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A global perspective on the epidemiology of acne

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Summary

Acne is estimated to affect 9.4% of the global population, making it the eighth most prevalent disease worldwide. Epidemiological studies have demonstrated that acne is most common in postpubescent teens, with boys most frequently affected particularly with more severe forms of the disease. This paper aims to provide an update on the epidemiology of acne worldwide. Recent general and institutional studies from around the world have shown that the prevalence of acne is broadly consistent globally (with the exception of specific populations, which are discussed). However, this review highlights that there is a wide range of disparate outcome measures being applied in epidemiology studies, and we emphasize the need to develop a widely accepted, credible, standard assessment scale to address this in the future. In addition we discuss special populations, such as those devoid of acne, as well as the impact of potential determinants of acne on disease epidemiology.

Acne vulgaris, or acne, is a common condition with a wide range of potential harms and associated costs. The former include symptomatic discomfort, scarring, emotional and psychosocial distress, occupational consequences and potential psychiatric disturbances including depression and suicide. Identification of individuals at risk of these sequelae can contribute to reducing the morbidity associated with acne.

The Global Burden of Disease Project estimates the prevalence of acne at 9.4%, ranking it as the eighth most prevalent disease worldwide.[1,2] This initiative established prevalence and disability data from primary research manuscripts and databases, and conducted subsequent data analysis with a Bayesian meta-regression methodology, providing a means to harmonize discordant data and to account for a lack of data in geographical, temporal or other demographic items.[2] While this project uses primary research findings to inform global metrics, there has not been a recent attempt to collate and present the world literature on acne prevalence collected over the past decade and a half. The last such review of acne prevalence in both general and school-aged populations comprised literature up to 1995.[3]

The objective of this paper is to provide an update on the epidemiology of acne, adding to reviews on acne prevalence and disease determinants.[3,4] In particular, we evaluate the global body of literature on acne prevalence over the past 15 years and seek to highlight epidemiological findings of relevance to clinicians and clinical epidemiologists.

Methods

The following computerized searches were undertaken. (i) Medline was searched with the date range of January 1996 to March 2014 using the terms ‘acne vulgaris’ or ‘acne’ with the following combinations: prevalence, disable, disables, disability, disabilities. (ii) PubMed was searched from January 1980 to March 2014 with the search terms ‘acne’ and ‘prevalence’ and ‘humans’. (iii) Medline was searched from November 2011 to 10 April 2014 using the term ‘acne vulgaris’, with the following combinations: epidemiology, diet, milk, dairy, dairy products, chocolate, overweight, obesity, glycaemic index, washing, sweat, cleanse, picking, sun, hygiene, smoking, prevention, climate, environment, hormones, *Propionibacterium acnes* (or *P. Acnes*),

ethnicity, genetics and twin. Additional studies from hand searches after the search dates until 1 June 2014 were added based on relevance.

Epidemiological studies

Prevalence studies

From the mid to late 20th century, the majority of epidemiological studies on acne were performed in the U.S.A. and the U.K.[3] The largest of these was a population-based study of over 20 000 Americans whose acne was evaluated by dermatologists or residents.[5] Similar smaller studies were performed in the U.K. with approximately one-tenth the sample size.[6,7] Studies from that era demonstrated that the age of peak incidence for acne was the late teens, with progressive reduction in prevalence with increasing age. Male patients were more frequently affected, particularly with more severe forms of acne. Seminal studies on adolescent maturation and acne included longitudinal studies in American schoolchildren. These showed that the prevalence and severity of acne increased with pubertal maturation and that comedonal acne predominated in preteens, with increasing inflammatory acne developing during the teen years.[8,9]

As a prior review on disease prevalence evaluated studies up to 1995, this paper is restricted to those published subsequently.[3]

General population surveys

Studies on skin disease have originated from various countries worldwide, providing further clarity on relative disease patterns and distribution (Table 1). Determination of the prevalence of a target disease requires screening of the general population by trained evaluators. In acne, prevalence data are best obtained via large-scale population-based evaluations conducted by healthcare personnel trained in the evaluation of acne (including assessment of the face and torso). Further details may be established by providing age and sex distribution, ethnic variation, rural vs. urban location, categorization into severity categories and evaluation of disease impact. Differences in acne prevalence measurements may be due to multiple factors, including inadequacies in survey methodology; lack of standardization of case definitions (physiological, minimal or almost clear may not be captured as cases of acne); operational issues including limited evaluation of affected regions (face only, rather than face and torso); and true variability.

Over the past 15 years, various general population prevalence studies on acne have been conducted. Table 1 shows studies published in the English language after 1995, addressing acne prevalence, and with objective means of acne evaluation (not self-rated).[10–23] The largest of these community-based studies in which participants were examined by dermatologists were performed in China (*n* = 17 345),[10] Germany (*n* = 90 880)[11] and Egypt (*n* = 8008).[12] Despite the geographical and temporal dispersion of these studies, the prevalence of acne was consistent, with point prevalence rates of 8.1%, 3.9% and 5.4%, respectively. These studies also provided evidence on the peak age (or age range) of acne, putting it within the age range of 16–20 years.[10,11] Acne prevalence from household surveys ranged from a low of 0.1% and 0.35% in rural villages of Northwest Tanzania[15] and Ethiopia,[18] to a high of 17% in the Iraqi city of Basrah.[21] For the former, these

rate variations may reflect differences in case ascertainment – mild acne may be more difficult to diagnose in darker phototypes, and full-body examination was not practical in all cases, leading to possible underdiagnosis of truncal acne. In the latter study, it was not stated whether the evaluators were dermatologists or trained in detection of skin disease.

Specific surveys in students and institutions

In view of the highest prevalence of acne being in the teenage years, surveys in child, teen and young adult populations may provide greater detail on the presentation and determinants of disease. Accordingly, targeted surveys of these populations have been performed in primary and high schools, universities and colleges, as well as in military institutions. These focused-population acne studies have also originated from around the world (Table 2 and Table S1; see Supporting Information) and have yielded further insights into associations, potential causes and impact across disparate populations.

Larger studies evaluating sex differences have shown that acne is more prevalent in girls at younger age ranges, with increasing prevalence in boys as they reach puberty.[24,25] Male subjects also tend to have more severe acne.[26–28] Following the teenage years, the prevalence in women again tends to be higher than in men.[10,28] Further analysis of physician visits was conducted in a large dataset representative of the U.S. population from 1979 to 2007, to evaluate acne vulgaris in children aged 6–18 years.[29] There was a significant decrease in the mean age of children seeking treatment over this time frame, with a reduction in age from 15.8 years in 1979 to 15.0 years in 2007. Sex and ethnic stratification revealed that black girls with acne had the lowest mean age, while white boys had the highest. In combination with prior studies showing an association of acne with pubertal onset, these findings suggest an earlier onset of puberty, particularly in black girls.

While comparison between studies is fraught with potential confounding factors, one study did evaluate variations in acne prevalence in almost 3000 women of different ethnicities. Recruiting from the general population of four large cosmopolitan cities (Los Angeles, U.S.A.; London, U.K.; Akita, Japan; Rome, Italy), the prevalence of clinical acne varied with ethnicity: African American, 37%; Hispanic, 32%; Asian, 39%; white, 24% and continental Indian women, 23%.[30] Nevertheless, other environmental factors may account for these differences, as within these groups variation in acne prevalence was observed based on the city of recruitment.

Of the studies summarized in Table 2, numerous different severity grading scales were used and three were developed ad hoc. The latter ranged from a three-grade scale (mild, moderate, severe, based on the presence of comedones, papules/pustules and nodules, respectively)[26,31] to a four-grade scale based on numerical range of lesions and lesion types.[25] For all methods of acne severity grading, where there was congruence in terminology between scales, severity distribution appeared consistent in those affected, with mild acne affecting approximately 66%, moderate acne 33% and severe acne < 10%.[10,26–28,32]

Anatomical sites affected by acne have been inconsistently addressed by surveys due to limitations in time and propriety. When evaluated, the most common extrafacial sites affected by acne were the upper back

(52%), upper chest (30%), lower back (22%), shoulders/arms (16%) and neck (8%).[33] These findings are similar to those obtained by researchers from other countries.[34,35]

In studies evaluating the course of acne, the mean duration was approximately 2 years,[24,27] with a median greater than 1 year.[32,36] A study of over 600 patients with acne showed that the majority had acne for more 2 years.[37] Based on these and other considerations, acne has been increasingly recognized as a potentially chronic disease.[38]

Scarring is the most concerning of the physical sequelae of acne, as it is persistent and not readily, or easily, reversible. However, scarring resulting from acne has been evaluated in only a few studies. Of these, one of the largest comprised almost 1000 patients with acne. Clinically relevant scarring was observed on the face, chest and back in 55%, 14% and 24% of patients, respectively. Acne duration also correlated with scarring.[39] These findings corroborate those of a U.K. study involving 185 patients with acne, which showed that the severity of acne scarring in each of these regions was associated with prior acne grade and duration of up to 3 years.[40]

Outcome measures

Clinical outcome measures

Clinical determination of acne severity is typically conducted in clinical trials by both lesion counting and global grading. As the former is impractical in epidemiological research involving large populations, global grading is typically used. This comprises an overall estimation of severity based on either textual and/or photographic descriptions of severity categories. Currently, more than 25 different clinically reported outcome scales are used in acne global grading.[41] The lack of a standardized, consistently used standard in clinical and epidemiological investigations has been identified as a major shortcoming, hindering the translation of research to treatment in the clinical paradigm and the complete understanding of acne in the global context.[3,41] However, recently the chief components and features of an ideal acne scale have been identified; essential clinical components include primary lesion evaluation, their quantity, extent and sites of involvement, and features including ease of use, clinimetric properties, categorization of severity and acceptance by users.[42] While none of the current scales fulfils all desired criteria, there is a core group that may provide a foundation to develop a widely accepted, credible standard assessment scale.[43]

Patient-reported outcome measures

Self-rated acne severity grading scales

Self-rated acne severity grading scales have been increasingly used in acne epidemiological surveys.[32,36,44–51] Their advantage is that a patient-based measure factors in the multiple dimensions of acne into a singular outcome response. Indeed, these responses seem to correlate more highly with quality-of-life dimensions than with clinically reported measures of acne severity. However, these scales have been developed ad hoc and are not based on psychometric methodology using patient-based input, evaluations or feedback.

Furthermore, their clinimetric properties (accuracy, reliability, responsivity, construct validity) are largely undetermined. The use of such self-rated scales when used in different countries also requires consideration of both linguistic translation and transcultural validation. Nevertheless, the value of these scales in identifying those at risk of anxiety, depression and suicidal risk has been demonstrated in two studies, discussed later.

Quality-of-life scales

There are several acne-specific quality-of-life scales that have been developed, primarily for clinical trial purposes. These scales have a number of limitations; many are (i) lengthy questionnaires that are impractical for epidemiological research in large communities; (ii) focused on facial acne, thus limiting extrapolation to patients who may also have truncal acne; and (iii) not available in languages other than English, leading to issues in linguistic and cultural validity.

Special populations

Populations devoid of acne

There are three special populations in which the absence of acne may be instructive regarding pathogenesis. Firstly, no acne was observed in two indigenous geographically disparate populations, in Papua New Guinea and Paraguay. During a 7-week study, 494 household visits were conducted and general health examinations performed in 1200 Kitavan islanders in Papua New Guinea. Skin evaluations to detect acne – including the face and torso for men, and face and neck for women – were conducted by a trained physician and no acne was observed, even in the 300 individuals at greatest risk of acne (aged 15–25 years).[52] These islanders were subsistence horticulturalists and fishermen with dietary habits uninfluenced by Western culture.

In a similar study conducted among the Ache of Eastern Paraguay, examination for skin and health disorders was conducted every 6 months for almost 3 years by family practitioners trained in recognition of acne. No active acne was observed in these individuals over that time. The diet of this group consisted primarily of foraged and cultivated foods, wild game and domestic meat, as well as collected forest products. In both instances these nonwesternized populations had minimal exposure to Western foods and the authors suggest that the differences in acne prevalence may be due to differing environmental factors.[52] While the findings of these studies are intriguing, they have not yet been repeated in other indigenous populations. In such cohorts, further evaluation of diet, dairy ingestion, *P. acnes* phylotypes and loads, and hormonal assessments are all of potential pathogenic interest.

Laron syndrome, a rare recessive disease characterized by primary growth hormone insensitivity due to either abnormalities in the growth hormone receptor or abnormal postreceptor pathway processing, leads to inadequate production of insulin growth factor (IGF)-1.[53] While complete sexual development with normal reproductive function is seen in this group, it is usually delayed. The development of recombinant IGF-1 (rIGF-1) has led to pharmacologically directed treatment.[53]A study comparing outcomes in pubertal patients with Laron syndrome treated with or without rIGF-1 showed that three of eight patients receiving rIGF-1

developed features of hyperandrogenism and acne (which subsided on reduction of dosage or cessation of treatment), compared with only one of 13 untreated patients who developed slight acne.[53] Delayed puberty was noted in the untreated group. Thus it has been proposed that IGF-1 deficiency may prevent acne, and interaction with androgens appears necessary for acne development.[54]

Details on the sequence of acne development were not reported in this study, but morphological progression with initiation, and regression with dose reduction, would be of pathogenic interest in the future. Furthermore, the presence of *P. acnes*, including phylotypes, was not detailed in individuals who did and did not develop acne with IGF-1 replacement.

Adult acne

Since the original studies on adult acne almost 15 years ago, this issue has been increasingly recognized in the literature,[55,56] and the topic is addressed elsewhere in this supplement.[57]

Psychosocial impact

As reviewed elsewhere, the psychosocial impact of acne includes adverse impact on multiple dimensions of quality of life. These include effects on self-perception, socialization, emotional health and occupational opportunities, and may be associated with anxiety and depressive symptoms, as well as body dissatisfaction.[58–60]

The effect of sex, age and acne location on appearance-related distress in patients with acne was evaluated in a study of 132 patients attending an acne clinic in the U.K.[61] This study used a self-rated acne severity scale based on Leeds reference photographs for the face, chest and back, and the Derriford Appearance Scale, which measures patient distress and dysfunction in relation to appearance.[62,63] Greater self-consciousness of appearance and negative self-concept was noted in women with acne, and patients over the age of 20 years had greater appearance-related distress than younger individuals. The effect of the anatomical site of acne was of particular interest, as moderate-to-severe acne on the back and chest was correlated with self-consciousness of sexual and bodily appearance, while facial acne was associated with social self-consciousness of appearance. Thus, the location of acne may impact differentially on human relationships – impacting social aspects with facial acne and sexual aspects with truncal acne.

Psychiatric effects

Recent investigations highlight important psychiatric comorbidities – specifically, depression and suicidal risk – affecting a large proportion of patients with acne. The association of ‘problem’ acne with increased risk of anxiety, depression and suicidal ideation has been investigated in several studies in adolescents, and is addressed elsewhere in this supplement.[64]

Self-rated 'problem acne' has been shown to be associated with increased risk of anxiety, depression and suicidal ideation in a New Zealand study, in which 9567 high school students aged 12–18 years completed a questionnaire to evaluate the impact of acne.[65]Problem acne was reported by 14% of students, and clinically relevant depressive symptoms were reported by 14%, anxiety by 5%, suicidal ideation by 24% and suicidal attempts by 8%. Compared with those without problem acne, significant associations were observed, with odds ratios (ORs) and 95% confidence intervals (CIs) of 2.04 (1.70–2.45), 2.30 (1.74–3.00), 1.74 (1.54–1.97) and 1.83 (1.51–2.22), respectively.[65] These results were corroborated in a cross-sectional survey of high school students in Norway involving 3775 students aged 18–19 years.[66] The presence and severity of acne were again self-evaluated, and mental health issues, social impairment and suicidal ideation were evaluated by screening instruments.

The New Zealand study included instruments such as the Reynolds Adolescent Depression Scale[67] and the Anxiety Disorder Index of the Multidimensional Anxiety Scale for Children,[68] and specific questions such as, 'Have you thought about killing yourself or attempted to kill yourself over the past 12 months?' In the Norwegian study, corresponding instruments used were derived from the Strengths and Difficulties Questionnaire[69]and the Hopkins Symptom Checklist.[70] The prevalence of substantial acne was 14% and was similar in boys and girls. The prevalence of mental health problems was 12% and of suicidal ideation 11%. However, both were significantly associated with increasing self-rated acne severity. Significant associations of substantial acne were observed with suicidal ideation (OR 1.80, CI 1.30–2.50) and with mental health problems (OR 2.25, CI 1.60–3.00).[66]

The association of suicide attempts with acne has also been investigated by a retrospective cohort study using patient linkage of drug registry data, hospitalization diagnostic codes and cause-of-death information from isotretinoin users in Sweden from 1980 to 2001. This study demonstrated that the standardized incidence ratio for attempted suicide progressively escalated in the 3 years prior to oral isotretinoin medication, suggesting that severe acne itself is a risk factor for attempted suicide.[71]

Potential determinants of acne

Diet

The potential determinants of acne have been systematically reviewed previously.[4] This section aims to provide an update on new insights into these determinants since 2011, including the role of diet, genetics and *P. acnes*.

The relationship between diet and acne has been controversial, and it has been debated in the literature since the early 1900s.[72] Recently, there has been a surge in studies providing greater insight, with several studies looking into glycaemic index (GI) and diet and their relationship with acne vulgaris, although a systematic review of these studies showed the relationship to be inconclusive.[4] More recently there has been an emphasis on the possible mechanisms through which high-GI foods could affect the actual pathogenesis of an acne lesion.

A dietary intervention trial of 32 people with acne, randomized to either a low-GI diet or a control group (instructed to eat a carbohydrate-rich diet), was conducted over 10 weeks. Subjective and objective improvement was observed in both groups, with greater improvement in the intervention group – a 70.9% decrease in the mean inflammatory lesion count compared with baseline.[73] Furthermore, sebaceous gland size was reduced in the low-GI diet group, indicating decreased activity and lower levels of sebum production, seborrhoea being a feature of acne vulgaris.

The association between acne and dairy consumption has been subject to larger studies. A 4-month case–control study demonstrated that individuals with acne had a diet with a higher GI load and consumed greater amounts of milk and ice cream compared with controls.[74] In a separate case–control study of 205 cases and 358 controls, the association of acne with dairy consumption was further corroborated.[75] Those consuming three or more portions of milk per week had a positive correlation with the incidence of acne, although it is not clear exactly how much milk there was per portion. In addition, this correlation was more marked with the consumption of skimmed milk than with whole milk, a finding confirming that of previous investigations.[76,77] This may in part be explained by the GI of skimmed milk being higher at 4 than that of full-fat milk, which is 3.[78]

The role of chocolate in acne remains controversial. A laboratory study using the peripheral blood cells of seven people showed that chocolate consumption (50 g for 4 days) primed these cells to release more of the inflammatory cytokines interleukin (IL)-1β and IL-10 upon stimulation with *P. acnes*.[79] This suggests that the pathogenesis of acne could involve a complex interplay involving not only *P. acnes (*discussed below) but also dietary factors, including chocolate or one of its constituents.

There has been a great interest in the possible mechanisms by which foods may affect acne, particularly the involvement of the insulin/IGF-1 signalling pathway. It is suggested that there exists a complex process of food-induced activation of this pathway, which ultimately triggers acnegenic effects such as sebaceous gland lipogenesis.[80] Hyperinsulinaemia, secondary to a high-GI diet, increases the ratio of IGF-1 to insulin-like growth factor-binding protein-3, thus enhancing the effects of IGF-1. In addition, milk and milk products contain IGF-1, and it has been hypothesized that high-GI foods, fats, meat and dairy proteins increase levels of insulin and IGF-1.[81–83] Levels of insulin and IGF-1 feed into the mammalian target of rapamycin complex-1 and forkhead box O1 signalling pathways, linking nutrient availability to the signalling processes involved in acne pathogenesis.[82] This complex signalling pathway, and how it is involved in acne pathogenesis, is discussed in more detail in another paper in this supplement.[84]

Overall these theories provide a plausible and useful guide to the possible mechanisms by which a high-GI diet and dairy products can exert their effects in the pathogenesis of acne and can explain in part why people native to Papua New Guinea and Paraguay, living nonwesternized lifestyles, have no acne compared with more westernization populations such as in Belgium (Table 2 and Table S1; see Supporting Information). However, they provide only the first step to understanding the link between diet and acne.

Propionibacterium acnes

P. acnes and its relationship to acne pathogenesis have long been debated in the literature, with no clear evidence of there being a link.[4]

Sebaceous follicles provide an ideal anaerobic lipid-rich environment for *P. acnes*. It was been proposed that *P. acnes* may exert an effect on naive CD4 cells, initiating their transformation into T helper (Th)17 cells; this results in the production of IL-17, which is expressed in acne lesions.[85,86] Both vitamins A and D could be effective tools in modulating Th17-mediated diseases such as acne; however, the relevance of IL-17 in the pathogenesis of acne requires further elucidation, and its importance both clinically and epidemiologically is not yet known.[86,87] In inflammatory acne lesions, *P. acnes* phylotype IA has been found to be increased, while phylotypes IB and type II are decreased.[87] These findings suggest that *P. acnes* phylotypes may have different associations with comedones (noninflammatory acne) compared with inflammatory lesions of acne.

Genetics

Genetic influences in acne have been suspected, but until recently there has been little in the way of genomic analyses.

The first genome-wide association study of severe teenage acne was undertaken using the Nurses' Health Study II cohort and comprised European American participants.[88] The results showed the chromosomal locus of 8q24 to be associated with severe teenage acne. This locus has previously been associated with prostrate, breast, colon, ovarian and bladder cancers, as well as chronic lymphocytic leukaemia and glioma; the association of this locus with these malignancies may be explained by its proximity to the proto-oncogene Myc. It has also been associated with the gene involved in the upregulation of androgen receptors.[88] This study would have benefited from a larger sample size, as, of the 928 people analysed, only 81 had a history of acne and there were no objective assessments of acne, as data were collected by self-reported questionnaires.

Another study conducted on a cohort containing individuals with and without acne in the Han Chinese population indicated that polymorphisms in cutaneous androgen metabolism-regulating genes, *HSD3B1* and *HSD17B3*, increased susceptibility to developing acne vulgaris in this population.[89]

Studies have also looked into the genetic variation of *P. acnes*. A comparative genomic analysis of 82 *P. acnes* phylotypes isolated from the skin of subjects with and without acne found that phylotypes from the same individual were more closely related to one another than phylotypes from other individuals, suggesting that this could be due to clonal expansion occurring in the environment of individual microbiomes.[90] The genetic basis of *P. acnes* provides a basis for a greater level of understanding of the differences between the *P. acnes* commensals in acne skin and those in nonacne skin, and why the presence of *P. acnes* in some individuals does not cause acne. Further work by the same group conducting metagenetic analyses of *P. acnes* samples from 49 people with acne and 52 without acne led to the sequencing of *P. acnes* phylotypes and analysis of 71 *P. acnes* genomes.[91] The authors found that *P. acnes* structures were markedly different

between the two groups, thus addressing the question of why some people with *P. acnes* do not develop acne. The advancement of genomic work in both humans and *P. acnes* is exciting as it provides a platform for the development of more molecular-based therapies, an area not yet exploited in acne treatment.

Conclusions

An increasing body of evidence from different countries and regions supports the estimated high prevalence of acne globally, particularly in teenage and early adult years. Furthermore, the potential for a prolonged course of acne along with increased potential for psychosocial, psychiatric and physical sequelae increases the burden of disease.

Epidemiological surveys of both populations with acne and those without have provided insight into potential mechanisms of pathogenesis that were previously unclear or unknown. Future investigations to evaluate potential mechanisms of acne in such populations may be instructive in understanding the interplay of intrinsic immunity, diet, hormones and the cutaneous microbiome in acne.

Through decades of acne research, multiple grading scales have been used as outcome measures. However, the continued use of numerous disparate measures impedes the collation and comparative evaluation of research results. The need for the development and consistent use of standardized measures in acne research, articulated almost two decades ago, is still unmet. Presently, a consortium of researchers is working to develop and validate both clinical and patient-reported outcome measures in acne clinical trials. As part of this effort, validated outcome measures in the acne epidemiological field of research may also be identified to support future initiatives.

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References

1 Vos T, Flaxman AD, Naghavi M *et al.* Years lived with disability (YLDs) for 1160 sequelae of 289 diseases and injuries 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet* 2012; **380**:2163–96.

2 Hay RJ, Johns NE, Williams HC *et al.* The global burden of skin disease in 2010: an analysis of the prevalence and impact of skin conditions. *J Invest Dermatol* 2013; **134**:1527–34.

3 Stathakis V, Kilkenny M, Marks R. Descriptive epidemiology of acne vulgaris in the community. *Australas J Dermatol* 1997; **38**:115–23.

4 Bhate K, Williams HC. Epidemiology of acne vulgaris. *Br J Dermatol* 2013; **168**:474–85.

5 Johnson MT, Roberts J. Skin conditions and related need for medical care among persons 1–74 years. United States, 1971–1974. *Vital Health Stat 11* 1978; **i–v**:1–72.

6 Cunliffe WJ, Gould DJ. Prevalence of facial acne vulgaris in late adolescence and in adults. *Br Med J* 1979; **1**:1109–10.

7 Rea JN, Newhouse ML, Halil T. Skin disease in Lambeth. A community study of prevalence and use of medical care. *Br J Prev Soc Med* 1976; **30**:107–14.

8 Lucky AW, Biro FM, Huster GA *et al.* Acne vulgaris in early adolescent boys. Correlations with pubertal maturation and age. *Arch Dermatol* 1991; **127**:210–16.

9 Lucky AW, Biro FM, Huster GA *et al.* Acne vulgaris in premenarchal girls. An early sign of puberty associated with rising levels of dehydroepiandrosterone. *Arch Dermatol* 1994; **130**:308–14.

10 Shen Y, Wang T, Zhou C *et al.* Prevalence of acne vulgaris in Chinese adolescents and adults: a community-based study of 17,345 subjects in six cities. *Acta Derm Venereol* 2012; **92**:40–4.

11 Augustin M, Herberger K, Hintzen S *et al.* Prevalence of skin lesions and need for treatment in a cohort of 90 880 workers. *Br J Dermatol* 2011; **165**:865–73.

12 Abdel-Hafez K, Abdel-Aty MA, Hofny ERM. Prevalence of skin diseases in rural areas of Assiut Governorate, Upper Egypt. *Int J Dermatol* 2003; **42**:887–92.

13 Walker SL, Shah M, Hubbard VG *et al.* Skin disease is common in rural Nepal: results of a point prevalence study. *Br J Dermatol* 2008; **158**:334–8.

14 Perera A, Atukorale DN, Sivayogan S *et al.* Prevalence of skin diseases in suburban Sri Lanka. *Ceylon Med J* 2000; **45**:123–8.

15 Gibbs S. Skin disease and socioeconomic conditions in rural Africa: Tanzania. *Int J Dermatol* 1996; **35**:633–9.

16 Satimia FT, McBride SR, Leppard B. Prevalence of skin disease in rural Tanzania and factors influencing the choice of health care, modern or traditional. *Arch Dermatol* 1998; **134**:1363–6.

17 Henderson CA. Skin disease in rural Tanzania. *Int J Dermatol* 1996; **35**:640–2.

18 Figueroa JI, Fuller LC, Abraha A, Hay RJ. Dermatology in southwestern Ethiopia: rationale for a community approach. *Int J Dermatol* 1998; **37**:752–8.

19 Leekassa R, Bizuneh E, Alem A *et al.* Community diagnosis of common skin diseases in the Zay community of the Zeway Islands, Ethiopia. *Ethiop Med J* 2005; **43**:189–95.

20 Bissek ACZK, Tabah EN, Kouotou E *et al.* The spectrum of skin diseases in a rural setting in Cameroon (sub-Saharan Africa). *BMC Dermatol* 2012; **12**:7.

21 Al-Rubiay KK, Al-Rubaiy LK. Dermatoepidemiology: a household survey among two urban areas in Basrah City, Iraq. *Internet J Dermatol* 2005; **4**:10.

22 Yamamah GA, Emam HM, Abdelhamid MF *et al.* Epidemiologic study of dermatologic disorders among children in South Sinai, Egypt. *Int J Dermatol* 2012; **51**:1180–5.

23 Gutierrez EL, Galarza C, Ramos W. Prevalencia de enfermedades dermatológicas en una comunidad rural de Ucayali, Perú. *Dermatol Peru* 2009; **19**:104–13.

24 Aksu AEK, Metintas S, Saracoglu ZN *et al.* Acne: prevalence and relationship with dietary habits in Eskisehir, Turkey. *J Eur Acad Dermatol Venereol* 2012; **26**:1503–9.

25 Kilkenny M, Merlin K, Plunkett A, Marks R. The prevalence of common skin conditions in Australian school students: 3. Acne vulgaris. *Br J Dermatol* 1998; **139**:840–5.

26 Uslu G, Sendur N, Uslu M *et al.* Acne: prevalence, perceptions and effects on psychological health among adolescents in Aydin, Turkey. *J Eur Acad Dermatol Venereol* 2008; **22**:462–9.

27 Aktan S, Ozmen E, Sanli B. Anxiety, depression, and nature of acne vulgaris in adolescents. *Int J Dermatol* 2000; **39**:354–7.

28 Shahzad N, Nasir J, Ikram U *et al.* Frequency and psychosocial impact of acne on university and college students. *J Coll Physicians Surg Pak* 2011; **21**:442–3.

29 Goldberg JL, Dabade TS, Davis SA *et al.* Changing age of acne vulgaris visits: another sign of earlier puberty? *Pediatr Dermatol* 2011; **28**:645–8.

30 Perkins AC, Cheng CE, Hillebrand GG *et al.* Comparison of the epidemiology of acne vulgaris among Caucasian, Asian, Continental Indian and African American women. *J Eur Acad Dermatol Venereol* 2011; **25**:1054–60.

31 Tuncel AA, Erbagci Z. Prevalence of skin diseases among male adolescent and post-adolescent boarding school students in Turkey. *J Dermatol* 2005; **32**:557–64.

32 Tan H-H, Tan AWH, Barkham T *et al.* Community-based study of acne vulgaris in adolescents in Singapore. *Br J Dermatol* 2007; **157**:547–51.

33 Nijsten T, Rombouts S, Lambert J. Acne is prevalent but use of its treatments is infrequent among adolescents from the general population. *J Eur Acad Dermatol Venereol* 2007; **21**:163–8.

34 Gonçalves G, Amado JM, Matos ME, Massa A. The prevalence of acne among a group of Portuguese medical students. *J Eur Acad Dermatol Venereol* 2012; **26**:514–17.

35 Wei B, Pang Y, Zhu H *et al.* The epidemiology of adolescent acne in North East China. *J Eur Acad Dermatol Venereol* 2010; **24**:953–7.

36 Kubota Y, Shirahige Y, Nakai K *et al.* Community-based epidemiological study of psychosocial effects of acne in Japanese adolescents. *J Dermatol* 2010; **37**:617–22.

37 Tan JKL. The Canadian acne epidemiological survey: baseline demographics and interim analysis. *J Am Acad Dermatol* 2004; **50** (3 Suppl.):P15.

38 Gollnick HPM, Finlay AY, Shear N, Global Alliance to Improve Outcomes in Acne. Can we define acne as a chronic disease? If so, how and when? *Am J Clin Dermatol* 2008; **9**:279–84.

39 Tan JKL, Tang J, Fung K *et al.* Development and validation of a Scale for Acne Scar Severity (SCAR-S) of the face and trunk. *J Cutan Med Surg* 2010; **14**:156–60.

40 Layton AM, Henderson CA, Cunliffe WJ. A clinical evaluation of acne scarring and its incidence. *Clin Exp Dermatol* 1994; **19**:303–8.

41 Barratt H, Hamilton F, Car J *et al.* Outcome measures in acne vulgaris: systematic review. *Br J Dermatol* 2009; **160**:132–6.

42 Tan J, Wolfe B, Weiss J *et al.* Acne severity grading: determining essential clinical components and features using a Delphi consensus. *J Am Acad Dermatol* 2012; **67**:187–93.

43 Tan JKL, Jones E, Allen E *et al.* Evaluation of essential clinical components and features of current acne global grading scales. *J Am Acad Dermatol* 2013; **69**:754–61.

44 Yeung CK, Teo LHY, Xiang LH, Chan HHL. A community-based epidemiological study of acne vulgaris in Hong Kong adolescents. *Acta Derm Venereol* 2002; **82**:104–7.

45 Purvis D, Robinson E, Watson P. Acne prevalence in secondary school students and their perceived difficulty in accessing acne treatment. *N Z Med J* 2004; **117**:U1018.

46 Dalgard F, Svensson A, Holm JØ, Sundby J. Self-reported skin morbidity in Oslo. Associations with sociodemographic factors among adults in a cross-sectional study. *Br J Dermatol* 2004; **151**:452–7.

47 Walker N, Lewis-Jones MS. Quality of life and acne in Scottish adolescent schoolchildren: use of the Children's Dermatology Life Quality Index (CDLQI) and the Cardiff Acne Disability Index (CADI). *J Eur Acad Dermatol Venereol* 2006; **20**:45–50.

48 Halvorsen JA, Braae Olesen A, Thoresen M *et al.* Comparison of self-reported skin complaints with objective skin signs among adolescents. *Acta Derm Venereol* 2008; **88**:573–7.

49 Halvorsen JA, Dalgard F, Thoresen M *et al.* Is the association between acne and mental distress influenced by diet? Results from a cross-sectional population study among 3775 late adolescents in Oslo, Norway. *BMC Public Health* 2009; **9**:340.

50 Jankovic S, Vukicevic J, Djordjevic S *et al.* Quality of life among schoolchildren with acne: results of a cross-sectional study. *Indian J Dermatol Venereol Leprol* 2012; **78**:454–8.

51 de Almeida H Jr, Cecconi J, Duquia RP *et al.* Sensitivity and specificity of self-reported acne in 18-year-old adolescent males. *Int J Dermatol* 2013; **52**:946–8.

52 Cordain L, Lindeberg S, Hurtado M *et al.* Acne vulgaris: a disease of Western civilization. *Arch Dermatol* 2002; **138**:1584–90.

53 Klinger B, Anin S, Silbergeld A *et al.* Development of hyperandrogenism during treatment with insulin-like growth factor-I (IGF-I) in female patients with Laron syndrome. *Clin Endocrinol (Oxf)* 1998; **48**:81–7.

54 Ben-Amitai D, Laron Z. Effect of insulin-like growth factor-1 deficiency or administration on the occurrence of acne. *J Eur Acad Dermatol Venereol* 2011; **25**:950–4.

55 Goulden V, Stables GI, Cunliffe WJ. Prevalence of facial acne in adults. *J Am Acad Dermatol* 1999; **41**:577–80.

56 Poli F, Dreno B, Verschoore M. An epidemiological study of acne in female adults: results of a survey conducted in France. *J Eur Acad Dermatol Venereol* 2001; **15**:541–5.

57 Ramos-e-Silva M, Ramos-e-Silva S, Carneiro S. Acne in adult women. *Br J Dermatol* 2014; in press.

58 Misery L. Consequences of psychological distress in adolescents with acne. *J Invest Dermatol* 2011; **131**:290–2.

59 Tan JKL. Psychosocial impact of acne vulgaris: evaluating the evidence. *Skin Ther Lett* 2004; **9**:1–3, 9.

60 Dunn LK, O'Neill JL, Feldman SR. Acne in adolescents: quality of life, self-esteem, mood, and psychological disorders. *Dermatol Online J* 2011; **17**:1.

61 Hassan J, Grogan S, Clark-Carter D *et al.* The individual health burden of acne: appearance-related distress in male and female adolescents and adults with back, chest and facial acne. *J Health Psychol* 2009; **14**:1105–18.

62 O'Brien S, Lewis J, Cunliffe W. The Leeds revised acne grading system. *J Dermatolog Treat* 1998; **9**:215–20.

63 Carr T, Moss T, Harris D. The DAS24: a short form of the Derriford Appearance Scale DAS59 to measure individual responses to living with problems of appearance. *Br J Health Psychol* 2005; **10**:285–98.

64 Revol O, Milliez N, Gerard D. Psychological impact of acne on 21st-century adolescents. *Br J Dermatol* 2014; in press.

65 Purvis D, Robinson E, Merry S, Watson P. Acne, anxiety, depression and suicide in teenagers: a cross-sectional survey of New Zealand secondary school students. *J Paediatr Child Health* 2006; **42**:793–6.

66 Halvorsen JA, Stern RS, Dalgard F *et al.* Suicidal ideation, mental health problems, and social impairment are increased in adolescents with acne: a population-based study. *J Invest Dermatol* 2011; **131**:363–70.

67 Reynolds WM. *Reynolds Adolescent Depression Scale: High School Version*. Odessa, FL: Psychological Assessment Resources, Inc., 1987.

68 March J. *MASC Multidimensional Anxiety Scale for Children*. New York: Multi-Health Systems Inc., 1997.

69 Goodman R. Psychometric properties of the strengths and difficulties questionnaire. *J Am Acad Child Adolesc Psychiatry* 2001; **40**:1337–45.

70 Lipman RS, Covi L, Shapiro AK. The Hopkins Symptom Checklist (HSCL) – factors derived from the HSCL-90. *J Affect Disord* 1979; **1**:9–24.

71 Sundström A, Alfredsson L, Sjölin-Forsberg G *et al.* Association of suicide attempts with acne and treatment with isotretinoin: retrospective Swedish cohort study. *BMJ* 2010; **341**:c5812.

72 Campbell GG. The relation of sugar intolerance to certain diseases of the skin. *Br J Dermatol* 1931; **43**:297–304.

73 Kwon H, Yoon J, Hong J *et al.* Clinical and histological effect of a low glycaemic load diet in treatment of acne vulgaris in Korean patients: a randomized, controlled trial. *Acta Derm Venereol* 2012; **92**:241–6.

74 Ismail NH, Manaf ZA, Azizan NZ. High glycemic load diet, milk and ice cream consumption are related to acne vulgaris in Malaysian young adults: a case control study. *BMC Dermatol* 2012; **12**:13.

75 Di Landro A, Cazzaniga S, Parazzini F *et al.* Family history, body mass index, selected dietary factors, menstrual history, and risk of moderate to severe acne in adolescents and young adults. *J Am Acad Dermatol* 2012; **67**:1129–35.

76 Adebamowo CA, Spiegelman D, Danby FW *et al.* High school dietary dairy intake and teenage acne. *J Am Acad Dermatol* 2005; **52**:207–14.

77 Adebamowo CA, Spiegelman D, Berkey CS *et al.* Milk consumption and acne in teenaged boys. *J Am Acad Dermatol* 2008; **58**:787–93.

78 Foster-Powell K, Holt SH, Brand-Miller JC. International table of glycemic index and glycemic load values: 2002. *Am J Clin Nutr* 2002; **76**:5–56.

79 Netea SA, Janssen SA, Jaeger M *et al.* Chocolate consumption modulates cytokine production in healthy individuals. *Cytokine* 2013; **62**:40–3.

80 Melnik BC, John SM, Schmitz G. Over-stimulation of insulin/IGF-1 signaling by Western diet may promote diseases of civilization: lessons learnt from Laron syndrome. *Nutr Metab* 2011; **8**:41.

81 Danby FW. Turning acne on/off via mTORC1. *Exp Dermatol* 2013; **22**:505–6.

82 Melnik BC, Zouboulis CC. Potential role of FoxO1 and mTORC1 in the pathogenesis of Western diet-induced acne. *Exp Dermatol* 2013; **22**:311–15.

83 Melnik BC, Schmitz G. Role of insulin, insulin-like growth factor-1, hyperglycaemic food and milk consumption in the pathogenesis of acne vulgaris. *Exp Dermatol* 2009; **18**:833–41.

84 Suh DH, Kwon HH. What's new in the physiopathology of acne? *Br J Dermatol* 2014; in press.

85 Agak GW, Qin M, Nobe J *et al. Propionibacterium acnes* induces an IL-17 response in acne vulgaris that is regulated by vitamin A and vitamin D. *J Invest Dermatol* 2014; **134**:366–73.

86 Thiboutot DM, Layton AM, Eady EA. IL-17: a key player in the *P. acnes* inflammatory cascade? *J Invest Dermatol* 2014; **134**:307–10.

87 Kwon HH, Yoon JY, Park SY, Suh DH. Analysis of distribution patterns of *Propionibacterium acnes* phylotypes and *Peptostreptococcus* species from acne lesions. *Br J Dermatol* 2013; **169**:1152–5.

88 Zhang M, Qureshi AA, Hunter DJ, Han J. A genome-wide association study of severe teenage acne in European Americans. *Hum Genet* 2014; **133**:259–64.

89 Yang X-Y, Wu W-J, Yang C *et al.* Association of *HSD17B3* and *HSD3B1* polymorphisms with acne vulgaris in Southwestern Han Chinese. *Dermatol Basel Switz* 2013; **227**:202–8.

90 Tomida S, Nguyen L, Chiu B-H *et al.* Pan-genome and comparative genome analyses of *Propionibacterium acnes* reveal its genomic diversity in the healthy and diseased human skin microbiome. *mBio* 2013; **4**:e00003–13.

91 Fitz-Gibbon S, Tomida S, Chiu B-H *et al. Propionibacterium acnes* strain populations in the human skin microbiome associated with acne. *J Invest Dermatol* 2013; **133**:2152–60.

Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's website:

Table S1 Studies on acne epidemiology in students and institutions.

Table 1 General population studies: acne prevalence

Publication	Region	Design	*N*	Age range (years)	Sex	Raters	Acne prevalence	Severity grading	Comments
Shen 2012[10]	Six cities, China	Cross-sectional, households	17 345	All	55% female	Dermatologists – face, upper neck and upper torso	8.1%	Pillsbury grade – face and trunk	Acne-specific very comprehensive study of demographics and acne; highest prevalence in 19 year olds (47%)
Augustin 2011[11]	Nationwide, Germany	Cross-sectional survey; workers in German companies	90 880	16–70	53% male	Dermatologists – whole-body exams	3.9%	NS	Prevalence varies with age: 26% in 16–20 years; 10% in 21–30 years (see their Table 4 and Fig. 2)
Abdel-Hafez 2003[12]	Three villages, Upper Egypt	Cross-sectional, households	8008	All	52% female	Dermatologists	5.4%	NS	
Walker 2008[13]	Five villages, Nepal	Cross-sectional, community-based screening	878	All	54% female	Dermatologists	7.7%	NS	
Perera 2000[14]	Piliyandala, Sri Lanka	Cross-sectional, household visits	1806	All	50.2% male	Midwives, medical students	5.9%	NS	Maximal prevalence at age 11–20 years with 50% of cases
Gibbs 1996[15]	Two villages, northwest Tanzania	Cross-sectional, households	1114	All	NS	Dermatologists	0.1%	NS	Only 10% with skin disease had sought treatment
Satimia 1998[16]	Chapwa Valley, Tanzania	Cross-sectional, households	800	All	52% female	Dermatology trainee	4%	NS	Only 33% with skin disease had sought treatment
Henderson 1996[17]	Ndebwe village, Tanzania	Cross-sectional, households	936	All	59% female	Dermatologists	5.8%	NS	Average age with acne; early 20s

Figueroa 1998[18]	Two villages, Ethiopia	Cross-sectional, households. Two-phase study: skin survey and case determination	768	All	NS	Dermatologists	0.35 %	NS	Confidence interval 0.17–0.53%
Leekassa 2005[19]	Lake Zeway communities, Ethiopia	Cross-sectional, households. Two-phase study: skin questionnaire and case assessment	4697 (992 positive in survey, 620 rated)	All	51% male	Dermatologists	2.7%	NS	
Bissek 2012[20]	Four villages, Cameroon	Cross-sectional survey (attendees at free clinics)	400	9–51	NS	Dermatologists	8.9%	NS	Acne prevalence highest in age 20–24 years: 21%
Al-Rubiay 2005[21]	Basrah, Iraq	Cross-sectional, community; 1001 household visits	6666	All	51% female	NS	17%	NS	
Yamamah 2012[22]	South Sinai, Egypt	Cross-sectional, general morbidity consultations and campaign field visits	2194	0–18	51% male	Dermatologists	2.6%	NS	Prevalence three times higher in urban vs. rural population
Gutierrez 2009[23]	Pueblo Libre, Peru	Entire community survey	111	0–70	52% male	Dermatologists	4.8%	ND	

NS, not stated; ND, not done/none.

Table 2 Overview of studies on acne epidemiology in students and institutions. For a full list of studies refer to Table S1 (see Supporting Information)

Publication	Sites	Design	Total *N*	Age range (years)	Sex, average male, %	Raters	Acne prevalence, % range	Severity grading scale (where used)
Far East								
11 papers, 2000–12	Taiwan, Malaysia, Singapore, Hong Kong, China, Korea, Japan	All cross-sectional: 7 school based; 2 university; 1 adolescent; 1 military corps	19 538	Mostly school aged (range 6–25)	53.7 (range 41–100)	7 dermatologists; 2 self-reported; 2 NS	9.8–91.3	1 Lehmann's; 2 GAG; 1 Pillsbury grade; 1 Korean grading system; 1 self-evaluated; 4 ND; 1 NS
Europe								
Nine papers, 1999–2013	Belgium, Portugal, Romania, Bulgaria, Turkey	All cross-sectional: 7 school based; 1 university; 1 various centres	~15 325	Mostly school aged (range 0–35)	54.9 (range 32–100)	6 dermatologist (or qualified equivalent); 3 NS	0.10–82	1 ECLA; 1 Burkes; 2 Pillsbury grade; 1 GAG; 3 ad hoc; 1 ND
Australasia								
Three papers, 1995–2004	New Zealand, Australia	All cross-sectional, school based	12 756	All school aged (range 10–19)	47 (no range)	2 dermatologist (or qualified equivalent); 1 self-reported	14–91	1 self-reported; 1 ad hoc; 1 Leeds
Africa								
Three papers, 2009–10	Tanzania, Ghana, Nigeria	All cross-sectional, school based	3229	All school aged (range 4–20)	49.6 (range 47–51)	2 dermatologists; 1 NS	0.2–36	3 ND
Middle East								
Six papers, 1996–2011	Saudi Arabia, Pakistan, Iran	All cross-sectional: 5 school based; 1 university based	6976	Mostly school aged (range 6–28)	57.6 (range 0–100)	5 dermatologists; 1 NS	13–93.2	1 Braun-Falco, Plewig; 1 Gollnick & Orfanos system; 1 Global Alliance system; 1 AAD classification; 1 ND

South America								
Three papers, 1981–2011	Peru, Brazil	All cross-sectional, school based	12 369	All school aged (range 6–18)	50.3 (range 47–56)	1 dermatologist; 1 paediatrician; 1 NS	3–42	1 James and Tisserand; 2 ND

GAG; global acne grading; NS, not stated; ND, not done; ECLA, Echelle de Cotation des Lésions d'Acné (Acne Lesion Score Scale); AAD, American Academy of Dermatology.