PLOS ONE  
  
®  
  
Check for  
updates  
  
a OPEN ACCESS  
  
Citation: Huang Y-x, Li J, Zhao Z-x, Zheng B-I,  
Deng Y-x, Shi W, et al. (2020) Effects of skin care  
habits on the development of rosacea: A multi-  
center retrospective case-control survey in Chinese  
population. PLoS ONE 15(4): €0231078. https://  
doi.org/10.1371/journal.pone.0231078  
  
Editor: Cheng-Shi Shiu, University of California Los  
Angeles, UNITED STATES  
  
Received: March 27, 2019  
Accepted: March 16, 2020  
Published: April 27, 2020  
  
Copyright: © 2020 Huang et al. This is an open  
access article distributed under the terms of the  
Creative Commons Attribution License, which  
permits unrestricted use, distribution, and  
reproduction in any medium, provided the original  
author and source are credited.  
  
Data Availability Statement: All relevant data are  
within the paper and its Supporting Information  
files.  
  
Funding: (1) Initial of the author who received each  
award: Y-x H (2) Grant numbers awarded to the  
author: 81502750 (3) The full name of each funder:  
the National Natural Science Foundation of China  
(4) URL of the funder website: http://www.nsfc.  
gov.cn/ (5) The funders had no role in study  
design, data collection and analysis, decision to  
publish, or preparation of the manuscript.  
  
RESEARCH ARTICLE  
  
Effects of skin care habits on the development  
of rosacea: A multi-center retrospective case-  
control survey in Chinese population  
  
Ying-xue Huang’®, Ji Li’”\*\*, Zhi-xiang Zhao’, Bo-lan Zheng’, Yu-xuan Deng’, Wei Shi’,  
Martin Steinhoff\*\*, Hong-fu Xie@'?\*  
  
1 Department of Dermatology, Xiangya Hospital, Central South University, Changsha, Hunan, China,  
  
2 National Clinical Research Center for Geriatric Disorders, Xiangya Hospital, Central South University,  
Changsha, Hunan, China, 3 Key Laboratory of Organ injury, Aging and Regenerative Medicine of Hunan  
Province, Changsha, Hunan, China, 4 Department of Dermatology, University College Dublin, Dublin,  
Ireland, 5 Department of Dermatology, Hamad Medical Hospital, Weill Cornell University-Qatar, Doha, Qatar  
  
® These authors contributed equally to this work.  
\* xiehongfu1964 @aliyun.com  
  
Abstract  
  
Background  
  
Certain cosmetic habits may trigger or aggravate rosacea, while there is little published epi-  
demiologic evidence to support this point.  
  
Purpose  
  
To examine if daily skin care habits have an effect on the development of rosacea in Chi-  
nese population.  
  
Methods  
  
A multi-center retrospective case-control survey of 1,245 rosacea cases and 1,538 skin-  
healthy controls was conducted in China. Participants completed the questionnaire com-  
prised of demographic characteristics, socioeconomic data and daily skin care habits. Data  
were collected retrospectively and analyzed using the chi-square test and t-test. Multivariate  
logistic regression analyses were used to predict rosacea.  
  
Results  
  
The multivariate logistic regression analysis highlighted some results: Dry, oily or mixed skin  
(OR = 6.3-6.9, P< .001), the usage of foaming cleanser (OR = 1.45, 95%Cl 1.115—-1.886, P  
= .01), make up more than 6 times a week (OR = 2.839, 95%Cl 1.962—4.108, P< .001),  
using facial mask more than 4 times a week (OR = 2.56-3.069, P< .001), facial treatments  
at beauty salon more than once a week (OR = 4.946, 95%Cl 2.005—12.198, P =.0018) and  
using beauty salon products (OR = 2.334, 95%Cl 1.435-3.976, P= .0018) are positively cor-  
related with the development of rosacea. Using of moisturizing products (OR = 0.602, 95%  
Cl 0.386—0.983, P= .035) and sunscreen cream (OR = 0.303-0.507, P< .001 or P= .0167  
  
PLOS ONE | hittps://doi.org/10.1371/journal.pone.0231078 April27, 2020  
  
1/14  
PLOS ONE Certain skin care habits were associated with the development of rosacea  
  
Competing interests: The authors have declared for different frequency) presented significantly negative correlations with rosacea. Fre-  
  
that no competing interests exist. quency of cleansing showed a nonlinear association with rosacea: using facial cleansers  
1~3 times per week (OR = 0.647, 95%CI 0.429-0.975, P = .038) showed beneficial effects  
while using facial cleanser excessively (twice or more daily) (OR = 2.131, 95%Cl 1.394—  
3.256, P< .001) positively correlated to rosacea strongly.  
  
Conclusions  
  
Excessive use of facial cleanser (twice or more a day) and facial mask (more than 4 times a  
week), frequent makeup (more than 6 times a week), regular skin care in beauty salon  
(more than once a week), and using beauty salon products were closely correlated to the  
development of rosacea in Chinese population.  
  
Introduction  
  
Rosacea is a chronic inflammatory cutaneous disorder that displays a broad diversity of clinical  
manifestations including central facial erythema which worsens suddenly (flushing), papules  
and pustules, telangiectasias and hypersensitive symptoms such as itching, stinging, burning,  
etc.[1]. The current classification system for rosacea describes four distinct clinical subtypes  
based on the main clinical characters: erythematotelangiectatic rosacea(ETR), papulopustular  
rosacea(PPR), phymatous rosacea(PhR), and ocular rosacea[2].  
  
Previous studies have demonstrated that the disorders of the innate immune system, dys-  
function of facial vascular regulation, neurogenic inflammation, skin barrier destruction, and  
elevated levels of Demodex mites as risk factors of rosacea[3-8]. Considering the hypersensi-  
tivity and hyperactivity of the skin in rosacea patients, skin barrier destruction as a predispos-  
ing factor has attracted more and more attention in recent years[6, 9-14]. Fortunately, the  
destruction can be mitigated by suitable skin care practice[15]. Skin care is a part of the lifestyle  
that mainly includes skin cleansing, moisturizing, sun protection, and makeup as well[16, 17].  
Mild cleansing, moisturizing, and photo protecting were common suggestions of skin care for  
  
eople with rosacea[15]. However, it has been reported that some inappropriate skin care regi-  
mens and specific cosmetic formulations may trigger or aggravate rosacea[16, 18, 19]. During  
our clinic work, we also noticed that some skin care practice such as excessive facial cleansing  
and using products from beauty salons could trigger the flare-up of rosacea. On the other  
hand, patients with rosacea always tended to visit the beauty parlors more or preferred using  
facial masks. Previous studies have paid more attention to the therapeutic effect of skin care  
habits/products on rosacea[16, 20-23]. However, there is little published epidemiologic evi-  
  
dence to support the point that skin care habits may affect rosacea occurring. To examine if  
skin care practice people routinely followed really has protective or accelerating effects on  
rosacea attack, we conducted a questionnaire-based multi-center case-control survey in a large  
  
opulation in China. Confirming the linkage may aid the dermatologists in providing useful  
suggestions about skin care regimen to the public to facilitate the prevention and management  
of rosacea.  
  
Materials and methods  
Study design  
  
A retrospective case-control survey of 1,308 rosacea cases and 1,560 skin-healthy controls were  
conducted. All the patients were the first visit to the hospital and met the diagnostic criteria of  
  
PLOS ONE | hittps://doi.org/10.1371/journal.pone.0231078 April27, 2020 2/14  
PLOS ONE  
  
Certain skin care habits were associated with the development of rosacea  
  
rosacea based on the National Rosacea Society Expert Committee[24], and diagnosed indepen-  
dently by two board-certified dermatologists. Patients have other concurrent facial skin dis-  
eases such as acne, Systemic Lupus Erythematosus, eczema, seborrheic dermatitis, and those  
who have been accepting treatments were excluded. Age- and sex-matched controls were skin-  
healthy individuals from the medical examination center who had neither facial skin disease  
nor familial antecedents of rosacea. All the patients and the healthy controls provided written  
informed consent. Data were collected from 5 hospitals in 5 cities of China, including Xiangya  
Hospital of Central South University, the First People’s Hospital of Changde, the First People’s  
Hospital of Wuhan, Huashan Hospital of Fudan University and Dermatology Hospital of  
Guangzhou between June 2013 and March 2016. Participants who incompletely answered the  
questionnaire or healthy control with sensitive skin were excluded. The detailed protocol of  
this study was approved by the Institutional Review Board of the above five hospitals.  
  
Survey questionnaires  
  
A self-reported questionnaire mainly including the skin care habits was developed by dermato-  
logical experts according to related articles and combined with the skin care habits routinely  
followed by the Chinese. The sample of the questionnaire was provided in supporting informa-  
tion, which covered age, gender, education level (high school level or less; university or junior  
college level; master degree or above), monthly income (less than 1000RMB; 1000-2000RMB;  
2001-4000RMB, more than 4000RMB), and skin care habits in the previous two-year before  
the onset of rosacea for the patient group and in the past two years for the control group. The  
  
investigated skin habits included skin cleansing, moisturizing, sun protection, makeup, facial  
mask, beauty salon items, and the sources of skin care or cosmetic products. It was developed  
based on the four classic steps of skin care combined with some specific skin care habits,  
which showed a close association with the flare-up of rosacea during our clinic work. Standard  
trained interviewers completed the questionnaire-based survey. Skin type (normal, dry, oily,  
and mixed types) and medical records (main characteristics and subtypes of rosacea) were  
evaluated by a designed dermatologist. Given that there is no consensus on a standardized  
quantitative method to measure a reliable cutaneous sebum level, skin type of the participants  
were determined to oily, dry according to the clinical signs such as natural unctuosity, seba-  
  
ceous follicle dilatation and desquamation as the previous study did[25]. As the sebum release  
rate of the skin is variable among different anatomic locations of the facial skin and diverse cir-  
cumstances, a combination of a greasy T-zone and dry cheeks was considered as mixed skin;  
those without the evident feature of oily or dry were determined as neutral skin.  
  
Online Resource 1 The sample of the questionnaire.  
  
Statistical analysis  
  
Continuous variables were described using means and standard deviations, and the differences  
were tested using the Student t-test. Categorical variables were described using proportion,  
and differences were tested using the chi-square test for the univariate analysis. Multiple logis-  
tic regression analysis was used to estimate the effect size of risk / protective factors for rosacea.  
The p-value was adjusted by Bonferroni correction to decrease the risk of false-positive results.  
Odds ratio (OR) was used to indicate the effect size, and the 95% confidence interval (CI) of  
OR was estimated. For unordered categorical variables (skin type) as well as graded variable,  
OR for each category was estimated respectively. Interactions between significant factors iden-  
tified by logistic regression were further modeled. In subgroup analyses, samples were strati-  
fied by different skin types. Statistical analyses were performed in SPSS 19.0 (SPSS Inc.,  
  
PLOS ONE | hittps://doi.org/10.1371/journal.pone.0231078 April27, 2020 3/14  
PLOS ONE  
  
Certain skin care habits were associated with the development of rosacea  
  
Chicago, IL, USA). The significance level for all statistical tests was 0.05, and the hypothesis  
tests were 2-sided.  
  
Results  
Characteristics of the study population  
  
A total of 1,245 patients and 1538 controls with informed consent and completed question-  
naires were finally enrolled in the study. The major part (98%) of the study population was eth-  
nic Han Chinese. The demographic characteristics of the case and the control group were  
shown in Table 1. The mean education level of the case group was lower than the control  
group. There were no statistically differences in gender and income between the case and the  
control group.  
  
Effects of skincare habits on rosacea  
  
A total of 13 factors related to skin care behaviors were evaluated by comparing the rosacea  
group with the skin-healthy control group through the univariate analysis (Table 2), and the  
factors which significantly associated with rosacea were further evaluated for multivariate  
analysis.  
  
Sex, age, education level, income, and working place were adjusted with a multiple logistic  
regression model. The results were shown in Table 2. It produced some potential risk factors  
that were significantly correlated with rosacea (adjusted P<0.05): skin type (dry, oily, or  
mixed), the usage of foaming cleanser and anti-allergy products, using facial mask frequently  
(more than 4 times a week), make up more than 6 times a week, using beauty salon products,  
frequent facial treatments at beauty salon (more than once a week), and accepting oil-control  
projects in beauty salon. Frequency of cleansing showed a nonlinear association with rosacea:  
compared with people hardly use facial cleanser, those who used facial cleansers 1~3 times per  
  
Table 1. Comparisons of demographic characteristics between the case and control groups.  
  
Characteristic Rosacea Cases n (%) Controls n (%) p value  
Gender  
Male 121(9.7) 150(9.8) 0.976  
Female 1124(90.3) 1388(90.2)  
Age, y 33.3 + 10.8 29.549.4 <0.001  
Education level  
High school level or less 549(43.8) 331(21.5) <0.001  
University or junior college 653(52.1) 846(55)  
Master degree or above 52(4.1) 361(23.5)  
Personal monthly income  
<1,000 Yuan 341(27.2) 245(15.9) 0.368  
1,000-2,000 Yuan 110(8.8) 529(34.4)  
2001-4000 Yuan 295(23.5) 284(18.5)  
>4000 Yuan 508(40.5) 480(31.2)  
Working place  
Outdoor 121(9.7) 117(7.6) 0.048  
Indoor 1124(90.3) 1421(92.4)  
(N = 2783).  
  
https://doi.org/10.1371/journal.pone.0231078.t001  
  
PLOS ONE | https://doi.org/10.1371/journal.pone.0231078 April 27,2020 4/14  
PLOS ONE  
  
Certain skin care habits were associated with the development of rosacea  
  
Table 2. Comparisons of skin care habits between the case and control groups.  
  
Rosacea N(%) Control N(%) p-value  
Skin type Neutral 110 (8.8) 529 (34.4) <0.001  
Dry 339 (27.2) 244 (15.9)  
Oily 292 (23.5) 284 (18.5)  
Mixed 504 (40.5) 481 (31.3)  
Skin care frequency Hardly 241 (19.4) 279 (18.1) <0.001  
1/ day 220 (17.7) 365 (23.7)  
2/ day 757 (60.8) 828 (53.8)  
>3/ day 27 (2.2) 66 (4.3)  
Function of skin care products Moisturizing 884 (71.0) 1162 (75.6) 0.007  
Whitening 261 (21.0) 368 (23.9) 0.063  
Antiaging 125 (10.0) 195 (12.7) 0.030  
Oil-control 254 (20.4) 236 (15.3) <0.001  
Antiallergy 200 (16.1) 169 (11) <0.001  
Ways of buying products Shopping mall/pharmacy 783 (62.9) 925 (60.1) 0.139  
Salon 140 (11.2) 72 (4.7) <0.001  
Online 142 (11.4) 348 (22.6) <0.001  
Self-made 24 (1.9) 23(1.5) 0.379  
Direct selling 92 (8) 182 (11.8) <0.001  
Cleansing frequency Hardly 369 (29.6) 411 (26.7) <0.001  
1~3 / week 143 (11.5) 357 (23.2)  
1/ day 429 (34.5) 582 (37.8)  
>2/ day 304 (24.4) 188 (12.2)  
Type of cleansers Soap 49 (3.9) 106 (6.9) 0.001  
Foam 497 (39.9) 516 (33.6) 0.001  
Emulsion 216 (17.4) 248 (16.1) 0.389  
Exfoliator 241 (19.4) 285 (18.5) 0.580  
Facial mask frequency Hardly 589 (47.3) 775 (50.4) <0.001  
1/ week 191 (15.3) 377 (24.5)  
2~3 / week 259 (20.8) 261 (17.0)  
4~5/ week 83 (6.7) 37 (2.4)  
> 6/week 123(9.9) 88 (5.7)  
Beauty salon frequency Hardly 944 (75.8) 1289 (83.8) <0.001  
<2/ month 156 (12.5) 197 (12.8)  
3~4/ month 76 (6.1) 40 (2.6)  
>1/ week 69 (5.6) 12 (0.8)  
Type of skin care in the salon Moisturizing 224 (18.0) 155 (10.1) <0.001  
Whitening 40 (3.2) 68 (4.4) 0.101  
Antiaging 18 (1.4) 49 (3.2) 0.003  
Oil-control 65 (5.2) 30 (2.0) <0.001  
Antiallergy 50 (4.0) 31 (2.0) 0.002  
Exfoliator 25 (2.0) 16 (1.0) 0.035  
Other 14(1.1) 4(0.3) 0.005  
Make-up frequency Hardly 786 (63.1) 988 (64.2) <0.001  
1~2/ week 64 (5.1) 211 (13.7)  
3~5 / week 135 (10.8) 201 (13.1)  
> 6/ week 260 (20.9) 140 (9.1)  
Use foundation products No 812 (65.2) 1042 (67.7) 0.182  
(Continued)  
  
PLOS ONE | https://doi.org/10.1371/journal.pone.0231078 April 27,2020  
  
5/14  
PLOS ONE  
  
Certain skin care habits were associated with the development of rosacea  
  
Table 2. (Continued)  
  
Rosacea N(%) Control N(%) p-value  
  
Yes 433 (34.8) 498 (32.4)  
  
Use make-up remover after making up No 930 (74.7) 1118 (72.7) 0.232  
Yes 315 (25.3) 420 (27.3)  
  
Sunscreen cream frequency Hardly 880 (70.7) 848 (55.1) <0.001  
1~2 / week 125 (10.0) 247 (16.1)  
3~5 / week 67 (5.4) 116 (7.5)  
> 6/ week 173 (13.9) 327 (21.3)  
  
https://doi.org/10.1371/journal.pone.0231078.t002  
  
week were negatively correlated with rosacea (OR = 0.647, 95%CI 0.429-0.975, P = .038); in  
contrast, those used facial cleansers excessively (twice or more daily) were closely related to  
rosacea with an OR of 2.5 (OR = 0.647, 95%CI 0.429-0.975, P = .038). Significant protective  
effects were found for applying moisturizing products and sunscreen cream, using anti-aging  
products, and using skin care products purchased through direct selling or online shopping.  
  
When considering skin type, we found the associations of excessive cleansing (applying  
facial cleansers twice or more daily) and frequent make up (almost every day) with rosacea  
were more distinct in those with dry or mixed skin and the OR values were the highest for dry  
skin. On the other hand, the beneficial effects of using moisturizing cream were only signifi-  
cant for those with dry skin, but insignificant for those with other skin types. Using sunscreen  
cream was the only factor that showed significant for all skin types (Table 3).  
  
Among the 1245 patients with rosacea, there were 680 cases of ETR, 451 cases of PPR, 107  
cases of PhR, and 7 cases of ocular rosacea. The distribution of the subtypes of ETR, PPR, PhR  
among rosacea patients with each possible high-risk factor was shown in Fig 1. Compared  
  
with the whole constituent ratio of the total patients, the relative proportion of ETR among  
patients with dry skin, patients using anti-allergy products or beauty salon products, and  
patients using facial mask or going beauty salon frequently were much higher; PPR accounted  
for a relatively higher proportion in patients with oily skin, and patients using facial cleanser  
frequently or doing oil-control skin care in beauty salon; the relative proportion of PhR in  
patients with oily skin was the highest among that in patients with other factors.  
  
Interactive effects  
  
Among significant factors identified by logistic regression, several pairs of potential interac-  
tions were considered. The previous risk effects of using foaming cleanser turned beneficial  
when it interacted with using moisturizers (OR = 0.298, 95% CI 0.16-0.557; P< .001). Simi-  
larly, the association of using facial masks (more than 4 times a week) with rosacea became  
insignificant when considering the interaction between using facial masks and purchasing  
skincare products from shopping mall/pharmacy.  
  
Discussion  
  
In the current study, we investigated the skin care habits before the onset of the disease in rosa-  
cea patients with different skin types and found some skincare behaviors were closely associ-  
ated with the development of rosacea in Chinese population. As far as we know, this is the first  
study to investigate the relationship between skin care habits and rosacea occurring.  
  
The oily or dry nature of skin is an essential consideration for skin care. Our results showed  
a close association of dry, oily, and mixed skin type with rosacea. A predominant oily skin  
always means abundant sebaceous secretion and high sebum casual levels. As rosacea’s  
  
PLOS ONE | hittps://doi.org/10.1371/journal.pone.0231078 April27, 2020 6/14  
PLOS ONE Certain skin care habits were associated with the development of rosacea  
  
Table 3. Associations of rosacea with skin care behaviors and subgroup analyses.  
  
Total patients Neutral skin Dry skin Oily skin Mixed skin  
OR (95%CI) | P (adjusted P\*)| OR (95%CI) P OR (95%CI) P OR (95%CI) P | OR(95%CI) P  
Skin type  
Neutral 1  
Dry 6.751 (4.606- <0.001 N/A N/A N/A N/A  
9.895) (<0.001)  
Oily 6.109 (4.153- <0.001 N/A N/A N/A N/A  
8.986) (<0.001)  
Mixed 6.624 (4.629- <0.001 N/A N/A N/A N/A  
9.480) (<0.001)  
Skin care frequency  
Hardly 1 1 1 1  
1/day 0.982 (0.567- 0.947 (0.947) N/AP 23.417 (1.664- | 0.019 0.548 (0.191- 0.264 | 1.360 (0.518- | 0.533  
17) 329.48) 1.573) 3.572)  
2/ day 1.841 (1.052- 0.032 (0.043) N/AP 27.225 (1.915- 0.015 1.825 (0.63- 0.268 | 2.303 (0.839- | 0.105  
3.221) 387.025) 5.289) 6.319)  
>3/day 0.492 (0.202- 0.117 (0.138) N/AP 32.103 (1.571- | 0.024 0.780 (0.128- 0.787 | 0.234 (0.045- | 0.084  
1.194) 656) 4.737) 1.218)  
Function of skin care products  
Moisturizing | 0.602 (0.386- 0.025 (0.035) N/AP 0.019 (0.002- 0.002 0.631 (0.284- 0.257 | 0.674 (0.322- | 0.295  
0.938) 0.237) 1.399) 1.41)  
Anti-aging 0.607 (0.396- 0.022 (0.032) 0.817 (0.206- 0.773 | 0.803 (0.265-2.44) | 0.699 0.325 (0.092- 0.080 | 0.569 (0.292- | 0.098  
0.929) 3.237) 1.142) 1.109)  
Anti-allergy 1.902 (1.297- 0.001 (0.002) 1.359 (0.338- 0.666 1.479 (0.477- 0.498 1.880 (0.801- 0.147 | 2.537 (1.417- | 0.002  
2.788) 5.458) 4.585) 4.41) 4.534)  
Ways of buying products  
Salon 2.334 (1.435- 0.001 (0.002) 6.250 (1.589- 0.009 4.437 (1.497- 0.007 0.825 (0.168- 0.813 | 2.222 (1.016- | 0.046  
3.796) 24.585) 13.151) 4.056) 4.86)  
Online 0.551 (0.391- 0.001 (0.002) 0.278 (0.074- 0.058 0.231 (0.074- 0.012 0.408 (0.179- | 0.032 0.821 (0.5- 0.435  
0.777) 1.043) 0.724) 0.927) 1.347)  
Direct 0.516 (0.339- 0.002 (0.003) 0.457 (0.118- 0.257 0.636 (0.239- 0.365 0.237 (0.083- | 0.007 0.621 (0.302- | 0.195  
selling 0.785) 1.771) 1.692) 0.677) 1.274)  
Cleansing frequency  
Hardly 1 1 1 1 1  
1~3 / week 0.647 (0.429- 0.038 (0.049) 0.240 (0.058- .049 0.576 (0.204— 0.298 0.361 (0.148- | 0.025 0.887 (0.445- | 0.733  
0.975) 0.996) 1.626) 0.882) 1.768)  
1/day 1.117 (0.783- 0.542 (0.556) | 1.358 (0.443-4.16) | 592 1.684 (0.721- 0.228 0.706 (0.328- 0.374 | 1.023 (0.553- | 0.942  
1.592) 3.932) 1.52) 1.895)  
>2/ day 2.131 (1.394- <0.001 2.472 (0.682- 168 3.103 (1.110- 0.031 1.493 (0.617- 0.374 | 2.308 (1.102- | 0.027  
3.256) (<0.001) 8.956) 8.677) 3.614) 4.835)  
Type of cleansers  
Foam 1.450 (1.115- 0.006 (0.01) | 3.752 (1.54-9.142) | 0.004 | 0.918 (0.457-1.84) | 0.809 2.255 (1.221- | 0.009 1.12 (0.741- 0.59  
1.886) 4.164) 1.692)  
Facial mask frequency  
Hardly 1 1 1 1 1  
1/ week 0.874 (0.62- 0.440 (0.477) 1.166 (0.4-3.396) | 0.779 | 0.977 (0.4-2.388) | 0.959 1.153 (0.528- 0.721 0.675 (0.387- | 0.165  
1.231) 2.514) 1.176)  
2~3 / week 1.460 (1.016- 0.041 (0.051) | 0.494 (0.131-1.86) | 0.297 1.733 (0.699- 0.235 2.267 (0.944- 0.067 | 1.504 (0.865- | 0.148  
2.096) 4.298) 5.447) 2.615)  
4~5/ week 3.069 (1.636- <0.001 4.161 (0.528- 0.176 23.001 (1.338- | 0.031 10.250 (2.567- | 0.001 1.644 (0.648- | 0.295  
5.757) (<0.001) 32.777) 395.484) 40.926) 4.17)  
> 6/week 2.560 (1.561- <0.001 2.726 (0.458- 0.271 6.826 (1.774- 0.005 2.572 (0.804— 0.111 1.968 (0.93- 0.077  
4.198) (<0.001) 16.231) 26.263) 8.223) 4.166)  
(Continued)  
  
PLOS ONE | https://doi.org/10.1371/journal.pone.0231078 April 27,2020 7/14  
PLOS ONE  
  
Certain skin care habits were associated with the development of rosacea  
  
Table 3. (Continued)  
  
Total patients Neutral skin Dry skin Oily skin Mixed skin  
OR (95%CI) | P (adjusted P\*)| OR (95%CI) P OR (95%CI) P OR (95%CI) P | OR(95%CI) P  
Beauty salon frequency  
Hardly 1 1 1 1 1  
<2/month 0.779 (0.532- 0.201 (0.231) 1.110 (0.322- 0.869 0.751 516 0.481 (0.158- 0.199 | 0.731 (0.407- | .292  
1.142) 3.823) (0.317-1.781) 1.467) 1.31)  
3~4/ month 1.929 (0.989- 0.054 (0.066) 0.523 (0.056- 0.569 1.025 (0.172- 978 4.091 (0.474- 0.200 | 3.454 (1.256- | 0.016  
3.763) 4.865) 6.098) 35.342) 9.5)  
> 1/ week 4.946 (2.005- 0.001 (0.002) 25.757 (1.902- | 0.015 5.502 (0.536- 51 4.657 (0.442- 0.200 | 2.703 (0.638- | .177  
12.198) 348.864) 56.471) 49.076) 11.452)  
Type of skin care in salon  
Anti-aging 0.199 (0.077- 0.001 (0.002) N/AP 0.368 (0.04-3.419) | 0.380 0.081 (0.009- .027 0.229 (0.048- | .063  
0.514) 0.751) 1.082)  
Oil-control 2.554 (1.241- 0.011 (0.017) 2.510 (0.114- 0.56 7.866 0.189 7.149 (1.209- 030 1.911 (1.692- | .211  
5.256) 55.432) (0.361-171.275) 42.273) 5.278)  
Frequency of make up  
Hardly 1 1 1 1 1  
1~2/ week 0.813 (0.501- 0.403 (0.45) 0.320 (0.042- 0.273 0.914 (0.297- 876 0.613 (0.181- 432 0.874 (0.425- | .0714  
1.32) 2.451) 2.818) 2.077) 1.796)  
3~5/ week 1.193 (0.718- 0.495 (0.522) 1.027 (0.217- 0.974 0.159 (0.022- 072 0.585 (0.155- A429 2.520 (1.221- | 0.012  
1.938) 4.861) 1.179) 2.207) 5.199)  
> 6/ week 2.839 (1.962- <0.001 2.422 (0.723- 0.152 5.200 (2.073- <0.001 1.331 (0.552- 524 3.015 (1.651- | <0.001  
4.018) (<0.001) 8.114) 13.048) 3.208) 5.508)  
Frequency of using sunscreen cream  
Hardly 1 1 1 1 1  
1~2/ week 0.507 (0.353- <0.001 0.235 (0.044- 090 0.712 (0.303- 0.436 0.622 (0.277- 0.249 | 0.297 (0.165- | <0.001  
0.727) (<0.001) 1.253) 1.673) 1.394) 0.534)  
3~5/ week 0.533 (0.328- 0.011 (0.017) 0.067 (0.008- 1015 | 0.842 (0.257-2.76) | 0.776 0.229 (0.057- | 0.038 0.498 (0.241- | 0.060  
0.867) 0.595) 0.922) 1.03)  
> 6/ week 0.303 (0.209- <0.001 0.343 (0.097-1.21) | .096 0.232 (0.085- 0.004 0.391 (0.163- | 0.035 0.252 (0.144- | <0.001  
0.44) (<0.001) 0.632) 0.934) 0.442)  
  
“The p-value was adjusted by Bonferroni correction.  
  
> The number of these cases was so small that not fit for calculating the OR value.  
  
https://doi.org/10.1371/journal.pone.0231078.t003  
  
predilection for sebaceous  
  
locations, and the efficacy of oral isotretinoin by the mechanism of  
  
reducing sebaceous gland size and decreasing sebum production, it is easy to consider rosacea  
to occur more easily on oily skin. Previous studies also have established that the sebum secre-  
tion and sebaceous lipids of the oily skin played an important role in the activation of the  
immunity mechanism[4, 26]. We also have demonstrated previously that rosacea patients with  
lesions mainly on the nose had higher oil content on the nasal skin[11], which could explain  
the higher proportion of PhR in patients with oily skin. Besides, Demodex infestation, a  
known aggravating factor of inflammation in rosacea, is common in more seborrheic skin[25,  
27], which may also contribute to the close relationship of oily skin with rosacea. Unexpect-  
edly, patients with rosacea frequently complain of dryness and tight feeling rather than greasy  
skin. Previous studies have demonstrated that patients with rosacea had reduced skin surface  
hydration levels and abnormal sebum composition because of the dysfunctions of skin barrier  
[11, 13], which might be the main reason for the positive correlation of dry skin with rosacea.  
Similarly, despite a relatively lower risk, patients with dry skin were also more likely to be  
infested with Demodex [27]. Another result we found was that the cases of ETR were the larg-  
est in patients with dry skin. It would be interesting to investigate the clinical features of  
  
PLOS ONE | https://doi.org/10.1371/journal.pone.0231078 April 27,2020 8/14  
PLOS ONE Certain skin care habits were associated with the development of rosacea  
  
‘Total patents ey skin Newval yee ay skin ied skin ‘Antalrgy preducts Facial cleansing Foaming cleanser ving facial mask make up Facial veatment at salon Beauty salon products Cliconto skin caren  
(eo or more aay) (oretnan times a (more han mesa (more than orcwa week) beauty salon  
woot) week)  
  
SETR SPPR &PhR  
  
Fig 1. The proportion of the subtypes of ETR, PPR, PhR in groups of rosacea patients with different high-risk factors. ETR was the most dominant subtype in the  
group of patients using anti-allergy products, PPR accounted for the relative highest proportion in the group of patients doing oil-control skin care in the beauty salon,  
and the relative proportion of PhR in the group of patients with oily skin was the highest.  
  
https://doi.org/10.1371/journal.pone.0231078.g001  
  
different skin types. Based on our results, as dry, oily, and mixed skin were all related to rosa-  
cea we concluded that the occurrence of rosacea might not be necessarily linked to a skin type,  
but is closely related to the imbalance of hydration and sebum level of the skin. Thus it was  
particularly vital to recommend a daily moisturizing routine and sebum-modifying treatments  
as adjuvant therapy or prevention for this disorder.  
  
Skin cleansing is the first step of general skin care. In our multivariate analysis, excessive  
cleansing (using facial cleansers twice or more a day) and the usage of foaming cleanser were  
closely related to rosacea occurring among Chinese population. Excessive cleansing may cause  
mechanical damage to the tightly arranged stratum corneum of the epidermis, and bring  
chemical irritation to the water and lipid-coated membrane of the skin, which will alter the  
normal pH of our skin[20]. Notably, we found that the proportion of PPR was the highest in  
patients who have a situation of excessive cleansing, but the reason was so far unknown. Foam-  
ing cleansers often contained special surfactants and showed excellent foaming and lathering  
characteristics, but they may strip natural moisturizing factors from the skin or protective lip-  
ids and proteins from the stratum corneum[18], leading to after-wash tightness, dryness and  
barrier damage. Excessive cleansing and deep cleansing foam might give adverse effects to  
rosacea by aggravating skin barrier destruction. Although the standard recommendation of  
facial cleansing for rosacea was to wash the face twice daily[28], based on our results, use facial  
cleanser less than two times a day would be safer, especially for those with dry skin, as the asso-  
ciation was the most distinct. What is more, the foaming cleanser should be avoided.  
  
Moisturizers are the most effective products to maintain and restore the skin barrier[29].  
Using moisturizing products showed beneficial effects on rosacea, and the effect was most dis-  
tinct for dry skin individuals. Also, it could weaken the association of using foaming cleanser  
with rosacea based on the results of interactive effects. Previous researches have shown mois-  
turizing cream could repair epidermal barrier dysfunction by improving the water content of  
the skin, reducing the damage to stratum corneum proteins, and maintaining the epidermal  
lipids, contributing to the patients with rosacea and alleviating the skin barrier dysfunction[21,  
30, 31]. Nowadays, bioactive ingredients with different mechanisms are added to the cosmetics  
to endow them with additional oil-control, anti-aging, brightening, or anti-allergic properties,  
  
PLOS ONE | https://doi.org/10.1371/journal.pone.0231078 April 27,2020 9/14  
PLOS ONE  
  
Certain skin care habits were associated with the development of rosacea  
  
including exfoliants, natural and herbal ingredients, different kinds of vitamins, proteins, min-  
erals, and other materials[32]. Some of the bioactive ingredients, such as green tea, could dis-  
play anti-inflammatory or antioxidant activity, thus were considered beneficial for  
inflammatory skin disorders, including rosacea[33]. But the combination of different catego-  
ries of ingredients would increase the possibility of skin sensitization and aggravate skin bar-  
rier destruction. Our study showed a higher frequency of previously using anti-allergy  
products in rosacea patients. That might be a result of the disease, as patients with rosacea  
often suffered sensitive symptoms before the onset of the disease (commonly-termed “pre-  
rosacea” or “early-onset rosacea”) [3], and they might seek anti-allergy products to relieve the  
symptom. The high proportion of ETR among the patients using anti-allergy products might  
be explained by the close relationship of this subtype with the skin barrier. For those products  
  
claiming anti-aging, oil-control, or brightening properties, there was no evidence to support  
that they had positive relationships with rosacea in our study, but doing oil-control skincare in  
the beauty salon seemed to relate to rosacea closely. It has been reported that salicylic acid and  
astringent compounds for the sebum-regulating purpose would cause dryness, skin irritation  
and barrier dysfunction[28]. Therefore, for better prevention and management of symptoms  
of rosacea, multi-bioactive ingredients and complicated properties were not recommended.  
The skin care regimen should be as simple as possible, choosing moisturizers without fra-  
grance, antiseptics, and surfactants, just as previous paper suggested[28].  
  
Strict sun protection is strongly recommended to prevent UV-induced rosacea, as UV irra-  
diation is widely acknowledged as triggers for flushing events[7]. We proved the use of sun-  
screen cream to be a beneficial factor for rosacea as expected, and the effect was significant for  
all skin types. Notably, other studies have proposed that due to the possible irritants or aller-  
gens contained in the sunscreen cream, the irritancy of sunscreen products were easy to occur  
[34, 35]. Therefore, daily use of sunscreen cream is necessary, but preference should be given  
to very high tolerance sunscreen products, such as physical sun-blocking creams[28], with  
simple formulations that contain the smallest possible number of ingredients.  
  
Makeup has been considered to increase the frequency of sensitization because of the min-  
eral oil added in cosmetics. Also, because the thick and occlusive characters contained in cos-  
metic products were difficult to remove, excessive cleansing was inevitable. In our study, we  
found frequent makeup (almost every day) had a close relationship with the development of  
rosacea, and the effect was most distinct for people with dry skin. However, this did not mean  
  
that makeup should be avoided. Makeup in moderation and use of found  
  
ation products and  
  
make-up remover were proved not to increase the risk of rosacea in our study. Corrective  
  
makeup and using foundation products can improve skin tone, even skin color, and cover red-  
  
ness, hence increasing the self-confidence of the individuals and exerting  
effects, thereby bringing benefits on rosacea[36]. Considering the facial s  
  
decompressing  
in of rosacea is  
  
always appearance-impaired, foundation products such as green-tinted makeup can be recom-  
  
mended to relieve the cosmetic symptoms of rosacea or other skin disorders[36].  
  
In addition to the everyday skin care habits of using cleansers, moisturizers, and sunscreen  
  
products, we found some additional factors that may be associated with t!  
  
he development of  
  
rosacea in the Chinese patients. These factors included frequent use of facial masks, regularly  
  
visiting a beauty salon, and using beauty salon products. Applying a facia  
  
mask is very preva-  
  
lent because of its instant hydrating function, covering nearly 50% of the participants in the  
  
current study. It is expected that the applied mask would moisturize the skin properly and  
  
deeply, remove the sebum, and rejuvenate the skin. Interestingly, it was proved to be no bene-  
  
fits but associated with the development of rosacea in our study. Althoug!  
  
h there were concerns  
  
about the safety of facial masks, for example, the different artificial fragrances and dyes, para-  
  
bens, and phthalate esters used for masks could be harmful to the skin, and the number of  
  
PLOS ONE | hittps://doi.org/10.1371/journal.pone.0231078 April27, 2020  
  
10/14  
PLOS ONE  
  
Certain skin care habits were associated with the development of rosacea  
  
bacteria on the surface skin might be increased when applying a mask, there was no evidence  
about the association of using facial masks with rosacea at present. Based on our results of the  
interaction effect, the association turned insignificant when facial mask interacted with pur-  
chasing cosmetics from shopping mall/pharmacy. Thus we inferred the positive correlation  
might be explained by the current non-standard cosmetic market and the inadequate supervi-  
sion of cosmetic manufacturing in our country, that many unqualified and unregulated skin  
care products escape into the marketplace. According to the National Food and Drug Admin-  
istration website of China, from 2016 to 2018, glucocorticoids were illegally added to many  
batches of cosmetic products. Notably, the abuse of glucocorticoid was particularly prevalent  
in facial masks and beauty salon products for short-term commercial effects[37, 38]. It has well  
accepted that dilation of blood vessels, red spots, and thinning of the facial skin like the feature  
of ETR would take place in the process of long-term use of glucocorticoid[38]. Therefore, if  
the source and the contents of skin care products are unreliable, the more frequent and more  
  
regular skin care people do, the more likely they will suffer skin barrier damage and even  
  
attack steroid-induced rosacea. That could also explain the relatively high proportion of ETR  
among the patients using facial masks or beauty salon products, and patients going beauty  
salons frequently. Based on these results, choosing safe and reliable steroid-sparing products is  
a crucial precondition for skin care.  
  
In this investigation, we found a lower level of education in rosacea patients, which was  
consistent with the results of our previous study[39]. Lower education means less knowledge  
of avoiding trigger factors, so they are more likely to suffer a flare-up of rosacea. Suffering rosa-  
cea might affect the work productivity of the patients and then influence the income levels  
more or less[40], but there were multiple factors influencing income, so we did not found a  
significant correlation of income levels with rosacea based on the multiple logistic regression.  
  
Limitations  
  
As the preliminary reports, our study has limitations in terms of the area and size of the survey.  
First, participants did not cover the whole Chinese population. Secondly, the present study  
was a retrospective case-control research, so the strength of cause and effect linkage was not  
strong enough. However, our study may be the first epidemiologic study showing skin care  
habits and their correlation with rosacea, and is valuable for establishing skincare guidelines  
for rosacea, but a well-designed prospective study is needed.  
  
Conclusions  
  
Poor skin care habits, including excessive use of facial cleanser (twice or more a day) and  
  
everyday makeup (more than 6 times a week) were correlated closely to the development of  
rosacea. Using mild moisturizers and sunscreen cream presented beneficial effects on rosacea.  
Mild cleansing (using facial cleanser less than two times a day and avoiding foaming cleanser)  
and choosing safe and qualified products are crucial for the prevention of rosacea. If makeup  
is necessary, simple medical make-up with foundation products should be recommended to  
minimize the risk to attack rosacea.  
  
Supporting information  
  
S1 Data. Questionnaire.  
(DOCX)  
  
$1 File. Rosacea work data.  
(SAV)  
  
PLOS ONE | hittps://doi.org/10.1371/journal.pone.0231078 April27, 2020 11/14  
PLOS ONE  
  
Certain skin care habits were associated with the development of rosacea  
  
Acknowledgments  
  
We want to acknowledge the guidance of Professor Minxue Shen in the statistical work of this  
  
manuscript.  
  
Author Contributions  
  
Conceptualization: Hong-fu Xie.  
  
Data curation: Zhi-xiang Zhao, Yu-xuan Deng.  
  
Formal analysis: Ying-xue Huang.  
  
Investigation: Zhi-xiang Zhao, Bo-lan Zheng.  
  
Methodology: Zhi-xiang Zhao, Bo-lan Zheng.  
  
Project administration: Ji Li.  
  
Resources: Wei Shi.  
  
Supervision: Hong-fu Xie.  
  
Writing - original draft: Ying-xue Huang.  
  
Writing - review & editing: Ji Li, Martin Steinhoff.  
  
References  
  
1.  
  
10.  
  
11.  
  
Steinhoff M, Schmelz M, Schauber J. Facial Erythema of Rosacea—Aetiology, Different Pathophysiolo-  
gies and Treatment Options. Acta Derm Venereol. 2016; 96:579-586. hitps://doi.org/10.2340/  
00015555-2335 PMID: 26714888  
  
Wilkin J, Dahl M, Detmar M, Drake L, Feinstein A, Odom R, et al. Standard classification of rosacea:  
Report of the National Rosacea Society Expert Committee on the Classification and Staging of Rosa-  
cea. J Am Acad Dermatol. 2002; 46:584—587. https://doi.org/10.1067/mjd.2002. 120625 PMID:  
11907512  
  
Abram K, Silm H, Maaroos HI, Oona M. Risk factors associated with rosacea. J Eur Acad Dermatol  
Venereol. 2010; 24:565-571. https://doi.org/10.1111/j.1468-3083.2009.03472.x PMID: 19874433  
  
Steinhoff M, Buddenkotte J, Aubert J, Sulk M, Novak P, Schwab VD, et al. Clinical, cellular, and molecu-  
lar aspects in the pathophysiology of rosacea. J Investig Dermatol Symp Proc. 2011; 15:2-11. https://  
doi.org/10.1038/jidsymp.2011.7 PMID: 22076321  
  
Crawford GH, Pelle MT, James WD. Rosacea: I. Etiology, pathogenesis, and subtype classification. J  
Am Acad Dermatol. 2004; 51:327-341; quiz 342-324. https://doi.org/10.1016/j.jaad.2004.03.030  
PMID: 15337973  
  
Addor FA. Skin barrier in rosacea. An Bras Dermatol. 2016; 91:59-63. https://doi.org/10.1590/  
abd1806-4841.20163541 PMID: 26982780  
  
Del Rosso JQ, Thiboutot D, Gallo R, Webster G, Tanghetti E, Eichenfield L, et al. Consensus recom-  
mendations from the American Acne & Rosacea Society on the management of rosacea, part 1: a sta-  
tus report on the disease state, general measures, and adjunctive skin care. Cutis. 2013; 92:234-240.  
PMID: 24343208  
  
Li Y, Xie H, Deng Z, Wang B, Tang Y, Zhao Z, et al. Tranexamic acid ameliorates rosacea symptoms  
through regulating immune response and angiogenesis. Int Immunopharmacol. 2019; 67:326-334.  
https://doi.org/10.1016/j.intimp.2018.12.031 PMID: 30578968  
  
Lee SH, Jeong SK, Ahn SK. An update of the defensive barrier function of skin. Yonsei Med J. 2006;  
47:293-306. https://doi.org/10.3349/ymj.2006.47.3.293 PMID: 16807977  
  
Ramos-e-Silva M, Jacques C. Epidermal barrier function and systemic diseases. Clin Dermatol. 2012;  
30:277-279. https://doi.org/10.1016/j.clindermatol.201 1.08.025 PMID: 22507041  
  
Xie HF, Huang YX, He L, Yang S, Deng YX, Jian D, et al. An observational descriptive survey of rosa-  
cea in the Chinese population: clinical features based on the affected locations. PeerJ. 2017; 5:e3527.  
https://doi.org/10.7717/peerj.3527 PMID: 28698821  
  
PLOS ONE | hittps://doi.org/10.1371/journal.pone.0231078 April27, 2020 12/14  
PLOS ONE  
  
Certain skin care habits were associated with the development of rosacea  
  
12.  
  
13.  
  
14.  
  
15.  
  
16.  
  
17.  
  
18.  
  
19.  
  
20.  
  
21.  
  
22.  
  
23.  
  
24.  
  
25.  
  
26.  
  
27.  
  
28.  
  
29.  
  
30.  
  
31.  
  
32.  
  
33.  
  
34.  
  
35.  
  
Dirschka T, Tronnier H, Folster-Holst R. Epithelial barrier function and atopic diathesis in rosacea and  
perioral dermatitis. Br J Dermatol. 2004; 150:1136—1 141. https://doi.org/10.1111/j.1365-2133.2004.  
05985.x PMID: 15214900  
  
Ni Raghallaigh S, Bender K, Lacey N, Brennan L, Powell FC. The fatty acid profile of the skin surface  
lipid layer in papulopustular rosacea. Br J Dermatol. 2012; 166:279-287. https://doi.org/10.1111/.1365-  
2133.2011.10662.x PMID: 21967555  
  
Deng Z, Chen M, Xie H, Jian D, Xu S, Peng Q, et al. Claudin reduction may relate to an impaired skin  
barrier in rosacea. J Dermatol. 2019; 46:314-321. https://doi.org/10.1111/1346-8138.14792 PMID:  
30714633  
  
Draelos ZD. New treatments for restoring impaired epidermal barrier permeability: skin barrier repair  
creams. Clin Dermatol. 2012; 30:345-348. https://doi.org/10.1016/j.clindermatol.2011.08.018 PMID:  
22507050  
  
Zip C. The Role of Skin Care in Optimizing Treatment of Acne and Rosacea. Skin Therapy Lett. 2017;  
22:5-7.  
  
Mansouri Y, Goldenberg G. Devices and topical agents for rosacea management. Cutis. 2014; 94:21—  
25. PMID: 25101340  
  
Levin J, Miller R. A Guide to the Ingredients and Potential Benefits of Over-the-Counter Cleansers and  
Moisturizers for Rosacea Patients. J Clin Aesthet Dermatol. 2011; 4:31-49.  
  
Society NR. Rosacea Triggers Survey 2017 [cited 2017 05/12]. Available from: http://www.rosacea.org/  
patients/materials/triggersgraph.php.  
  
Del Rosso JQ. Adjunctive skin care in the management of rosacea: cleansers, moisturizers, and photo-  
protectants. Cutis. 2005; 75:17-21; discussion 33-16.  
  
Loden M. Role of topical emollients and moisturizers in the treatment of dry skin barrier disorders. Am J  
Clin Dermatol. 2003; 4:771-788. https://doi.org/10.2165/0012807 1-2003041 10-00005 PMID:  
14572299  
  
Lanoue J, Goldenberg G. Therapies to improve the cosmetic symptoms of rosacea. Cutis. 2015; 96:19—  
26. PMID: 26244351  
  
Loden M. Effect of moisturizers on epidermal barrier function. Clin Dermatol. 2012; 30:286-296. https://  
doi.org/10.1016/j.clindermatol.2011.08.015 PMID: 22507043  
  
Wilkin J, Dahl M, Detmar M, Drake L, Liang MH, Odom R, et al. Standard grading system for rosacea:  
report of the National Rosacea Society Expert Committee on the classification and staging of rosacea. J  
Am Acad Dermatol. 2004; 50:907-912. https://doi.org/10.1016/j.jaad.2004.01.048 PMID: 15153893  
  
Porta Guardia CA. Demodex folliculorum: its association with oily skin surface rather than rosacea  
lesions. Int J Dermatol. 2015; 54:e14—17. https://doi.org/10.111 1/ijjd.12398 PMID: 24898344  
  
Shi VY, Leo M, Hassoun L, Chahal DS, Maibach HI, Sivamani RK. Role of sebaceous glands in inflam-  
matory dermatoses. J Am Acad Dermatol. 2015; 73:856-863. https://doi.org/10.1016/j.jaad.2015.08.  
015 PMID: 26386632  
  
Zhao YE, Peng Y, Wang XL, Wu LP, WangM, Yan HL, et al. Facial dermatosis associated with Demo-  
dex: a case-control study. J Zhejiang Univ Sci B. 2011; 12:1008-1015. https://doi.org/10.1631/jzus.  
B1100179 PMID: 22135150  
  
Guerrero D. Dermocosmetic management of the red face and rosacea. Ann Dermatol Venereol. 2011;  
138 Suppl 3:S215-218.  
  
Draelos ZD, Ertel K, Berge C. Niacinamide-containing facial moisturizer improves skin barrier and bene-  
fits subjects with rosacea. Cutis. 2005; 76:135-141. PMID: 16209160  
  
Schwartz J, Friedman AJ. Exogenous Factors in Skin Barrier Repair. J Drugs Dermatol. 2016;  
15:1289-1294. PMID: 28095538,  
  
Rawlings AV, Harding CR. Moisturization and skin barrier function. Dermatol Ther. 2004; 17 Suppl  
1:43-48.  
  
Nilforoushzadeh MA, Amirkhani MA, Zarrintaj P, Salehi Moghaddam A, Mehrabi T, Alavi S, et al. Skin  
care and rejuvenation by cosmeceutical facial mask. J Cosmet Dermatol. 2018; 17:693-—702. https://  
doi.org/10.1111/jocd.12730 PMID: 30133135  
  
Fowler JF Jr., Woolery-Lloyd H, Waldorf H, Saini R. Innovations in natural ingredients and their use in  
skin care. J Drugs Dermatol. 2010; 9:572-81; quiz s82-73. PMID: 20626172  
  
Alinia H, Moradi Tuchayi S, Farhangian ME, Huang KE, Taylor SL, Kuo S, et al. Rosacea patients seek-  
ing advice: Qualitative analysis of patients’ posts on a rosacea support forum. J Dermatolog Treat.  
2016; 27:99-102. https://doi.org/10.3109/09546634.2015.1133881 PMID: 26815357  
  
Elewski BE, Draelos Z, Dreno B, Jansen T, Layton A, Picardo M. Rosacea—global diversity and opti-  
mized outcome: proposed international consensus from the Rosacea International Expert Group. J Eur  
  
PLOS ONE | hittps://doi.org/10.1371/journal.pone.0231078 April27, 2020 13/14  
PLOS ONE  
  
Certain skin care habits were associated with the development of rosacea  
  
36.  
  
37.  
  
38.  
  
39.  
  
40.  
  
Acad Dermatol Venereol. 2011; 25:188-200. https://doi.org/10.1111/j.1468-3083.2010.03751.x PMID:  
20586834  
  
Moustafa F, Lewallen RS, Feldman SR. The psychological impact of rosacea and the influence of cur-  
rent management options. J Am Acad Dermatol. 2014; 71:973-980. https://doi.org/10.1016/j.jaad.  
2014.05.036 PMID: 24993600  
  
Xie H, Xiao X, Li J. Topical Steroids in Chinese Cosmetics. JAMA Dermatol. 2017; 153:855-856.  
https://doi.org/10.1001/jamadermatol.2017.1615 PMID: 28678994  
  
Wang M, Guo L, Yu M, Zhao H. The application of a lateral flow immunographic assay to rapidly test for  
dexamethasone in commercial facial masks. Anal Bioanal Chem. 2019; 411:5703-5710. https://doi.  
org/10.1007/s00216-019-01948-2 PMID: 31342091  
  
Yuan X, Huang X, Wang B, Huang YX, Zhang YY, Tang Y, et al. Relationship between rosacea and die-  
tary factors: A multicenter retrospective case-control survey. J Dermatol. 2019; 46:219-225. https://doi.  
org/10.1111/1346-8138.14771 PMID: 30656725  
  
JT, MS, AB, UG. Rosacea: beyond the visible. The BMJ Hosted Content 2018; Available from: https://  
hosted.bmj.com/rosaceabeyondthevisible. Accessed May 2019  
  
PLOS ONE | hittps://doi.org/10.1371/journal.pone.0231078 April27, 2020 14/14