Systematic review examining changes over time and variation in the incidence and prevalence of psoriasis by age and gender*

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Summary

Background There is a lack of any overview of changes over time and variation in the epidemiology of psoriasis with age and between genders.

Objectives To perform a systematic review of published population-based studies on variations in psoriasis incidence and prevalence with age and between genders, and to explore trends in psoriasis epidemiology over time.

Methods Eleven electronic and regional databases were searched from their inception dates to October 2019. No language restrictions were applied. Studies were eligible if they reported on changes in psoriasis incidence and/or prevalence over time and/or by age group and gender.

Results In total 308 papers were critically appraised, from which 90 studies from 22 countries were included. Incidence data confirmed a clear bimodal age pattern in psoriasis onset, with the first and second peaks at around 30–39 and 60–69 years of age, respectively, and evidence suggesting that it presents slightly earlier in women than in men. Prevalence data showed an increasing trend with age until around 60 or 70 years, after which it decreases. Although there was lack of agreement on specific gender differences in psoriasis incidence and prevalence, a slight male predominance was reported in several studies. Studies worldwide suggested a stable or slightly decreasing trend in psoriasis incidence, while an increasing trend in psoriasis prevalence has been consistently reported. One particular challenge faced was the vastly different methodologies used in the included studies, which contributed to some of the heterogeneity of the results.

Conclusions Studies on changes over time in the occurrence of psoriasis have contributed to a greater appreciation of the increasing burden of the disease. However, further research is required to determine the reasons driving the increase in psoriasis prevalence over time.

What is already known about this topic?

- Systematic reviews examining the global epidemiology of psoriasis have explored variations in the incidence and prevalence of psoriasis in children and adults, and in the overall population.
- The extent to which the occurrence of psoriasis varies over time, as well as by gender and with age, has not been systematically explored.
Psoriasis has been recognized by the World Health Organization as a serious, disfiguring, disabling, noncommunicable disease that represents a significant public health challenge due to its psychological, social and economic burden. In 2016, the World Health Organization emphasized the need to understand the better the global epidemiology of psoriasis so as to inform policymakers and healthcare professionals on the public health impact of the disease.

The Global Psoriasis Atlas (GPA) aims to improve the understanding of psoriasis epidemiology and its comorbidities, and to provide a common benchmark on the global burden of psoriasis. Recently, the GPA group generated global, regional and country-specific estimates of the prevalence of psoriasis in children, in adults and in the overall population. However, the extent to which the incidence and prevalence of psoriasis vary with age, between genders and over time has not yet been systematically examined. In recent years, a number of studies have been published examining the epidemiology of psoriasis and providing data on temporal trends in the incidence and prevalence of this important skin disease. Such data are important in order to determine whether the global burden of the disease is changing in the context of an ageing population.

Therefore, the aims of this systemic review were to examine worldwide variations in the prevalence and incidence of psoriasis on the basis of age and gender, and to explore trends in its epidemiology over time.

Methods

Study design

This systematic review was conducted and reported in accordance with the PRISMA guidelines (Figure 1) and was registered with PROSPERO, a registry of systematic reviews (registration no. CRD42019160796).

Literature searches and selection

Eleven electronic (Embase, MEDLINE, Web of Science, SciELO, Korean Journal Databases, Russian Science Citation Index) and regional (Western Pacific Region Index Medicus, SaudiMedLit, Informit, IndMED and Health Research and Development Information Network) databases were searched systematically from their respective inception dates to October 2019. The search strategy incorporated three concepts using the following key search terms: ’psoriasis’ (’psoriasis’, ’psoriatic skin’, ’pustulosis’), ’incidence’ (’incident stud*’ or ’cohort stud*’) and ’prevalence’ (’prevalent stud*’ or ’cross-sectional stud*’).

There were no language restrictions and studies were limited to humans. Further details of the search strategy are provided in Appendix S1 (see Supporting Information).

Inclusion and exclusion criteria

Studies were included if they were population based and reported on changes in psoriasis prevalence and/or incidence by age and/or gender and/or over time. Conversely, studies using hospital or dermatology clinic case series; or specific subgroups of the population; or only focusing on psoriatic arthritis; or not providing sufficient information to calculate prevalence and/or incidence rates by age, by gender or over time were excluded.

Data extraction

The titles and abstracts of all records were independently screened for eligibility by two authors (I.Y.K.I. and R.P.). The full texts of papers deemed potentially eligible were critically appraised and assessed for eligibility. Any disagreement on the inclusion or exclusion of a paper between the two investigators was reviewed by a third investigator (D.M.A.) to reach consensus.

Data extracted from each study included citation data (title of the study, authors, publication year); study design (study aim, period, setting, database and disease codes, if used); study population (country, ethnicity, age group, gender); study methods [diagnostic method (e.g. dermatologist, physician or self-reported), case definition and validation]; outcome measure (incidence and/or prevalence); type of prevalence measure (point, period or lifetime); and study findings [number of people with psoriasis, number of people at risk and/or

What does this study add?

- Incidence data confirm a clear bimodal age pattern in psoriasis onset, with evidence suggesting it presents slightly earlier in women than in men.
- Psoriasis prevalence shows an increasing trend with age until 60 or 70 years, after which it decreases.
- There is lack of agreement on specific gender differences in psoriasis incidence and prevalence; however, several studies report a slight male predominance.
- The increasing trend in psoriasis prevalence, despite a stable or a slightly decreasing trend in its incidence, warrants further investigation.
Records identified through electronic database\textsuperscript{a} searching
\((n = 39\,659)\)

Records identified through regional database\textsuperscript{b} searching
\((n = 14\,82)\)

Additional papers identified from screening reference list of eligible studies
\((n = 23)\)

Records before duplicates removed
\((n = 41\,164)\)

Duplicates removed
\((n = 11\,502)\)

Records after duplicates removed
\((n = 29\,662)\)

Records screened
\((n = 29\,662)\)

Records excluded
\((n = 29\,354)\)

Full-text articles assessed for eligibility
\((n = 308)\)

Full-text articles excluded
\((n = 218)\)

Studies included in the systematic review
\((n = 90)\)

Studies on incidence of psoriasis
\((n = 9)\)

Studies on prevalence of psoriasis
\((n = 69)\)

Studies on prevalence and incidence of psoriasis
\((n = 12)\)

Figure 1 PRISMA flow diagram detailing the stages of the systematic review and numbers of records included or excluded. \textsuperscript{a}Embase, MEDLINE, Web of Science, SciELO, Korean Journal Databases and Russian Science Citation Index. \textsuperscript{b}Western Pacific Region Index Medicus, SaudiMedLit, Informit, IndMED and Health Research and Development Information Network. \textsuperscript{c}Reasons for exclusion included: (i) studies not carried out on the general population (i.e. patients were identified from specific populations such as dermatology clinics, hospital admission/visits or specific subgroups of the population); (ii) studies not providing sufficient information to calculate prevalence and/or incidence rates for psoriasis; (iii) studies only focused on psoriatic arthritis; and (iv) studies not providing information on trends in prevalence and/or incidence over time, or information on the prevalence and/or incidence by age groups or gender.
denominator, values of the prevalence and/or incidence reported and their 95% confidence intervals (CIs)).

Quality assessment

An assessment of the quality of all included studies was performed using the Appraisal tool of Cross-Sectional Studies (AXIS). The tool includes 20 items pertaining to the identification of research aims, appropriateness of study design, use of valid measures and statistical analyses and consideration of potential bias. Studies were classified as having high, medium or low risk of bias, or unclear rating (if there was insufficient information) according to the overall quality of the study design, methods and reporting of the results.

Data analysis

Prevalence measures are presented as percentage values, while incidence rates are presented as the rate per 100 000 person-years. Values were checked for potential errors (when possible) on the basis of the number of cases of psoriasis and the population sample size. Missing information, such as the prevalence and/or incidence rates and their 95% CIs, were calculated when not reported in the study, if information on the number of cases of psoriasis and population sample size were provided. Nevertheless, it was not possible to estimate the 95% CIs for some studies due to the lack of information reported. Negative lower bounds of CIs were replaced by zero.

Results

Literature search

In total, 41 164 records were identified from searching the databases and reviewing the reference lists of eligible studies. Of the 308 studies that were critically appraised and assessed for eligibility, 90 studies met all eligibility criteria and were included in the systematic review (Figure 1). The characteristics of the included studies are summarized in Tables S1 and S2 (see Supporting Information). Nine studies reported on the incidence of psoriasis (Table S1), 69 studies reported on the prevalence of psoriasis (Table S2) and 12 studies reported on both incidence and prevalence. Data were available from 22 countries (Figure 2).

Quality assessment found that the majority of the included studies complied with most of the criteria of the AXIS tool (Table S3; see Supporting Information). However, 11 of the 90 studies were given high risk of bias as they met fewer criteria. Where an ‘unclear’ response was assigned, it was most commonly associated with lack of clarity in reporting.

Variation in incidence and prevalence by age

Only one study, conducted in the USA, reported on psoriasis incidence by age in children. This indicated that the incidence increased with age from 13.5 per 100 000 person-years at the age of 0–3 years to 53.1 per 100 000 person-years at the age of 14–17 years (Table 1). Despite higher estimates of psoriasis incidence in European countries compared with the USA, studies both in adults and for all ages showed bimodal trends of increasing psoriasis incidence with age up to either 30–39 or 35–44 years (UK, USA and Italy), which then decreased, before it increased again with a second peak at around either 60–69 or 65–74 years of age (UK, USA and Italy). The incidence of psoriasis then decreased towards the end of life (Tables 1 and 2). One recent study, from Israel, reported that the first peak in psoriasis incidence occurred at a slightly younger age (25–34 years) compared with the findings from other countries (Table 2).

Before the age of 9 years, the prevalence of psoriasis varied from 0% (China and Norway) to 0.55% (UK; Table S4; see Supporting Information), indicating that psoriasis is uncommon in children. There was an increasing trend in psoriasis prevalence with age in children, from 0.13% at the age of 0–2 years to 0.67% at the age of 14–18 years (Table S4). In adults, some studies showed a trend of increasing psoriasis prevalence with age up to either 20–29 or 30–39 years of age, which then decreased at the age of 40–49 years, before it increased again with a second peak at around either 50–59 or 60–69 years of age. However, most studies reported an increasing trend with age until around 60 or 70 years, after which the prevalence decreased (Table S4).

Variation in incidence and prevalence by gender

In children, although the overall incidence rate was lower in boys than in girls (27-9 vs. 43.9 per 100 000 person-years, respectively), this pattern was not consistent across all age bands (Table 1). In adults and in people of all ages, several studies reported a higher incidence in women than in men, but some reported the opposite finding (Table 1). Furthermore, the pattern in variation in psoriasis incidence between genders was not consistent over time (Table 2). When looking at variation in psoriasis incidence between genders by age bands in adults, the two peaks for age at onset in men more frequently occurred around 30–39 and 60–69 years of age, whereas in women they occurred more frequently around 18–29 and 50–59 or 60–69 years of age (Table 1).

There was no difference in the prevalence of psoriasis between boys and girls in Brazil and Taiwan. Contrarily, studies from Denmark, Germany and Sweden reported a prevalence measure that was slightly higher in girls than in boys (Table S5; see Supporting Information). An exception was the findings from one study in China, which reported a prevalence rate that was five times higher in girls than in boys. However, this study was conducted in adolescents (age 12–20 years). Likewise, for adults, several studies found higher prevalence rates in men than in women, but other studies reported contrasting
findings (Table S6; see Supporting Information).14,21,22,29,65–71 When examining variation in psoriasis prevalence between genders for all ages, the majority of the studies reported a higher prevalence rate in male than in female patients.16,18,23,24,30,33,34,36–38,40,51,72–81 However, studies from Denmark,31 Norway,17,25,82 Poland,83,84 Scotland16 and Sweden85 reported contrasting findings (Table S7; see Supporting Information). Nevertheless, the absolute magnitude of the difference between genders in most of the studies was very small, except for a study from Australia, which reported a prevalence rate in men that was almost double that in women.56 It is important to note that the patterns in variation in psoriasis prevalence between genders in adults and in people of all ages were not consistent across all age bands (Table S4; see Supporting Information).

Variation in incidence and prevalence over time

There has been lack of agreement about variation in psoriasis incidence over time. In children, although a study conducted in the USA reported an increasing trend in the incidence of psoriasis between 1970 and 1999 (from 40·8 to 62·7 per 100 000 person-years),9 data from Italy showed that the incidence of psoriasis was fairly constant between 2006 and 2012 (from 61·0 to 57·0 per 100 000 person-years; Table 3).86 In adults, while Icen et al.12 reported a steadily increasing trend in psoriasis incidence in the USA between 1970 and 1999 (from 78·9 to 10·5 per 100 000 person-years), Eder et al.87,88 (from 111·1 to 68·7 per 100 000 person-years between 2000 and 2015), Vena et al.61 (from 321·0 to 230·0 per 100 000 person-years between 2001 and 2005) and Wei et al.89 (from 42·0 to 30·3 per 100 000 person-years between 2001 and 2013) reported a steadily decreasing trend in psoriasis incidence in Canada, Italy and Taiwan, respectively (Table 2).

When examining trends in psoriasis incidence over time in people of all ages, data from Germany,41 the Netherlands,90 Israel,15,91 the UK43 and Russia92–94 demonstrate that psoriasis incidence either remains fairly stable or decreases slightly over time. However, in Denmark the incidence of psoriasis in people of all ages has been inconsistent over time, with a decrease in incidence from 140·1 to 104·0 per 100 000 person-years between 2003 and 2005, followed by an increase to 181·0 per 100 000 person-years in 2010, which then decreased to 151·2 per 100 000 person-years in 2012 (Table 4).31

Only one study, conducted in Italy, reported on variation of psoriasis prevalence over time in children, indicating an increasing trend in prevalence between 2006 and 2012 (from 0·09% to 0·22%; Table S5; see Supporting Information).86 In adults, Eder et al.87,88 (from 1·74% to 2·32% between 2000 and 2015) and Wei et al.89 (from 0·18% to 0·28% between 2000 and 2013) reported a steadily increasing trend in psoriasis prevalence in Canada and Taiwan, respectively (Table S6; see Supporting Information). A similar pattern of a steadily increasing trend in psoriasis prevalence in individuals of all ages has been reported in Germany,41 Israel,15 Korea,95,96 Russia,92–94 Taiwan97 and the UK43 (Table S7; see Supporting Information).

Discussion

This systematic review provides a comprehensive critique of published data on the worldwide variation of psoriasis incidence and prevalence on the basis of age, gender and passage of time. Studies reporting on the age-specific incidence of
psoriasis consistently showed a dual peak for psoriasis onset, with evidence suggesting that the two peaks for age at onset occur slightly earlier in women than in men. Studies reporting the age-specific prevalence of psoriasis showed an increasing trend with age until around 60 or 70 years of age, after which it decreases. There was no agreement on differences in psoriasis incidence and prevalence between genders. However, the absolute magnitude of the difference between genders observed in most of the studies was small. Studies consistently reported an increasing trend in psoriasis prevalence over time, while studies reporting on trends in psoriasis incidence reported a stable or a slightly decreasing trend, except for two studies from the USA, which reported a steadily increasing trend in psoriasis incidence.

Incidence data revealed a clear bimodal age pattern in psoriasis onset, with the first peak of psoriasis incidence around 30–39 years of age and a second peak around 60–69 years of age. This is entirely consistent with the accepted classification of chronic plaque psoriasis as ‘type I’ (early onset) and ‘type II’ (late onset) disease, which are defined as presenting at ≤ 40 and > 40 years of age, respectively. Furthermore, the results from this systematic

### Table 1 Studies reporting incidence rates by gender in children and adults

| Study     | Country | Study period | Diagnostic method | Age (years) | People with Ps | Incidence rate per 100 000 person-years (95% CI)a |
|-----------|---------|--------------|-------------------|-------------|----------------|-----------------------------------------------|
| **Children** |         |              |                   |             |                |                                               |
| Tollefsen 2010a | USA | 1970–1999  | D/Ph              | < 18        | 357            | 40.8 (36.6–45.1)b  |
|            |        |              |                   | 0–3         | 27             | 13.5 (11.4–15.6)b   |
|            |        |              |                   | 4–7         | 84             | 42.2 (40.4–44.5)     |
|            |        |              |                   | 8–10        | 69             | 40.0 (37.5–42.7)     |
|            |        |              |                   | 11–13       | 75             | 52.2 (49.9–54.8)     |
|            |        |              |                   | 14–17       | 102            | 53.1 (49.9–56.6)     |
| **Adults**  |         |              |                   |             |                |                                               |
| Pezzolo 2019a | Italy | 2003–2004  | SR                | 25–75+      | 302            | 302 (232–392)        |
|            |        |              |                   | < 35        | 186            | 186 (95–365)         |
|            |        |              |                   | 35–44       | 342            | 342 (193–605)        |
|            |        |              |                   | 45–54       | 211            | 211 (110–435)        |
|            |        |              |                   | 55–64       | 385            | 385 (223–665)        |
|            |        |              |                   | 65–74       | 420            | 420 (253–697)        |
|            |        |              |                   | > 74        | –              | –                  |
| Khalid 2013a | UK    | 2007–2009   | Ph                | 18–80+      | 10 832         | 280 (280–290)b       |
|            |        |              |                   | 18–29       | 350            | 350 (320–380)        |
|            |        |              |                   | 30–39       | 320 (280–350)   |                                 |
|            |        |              |                   | 40–49       | 320 (280–350)   |                                 |
|            |        |              |                   | 50–59       | 320 (300–350)   |                                 |
|            |        |              |                   | 60–69       | 320 (280–350)   |                                 |
|            |        |              |                   | 70–79       | 290 (250–320)   |                                 |
|            |        |              |                   | ≥ 80        | 160 (130–190)   |                                 |
| Tillett 2017a | UK    | 1998–2014   | Ph                | 18–89       | 88 858         | 183 (182–184)        |
|            |        |              |                   | 18–29       | 186 (184–188)   |                                 |
|            |        |              |                   | 29–39       | 193 (188–197)   |                                 |
|            |        |              |                   | 30–40       | 182 (178–186)   |                                 |
|            |        |              |                   | 40–49       | 158 (155–162)   |                                 |
|            |        |              |                   | 50–59       | 200 (196–204)   |                                 |
|            |        |              |                   | 60–69       | 217 (212–222)   |                                 |
|            |        |              |                   | 70–79       | 196 (191–201)   |                                 |
|            |        |              |                   | ≥ 80        | 145 (139–151)   |                                 |
| Icen 2009b | USA    | 1970–1999   | D/Ph              | ≥ 18        | 1633           | 78.9 (75.0–82.9)b,c  |
|            |        |              |                   | 18–29       | 75.6           | 75.6 (68.0–82.8)b,c   |
|            |        |              |                   | 30–39       | 69.2           | 69.2 (63.5–75.0)     |
|            |        |              |                   | 40–49       | 73.6           | 73.6 (67.0–80.6)     |
|            |        |              |                   | 50–59       | 85.2           | 85.2 (78.5–91.8)b,c   |
|            |        |              |                   | 60–69       | 115.3          | 115.3 (103.1–129.0)  |
|            |        |              |                   | 70–79       | 77.9           | 77.9 (70.3–85.7)     |
|            |        |              |                   | ≥ 80        | 80.0           | 80.0 (72.5–87.5)     |

CI, confidence interval; D, dermatologist; Ph, physician; Ps, psoriasis; SR, self-reported. All values are as reported in the studies. Adjusted for age and/or gender. Rate adjusted by linear interpolation between census years.
| Study     | Country           | Study period | Diagnostic method | Age (years) | People with Ps | Incidence rate per 100 000 person-years (95% CI)a |
|-----------|-------------------|--------------|-------------------|------------|----------------|-----------------------------------------------|
|           |                   |              |                   |            |                | Overall | Female | Male |
| Schonmann | Israel            | 2015         | D                 | < 1        |                | 23.0    |        |      |
|           |                   |              |                   | 1–4        |                | 58.0    |        |      |
|           |                   |              |                   | 5–14       |                | 117.0   |        |      |
|           |                   |              |                   | 15–24      |                | 186.0   |        |      |
|           |                   |              |                   | 25–34      |                | 315.0   |        |      |
|           |                   |              |                   | 35–44      |                | 299.0   |        |      |
|           |                   |              |                   | 45–54      |                | 302.0   |        |      |
|           |                   |              |                   | 55–64      |                | 347.0   |        |      |
|           |                   |              |                   | 65–74      |                | 350.0   |        |      |
|           |                   |              |                   | 75–84      |                | 288.0   |        |      |
|           |                   |              |                   | ≥ 85       |                | 173.0   |        |      |
| Znamenskaya | Russian Federation | 2009          | Ph                | 0–18+      | 99,988         | 70.5    |        |      |
|           |                   |              |                   | 0–14       | 6069           | 28.8    |        |      |
|           |                   |              |                   | 15–17      | 5864           | 118.2   |        |      |
|           |                   | 2010          |                   | ≥ 18       | 88,055         | 76.0    |        |      |
|           |                   |              |                   | 0–18+      | 99,348         | 69.8    |        |      |
|           |                   |              |                   | 0–14       | 6045           | 28.2    |        |      |
|           |                   |              |                   | 15–17      | 5873           | 128.2   |        |      |
|           |                   | 2011          |                   | ≥ 18       | 87,430         | 75.4    |        |      |
|           |                   |              |                   | 0–18+      | 99,436         | 69.6    |        |      |
|           |                   |              |                   | 0–14       | 6104           | 28.0    |        |      |
|           |                   |              |                   | 15–17      | 5681           | 126.7   |        |      |
|           |                   |              |                   | ≥ 18       | 87,651         | 75.2    |        |      |
| Kubanova  | Russian Federation | 2010          | Ph                | 0–18+      | 99,988         | 69.8    |        |      |
|           |                   |              |                   | 0–14       | 6009           | 27.9    |        |      |
|           |                   |              |                   | 15–17      | 5864           | 127.2   |        |      |
|           |                   | 2011          |                   | ≥ 18       | 88,055         | 75.4    |        |      |
|           |                   |              |                   | 0–18+      | 99,348         | 69.6    |        |      |
|           |                   |              |                   | 0–14       | 6045           | 28.0    |        |      |
|           |                   |              |                   | 15–17      | 5873           | 126.7   |        |      |
|           |                   | 2012          |                   | ≥ 18       | 87,430         | 75.2    |        |      |
|           |                   |              |                   | 0–18+      | 99,436         | 69.6    |        |      |
|           |                   |              |                   | 0–14       | 6104           | 28.0    |        |      |
|           |                   |              |                   | 15–17      | 5681           | 126.7   |        |      |
|           |                   |              |                   | ≥ 18       | 87,651         | 75.2    |        |      |
|           |                   | 2013          |                   | 0–18+      | 99,988         | 69.8    |        |      |
|           |                   |              |                   | 0–14       | 6069           | 27.9    |        |      |
|           |                   |              |                   | 15–17      | 5864           | 118.8   |        |      |
|           |                   | 2014          |                   | ≥ 18       | 88,055         | 74.2    |        |      |
|           |                   |              |                   | 0–18+      | 99,348         | 69.6    |        |      |
|           |                   |              |                   | 0–14       | 6045           | 28.0    |        |      |
|           |                   |              |                   | 15–17      | 5873           | 118.8   |        |      |
|           |                   | 2015          |                   | ≥ 18       | 87,430         | 74.2    |        |      |
|           |                   |              |                   | 0–18+      | 99,436         | 69.6    |        |      |
|           |                   |              |                   | 0–14       | 6104           | 28.0    |        |      |
|           |                   |              |                   | 15–17      | 5681           | 115.6   |        |      |
|           |                   | 2016          |                   | ≥ 18       | 87,651         | 71.7    |        |      |
|           |                   |              |                   | 0–18+      | 99,988         | 69.8    |        |      |
|           |                   |              |                   | 0–14       | 6009           | 27.9    |        |      |
|           |                   |              |                   | 15–17      | 5864           | 108.4   |        |      |
|           |                   | 2015          |                   | ≥ 18       | 88,055         | 72.4    |        |      |
|           |                   |              |                   | 0–18+      | 99,348         | 69.6    |        |      |
|           |                   |              |                   | 0–14       | 6045           | 28.0    |        |      |
|           |                   |              |                   | 15–17      | 5873           | 95.6    |        |      |
|           |                   | 2016          |                   | ≥ 18       | 87,651         | 72.6    |        |      |
| Huerta 200711 | UK          | 1996–1997 Ph | 0–80+ | 3994 | 140.0 | 121.0 | 110.0 |
review are consistent with what is already known, that
care tend to have a higher incidence of early-onset psoriasis and the peak of psoriasis occurs in their late teens and early twenties. The corresponding peak of early-onset psoriasis in men appeared later, in their thirties. However, this difference is not observed in late-onset psoriasis, in which the pattern of incidence by age did not appear to differ between men and women.\textsuperscript{10–13,44}

There was lack of agreement on specific gender differences in psoriasis incidence and prevalence, with some studies reporting no difference between the genders while others reported an increased incidence and/or prevalence in one gender compared with the other. However, a male preponderance was reported in the vast majority of the studies.\textsuperscript{16,18,20,23,24,27,28,30,33,36–38,49,51,56–64,72–81} The reason for this is unclear.\textsuperscript{99} However, societal taboo (for women), racial differences,\textsuperscript{100} and differences in self-directed health behaviours (e.g. diet, exercise, smoking or alcohol consumption)\textsuperscript{101} are some reasons that have been speculated to cause the difference in the incidence and prevalence of psoriasis observed between genders. Nevertheless, it is important to note that the absolute magnitude of the difference between genders observed in most of the studies was small, and its clinical implications are therefore questionable.

Longitudinal studies of the incidence and prevalence of psoriasis were scarce. Results from several studies suggested a stable or slightly decreasing trend in psoriasis incidence in children, adults and populations of all ages. However, two studies from the USA using the Rochester Epidemiology Project database suggested an increasing trend of incident cases of psoriasis over a 30-year period both in children\textsuperscript{9} and in adults.\textsuperscript{12} Nevertheless, it was unclear whether this represented a true change in psoriasis incidence in the USA, a change in the pattern of diagnosis and awareness of the disease over time,\textsuperscript{12} or an increase in risk factors (obesity, stress, psychological conditions) for psoriasis.\textsuperscript{9}

Studies on the prevalence of psoriasis longitudinally suggested a steadily increasing trend in psoriasis prevalence in children, adults and populations including all ages. This observed increase in psoriasis prevalence has previously been speculated to be related to a better awareness of the disease among physicians and in the general population rather than a real increase in the prevalence of the disease.\textsuperscript{36} However, recently, Springate et al.\textsuperscript{43} and Schonmann et al.\textsuperscript{15} were able to consider this steady increase in psoriasis prevalence in the context of a decreasing risk of mortality. Further epidemiological studies are required to examine simultaneously the longitudinal trends in incidence, prevalence and mortality of patients with psoriasis to determine whether the increase in psoriasis prevalence over time is driven by increasing trends in incidence (more new cases of psoriasis) or, as seems more likely, whether patients are living longer with psoriasis due to a reduction in early mortality.

One of the key strengths of this systematic review is the extensive search of all published literature since inception, using 11 electronic and regional databases with no language restrictions. Furthermore, using the AXIS tool to assess the quality of the included studies we were able to assess each aspect of the study design and also to incorporate risk of bias and quality of reporting when making a judgement on the overall quality of the study – a feature that is not provided by other quality-assessment tools.\textsuperscript{101,103}

One particular challenge faced was the vastly different methodologies used in the included studies, namely type of measure (point, period or lifetime estimate), age groups studied, case definition (patient reported vs. physician diagnosis) and sampling techniques (questionnaires, clinical examination and electronic health records). This undoubtedly contributed to...
### Table 3: Studies reporting incidence rates in children and adults, over time and by gender

| Study        | Country | Study period | Diagnostic method | Age (years) | People with Ps | Incidence rate per 100,000 person-years (95% CI)* |
|--------------|---------|--------------|-------------------|-------------|----------------|-----------------------------------------------|
|              |         |              |                   |             |                | Overall | Female | Male |
| **Children** |         |              |                   |             |                |         |        |      |
| Cantarutti 2015 | Italy  | 2006         | FP                | ≤ 14        |                | 61.0 (50.0–80.0) |         |       |      |
|              |         | 2007         |                   |             |                | 45.0 (30.0–60.0) |         |       |      |
|              |         | 2008         |                   |             |                | 54.0 (40.0–70.0) |         |       |      |
|              |         | 2009         |                   |             |                | 53.0 (40.0–70.0) |         |       |      |
|              |         | 2010         |                   |             |                | 53.0 (40.0–70.0) |         |       |      |
|              |         | 2011         |                   |             |                | 40.0 (30.0–50.0) |         |       |      |
|              |         | 2012         |                   |             |                | 57.0 (40.0–80.0) |         |       |      |
| Tolleson 2010 | USA     | 1970–1999    | D/Ph              | < 18        | 357            | 40.8 (36.6–45.1)b | 43.9 (37.6–50.2)b | 37.9 (32.2–43.6)b |
|              |         | 1970–1974    |                   |             |                | 29.6 (20.9–38.3)b |         |       |      |
|              |         | 1975–1979    |                   |             |                | 35.7 (25.9–45.5)b |         |       |      |
|              |         | 1980–1984    |                   |             |                | 31.4 (22.0–40.8)b |         |       |      |
|              |         | 1985–1989    |                   |             |                | 42.7 (31.8–53.7)b |         |       |      |
|              |         | 1990–1994    |                   |             |                | 40.0 (29.7–50.3)b |         |       |      |
|              |         | 1995–1999    |                   |             |                | 62.7 (50.4–65.0)b |         |       |      |
| **Adults**   |         |              |                   |             |                |         |        |      |
| Eder 2017     | Canada  | 2000         | Ph                | ≥ 20        |                | 114.0 (112.0–116.0)b |         |       |      |
|              |         | 2001         |                   |             |                | 111.0 (109.0–113.0)b |         |       |      |
|              |         | 2002         |                   |             |                | 103.0 (101.0–105.0)b |         |       |      |
|              |         | 2003         |                   |             |                | 101.0 (99.0–103.0)b |         |       |      |
|              |         | 2004         |                   |             |                | 101.0 (99.0–103.0)b |         |       |      |
|              |         | 2005         |                   |             |                | 97.0 (95.0–99.0)b |         |       |      |
|              |         | 2006         |                   |             |                | 97.0 (95.0–99.0)b |         |       |      |
|              |         | 2007         |                   |             |                | 96.0 (94.0–98.0)b |         |       |      |
|              |         | 2008         |                   |             |                | 96.0 (94.0–98.0)b |         |       |      |
|              |         | 2009         |                   |             |                | 95.0 (93.0–97.0)b |         |       |      |
|              |         | 2010         |                   |             |                | 95.0 (93.0–97.0)b |         |       |      |
|              |         | 2011         |                   |             |                | 98.0 (96.0–100.0)b |         |       |      |
|              |         | 2012         |                   |             |                | 100.0 (98.0–102.0)b |         |       |      |
|              |         | 2013         |                   |             |                | 105.0 (103.0–107.0)b |         |       |      |
|              |         | 2014         |                   |             |                | 102.0 (100.0–104.0)b |         |       |      |
|              |         | 2015         |                   |             |                | 105.0 (103.0–107.0)b |         |       |      |
| Eder 2019     | Canada  | 2000         | Ph                | ≥ 20        | 9873           | 111.1 (108.9–113.4)b |         |       |      |
|              |         | 2001         |                   |             | 9849           | 108.6 (106.5–110.8)b |         |       |      |
|              |         | 2002         |                   |             | 9203           | 99.7 (97.6–101.8)b |         |       |      |
|              |         | 2003         |                   |             | 9111           | 97.3 (95.3–99.3)b |         |       |      |
|              |         | 2004         |                   |             | 9060           | 95.3 (93.3–97.3)b |         |       |      |

(continued)
Table 3 (continued)

| Study          | Country          | Study period | Diagnostic method | Age (years) | People with Ps | Incidence rate per 100,000 person-years (95% CI)* | Overall | Female | Male |
|----------------|------------------|--------------|-------------------|-------------|----------------|-----------------------------------------------|---------|--------|------|
| Vena 2010c,d    | Italy            | 2001–2005    | Ph                | ≥ 18        | 5792           |                                               |         |        |      |
|                |                  | 2001          |                   |             |                |                                               |         |        |      |
|                |                  | 2005          |                   |             |                |                                               |         |        |      |
|                |                  | 2002          |                   |             |                |                                               |         |        |      |
|                |                  | 2003          |                   |             |                |                                               |         |        |      |
|                |                  | 2004          |                   |             |                |                                               |         |        |      |
|                |                  | 2005          |                   |             |                |                                               |         |        |      |
|                |                  | 2006          |                   |             |                |                                               |         |        |      |
|                |                  | 2007          |                   |             |                |                                               |         |        |      |
|                |                  | 2008          |                   |             |                |                                               |         |        |      |
|                |                  | 2009          |                   |             |                |                                               |         |        |      |
|                |                  | 2010          |                   |             |                |                                               |         |        |      |
|                |                  | 2011          |                   |             |                |                                               |         |        |      |
|                |                  | 2012          |                   |             |                |                                               |         |        |      |
|                |                  | 2013          |                   |             |                |                                               |         |        |      |
|                |                  | 2014          |                   |             |                |                                               |         |        |      |
|                |                  | 2015          |                   |             |                |                                               |         |        |      |
| Pezzolo 2019e   | Italy            | 2003–2004    | SR                | 25–75+      | 333            | 302.0 (232.0–392.0)                            | 380.0 (270.0–535.0) | 296.0 (197.0–443.0) |
|                |                  | 2001          |                   |             |                |                                               |         |        |      |
|                |                  | 2002          |                   |             |                |                                               |         |        |      |
|                |                  | 2003          |                   |             |                |                                               |         |        |      |
|                |                  | 2004          |                   |             |                |                                               |         |        |      |
|                |                  | 2005          |                   |             |                |                                               |         |        |      |
|                |                  | 2006          |                   |             |                |                                               |         |        |      |
|                |                  | 2007          |                   |             |                |                                               |         |        |      |
|                |                  | 2008          |                   |             |                |                                               |         |        |      |
|                |                  | 2009          |                   |             |                |                                               |         |        |      |
|                |                  | 2010          |                   |             |                |                                               |         |        |      |
|                |                  | 2011          |                   |             |                |                                               |         |        |      |
|                |                  | 2012          |                   |             |                |                                               |         |        |      |
|                |                  | 2013          |                   |             |                |                                               |         |        |      |
| Wei 2018f,g     | Taiwan           | 2001–2004    | SR                | 25–75+      | 333            | 42.0 (37.5–46.5)                               | 44.1 (37.5–51.8)   | 44.1 (37.5–51.8)   |
|                |                  | 2001          |                   |             |                |                                               |         |        |      |
|                |                  | 2002          |                   |             |                |                                               |         |        |      |
|                |                  | 2003          |                   |             |                |                                               |         |        |      |
|                |                  | 2004          |                   |             |                |                                               |         |        |      |
|                |                  | 2005          |                   |             |                |                                               |         |        |      |
|                |                  | 2006          |                   |             |                |                                               |         |        |      |
|                |                  | 2007          |                   |             |                |                                               |         |        |      |
|                |                  | 2008          |                   |             |                |                                               |         |        |      |
|                |                  | 2009          |                   |             |                |                                               |         |        |      |
|                |                  | 2010          |                   |             |                |                                               |         |        |      |
|                |                  | 2011          |                   |             |                |                                               |         |        |      |
|                |                  | 2012          |                   |             |                |                                               |         |        |      |
|                |                  | 2013          |                   |             |                |                                               |         |        |      |
| Tillett 2017h,i  | UK               | 1998–2014    | Ph                | 18–89       | 88,858         | 183.0 (182.0–184.0)                            | 186.0 (184.0–188.0) | 179.0 (184.0–181.0) |
|                |                  | 1970–1999    | D/Ph              | ≥ 18        | 1633           | 78.9 (75.0–82.9)                               | 73.2 (68.0–78.4)   | 85.5 (79.5–91.6)   |
|                |                  | 1970–1974    | D/Ph              |             |                |                                               |         |        |      |
|                |                  | 1975–1979    | D/Ph              |             |                |                                               |         |        |      |
|                |                  | 1980–1984    | D/Ph              |             |                |                                               |         |        |      |
|                |                  | 1985–1989    | D/Ph              |             |                |                                               |         |        |      |
|                |                  | 1990–1994    | D/Ph              |             |                |                                               |         |        |      |
|                |                  | 1995–1999    | D/Ph              |             |                |                                               |         |        |      |
| Ieen 2009j,k    | USA              | 1998–2014    | Ph                | 18–89       | 88,858         | 183.0 (182.0–184.0)                            | 186.0 (184.0–188.0) | 179.0 (184.0–181.0) |
|                |                  | 1970–1999    | D/Ph              | ≥ 18        | 1633           | 78.9 (75.0–82.9)                               | 73.2 (68.0–78.4)   | 85.5 (79.5–91.6)   |
|                |                  | 1970–1974    | D/Ph              |             |                |                                               |         |        |      |
|                |                  | 1975–1979    | D/Ph              |             |                |                                               |         |        |      |
|                |                  | 1980–1984    | D/Ph              |             |                |                                               |         |        |      |
|                |                  | 1985–1989    | D/Ph              |             |                |                                               |         |        |      |
|                |                  | 1990–1994    | D/Ph              |             |                |                                               |         |        |      |
|                |                  | 1995–1999    | D/Ph              |             |                |                                               |         |        |      |

CI, confidence interval; D, dermatologist; FP, family paediatrician; Ph, physician; Ps, psoriasis; SR, self-reported diagnosis. *All values are as reported in the studies. **Adjusted for age and/or gender. *Rate adjusted with linear interpolation between census years.
| Study          | Country              | Study period | Diagnostic method | Age (years) | People with Ps | Incidence rate per 100,000 person-years (95% CI)¹ |
|---------------|----------------------|--------------|-------------------|-------------|----------------|-----------------------------------------------|
|               |                      |              |                   | Overall     | Female         | Male                                         |
| Egeberg 2017²¹| Denmark              | 2003         | Ph                | 0–70+       |                | 140.1 (137.1–143.2) 146.8 133.4                |
|               |                      | 2004         |                   |             |                | 122.2 (119.4–125.1) 130.7 113.6                |
|               |                      | 2005         |                   |             |                | 104.0 (101.4–106.7) 107.5 100.5                |
|               |                      | 2006         |                   |             |                | 105.5 (102.9–108.2) 110.4 100.4                |
|               |                      | 2007         |                   |             |                | 111.5 (108.7–114.2) 110.8 112.2                |
|               |                      | 2008         |                   |             |                | 128.6 (125.7–131.6) 128.8 128.4                |
|               |                      | 2009         |                   |             |                | 174.8 (171.4–178.3) 192.6 156.8                |
|               |                      | 2010         |                   |             |                | 181.0 (177.5–184.5) 199.5 162.3                |
|               |                      | 2011         |                   |             |                | 171.3 (167.9–174.7) 187.9 154.5                |
|               |                      | 2012         |                   |             |                | 151.2 (148.0–154.5) 165.9 136.4                |
| Sewerin 2019²¹| Germany              | 2009         |                   |             |                | 463.3 (458.2) 354.5 (343.0–350.3) 354.5–350.3 |
|               |                      | 2010         |                   |             |                | 353.3 (345.6) 264.4 (263.0–263.4)                |
|               |                      | 2011         |                   |             |                | 217.3 (210.5) 17.3 (14.1–29.3)                  |
|               |                      | 2012         |                   |             |                | 19.1 (19.1–26.4) 17.1–26.3                      |
| Shalom 2018²¹ | Israel               | 2016         | D                 | 0–85+       | 9770           | 246.0 (241.0–251.0) 243.0 (239.0–248.0)         |
|               |                      | 2017         |                   |             |                | 243.0 (239.0–248.0) 243.0 (239.0–248.0)         |
| Schonmann 2019²¹| Israel           | 2011         | D                 | 0–85+       | 9796           | 282.0 (276.0–288.0) 268.0 (261.0–276.0) 296.0 (287.0–305.0) |
|               |                      | 2012         |                   |             | 10 430         | 278.0 (272.0–284.0) 273.0 (265.0–281.0) 283.0 (275.0–292.0) |
|               |                      | 2013         |                   |             | 10 072         | 291.0 (285.0–297.0) 278.0 (270.0–286.0) 304.0 (295.0–312.0) |
|               |                      | 2014         |                   |             | 10 333         | 276.0 (271.0–282.0) 263.0 (256.0–271.0) 290.0 (281.0–298.0) |
|               |                      | 2015         |                   |             | 10 033         | 273.0 (267.0–279.0) 257.0 (250.0–265.0) 289.0 (280.0–297.0) |
|               |                      | 2016         |                   |             | 10 505         | 281.0 (276.0–287.0) 269.0 (261.0–276.0) 294.0 (286.0–302.0) |
|               |                      | 2017         |                   |             | 10 489         | 276.0 (270.0–281.0) 263.0 (256.0–271.0) 288.0 (280.0–296.0) |
| Znamenskaya 2012²¹| Russian Federation | 2009         | Ph                | 0–18+       | 99 988         | 70.5                                         |
|               |                      | 2010         |                   |             | 99 348         | 69.8                                         |
|               |                      | 2011         |                   |             | 99 436         | 69.6                                         |
| Kubanova 2017²¹| Russian Federation | 2010         | Ph                | 0–18+       |                | 69.8                                         |
|               |                      | 2011         |                   |             |                | 69.6                                         |
|               |                      | 2012         |                   |             |                | 68.4                                         |
|               |                      | 2013         |                   |             |                | 65.9                                         |
|               |                      | 2014         |                   |             |                | 64.7                                         |
|               |                      | 2015         |                   |             |                | 62.8                                         |
|               |                      | 2016         |                   |             |                | 65.0                                         |
| Odinets 2017²¹| Russian Federation  | 2010         | Ph                | 0–18+       | 11 800         | 42.5                                         |
|               |                      | 2011         |                   |             | 11 136         | 40.8                                         |
|               |                      | 2012         |                   |             | 12 575         | 45.1                                         |
|               |                      | 2013         |                   |             | 87 5           | 31.4                                         |
|               |                      | 2014         |                   |             | 94 5           | 33.8                                         |
| Study     | Country       | Study period | Diagnostic method | Age (years) | People with Ps | Incidence rate per 100 000 person-years (95% CI) |
|-----------|---------------|--------------|-------------------|-------------|----------------|-----------------------------------------------|
|           |               |              |                   |             |                | Overall | Female | Male |
| Donker 199890 | the Netherlands | 1987–1988 | Ph                | 0–65+       | 106            | 130.0 (120.0–140.0)b   |
|           |               | 1995         |                   |             | 24             | 120.0 (70.0–190.0)b   |
| Springate 201743 | UK      | 1999         | Ph                | 0–100       | 4279           | 159.0 (155.0–164.0)b |
|           |               | 2000         |                   |             | 5398           | 163.0 (158.0–167.0)b |
|           |               | 2001         |                   |             | 6286           | 164.0 (160.0–168.0)b |
|           |               | 2002         |                   |             | 7259           | 170.0 (166.0–174.0)b |
|           |               | 2003         |                   |             | 7977           | 172.0 (168.0–176.0)b |
|           |               | 2004         |                   |             | 8209           | 166.0 (163.0–170.0)b |
|           |               | 2005         |                   |             | 8522           | 165.0 (162.0–169.0)b |
|           |               | 2006         |                   |             | 8499           | 161.0 (158.0–165.0)b |
|           |               | 2007         |                   |             | 8807           | 165.0 (162.0–168.0)b |
|           |               | 2008         |                   |             | 8964           | 163.0 (160.0–167.0)b |
|           |               | 2009         |                   |             | 8518           | 155.0 (152.0–158.0)b |
|           |               | 2010         |                   |             | 7715           | 143.0 (140.0–146.0)b |
|           |               | 2011         |                   |             | 7499           | 140.0 (137.0–143.0)b |
|           |               | 2012         |                   |             | 6992           | 131.0 (128.0–134.0)b |
|           |               | 2013         |                   |             | 6350           | 129.0 (126.0–133.0)b |
| Bell 199113 | USA          | 1980–1983    | D/Ph              | 0–70+       | 132            | 59.9 (49.5–70.3)b   |

CI, confidence interval; D, dermatologist; Ph, physician; Ps, Psoriasis. *All values are as reported in the studies. +Adjusted for age and/or gender.
some of the heterogeneity of the results. One of the main goals of the GPA is to improve the quality of reporting of epidemiological studies on the occurrence of psoriasis. Specifically, future studies are encouraged to select an appropriate population base that closely represents the general population so as not to provide an underestimate. For example, estimates generated using data from insurance databases are generally lower than those based on electronic health record databases or population surveys. This is probably because insurance databases likely represent a proportion of the general population (e.g. employed), but may under-represent other subgroups (e.g. the unemployed and retired), or because limited periods of enrolment may result in more restricted observable person-time.\textsuperscript{100,104} Furthermore, it is recommended that future studies should adopt a more consistent approach for the accurate identification of cases so as to minimize the biases that could arise due to variation of patient-reported diagnosis, sampling and other methodological differences. Finally, studies should routinely provide standardized information on the prevalence and incidence of psoriasis by age bands and gender to facilitate the comparison of results between different studies.

**Conclusions**

We found an increasing number of studies examining the epidemiology of psoriasis, which have improved our understanding of the variation in disease incidence and prevalence with age and between genders. Furthermore, considering population growth and ageing, and the fact that psoriasis is a chronic, disabling, stigmatizing condition that mainly affects adults, studies examining variation in psoriasis epidemiology over time have contributed to a greater appreciation of its increasing burden to society. Nevertheless, there are considerable gaps in coverage of the geographical areas reporting this information. There is a need for future international research collaborations using standardized methodology, and reporting of the incidence and prevalence of the disease by age bands and genders, to address knowledge gaps that still exist. Specifically, the increase in psoriasis prevalence over time despite a stable or a slightly decreasing trend in its incidence warrants further investigation. Information gained from epidemiological studies can be positioned to quantify the social and economic burden of the disease and ultimately inform policy decisions on the delivery of healthcare services and resource allocation to reduce the morbidity associated with the disease.

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Supporting Information

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

Appendix S1 Search strategy.

Table S1 Characteristics of studies reporting on the incidence of psoriasis.

Table S2 Characteristics of studies reporting on the prevalence of psoriasis.

Table S3 Quality assessment of studies reporting on the incidence and prevalence of psoriasis using the AXIS tool.

Table S4 Studies reporting prevalence rates in children, adults and all ages by age and gender.

Table S5 Studies reporting prevalence rates in children over time and by gender.

Table S6 Studies reporting prevalence rates in adults over time and by gender.

Table S7 Studies reporting prevalence rates in all ages over time and by gender.

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