Fisher's exact $p = 0.601$; OR for heavy vs moderate exposure = 2.02; 95% CI 0.35–11.76). **Conclusion:** In this sample, neither air pollution exposure nor face-washing behavior was significantly associated with AV. Interpretation is limited by the highly imbalanced exposure distribution, the small moderate-exposure group, and the cross-sectional design.

Keywords: Acne vulgaris, air pollution exposure, cross-sectional study, face-washing behavior, medical students.



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INTRODUCTION

Acne vulgaris (AV) is a chronic inflammatory disease of the pilosebaceous unit characterized by comedones, papules, pustules, and, in more severe cases, nodules. Its pathogenesis involves increased sebum production, follicular hyperkeratinization, *Cutibacterium acnes* colonization, and an inflammatory response.^{1,2} AV most commonly affects the face but may also involve the chest, back, and upper arms. The burden is particularly high among adolescents and young adults.³

In Indonesia, AV is frequently reported among adolescents and young adults, although national population-based prevalence estimates

remain limited. Its impact is nevertheless important because visible lesions can affect body image, self-confidence, and psychological well-being.⁴

Genetic, hormonal, environmental, psychological, dietary, cosmetic, and medication-related factors influence the pathogenesis of AV. Air pollution may affect the skin by promoting oxidative stress, altering sebum production, and impairing barrier function.⁵ These factors interact in complex ways and may influence both the development and severity of AV.

Hastuti, et al., reported that face-washing frequency may influence lesion counts, suggesting that appropriate facial cleansing

should be considered in AV care.⁶ However, AV is multifactorial, and evidence regarding the association between facial hygiene and AV remains inconsistent. Air pollution may also affect the skin through oxidative stress and barrier disruption. Given young adults' vulnerability and urban environmental exposure, this study aimed to analyze the associations between air pollution exposure, face-washing behavior, and AV among medical students.

METHODS

Study Design and Setting

This observational analytical study used a cross-sectional design to analyze associations between air pollution exposure

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and face-washing behavior and AV at a single observation point (point prevalence). The study was conducted at the Faculty of Medicine, Universitas Muhammadiyah Surakarta (FK UMS). Data were collected from February to April 2025.

Population and Sample

The target population comprised 186 students from the 2024 cohort of FK UMS. Total sampling was applied according to the prespecified inclusion and exclusion criteria.

Inclusion Criterion:

- Students in the 2024 cohort of the Faculty of Medicine, Universitas Muhammadiyah Surakarta.

Exclusion Criteria:

- Students who routinely used corticosteroids ($n = 9$), because these agents can induce acne through hormonal and inflammatory effects.⁷
- Students receiving active acne treatment ($n = 23$), because treatment could substantially modify skin findings.⁸
- Students who used an enclosed car as their primary daily mode of transport, whether a private car or an app-based ride service ($n = 22$), because an enclosed cabin may reduce direct exposure compared with open vehicles; authors must confirm the inclusion of app-based car users in this count.⁹
- Students who used heavy makeup every day beyond powder, lipstick, and eyebrow products ($n = 15$), because sustained use of comedogenic cosmetics may represent an independent risk factor for acne cosmetica.¹⁰
- Of the 186 students invited to complete the questionnaire, 117 (62.9%) met the eligibility criteria and formed the final sample.

Study Variables

Dependent Variable (Outcome):

- Acne vulgaris status (present/absent), based on clinical observation by the investigators; the diagnostic criteria and evaluator qualifications/training require author confirmation.

Independent Variables:

- Face-washing behavior (positive/negative).
- Air pollution exposure (light/moderate/heavy).

Other Recorded Variables:

- Sex, age, and type of facial cleanser used.

Data Collection Instruments

Air Pollution Exposure Questionnaire

The air pollution exposure questionnaire comprised 18 items modified from the exposure domains described by Haddad, et al., including proximity to busy roads and industrial areas, frequency of exposure to vehicle exhaust, duration of outdoor activity, traffic conditions, and mask use.¹¹ The source instrument did not define a composite score identical to that used in this study. Accordingly, the total score and cutoffs below were operational definitions established before analysis and should be confirmed against the study protocol. With item scores of 0–3 or 1/3, as applicable, the theoretical total score ranged from 6 to 54 if all six dichotomous items had a minimum score of 1. The handling of a 'not applicable' response to item 12 and reverse coding of protective items must be confirmed against the raw data:

- Light exposure: score 6–10.
- Moderate exposure: score 11–20.
- Heavy exposure: score 21–54.

Instrument validation was conducted in two stages in accordance with recommendations on content and face validity:^{12–14}

- Expert review (content validity): Supervisors and examiners assessed the relevance, clarity, and alignment of each item with the study objective.
- Face validity: The questionnaire was piloted among 13 students who met the inclusion criteria to assess readability and comprehension. Participants commented on language clarity and the relevance of each question to their experience.

Content and face validity indicated that the instrument was understandable and relevant to the study context. However, further psychometric evaluation, including reliability and construct validity, was not performed.

Face-Washing Behavior Questionnaire

The face-washing behavior questionnaire was adapted from Tyas, et al.,¹⁵ and modified for the study context. Six items assessed perceived effectiveness, frequency, duration, consistency, and timing of facial-cleanser use.

The questionnaire underwent two types of validation:

- Content validity: The investigators

reviewed literature on facial cleansing practices and skin-barrier care^{6,16} and consulted dermatology experts to assess the theoretical appropriateness and clinical relevance of each item.

- Face validity: The questionnaire was piloted among 13 students who met the inclusion criteria to assess readability, comprehension, and relevance to respondents' experience.

The face-washing behavior questionnaire was categorized as follows:

- Negative behavior: score 6–15 (indicating less favorable or infrequent face-washing behavior).
- Positive behavior: score 16–30 (indicating favorable and regular face-washing behavior).

Each of the six items was scored from 1 to 5, and the item scores were summed to produce a total score ranging from 6 to 30.

Data Collection Procedure

Data were collected using a self-administered questionnaire. Students received a brief explanation of the study purpose and completion procedure and were given sufficient time to respond without pressure. The researchers also collected demographic and clinical data, including observations of the presence and characteristics of facial acne lesions.

Data Analysis

Data analysis included univariable analysis to present frequencies and percentages of respondent characteristics and bivariable analysis to assess associations between the independent variables and AV. The association between face-washing behavior and AV was analyzed using Pearson's Chi-square test. The association between air pollution exposure and AV was analyzed using Fisher's exact test because an expected cell frequency was below 5. Crude odds ratios (ORs) and 95% confidence intervals (CIs) were reported as measures of association. Statistical significance was set at $\alpha = 0.05$. The primary analyses were performed using SPSS version 25.0 for Windows; ORs and 95% CIs were verified from the reported contingency tables.



RESULTS

Respondent Characteristics

Table 1 presents the characteristics of the 117 respondents. Most were female (63.2%; $n = 74$), and the largest age group was 18 years (47.0%; $n = 55$). Positive face-washing behavior was reported by 70 respondents (59.8%). Nearly all respondents had heavy air pollution exposure (94.9%; $n = 111$), while 6 (5.1%) had moderate exposure. The most frequently used facial cleanser was face wash (53.0%; $n = 62$), followed by micellar water (35.0%; $n = 41$).

AV prevalence in the sample was 79.5% (93 of 117 respondents). AV prevalence was 74.3% among female and 88.4% among male respondents. By age, prevalence was 78.2% at 18 years, 79.2% at 19 years, and 85.7% at 20 years; these comparisons were descriptive and were not tested as primary study objectives.

Association Between Face-Washing Behavior and AV

Among respondents with positive face-washing behavior, 53 of 70 (75.7%) had AV. Among those with negative behavior, 40

of 47 (85.1%) had AV. The distribution of AV according to face-washing behavior is presented in **Table 2**.

Pearson's Chi-square test showed no significant association between face-washing behavior and AV (Chi-square = 1.521; $p = 0.217$). Respondents with negative behavior had 1.83 times the odds of AV compared with those with positive behavior, but the confidence interval included the null value (OR = 1.83; 95% CI 0.69–4.84).

Association Between Air Pollution Exposure and AV

In the moderate-exposure group, 4 of 6 respondents (66.7%) had AV, compared with 89 of 111 respondents (80.2%) in the heavy-exposure group. Fisher's exact test was used because the moderate-exposure group was small and an expected cell frequency was below 5. The distribution of AV according to air pollution exposure is presented in **Table 3**.

Air pollution exposure category was not significantly associated with AV (Fisher's exact $p = 0.601$). The odds of AV in the heavy-exposure group were 2.02 times those in the moderate-exposure group, with a wide confidence interval (OR = 2.02; 95% CI 0.35–11.76), indicating imprecision.

DISCUSSION

Association Between Face-Washing Behavior and Acne Vulgaris

This study found no significant association between face-washing behavior and AV. Although the proportion with AV was higher in the negative-behavior group than in the positive-behavior group (85.1% vs 75.7%), the estimate was imprecise and remained compatible with no association. This finding is consistent with studies by Al-Muzaki, *et al.*, and Hapsari, *et al.*, which likewise reported no meaningful association between skincare or facial-hygiene behavior and AV among students.^{17,18} AV is multifactorial; hormonal, genetic, psychological, dietary, skincare-product, and skin-related factors may act concurrently.^{15,19}

The effectiveness of facial cleansing depends not only on frequency but also on technique, product suitability, and skin tolerance. Excessive cleansing or irritating products may

Table 1. Respondent characteristics ($n = 117$).

Variable	Count	Percentage (%)	AV status, n (%)	
	n	%	Yes	No
Sex				
Female	74	63.2	55 (74.3)	19 (25.7)
Male	43	36.8	38 (88.4)	5 (11.6)
Age				
18 years	55	47.0	43 (78.2)	12 (21.8)
19 years	48	41.0	38 (79.2)	10 (20.8)
20 years	14	12.0	12 (85.7)	2 (14.3)
Face-Washing Behavior				
Positive	70	59.8	53 (75.7)	17 (24.3)
Negative	47	40.2	40 (85.1)	7 (14.9)
Air Pollution Exposure				
Moderate	6	5.1	4 (66.7)	2 (33.3)
Heavy	111	94.9	89 (80.2)	22 (19.8)
Type of Facial Cleanser				
Micellar water	41	35.0	34 (82.9)	7 (17.1)
Face wash	62	53.0	49 (79.0)	13 (21.0)
Milk cleanser	7	6.0	5 (71.4)	2 (28.6)
Oil cleanser	6	5.1	5 (83.3)	1 (16.7)

Note: Facial-cleanser type was reported by 116 of 117 respondents; data were missing for one respondent. Percentages were calculated using the full sample ($n = 117$).

Table 2. Association between face-washing behavior and AV.

Face-Washing Behavior	AV Status		Total		p-value
	Present, n (%)	Absent, n (%)	n	%	
Positive	53 (75.7)	17 (24.3)	70	59.8	0.217
Negative	40 (85.1)	7 (14.9)	47	40.2	
Total	93 (79.5)	24 (20.5)	117	100	

*Test: Pearson's Chi-square; OR for negative vs positive behavior = 1.83 (95% CI 0.69–4.84).

**Table 3.** Association between air pollution exposure and AV.

Air Pollution Exposure	AV Status		Total		p-value
	Present, n (%)	Absent, n (%)	n	%	
Moderate	4 (66.7)	2 (33.3)	6	5.1	0.601
Heavy	89 (80.2)	22 (19.8)	111	94.9	
Total	93 (79.5)	24 (20.5)	117	100	

*Test: Fisher's exact; OR for heavy vs moderate exposure = 2.02 (95% CI 0.35–11.76).

impair the skin barrier, whereas appropriate cleansers and moisturizers may help maintain barrier function.^{16,20} Because AV pathogenesis involves processes within the pilosebaceous unit, face-washing behavior alone is unlikely to explain all variation in AV.²¹

Association Between Air Pollution Exposure and Acne Vulgaris

This study found no significant association between air pollution exposure category and AV. This differs from Haddad, *et al.*, who reported associations between selected pollutant-exposure indicators and inflammatory acne in an adult population.¹¹ Differences in exposure assessment, population characteristics, and category distribution may explain the contrasting results. In the present study, 94.9% of respondents were classified as having heavy exposure, leaving only six respondents in the comparison group.

The homogeneous and highly imbalanced exposure distribution reduced the analysis's ability to detect between-group differences and produced a wide confidence interval. Therefore, a nonsignificant result does not establish that air pollution has no role in AV. Previous biological and epidemiological evidence indicates that pollutants such as PM_{2.5} and NO₂ may increase oxidative stress and inflammatory responses in the skin,^{22–27} but these mechanisms were not measured directly in this study.

Prevalence of Acne Vulgaris Among Medical Students

AV prevalence in this study was 79.5%, higher than the global estimate of approximately 9.4% across all age groups.²⁸ This comparison requires caution because the study sample

consisted of students aged 18–20 years, an age group with high sebaceous-gland activity. Pubertal hormonal changes, academic stress, and sleep and dietary patterns are relevant characteristics of this age group but were not measured as primary variables.^{29–31} The study therefore cannot determine the relative roles of these factors.

Among university students, skincare knowledge and behavior, anxiety, diet, and stress may be associated with AV.^{32–34} These findings support a multifactorial approach but do not change the present study's main result: neither air pollution exposure nor face-washing behavior showed a significant association with AV in this sample.

This study has several limitations. Its cross-sectional design cannot establish temporality or causality. The study involved a single cohort at one institution, limiting generalizability. Air pollution exposure was measured using a modified questionnaire score rather than individual-pollutant measurements or personal monitoring, and psychometric evaluation was limited to content and face validation. The exposure distribution was highly imbalanced, with only six respondents in the moderate category, resulting in low statistical power and imprecise association estimates. Important confounders, including family history, skin type, stress, diet, sleep, and cosmetic use, were not controlled through multivariable analysis. The transport-related exclusion criterion may also have introduced selection bias. Multicenter studies using objective exposure measurements, psychometrically validated instruments, and multivariable analysis should confirm these findings.

CONCLUSION

Among the 117 medical students studied, AV prevalence was 79.5%. Neither face-washing behavior nor air pollution exposure category was significantly associated with AV. These findings should be interpreted in light of the imbalanced exposure categories, small comparison group, potential confounding, and cross-sectional design. Further studies using objective exposure measurements and more diverse populations are needed.

DECLARATIONS

Ethics Statement

This study was reviewed and approved by the Health Research Ethics Committee of Dr. Moewardi General Hospital (RSUD Dr. Moewardi), Surakarta, Indonesia, with ethical clearance number 12/I/HREC/2025, issued on 7 January 2025.

Consent for Publication

Not applicable.

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Author Contributions

FRSP: Conceptualization, Methodology, Investigation, Data curation, Formal analysis, and Writing – original draft. NP: Conceptualization, Methodology, Supervision, Validation, and Writing – review and editing. DND: Investigation, Data curation, Project administration, and Writing – review and editing. RP: Formal analysis, Validation, and Writing – review and editing. YPK: Conceptualization, Supervision, Validation, and Writing – review and editing. All authors reviewed and approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

Conflict of Interest

The authors declare no financial or non-financial conflicts of interest.

Declaration on the Use of Artificial Intelligence (AI)

Generative AI (ChatGPT by OpenAI) was used to assist English translation and editorial refinement of the manuscript; it was not used to generate study data.



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**APPENDICES: STUDY QUESTIONNAIRES**

Appendix 1. Questionnaire on respondents' face-cleanser use.

Instructions: Circle the answer that best reflects your condition.

1. Based on your experience, how effective is regular use of a facial cleanser in preventing acne?
 - a. Not effective
 - b. Slightly effective
 - c. Neutral
 - d. Effective
 - e. Very effective
2. Based on your experience, how effective is regular facial-cleanser use in improving facial skin condition?
 - a. Not effective
 - b. Slightly effective
 - c. Neutral
 - d. Effective
 - e. Very effective
3. How many times per day do you use a facial cleanser?
 - a. Never
 - b. Once
 - c. Twice
 - d. Three times
 - e. More than three times
4. How long do you cleanse your face with a facial cleanser?
 - a. Less than 1 minute
 - b. 1 minute
 - c. 2 minutes
 - d. 3 minutes
 - e. More than 3 minutes
5. When I intend to use a facial cleanser, I usually choose:
 - a. Never use one
 - b. Rarely
 - c. Neutral
 - d. Often
 - e. Every day
6. When do you use a facial cleanser?
 - a. While bathing
 - b. After wearing makeup
 - c. After activities
 - d. Before sleeping
 - e. No specific time

Scoring Criteria

- Negative behavior: score 6–15 (indicating less favorable frequency and consistency of facial-cleanser use).
- Positive behavior: score 16–30 (indicating favorable frequency and consistency of facial-cleanser use).


Appendix 2. Air pollution exposure questionnaire.

Instructions: Circle the answer that best reflects your condition.

No.	Question	Response	Score
1	Is your home or workplace within 100 m of a busy road used by motor vehicles such as cars and trucks?	Yes/No	3/1
2	How often do you hear heavy vehicles, such as trucks or buses, near your home or workplace?	Almost every day/Several times a week/ Rarely/Never	3/2/1/0
3	Are you frequently exposed to motor-vehicle or diesel exhaust while traveling or working?	Yes/No	3/1
4	How often do you smell exhaust fumes when outdoors?	Almost every day/Several times a week/ Rarely/Never	3/2/1/0
5	Do you live near an industrial area that emits factory or coal-combustion smoke?	Yes/No	3/1
6	How often do you see smoke or smell chemicals from factories near your home or workplace?	Almost every day/Several times a week/ Rarely/Never	3/2/1/0
7	How often do you see or smell dense smoke or dust around your home or workplace?	Almost every day/Several times a week/ Rarely/Never	3/2/1/0
8	Do you frequently see dust deposited on objects or buildings near your home or workplace?	Yes/No	3/1
9	On average, how long do you spend outdoors in polluted areas such as busy roads or industrial zones?	More than 5 h per day/3–4 h per day/1–2 h per day/Less than 1 h per day	3/2/1/0
10	How often are you caught in traffic congestion for more than 30 minutes per day?	Almost every day/Several times a week/ Rarely/Never	3/2/1/0
11	Do you routinely drive a motorcycle or another open vehicle?	Yes/No	3/1
12	If you travel by car, do you use air conditioning with the windows closed?	Yes/No/Not applicable	1/3/*
13	How long do you spend in traffic congestion each day?	More than 5 h/3–4 h/1–2 h/None	3/2/1/0
14	How long do you spend in outdoor activities each day?	More than 5 h/3–4 h/1–2 h/None	3/2/1/0
15	How often do you wear a mask outdoors in polluted areas?	Always/Often/Sometimes/Never	0/1/2/3
16	How comfortable is your mask during prolonged use?	Very comfortable/Somewhat comfortable/ Uncomfortable/Very uncomfortable	0/1/2/3
17	How often do you experience difficulty breathing while wearing a mask outdoors?	Never/Sometimes/Fairly often/Very often	0/1/2/3
18	How effective do you consider your mask to be in protecting you from air pollution?	Very effective/Somewhat effective/Not very effective/Not effective at all	0/1/2/3

Coding note: *Confirm the code for 'not applicable' in item 12 and reverse coding of items 12 and 15–18 against the raw/SPSS data; if different, recalculate the scores, exposure categories, and related analyses.

Scoring Criteria (Total Score):

- Light exposure: score 6–10
- Moderate exposure: score 11–20
- Heavy exposure: score 21–54