





# Clinical experience and psychometric properties of the Cardiff Acne Disability Index (CADI)

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## Summary

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### Accepted for publication

12 April 2021

### Funding sources

None.

### Conflicts of interest

A.Y.F. is joint copyright owner of the Cardiff Acne Disability Index.

DOI 10.1111/bjd.20391

The Cardiff Acne Disability Index (CADI) is a questionnaire designed to measure the quality of life of teenagers and young adults with acne. It has been used clinically and within therapeutic research globally. This review aims to appraise all published data regarding the clinical and research experience of the CADI, its psychometric properties and validation, from its publication in 1992 until September 2020, in a single reference source. A literature search was conducted using MEDLINE via Ovid, PubMed, EBSCOhost, Web of Science and Scopus. All full articles in the English language were included. A total of 96 clinical studies were identified and analysed. The CADI has been used in 44 different countries, including four multinational studies, and has validated translations in 25 languages. Overall, 29 therapeutic interventions have used the CADI, demonstrating its responsiveness to change. The reliability of the CADI has been assessed in 14 studies through test–retest and internal consistency studies. In total, 57 studies have demonstrated aspects of its validity through correlation to other measures, and five studies have investigated the dimensionality of the CADI. There is evidence of high internal consistency, test–retest reliability, responsiveness to change and significant correlation with other objective measures. The minimal clinically important difference and validated score meaning bands have not yet been reported. This information is needed to improve the interpretability of CADI scores for clinical use and in research. The authors of the CADI have also rephrased Question 2 of the measure to ensure inclusivity.

### What is already known about this topic?

- Acne significantly impacts quality of life in patients.
- There are several skin-specific and acne-specific instruments used in day-to-day practice and research.
- The validation and other measurement properties of the Cardiff Acne Disability Index (CADI) have not been easily accessible.

### What does this study add?

- The CADI has been extensively used and is a reliable and valid tool.
- There is a need to develop validated CADI score bands and calculate the minimal clinically important difference.
- The CADI authors have rephrased Question 2 to ensure that the wording is inclusive.
- There is inconsistent reporting of CADI data and a need for guidelines when reporting and publishing quality-of-life data.

## Introduction

Acne, with an estimated global prevalence of 9.38%, is an inflammatory condition primarily affecting the face and upper back.<sup>1</sup> Patients are generally treated in primary care; however, those with severe disease or whose lives are adversely affected are often referred to secondary care where they frequently receive isotretinoin. Acne is most common during adolescence with an estimated prevalence of 35% to almost 100% at any one point.<sup>1</sup>

Adolescence is a particularly challenging period owing to the significant biopsychosocial changes associated with individuals undergoing puberty, establishing relationships, developing persona and exploring their self-image within the adult world. There is a great need for clinicians to fully understand the extent of a patient's quality-of-life (QoL) impairment in order to inform treatment decisions. The Acne Disability Index (ADI),<sup>2</sup> from which the Cardiff Acne Disability Index (CADI) was developed, was the first to measure acne-specific QoL. As the ADI has never been used, to our knowledge, this review focuses on the CADI.

The CADI has been used worldwide in many settings. However, valuable information regarding its clinical use and psychometric properties is scattered across publications and there has been no previous attempt to collate and appraise this published data. It may be useful for researchers and clinicians who wish to assess the QoL impact of acne to have ready access to a one-stop source of all the known literature. This review aims to collate and consolidate the data, from the inception of the CADI in 1992<sup>3</sup> to 2020, as a one-stop reference source. This review also aims to highlight both strengths and weaknesses of the CADI, providing a transparent reference source while also pointing to areas requiring further validation and identifying potential limitations of the CADI.

## The Cardiff Acne Disability Index

The CADI,<sup>3</sup> developed in 1992 by Motley and Finlay, is a short questionnaire for use in teenagers and young adults with acne. The CADI consists of five items with each question answered on a 4-point Likert scale, scored from 0 to 3, resulting in a score range of 0 to 15. A higher score represents greater QoL impairment. Questions are based on the impact experienced over the previous month. Questions 1 and 2 assess the psychological and social consequences, Question 3 focuses on truncal acne, Question 4 addresses the patient's psychological state and Question 5 asks for the patient's assessment of their acne severity. The questions were created after identifying areas of greatest concern for patients with acne.<sup>2</sup>

## Methods

### Search strategy

A literature search was conducted from May to September 2020 using MEDLINE via Ovid, PubMed, EBSCOhost, Web of

Science and Scopus to identify all studies that used the CADI from 1992 until September 2020. The search terms used in each database were 'Cardiff Acne Disability Index' or 'CADI' and 'acne'. Furthermore, all citations on Google Scholar of the original 1992 publication were reviewed to identify other studies and ensure none had been missed. Although this is not a systematic review, PRISMA guidelines were used in part to improve the robustness of this study. The inclusion criteria were full-text articles that were written in English. Publications only available as abstracts were excluded; however, citations were checked for further relevant studies. All articles that fulfilled the inclusion criteria were reviewed to identify clinical and psychometric aspects of the CADI. Y.T.A. screened the records and extracted the data. However, any ambiguity was discussed and resolved between all other coauthors. Data were recorded on Excel<sup>®</sup> (Microsoft, Redmond, WA, USA) for categorization and information analysis. The research process is shown in Figure S1 (see Supporting Information).

### Data extraction

The psychometric data extracted included the following: dimensionality and factor structure, test-retest reliability, internal consistency reliability, validation against other measures, sensitivity to change, specificity compared with nonacne populations, translations, cross-cultural adaptations and any statistical test used. Furthermore, we extracted data on the interpretability and clinical meaningfulness of the CADI.

The clinical information extracted included the following: the primary aim of the study, study design and setting, country, language, therapeutic intervention, patient ages, sample size, mean/median CADI scores for both the patients and controls at baseline and postintervention, and any statistical test used. The translation certificates of the CADI on the Cardiff University Dermatology Quality of Life website were also analysed.<sup>4</sup> All data were cross-checked with the original articles to ensure accuracy.

## Results

A total of 96 publications fulfilled the inclusion criteria. However, three of these studies used the CADI without reporting data.<sup>5-7</sup> Studies using the CADI were published in > 65 journals, most frequently in the *Journal of the European Academy of Dermatology and Venerology* (eight articles) and in *Dermatology* (six articles).

### Psychometric data

#### Dimensionality and factor structure

A measure is unidimensional if there is one latent variable between the separate items.<sup>8</sup> Five studies<sup>9-13</sup> analysed the dimensionality of the CADI through factor analysis. Four of these reported the CADI to have two factors<sup>9-11,13</sup> (two of which identified the same two factors)<sup>9,13</sup> and one study

reported the CADI to have one factor (Table S1; see Supporting Information).<sup>12</sup> The two studies<sup>9,13</sup> reported that the first dimension comprised three items addressing emotional well-being and the second dimension comprised the two items addressing the social impact of acne.

### Test–retest and internal consistency reliability

Test–retest reliability ensures that a scale has a low random measurement error. If the acne severity has not changed over time, CADI scores should not change.<sup>14,15</sup> The test–retest reliability of the CADI was assessed in six studies. Two studies reported Spearman's rank correlation ( $r_s = 0.98$ <sup>16</sup> and  $r_s = 0.80$ );<sup>17</sup> two studies reported Pearson's correlation ( $r = 0.40$ <sup>18</sup> and  $r = 0.90$ ).<sup>19</sup> Four studies<sup>9,17,19,20</sup> showed intraclass correlation coefficients (ICCs) ranging from 0.78<sup>17</sup> to 0.97,<sup>20</sup> demonstrating high test–retest reliability (Table 1). As the level of measurement of such data is ordinal, it would be more appropriate to employ Spearman's rank correlation coefficient ( $r_s$ ) rather than Pearson's correlation. It would also be more appropriate to use ICC to test the level of agreement between test 1 (T1) and test 2 (T2), weighing the difference between T1 and T2 for each patient.

Overall, 12 studies reported internal consistency of the CADI using Cronbach's  $\alpha$ .<sup>9,10,12,13,16,17,19–24</sup> Values ranged from  $\alpha = 0.70$ <sup>24</sup> to  $\alpha = 0.90$ <sup>16</sup> indicating good internal consistency. The item total score correlation was reported in five studies<sup>3,10,13,22,23</sup> with a Spearman's rank correlation ranging from  $r_s = 0.60$ <sup>23</sup> to  $r_s = 0.81$ ,<sup>22</sup> demonstrating strong correlation between CADI items (Table 1). Four of 14 studies reporting either test–retest or internal consistency reliability used a parametric test, assuming normal data distribution.

### Validation against other measures

A total of 57 studies in 26 countries described CADI usage in parallel with other closely related measures, allowing assessment of construct validity of convergent type. Few studies also described using more distantly related measures, allowing divergent validity to be assessed (Table S2; see Supporting Information). The most frequently reported comparator instruments were the Dermatology Life Quality Index (DLQI) (convergent validity,<sup>25</sup> 12 studies), the Global Acne Grading System (GAGS) (convergent validity,<sup>26</sup> 12 studies) and the Children's Dermatology Life Quality Index (CDLQI) (convergent validity,<sup>27</sup> five studies). The DLQI is the most commonly used dermatology-specific QoL measure that has been extensively validated.<sup>14</sup> In total, 12 studies examined the correlation between CADI and DLQI scores; most demonstrated a good positive correlation with Spearman's rank correlation ranging from  $r_s = 0.58$ <sup>17</sup> to  $r_s = 0.88$ <sup>10</sup> (Table S2; see Supporting Information). Overall, 11 of 57 studies reported using parametric tests when comparing the CADI with other measures, inappropriately assuming normality.

Many studies correlated the CADI with the clinicians' evaluation of acne severity using a range of clinical grading

systems, with the majority showing significant correlation (Table S2; see Supporting Information).

### Sensitivity to change

A total of 29 publications have demonstrated the sensitivity of the CADI to change following intervention (Tables 2, 3 and 4). These studies were carried out in 22 countries, including four multinational trials, the largest of which was conducted across 15 countries.<sup>28</sup> Patient numbers ranged from 10 to 3746.<sup>29,30</sup> The reported mean decrease in CADI scores following a variety of interventions ranged from 1.5 to 7.4.<sup>31,32</sup> All studies demonstrated an improvement in CADI scores following intervention. One study<sup>7</sup> did not report CADI data. Despite many studies reporting statistically significant improvement in CADI scores, it is not possible to directly interpret these score changes based on their clinical significance as the minimal clinically important difference (MCID) for CADI is not yet known.

### Specificity compared with nonacne populations

A prospective UK study<sup>16</sup> reported the mean CADI score to be significantly higher in patients with acne (mean 6.31) compared with healthy volunteers (1.98), confirming high specificity for acne.

However, a retrospective Shanghai study by Wang *et al.*<sup>33</sup> demonstrated a mean CADI score of 7.85 in patients with acne ( $n = 1037$ ) vs. 5.37 in healthy volunteers ( $n = 1046$ ). However, the method of acne assessment was not specified. A study by Mojica *et al.*<sup>24</sup> in the Philippines conducted in pupils in high school (aged 11 to 18 years), found that pupils with acne scored around one point higher than those without acne.

### Interpretability and clinical meaningfulness of the scores

The MCID of a measure is the smallest change in outcome that would be considered beneficial by the patient. Knowledge of the MCID may help clinicians interpret scores when making clinical decisions.<sup>34,35</sup> The MCID for CADI has not yet been calculated and there is no validated score banding system to provide further meaning to the scores. However, in 25 studies, unvalidated score descriptor bands were used to interpret data (Table S3; see Supporting Information). These unvalidated descriptors were first introduced in 2009 and since then they have been used in many studies.

### Descriptive and clinical studies

#### Translations, cross-cultural adaptations and use in other countries

Often a literal translation of a measure does not account for linguistic, cultural and health behaviour differences.<sup>36,37</sup> Cross-cultural adaptation aims to bridge this gap through adopting rigorous methodology to ensure that a measure

Table 1 Test–retest and internal consistency reliability studies

Reference	Year	Setting	Country	Sample size	Test–retest	Internal consistency	Comment
Aghaei <i>et al.</i> <sup>13</sup>	2006	Hospital outpatients	Iran	100	Not conducted	Cronbach's alpha: $\alpha = 0.79$ Pearson's correlation coefficient $r = 0.68$ Spearman's rank correlation coefficient (item total score correlation): $r_s$ range = $0.62$ – $0.73$ ; $P < 0.01$	Good internal consistency
Chandani <i>et al.</i> <sup>21</sup>	2018	OPD clinic	India	90	Not conducted	Cronbach's alpha: $\alpha = 0.70$	Good internal consistency
Dreno <i>et al.</i> <sup>19</sup>	2004	Hospital outpatients	France	16 (test–retest) 22 (internal consistency)	Mean CADI difference between T1 and T2 = $1.1$ ; $P = 0.20$ Pearson's correlation coefficient: $r = 0.90$	Cronbach's alpha: $\alpha = 0.87$	High test–retest reliability and internal consistency
Grando <i>et al.</i> <sup>9</sup>	2016	Hospital	Brazil	100 (internal consistency) Good internal consistency	ICC = $0.87$ difference= Not reported; $P = 0.21$	ICC = $0.89$	Cronbach's alpha: $\alpha = 0.73$
Gupta <i>et al.</i> <sup>10</sup>	2015	Hospital	India	100	Not conducted	High test–retest reliability Cronbach's alpha: $\alpha = 0.722$ Item-total correlation coefficient (item total score correlation): $r$ range = $0.502$ – $0.76$	Good internal consistency Moderate-to-strong total score correlation
Jankovic <i>et al.</i> <sup>22</sup>	2012	High school	Serbia	465	Not conducted	Cronbach's alpha: $\alpha = 0.79$ Item-total correlation coefficient (item total score correlation): $r$ mean = $0.74$ ; range = $0.53$ – $0.81$	Good internal consistency
Krich <i>et al.</i> <sup>20</sup>	2014	Hospital clinic	Morocco	120 60 (test–retest)	ICC = $0.97$ (95% CI $0.95$ – $0.98$ )	Cronbach's alpha: $\alpha = 0.75$	Good internal consistency
Kyeong-Han <i>et al.</i> <sup>12</sup>	2017	Community	Korea	254	Not conducted	Cronbach's alpha: $\alpha = 0.83$	Good internal consistency Almost perfect agreement
Law <i>et al.</i> <sup>17</sup>	2009	Two high schools	China	85 33 (test–retest)	Spearman's rank correlation coefficient: $r_s = 0.80$ ; $P < 0.01$ ICC = $0.78$ ; $P < 0.01$	Cronbach's alpha: $\alpha = 0.76$	Good internal consistency and high test–retest reliability
Motley and Finlay <sup>3</sup>	1992	Hospital clinic	UK	49	Not conducted	Correlation between individual CADI items: Spearman's rank correlation coefficient	All significantly associated with each other except for Questions 1 and 5

(continued)

**Table 1** (continued)

Reference	Year	Setting	Country	Sample size	Test–retest	Internal consistency	Comment
Perić <i>et al.</i> <sup>23</sup>	2013	School	Serbia	440	Not conducted	Cronbach's alpha: $\alpha = 0.82$ Spearman's rank correlation (item total score correlation): $r_s$ range $= 0.60–0.79$ ; $P < 0.05$	Good internal consistency
Salek <i>et al.</i> <sup>16</sup>	1996	Hospital outpatients	UK	70	Spearman rank correlation coefficient: $r_s =$ $0.98$ ; $P < 0.01$	Cronbach's alpha: $\alpha = 0.90$	High test–retest and internal consistency
Tan <i>et al.</i> <sup>18</sup>	2012	Clinic	France and Quebec	14	Pearson's correlation coefficient: $r = 0.40$	Not conducted	
Mojica <i>et al.</i> <sup>24</sup>	2017	Community	Philippines	400	Not conducted	Cronbach's alpha: $\alpha = 0.70$	Good internal consistency

CADI, Cardiff Acne Disability Index; ICC, intraclass correlation coefficient; OPD, outpatients department. Where reported, 95% confidence intervals (CIs) and P-values have been displayed.

retains its conceptual, experiential and semantic meaning in a different language, culture and country.<sup>36,38</sup> Figure 1 summarizes the internationally recommended translation and cross-cultural adaptation process.<sup>38</sup> This includes independent forward and back translation, reconciliation and cognitive debriefing, which involves ensuring face validity.

The CADI has undergone linguistic validation in 25 languages (Table S4; see Supporting Information). Nine studies reported cross-cultural adaptation and subsequent validation in Cantonese, Filipino, French, Hindi, Korean, Moroccan Arabic, Persian, Portuguese and Serbian (Table S5; see Supporting Information). A study that reported cross-cultural adaptation in Ukrainian was otherwise excluded from this review as it was not in English.<sup>39</sup> The CADI has been used in 44 countries (Table S6; see Supporting Information) and in four multinational studies (one phase IV,<sup>30</sup> one epidemiological,<sup>40</sup> one observational<sup>28</sup> and one randomized therapeutic phase III study)<sup>41</sup> (Supplementary Table 7; see Supporting Information). These took place in 15 countries across six continents.

### Topical drug interventions

The CADI has been used in 13 studies<sup>30,31,41–51</sup> describing pharmacological topical interventions (Table 2). The studies investigated the use of topical nadifloxacin and benzoyl peroxide, clindamycin and benzoyl peroxide, combined retinaldehyde and glycolic acid cream, adapalene and benzoyl peroxide, erythromycin and zinc acetate and several dermocosmetic products. The pretreatment and post-treatment CADI scores were reported in 10 studies.<sup>30,31,42,43,45–47,49–51</sup> One study<sup>48</sup> reported the percentage improvement and two studies gave a descriptive account of QoL improvement.<sup>41,44</sup> All 14 studies depicted improvement in CADI scores following

intervention; however statistical significance was not always reported.

### Systemic drug interventions

The CADI has been used in seven studies<sup>3,7,52–56</sup> that involved systemic pharmacological interventions (Table 3). The systemic interventions included the following: isotretinoin, azithromycin, tetracycline, metformin and 'Perfact' face tablets. The CADI scores were reported before and after treatment showing statistically significant improvement in five studies. One study<sup>54</sup> gave a descriptive account of improvement and another study<sup>7</sup> did not report CADI data.

### Other therapeutic interventions

Three studies<sup>57–59</sup> reported the outcome of nonpharmacological interventions with an educational focus (Table 4). One study compared the use of daily text-message reminders and patient information leaflets alongside the application of benzoyl peroxide, in comparison with standard patient instructions.<sup>57</sup> Another study focused on the outcome of text-message reminders for adherence to treatment.<sup>58</sup> Both studies reported significant improvement in CADI scores following intervention, with the greatest improvement in the text-message group. Additionally, one study reported the impact of patient education alongside the use of a mobile application on the enhancement of treatment outcome.<sup>59</sup>

Four studies<sup>60–63</sup> reported using phototherapy in treating acne. Two studies reported CADI scores showing a significant improvement following intervention and two gave descriptive accounts of improvement in CADI score; however, P-values were not always reported. One study<sup>32</sup> describing the use of bone marrow stem cells to treat atrophic acne scars showed a

Table 2 Responsiveness of the Cardiff Acne Disability Index (CADI) to topical interventions

Reference	Year	Sample size	Therapeutic intervention	Treatment length	Mean CADI before	Mean CADI after	Comments
Bettoli <i>et al.</i> <sup>30</sup>	2019	3746	Cosmetic emulsion	2–3 months treatment	5.0, SD $\pm$ 3.0 (range = 0–15)	2.7, SD $\pm$ 2.4 (range 0–13) P < 0.01	Significant improvement in mean CADI scores
Choudhury <i>et al.</i> <sup>42</sup>	2011	79	Nadifloxacin Clindamycin	8 weeks	8.21, SD $\pm$ 2.42 7.7, SD $\pm$ 2.33	4.24, SD $\pm$ 2.36 5.41, SD $\pm$ 2.67 Group difference: P = 0.35 Change from baseline: P < 0.01	Significant improvement in mean CADI scores in favour of nadifloxacin
Dreno <i>et al.</i> <sup>41</sup>	2007	128	Combined 0.1% retinaldehyde/ 6% glycolic acid cream	78 days	Retinaldehyde + glycolic acid D0: NR  Vehicle cream D0: NR	Day 78: retinaldehyde: 3.26, SD $\pm$ 3.07; P < 0.01  Day 78: vehicle cream: 3.96, SD $\pm$ 3.24; P < 0.01 Group difference: P < 0.01	Significant improvement in mean CADI scores
Gollnick <i>et al.</i> <sup>43</sup>	2015	5131	Adapalene 0.1% and benzoyl peroxide 2.5% topical gel	9 months	5.9, SD $\pm$ 3.0	3 months: 3.8, SD $\pm$ 2.7 9 months: 2.4, SD $\pm$ 2.7, P < 0.01	Significant improvement in mean CADI scores
Gosh and Das <sup>51</sup>	2018	37	Group A: nadifloxacin and benzoyl peroxide Group B: adapalene and benzoyl peroxide	12 weeks	Baseline group A: 6.64, SD $\pm$ 0.4  Baseline Group B: 5.76, SD $\pm$ 0.4  P < 0.14	Group A: week 12 = 0.88, SD $\pm$ 0.1; P < 0.01  Group B: week 12 = 0.23, SD $\pm$ 0.1; P < 0.01	Significant improvement in mean CADI scores in favour of Group B
Italian Acne Board <sup>50</sup>	2011	72	Topical cream containing Efectiose, retinaldehyde and glycolic acid	12 weeks	4.97	2.38 52% decrease	Significant improvement in mean CADI scores
Kyrgidis <i>et al.</i> <sup>44</sup>	2019	49	Cosmetic product	112 days	NR	CADI score 'improved' P < 0.01	Significant improvement in mean CADI scores
Mohammadi <i>et al.</i> <sup>49</sup>	2019	110	Niosomal benzoyl peroxide and clindamycin lotion	12 weeks	Cases: 11.89, SD $\pm$ 1.77 Controls: 11.38, SD $\pm$ 1.63	Cases: 8.60, SD $\pm$ 2.52 Controls: 10.06, SD $\pm$ 2.04 P < 0.01	Niosomal benzoyl peroxide and clindamycin lotion combination more effective
Mohammadi <i>et al.</i> <sup>45</sup>	2017	70	Group A: niosomal 4% erythromycin suspension Group B: erythromycin 4% and zinc acetate 1.2%	12 weeks	Group A: 8.5, SD $\pm$ 3.69  Group B: 10.5, SD $\pm$ 3.08	Group A: 3.64, SD $\pm$ 2.80; P = 0.02  Group B: 2.87, SD $\pm$ 1.99; P = 0.04	Significant improvement in mean CADI scores in favour of erythromycin and zinc acetate
Pantoja-Villa <i>et al.</i> <sup>46</sup>	2019	50	Benzoyl peroxide and adapalene	NR	NR QoL: 40% good, 46% regular, 14% poor	NR QoL: 72% good, 24% regular, 4% poor	Improvement in CADI scores following treatment

(continued)

**Table 2** (continued)

Reference	Year	Sample size	Therapeutic intervention	Treatment length	Mean CADI before	Mean CADI after	Comments
Poláková <i>et al.</i> <sup>31</sup>	2015	111	Group A: adapalene 0.1% gel and bakuchiol, Ginkgo biloba extract (BGM) complex	2 months	Group A: 4.9, SD ± 2.6	Group A: 2.3, SD ± 2.0 (−54%)	Significant improvement in mean CADI scores
			Group B: vehicle cream		Group B: 4.7, SD ± 2.3	Group B: 3.2, SD ± 2.8 (−31.2%) P < 0.01	
Tabasum <i>et al.</i> <sup>47</sup>	2014	48	Test group: 'Zimade Mahusa' a Unani antiacne formulation	6 weeks	12.25 ± 2.45; P < 0.01	4.95 ± 0.94; P < 0.01	Statistically significant improvement in mean CADI scores with no statistical difference between regimens
			Control group: 5% benzoyl peroxide		12.00 ± 1.78; P < 0.01	5.80 ± 3.64; P < 0.01	
Scherdin <i>et al.</i> <sup>48</sup>	2004	81	Group 1: Eucerin® Impure Skin Cleansing Gel (basic treatment)	3 months	Group 1: NR	NR	Group 1: 21.5% improvement in CADI
			Group 2: Eucerin® Impure Skin cleansing Gel + cream gel		Group 2: NR	NR	Group 2: 17.7% improvement in CADI
			Group 3: Eucerin® Impure Skin Cleansing Gel + cream gel + tonic (full treatment group)		Group 3: 4.07	Approximately 2	Group 3: 44.9% improvement in CADI

NR, not reported; QoL, quality of life. Where reported, 95% confidence intervals and P-values have been displayed.

statistically significant improvement in CADI scores 6 months post-treatment. One study reported a significant reduction in CADI scores following treatment but did not report which therapeutic intervention was used.<sup>18</sup>

### Epidemiological surveys and other uses

A multinational epidemiological study conducted in 2962 patients with mild-to-moderate acne in France, Italy, Portugal and Switzerland reported a mean CADI score of  $5.0 \pm 3.0$  with a range of 0–15.<sup>40</sup> The CADI has also been used in several studies assessing the impact of acne on QoL in nonclinical settings. Overall, 17 studies<sup>11,17,22,23,64–76</sup> were conducted in schools, with reported mean CADI scores ranging from 2.91<sup>17</sup> to 5.8<sup>65</sup> in high schools and a mean of 1.9<sup>74</sup> in primary school children and 1.21<sup>73</sup> in preadolescents. Seven studies<sup>71,77–82</sup> were conducted in universities reporting a mean CADI score ranging from 1.47<sup>77</sup> to 3.7.<sup>82</sup> A study by Chernyshov *et al.*<sup>83</sup> reported a mean CADI score of 6.91 in hospital and 3.81 in the community for individuals with a confirmed acne diagnosis.

All studies used CADI in patients with acne, except for a report of its use in Birt–Hogg–Dubé syndrome,<sup>84</sup> where the questionnaire was modified by changing the term 'acne' to 'fibrofolliculomas'.

### Wording of Question 2

During the process of reviewing the complete CADI literature it became apparent that the original wording of question two is no longer appropriate in the 2020s. This review publication provides the opportunity to announce a change in the wording of one CADI question. The original wording of Question 2, addressing relationships 'with the opposite sex', does not take different sexual orientations into account. We confirm that the authors of the CADI (R.J.M. and A.Y.F.) have rephrased Question 2 to ensure that the CADI is inclusive and suitable for all patients. The phrase 'relationships with members of the opposite sex' has been changed to 'intimate personal relationships'. Therefore, the revised wording of Question 2 is 'Do you think that having acne during the last month interfered with your daily social life, social events or

Table 3 Responsiveness of the Cardiff Acne Disability Index (CADI) to systemic interventions

Reference	Year	Sample size	Therapeutic intervention	Treatment length	Mean CADI before	Mean CADI after	Comments
Ergun <i>et al.</i> <sup>52</sup>	2012	63	Isotretinoin	NR	6.10	1 month: 4.10 End of treatment: 1.70 P < 0.01	Significant improvement in mean CADI scores
Metekoglu <i>et al.</i> <sup>53</sup>	2019	72	Isotretinoin	NR	6.10	1.39, SD ± 1.60; P < 0.01	Significant improvement in mean CADI scores
Motley and Finlay <sup>3</sup>	1992	20	Isotretinoin	2–13 months	Median CADI: 8	After: 2	Isotretinoin more effective in reducing mean CADI score
Pezza and Carlomagno <sup>7</sup>	2017	100	Antibiotics Group A: inositol Group B: placebo	(median 6 months) 6 months	Median CADI: 5 NR	After: 3 NR	
Rehman <i>et al.</i> <sup>54</sup>	2020	26	Group 1: azithromycin 500 mg 3 consecutive days every 10 days Group 2: azithromycin 500 mg 4 consecutive days every month	3 months	NR	NR	Reported statistically significant improvement in CADI overall
Robinson <i>et al.</i> <sup>55</sup>	2019	84	Group 1: metformin + tetracycline + benzoyl peroxide Group 2: tetracycline + benzoyl peroxide	12 weeks	Group 1: 9.1, SD ± 3.13 Group 2: 8.8, SD ± 2.78	Mean reduction: 4.82, SD ± 3.39 4.22, SD ± 3.56	No statistical significance between regimens Significant reduction in CADI from baseline following both interventions
Yadav <i>et al.</i> <sup>56</sup>	2011	141	Group I: oral tablets (Perfact Tablet) Group II: dermatological gel (Perfact gel) Group III: oral tablets containing dermatological gel	4 weeks	P = 0.66 Group I: 8.45, SD ± 0.48 Group II: 8.45, SD ± 0.46 Group III: 8.56, SD ± 0.47	P = 0.45 Group I: 4.97, SD ± 0.49; P < 0.05 Group II: 4.82, SD ± 0.24; P < 0.01 Group III: 4.78, SD ± 0.48; P < 0.05	CADI significantly improved with all three treatments

NR, not reported. Where reported, 95% confidence interval and P-values have been displayed.



**Table 4** Responsiveness of the Cardiff Acne Disability Index (CADI) to other therapeutic interventions

Reference	Year	Sample size	Therapeutic intervention	Treatment length	Mean CADI before	Mean CADI after	Comments
Antoniou <i>et al.</i> <sup>60</sup>	2016	89	Group A: LED and photoconverter chromophores + skin cleanser and noncomedogenic cream Group B: skin cleanser and noncomedogenic cream IPL treatment	6 weeks	NR	Group A: 40% CADI score improvement between weeks 6 and 12 Group B: CADI score increase between weeks 6 and 12 2 weeks after treatment: 5.04, SD ± 2.22 3 months after treatment: 5.25, SD ± 2.42 Median CADI scores: Group 1: 5 (IQR = 4-9) Change: -2 (range -4-0) Group 2: 5 (IQR = 2-7) Change: -3 (range -6 to -1) Group 3: 6 (IQR = 4-9) Change: -2 (IQR = -3-0) P = 0.03	Chromophore-assisted blue light phototherapy was more effective at improving CADI scores Significant improvement in mean CADI scores
Barakat <i>et al.</i> <sup>61</sup>	2017	24	IPL treatment	6 weeks	11.21 ± 1.56 P < 0.01		
Donnarumma <i>et al.</i> <sup>57</sup>	2019	126	Topical adapalene 0.3%/benzoyl peroxide 2.5% Group 1: trained on the gel application by an explicative leaflet Group 2: leaflet + daily SMS Group 3: standard instructions	12 weeks	Median CADI scores: Group 1: 8 (IQR = 7-11) Group 2: 8 (IQR = 6-11) Group 3: 9 (IQR = 6-12)		Use of leaflet and SMS alongside gel application training is most effective at improving QoL
Fabbrocini <i>et al.</i> <sup>58</sup>	2014	160	Nonpharmacological: SMS reminders for treatment adherence	12 weeks	SMS group = 8.6, SD ± 1.3 Control group = 7.8, SD ± 1.2		Greater mean CADI score improvement in SMS group
Ianos <i>et al.</i> <sup>62</sup>	2013	123	Group A: IPL wavelength 500-1200 nm and vacuum Group V: IPL with dual wavelength 400-700 nm and 870-1200 nm, no vacuum	5 weeks	NR		Group A more satisfied with treatment compared with Group V; P = 0.00 Groups A and V significantly more satisfied compared with Group 0 (control); P < 0.01
Ibrahim <i>et al.</i> <sup>32</sup>	2015	14	Group 0 (control): topical treatment Single session of autologous bone marrow stem cell therapy	6 months	12, SD ± 3.1		Significant improvement in mean CADI scores
Liu <i>et al.</i> <sup>59</sup>	2020	30	Patient education and mobile application	4 weeks	7.45, SD ± 3.21		Significant improvement in mean CADI scores
Moftah <i>et al.</i> <sup>63</sup>	2016	35	Topical liposomal methylene blue hydrogel followed by IPL on one half of back vs. IPL alone on the other half	3 weeks	11.28 ± 3.07		Significant improvement in mean CADI scores
Tan <i>et al.</i> <sup>18</sup>	2012	19	NR	60-90 days	NR	Mean CADI score reduction = 1.9; P = 0.01	Significant improvement in mean CADI scores

IPL, intense pulsed light; IQR, interquartile range; LED, light-emitting diode; NR, not reported; QoL, quality of life; SMS, short message service. Where reported, 95% confidence intervals and P-values have been displayed.

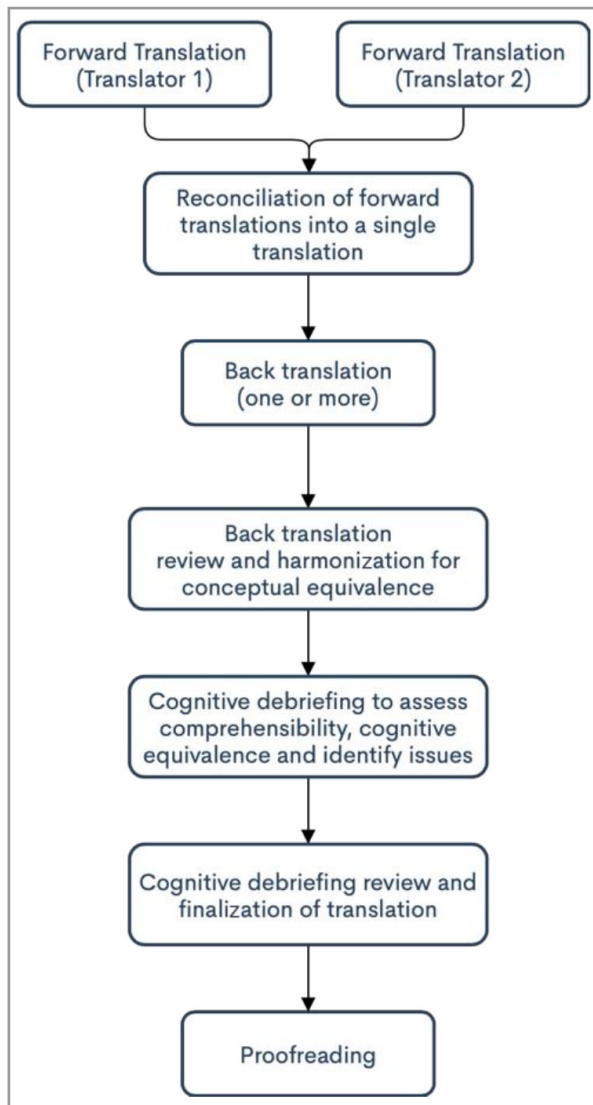


Figure 1 Recommended translation and cultural adaptation process.<sup>38</sup>

intimate personal relationships?' However, this change requires confirmation by a content validity study.

## Discussion

Understanding the impact of disease allows a more holistic and patient-centred approach to healthcare. The concept of measuring the effect of skin disease on a patient's QoL is becoming increasingly accepted and integrated within routine clinical practice and research.<sup>85,86</sup>

This review has demonstrated the extensive use of the CADI, described as the easiest QoL scale to use in routine dermatology practice.<sup>87</sup> Additionally, a recent systematic review identified the CADI to be among the top five most commonly used instruments for measuring the impacts of acne.<sup>88</sup> However, frequency of use is not a guide to the quality of a measure. Several studies reported choosing the CADI because of its short completion time of around 1 min in English<sup>4</sup> and

1.5 minutes in Filipino.<sup>24</sup> However, the practicalities of a measure must be balanced against its validity. We have collated the psychometric properties of the CADI, demonstrating aspects of its reliability and validity. It is responsive to change and can discriminate between treatments of different effectiveness (Tables 2–4). Although acne severity does not always correlate with QoL impairment,<sup>3</sup> the majority of studies reported a correlation between CADI and clinicians' acne grading, as an objective measure. Four studies reported the CADI to be bidimensional with the exception of a study by Kyeong-Han *et al.* that reported unidimensionality.<sup>12</sup> This may be due to the researchers examining the Korean translated version of the CADI in addition to the different study population. Furthermore, no studies performed confirmatory factor analysis.

There are a variety of QoL questionnaires used in acne. These include generic measures, such as the 36-Item Short Form Survey or EQ-5D and dermatology-specific measures, such as DLQI, CDLQI, Skindex or Teenagers' Quality of Life (T-QoL), a questionnaire designed for teenagers with any skin disease.<sup>89</sup> In addition to the CADI, there are other acne-specific QoL measures, including Assessment of the Psychological and Social Effects of Acne (APSEA), Acne-specific Quality of life questionnaire (Acne-QoL), Acne-Q4, Acne Quality of Life Scale (AQOL), Acne Quality of Life Index (Acne-QOLI) and Acne Symptom and Impact Scale (ASIS).<sup>90</sup> The validation of these measures has been summarized.<sup>90</sup>

Despite the extensive validation of the CADI, certain psychometric properties require further investigation. The use of arbitrary unvalidated score bands by investigators highlights the need for developing validated score meaning bands. The anchor-based approach<sup>91</sup> might be the most suitable for the CADI as it is a short, simple questionnaire.<sup>92</sup> There is also no MCID reported for the CADI, and users of the CADI should be aware of this when interpreting score change in order to inform routine clinical decision making and when carrying out research.<sup>93</sup>

Several studies have attempted to correlate CADI data with a range of demographic items such as sex, education level and socioeconomic class. Correlation results were varied and inconclusive overall. The majority of participants in these studies were female. This may be due to the clinic-based setting of most studies, and the possibility that women may be more likely to seek treatment for their acne than men. Although the CADI was designed for use in adolescents and young adults with acne, this review identified that the CADI has also been used in older age groups, both in routine practice and for therapeutic research.

There are 25 validated translations of the CADI; however, the majority of translations, although created using a standard process of forward and backward translations, have not undergone full cross-cultural adaptation. Ideally this should be conducted for all translations.<sup>36,38</sup> Several authors chose the CADI because there was a validated version in their language. The use of trained translators and pretesting on bilingual lay people is recommended by guidelines to ensure optimal comprehension,<sup>36</sup> and this was mostly adhered to. Studies often

compared CADI scores between different cultures; however, as for all QoL measures, despite cross-cultural adaptation, similar CADI scores in different countries should not be assumed to be directly comparable as perceptions of health and QoL are culturally influenced.<sup>37</sup>

Patients should ideally complete QoL questionnaires alone, as having the clinician present may influence responses. However, in one study, the CADI was read aloud to patients who were illiterate<sup>17</sup> and in another study, the CADI questionnaire was administered over the phone.<sup>94</sup> As virtual appointments become integrated into outpatient dermatology care, it may become routine practice for QoL questionnaires to be completed via apps or over the phone. The use of the DLQI on an app has been validated against the paper version,<sup>95</sup> providing encouragement that other QoL questionnaires delivered in this way may also be valid; however, this remains to be established for the CADI. For future research, it would be prudent to develop an electronic version of the CADI and test it for psychometric equivalency to that of the paper version.

The European Academy of Dermatology and Venereology Quality of Life Task Force has published recommendations for the use of QoL measures generally, and specifically in acne.<sup>90</sup> Inconsistencies within QoL reporting have been previously identified.<sup>96</sup> This has also occurred in the reporting of CADI data; inappropriate unvalidated score banding has been introduced and frequently used. Baseline and end-of-treatment data values were sometimes missing and P-values not always reported. SDs and confidence intervals were frequently omitted. The CADI is an ordinal scale, but parametric tests were sometimes applied, inappropriately assuming normality. In a few reports it was not clear which statistical test was used. Two studies used an incorrect score range<sup>52,53</sup> and another reported data outside the possible range.<sup>21</sup> We have previously highlighted this lack of quality assurance in the use and reporting of QoL studies<sup>97–100</sup> and recommend the implementation of formal guidelines and tighter requirements for publishing QoL data.<sup>96</sup>

The main limitation of this review is that only English-language reports were included; however, several studies using the CADI in other languages were identified. We were not able to obtain the articles describing three studies that used the CADI. Articles frequently had inadequate QoL reporting, which affected the ability to interpret data. Although extensive searching was conducted to identify all articles, it is possible that some may have been missed.

## Conclusions

We have presented the extensive use and psychometric properties of the CADI, to act as a reference for potential users. The CADI is a short, practical and effective measure to assess acne-related QoL impairment. Question 2 of the CADI has been rephrased to ensure that it is an appropriate measure for all patients. Further investigation with regards to score meaning banding and the MCID is needed to assist the

interpretation of CADI scores. Finally, validation of CADI delivery by app or over the phone should be carried out.

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## Supporting Information

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

**Figure S1** Summary of the steps undertaken in the research process.

**Table S1** Dimensionality and factor structure of the Cardiff Acne Disability Index.

**Table S2** Correlation of the Cardiff Acne Disability Index with other measures.<sup>101–122</sup>

**Table S3** Unvalidated descriptor bands of the Cardiff Acne Disability Index.<sup>122–125</sup>

**Table S4** Validated language translations of the Cardiff Acne Disability Index.<sup>126</sup>

**Table S5** Published studies reporting cross-cultural adaptation of the Cardiff Acne Disability Index.

**Table S6** Countries where the Cardiff Acne Disability Index has been used.<sup>127,128</sup>

**Table S7** Multinational studies using the Cardiff Acne Disability Index.