BMJ Open

Prevalence of foot disease and risk factors in general inpatient populations: a systematic review and meta-analysis

Peter A Lazzarini,[1,2,3,4] Sheree E Hurn,[1,2] Malindu E Fernando,[5,6] Scott D Jen,[7] Suzanne S Kuys,[3,8] Maarten C Kamp,[1] Lloyd F Reed[1,2]

To cite: Lazzarini PA, Hurn SE, Fernando ME, *et al*. Prevalence of foot disease and risk factors in general inpatient populations: a systematic review and meta-analysis. *BMJ Open* 2015;**5**: e008544. doi:10.1136/bmjopen-2015-008544

▸ Prepublication history and additional material is available. To view please visit the journal (http://dx.doi.org/10.1136/bmjopen-2015-008544).

Received 21 April 2015
Revised 7 September 2015
Accepted 21 October 2015

For numbered affiliations see end of article.

Correspondence to
Peter A Lazzarini;
Peter.Lazzarini@health.qld.gov.au

ABSTRACT

Objective: To systematically review studies reporting the prevalence in general adult inpatient populations of foot disease disorders (foot wounds, foot infections, collective 'foot disease') and risk factors (peripheral arterial disease (PAD), peripheral neuropathy (PN), foot deformity).

Methods: A systematic review of studies published between 1980 and 2013 was undertaken using electronic databases (MEDLINE, EMBASE and CINAHL). Keywords and synonyms relating to prevalence, inpatients, foot disease disorders and risk factors were used. Studies reporting foot disease or risk factor prevalence data in general inpatient populations were included. Included study's reference lists and citations were searched and experts consulted to identify additional relevant studies. 2 authors, blinded to each other, assessed the methodological quality of included studies. Applicable data were extracted by 1 author and checked by a second author. Prevalence proportions and SEs were calculated for all included studies. Pooled prevalence estimates were calculated using random-effects models where 3 eligible studies were available.

Results: Of the 4972 studies initially identified, 78 studies reporting 84 different cohorts (total 60 231 517 participants) were included. Foot disease prevalence included: foot wounds 0.01–13.5% (70 cohorts), foot infections 0.05–6.4% (7 cohorts), collective foot disease 0.2–11.9% (12 cohorts). Risk factor prevalence included: PAD 0.01–36.0% (10 cohorts), PN 0.003–2.8% (6 cohorts), foot deformity was not reported. Pooled prevalence estimates were only able to be calculated for pressure ulcer-related foot wounds 4.6% (95% CI 3.7% to 5.4%)), diabetes-related foot wounds 2.4% (1.5% to 3.4%), diabetes-related foot infections 3.4% (0.2% to 6.5%), diabetes-related foot disease 4.7% (0.3% to 9.2%). Heterogeneity was high in all pooled estimates (I^2=94.2–97.8%, p<0.001).

Conclusions: This review found high heterogeneity, yet suggests foot disease was present in 1 in every 20 inpatients and a major risk factor in 1 in 3 inpatients. These findings are likely an underestimate and more robust studies are required to provide more precise estimates.

Strengths and limitations of this study

- This is the first systematic review and meta-analysis to investigate the prevalence of foot disease in general inpatient populations.
- A broad search strategy was used to minimise the risk of missing relevant studies.
- One author extracted data; however, this was checked by a second author.
- Studies reporting foot disease and risk factor prevalence in inpatient populations had high heterogeneity and thus pooled estimates should be interpreted with caution.
- Very few studies reported foot disease or risk factor data as the primary study outcome and most are likely to have under-reported.

INTRODUCTION

Foot disease is a common result of the pathophysiology of chronic conditions.[1–6] Foot disease disorders have been reported to be present in significant numbers of people hospitalised throughout the world.[1–6] The presence of foot disease disorders in those hospitalised has also been associated with extended hospital stays,[1–5] amputations,[1–3 6–9] institutionalisation,[10 11] high mortality rates[1 2 7 12] and significant ongoing healthcare needs.[1 2 6 13 14]

Foot disease is a term typically used to denote severe foot-related disorders that are likely to result in hospitalisation and amputation and most commonly refers to foot wounds and foot infections.[1 2 12–14] However, 'foot disease' is also commonly used as a catchall term that collectively includes foot wounds, foot infection and other less common severe foot-related disorders, such as critical ischaemia, and Charcot neuroarthropathy.[1 2 12–14] The major risk factors for foot disease include peripheral arterial disease (PAD), peripheral neuropathy (PN) and foot deformity.[1 2 5 6 12–16] However, these risk factors can also become foot disease

disorders if severe and result in hospitalisation or amputation.[1 2 5 6 12–16] Foot disease disorders and risk factors typically result from chronic conditions,[3 5–9] such as diabetes,[1 2 7–9 11–14] cardiovascular disease,[10 17–19] chronic kidney disease[6 15 20] and cancer.[7 8 21]

Studies investigating the presence of foot disease in hospital inpatients have predominantly focused within discrete inpatient populations, such as only geriatric or patients with diabetes.[1 2 5 11 14 20 22 23] Fewer studies have reported the prevalence of foot disease across more representative general inpatient populations that include the diverse range of people typically hospitalised at any one time.[4 24] Thus, precise estimates of the prevalence of foot disease in general inpatient populations are unknown.[4 24] Furthermore, there have been no known systematic reviews investigating the prevalence of foot disease in inpatient populations. In order for clinicians, researchers and policymakers to begin to quantify, understand and address the burden that foot disease imposes on inpatient care, it seems necessary to determine the foot disease prevalence in general inpatient populations rather than discrete segments of the inpatient population.

The primary aim of this study was to systematically review all studies reporting the prevalence in general adult inpatient populations of foot disease disorders (foot wounds, foot infections and collective 'foot disease') and risk factors (PAD, PN and foot deformity). Secondary aims were to determine the pooled prevalence estimates for each foot disease disorder and risk factor, and investigate the prevalence of amputations from included studies.

METHODS

The authors have adhered to the PRISMA guideline reporting checklist (see online supplementary table S1) and PRISMA flow diagram (see figure 1).[25]

Search strategy

Electronic databases (MEDLINE, EMBASE and CINAHL) were systematically searched by the first author (PAL) for all studies published between 1980 and 2013 reporting the prevalence of foot disease disorders or risk factors in an inpatient population. The year 1980 was chosen due to the advent of validated outcome measures to investigate foot disease disorders at this time.[26 27] The search strategy included broad keywords and synonyms combining the anatomical area (eg, foot); disease (eg, wounds, infection) or risk factors (eg, PAD, PN); populations (eg, inpatients); and epidemiological terms (eg, prevalence) of interest. See online supplementary table S2 for the full search syntax with truncation used for the electronic database search.

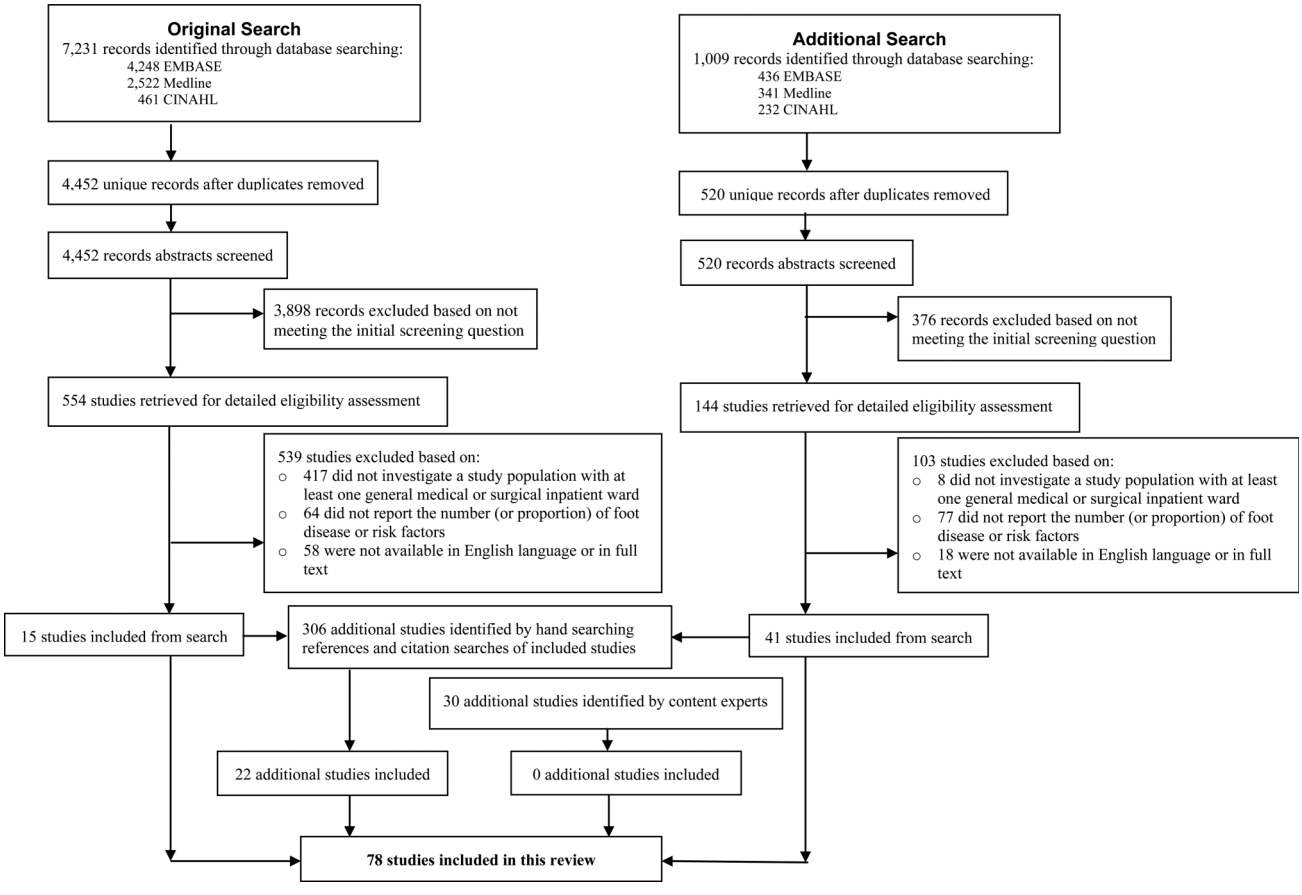

Figure 1 Search strategy and study selection results.

Study selection

All unique study abstracts identified were screened by the first author (PAL) using an overarching initial screening question: *Does the article appear to discuss original findings on the prevalence of foot disease or risk factors within adult populations staying overnight in a hospital?* The full text was sought if it appeared to address the screening question.

A detailed eligibility assessment was then undertaken by the first author (PAL) for final inclusion. Studies were eligible for inclusion if they met all of the below inclusion criteria and did not meet any exclusion criteria. Inclusion criteria were studies:

- Indexed in the aforementioned electronic databases;
- Published in peer-reviewed academic journals;
- Available in full text;
- Written in the English language;
- Reporting a study population representative of a general adult inpatient population. General adult inpatient populations were defined as reporting all eligible participants from at least one general medical or surgical hospital inpatient ward; and
- Reporting the number, or proportion, of a foot disease disorder or risk factor. Foot disease disorders (foot wound, foot infection or collective 'foot disease') and risk factors (PAD, PN or foot deformity) were defined as listing of the foot disease disorder or risk factor concerned (or a synonym) in the study. Thus, no specific diagnostic criteria were used and reporting could have been elicited from a range of self-report, medical record audit or clinical examination methods. 'Foot disease' was defined as the collective reporting of foot wounds, foot infections and other severe foot-related disorders together.

However, studies were excluded if they met any of the following exclusion criteria:

- Studies reporting designs that were primarily case studies, literature reviews, case–control, validity or reliability studies; and
- Studies reporting a study population that was not defined as representative of a general adult hospital inpatient population; including studies investigating primarily children (<18 years), outpatients, geriatric inpatients (>65 years), long-term care inpatients or discrete condition-related inpatients (such as only patients with diabetes).

At completion of the search strategy and study selection, the first author (PAL) hand searched the reference lists of all included studies and citation searched (Scopus) all studies citing the included studies. Following this process it became apparent that all relevant studies had been identified, with the notable exception of pressure ulcers on very specific anatomical locations of the foot, such as the heel or ankle. Thus, an additional search was conducted for all studies reporting only the prevalence of pressure ulcers in inpatient populations using a similar search strategy (see online supplementary table S2). The hand searching of references lists and citation search process was repeated for any additional identified included studies from this additional search. Lastly, the authors consulted six external content experts (eg, physicians, surgeons, nurses, podiatrists) in the field. The authors forwarded the systematic review abstract, search terms and a list of all identified included studies to the content experts, and content experts provided any additional study titles they considered may have also met the inclusion criteria.

Quality assessment

A study quality assessment tool was used to perform the study quality assessments of all included studies.[28] This tool was originally designed to assess the methodological quality of pressure ulcer prevalence in inpatient populations.[28] The authors made minor modifications to this tool to reflect the focus of foot disease rather than pressure ulcers. See online supplementary table S3 for the modified 10-item questions used to evaluate the methodological quality of studies included in this review. Each item was scored either as a 'yes' (score=1) or 'no/not reported' (score=0) with a total possible score of 10.[28]

Two authors (PAL and MEF), blinded to each other's assessments, assessed the methodological quality of all included studies using the aforementioned tool. A research assistant independent of the authors redacted all identifying features (title, authors and journal details) of all included studies prior to forwarding studies in a random order to the authors individually for assessment. At the conclusion of this process, the overall agreement between the two blinded author's scores was calculated and reported for all items. Any differences in the original blinded assessments between the two authors (PAL and MEF) were then resolved by consensus agreement between the two authors. A third author (SEH) was used to make a final adjudication if agreement could not be reached. Studies were given a total study quality score which was classified as either 'poor' (total score=0–3), 'moderate' (total score=4–6) or 'good' (total score=7–10) study quality.

Data extraction

Data extraction was completed for each included study by the first author (PAL) using a custom-designed data extraction spreadsheet. Data were extracted for total sample size, average age (mean or median), age range, proportion of males, and any numbers or prevalence data for the foot disease or risk factor variables. Sample size data were also extracted on condition-specific subgroups (diabetes or pressure ulcers) and amputations if reported. All extracted data were then checked for accuracy and omissions by a non-blinded second author (SDJ). At the conclusion of this data extracting checking process, the overall agreement between the second checking author's findings (SDJ) and the original author's findings (PAL) was calculated and reported. Any differences in the data extraction finding between the two authors (PAL and SDJ) were then resolved by consensus agreement between the two authors (PAL

and SDJ). A third author (SEH) was used to make a final adjudication if agreement could not be reached.

Statistical analysis

Data were analysed using Stata V.13 (StataCorp LP, College Station, Texas, USA) and Microsoft Excel V.2010 (Microsoft Corporation, Redmond, Washington, USA). Descriptive statistics were reported on all included studies. Medians (IQRs) were calculated for the study quality scores of groups of studies using similar study design and reporting the same foot disease disorder or risk factor. Kruskal-Wallis and Mann-Whitney U tests were used to test study quality score differences between these groups. For the purposes of measures of agreement between authors, a percentage agreement and κ statistic were used.[29] The κ value (SEs) strengths of agreement were categorised as: no agreement<0; slight agreement=0–0.20; fair agreement=0.21–0.40; moderate agreement=0.41–0.6; substantial agreement=0.61–0.8; and near-perfect agreement=0.81–1.0.[29]

The summary statistic used for each study's foot disease disorder or risk factor variable was a prevalence proportion. The SE for each prevalence estimate was then calculated. If a study only reported numbers, these numbers were converted to a prevalence proportion using the ratio of the number of individuals with the foot disease disorder or risk factor variable reported (numerator) and the number of the total sample size of the study (denominator). Studies reporting only numbers of a foot disease disorder or risk factor per total disorder (eg, foot wounds per total wounds) were converted to numbers of patients with the foot disease disorder or risk factor for the purpose of this review. This was performed using the ratio of the number of the foot disease disorder or risk factor and the number of total disorder, multiplied by the total sample size population. These studies were excluded from any meta-analyses performed.

Meta-analyses were calculated where three or more studies of at least 'moderate' methodological quality had reported the same foot disease disorder or risk factor using a similar study design.[29] Meta-analyses were used to calculate pooled prevalence estimates for the foot disease disorder or risk factor using a random-effects model.[29] Random effects were used to give an average estimate across heterogeneous studies weighted on total sample size.[29] The I^2 test was used to test for heterogeneity across studies included in individual meta-analysis; I^2 values of <25%, 25–75% and >75% were rated as low, moderate and high heterogeneity, respectively.[29] Scatterplots were used to investigate if individual meta-analysis prevalence estimates were influenced by factors, such as sample size or study quality.[29]

RESULTS

Search results

Figure 1 displays the search strategy and study selection results. The search strategy yielded a total of 4972 unique records of which 698 studies were retrieved for detailed eligibility assessment. Of those, 56 studies met the eligibility criteria and were included. An additional 306 potentially eligible articles were identified from hand searching references and citation searching processes from the 56 included studies and 22 of those met eligibility criteria and were included. Lastly, 30 further additional studies were identified by the external content experts and none of those met the eligibility criteria. Overall, 78 studies, reporting 84 individual hospital cohorts, were included in this systematic review.

Study characteristics

Table 1 displays the summary characteristics of the 84 individual study cohorts from the 78 included studies. Online supplementary tables S4–6 display the specific individual characteristics and citations for each of the 84 individual study cohorts. Rather than presenting tables in alphabetical order, the authors chose to group similar studies together for ease of comparison. Study cohorts were grouped according to the foot disease disorder or risk factor reported and study design (prospective or retrospective) used due to the reported prevalence differences ascertained from different foot disease disorders, risk factors and study designs.[30 31]

The 84 included study cohorts included a total of 60 231 517 participants; 66 (79%) prospective cohorts reported on a total of 643 141 participants and 18 (21%) retrospective cohorts reported on a total of 59 588 376 participants (table 1). Sample sizes ranged from 59 to 57 639 000, 59 to 158 236 in prospective studies and 167 to 57 539 000 in retrospective studies. Only 15 (18%) included study cohorts were investigated for foot disease disorders or risk factors as the primary aim of the study; 8 in prospective cohorts and 7 in retrospective cohorts. Study cohorts reporting foot disease disorders included: 70 (83%) foot wounds, 7 (8%) foot infection and 12 (14%) reported foot disease collectively. Study cohorts reporting risk factors included: 10 (12%) PAD, 6 (7%) PN and no studies reported foot deformity. Study cohorts could be grouped into three distinct subgroups of condition-related studies, including: 8 (10%) reporting all-cause foot disease disorders or risk factors (see online supplementary table S4), 24 (29%) reporting diabetes-related foot disease disorders or risk factors (see online supplementary table S5), and 52 (62%) reporting pressure ulcer-related foot disease disorders or risk factors (see online supplementary table S6) in their general inpatient population sample. Three studies reported both all-cause and diabetes-related foot disease disorders or risk factor prevalence in their general inpatient population sample.

Quality assessment

Online supplementary table S7 displays the original methodological quality assessments from the two blinded authors for the 78 included studies. The κ (SE) values calculated between the two blinded author's

assessments ranged from 0.69 (0.10) to 0.96 (0.04) which corresponded to 'substantial' or 'near-perfect' strengths of agreement for each item analysed. The percentage agreements between the two blinded author's assessments ranged between 86% and 99% with an overall agreement of 92% (720 of the 780 total items). Table 2 displays the final agreed methodological quality assessment results for all included studies. Overall, 25 (32%) studies had 'good' methodological study quality scores, 40 (51%) had 'moderate' study quality scores and 13 (17%) had 'poor' study quality scores.

Table 1 displays differences in median study quality scores between studies reporting different study designs and different condition-related foot disease disorders or risk factors. Prospective studies reported statistically significant higher study quality scores (median (IQR) 6(5–7)) than retrospective studies (3(3–5); p<0.05). Studies reporting pressure ulcer-related foot disease or risk factors also reported statistically significant higher study quality scores (7(5–8)) than those reporting all-cause foot disease or risk factors (5(4.5–6)) or diabetes foot-related foot disease or risk factors (4(3–5); (p<0.05). Table 2 displays the findings from the assessment of all 10 individual methodological quality items used. These findings revealed: 83% of studies reported a prospective design, 83% reported an appropriately sampled population, 88% recruited an adequate sample size (>300 participants), 68% used a physical examination to determine the foot disease disorder or risk factor, 67% used a validated outcome measure and 60% had an adequate response rate of eligible participants. It also revealed: only 22% reported measuring the foot disease disorder or risk factor in an unbiased manner and 0% reported foot disease or risk factor prevalence estimates with CIs.

Data extraction

Overall percentage agreement between the findings of the two authors performing data extraction was 97% (720 of the 740 total items). The 20 differences between the second author (SDJ) checking the data extraction findings of the first author (PAL) included: eight rounding, eight data entry and four case definition errors. All 20 differences were errors originally made in the data extraction process by the first author (PAL). Table 1 and online supplementary tables S4–6 display the final agreed consensus findings from the data extraction process for all included studies.

Prevalence of foot disease disorders and risk factors

Table 1 reports the total and subgroups of condition-related foot disease disorders and risk factor prevalence ranges in general inpatient populations. Total foot disease disorder prevalence ranges included: 0.01–13.5% for foot wounds, 0.05–6.4% for foot infections and 0.2–11.9% for collective foot disease. Total risk factor prevalence ranges included: 0.01–36.0% for PAD, 0.003–2.8% for PN and foot deformity was not reported.

Table 1 Summary characteristics of included studies

Group	Study cohorts (k (%))	Total sample (n)	Sample (m)	Sample range	Study aim k (%)	Study quality (M (IQR))	k	Foot wound (%)	k	Foot infection (%)	k	Foot disease (%)	k	PAD (%)	k	PN (%)	k	Amp (%)
Total	84 (100%)	60 231 517	717 042	59–57 639 000	15 (18%)	5 (4–7)	70	0.01–13.5	7	0.05–6.4	12	0.2–11.9	10	0.01–36.0	6	0.003–2.8	10	0.03–1.5
Prospective	66 (79%)	643 141	9745	59–158 236	8 (12%)	6 (5–7)	63	0.3–13.5	4	0.09–6.4	3	1.1–8.3	3	0.2–36.0	1	2.80	3	0.2–1.5
Retrospective	18 (21%)	59 588 376	3 310 465	167–57 639 000	7 (39%)	3 (3–5)	7	0.01–2.3	3	0.05–0.5	9	0.2–11.9	7	0.01–0.5	5	0.003–2.8	7	0.03–0.4
All-cause	8 (10%)	58 122 891	7 265 361	291–57 639 000	4 (50%)	5 (4.5–6)	3	0.7–4.2	2	0.09–0.5	2	0.2–1.2	4	0.3–36.0	1	0.2	3	0.03–0.2
Prospective	4 (50%)	2471	618	291–990	2 (50%)	6 (4.5–7)	2	1.6–4.2	–	–	–	–	2	29.6–36.0	–	–	–	–
Retrospective	4 (50%)	58 120 420	14 530 105	46 126–57 639 000	2 (50%)	5 (4.5–5)	1	0.7	2	0.09–0.5	2	0.2–1.2	2	0.3–0.5	1	0.2	3	0.03–0.2
Diabetes-related	24 (29%)	1 965 035	81 876	167–596 591	8 (33%)	4 (3–5)	15	0.01–7.0	5	0.05–6.4	10	0.2–11.9	6	0.01–0.4	5	0.003–2.8	7	0.04–1.5
Prospective	10 (42%)	15 659	1566	372–5188	3 (33%)	4 (4–5)	9	0.3–7.0	4	0.09–6.4	3	1.1–8.3	1	0.2	1	2.8	3	0.2–1.5
Retrospective	14 (58%)	1 949 376	139 241	167–596 591	5 (36%)	3 (3–4)	6	0.01–2.3	1	0.05	7	0.2–11.9	5	0.01–0.4	4	0.003–2.8	4	0.04–0.4
Pressure ulcer-related	52 (62%)	625 011	12 019	59–158 236	3 (6%)	7 (5–8)	52	0.3–13.5	–	–	–	–	–	–	–	–	–	–
Per person	15 (29%)	81 094	5406	60–37 307	1 (7%)	7 (6–8)	15	3.0–8.5	–	–	–	–	–	–	–	–	–	–
Per ulcer	37 (71%)	543 917	14 700	59–158 236	2 (5%)	6 (5–7)	37	0.3–13.5	–	–	–	–	–	–	–	–	–	–

-, not reported; %, prevalence; Amp, amputation; IQR, interquartile range; K, Study cohort numbers; m, mean; M, Median; n, patient numbers; PAD, peripheral arterial disease; PN, peripheral neuropathy. Study Aim: 1 = Investigating a foot disease disorder or risk factor is a primary aim of study, 0 = Investigating a foot disease disorder or risk factor is not a primary aim of study; Study Quality: Total agreed study quality score from the methodological assessment performed in table 2 (total possible score is 10).

Table 2 Final agreed methodological quality assessment results for all included studies*

Author	Year	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Question 7	Question 8	Question 9	Question 10	Total score†	Quality category‡
All-cause													
Antonopoulos[32]	2005	0	1	1	1	1	0	0	0	1	1	6	Moderate
Currie[24]	1998	1	0	0	1	0	0	1	0	1	1	5	Moderate
Donnan[33]	2000	1	0	0	1	0	0	1	0	1	1	5	Moderate
Gottrup[34]	2013	1	1	0	1	0	0	0	0	0	0	3	Poor
Gruen[35]	1997	1	1	1	1	0	0	1	0	0	1	6	Moderate
Henke[36]	2005	1	0	0	1	0	0	1	0	1	0	4	Moderate
Lacroix[37]	2008	1	1	1	0	1	1	1	0	1	1	8	Good
Morgan[38]	2010	1	0	0	1	0	0	1	0	1	1	5	Moderate
Diabetes-related													
Ajayi[39]	2009	0	0	0	1	0	0	1	0	0	1	3	Poor
Asumanu[40]	2010	0	1	1	1	1	0	0	0	1	0	5	Moderate
Chijioke[41]	2010	0	0	0	1	0	0	1	0	1	0	3	Poor
Daultry[42]	2011	1	1	1	1	0	0	0	0	0	0	4	Moderate
Hurd[43]	2009	1	1	1	1	1	0	1	0	0	0	6	Moderate
Leichter[44]	1982	0	0	0	1	0	0	1	0	0	0	2	Poor
Mahe[45]	2006	1	1	1	1	0	0	1	0	0	1	6	Moderate
Masson[46]	1992	1	1	0	1	0	0	1	0	0	0	4	Moderate
Mohammad Akther[47]	2011	0	1	1	1	1	0	0	0	1	0	5	Moderate
Mottini[48]	2003	0	0	0	1	0	0	1	0	0	0	2	Poor
Nason[49]	2013	1	0	0	1	0	0	1	0	0	0	3	Poor
Ogbera[50]	2006	1	0	0	1	0	0	1	0	0	0	3	Poor
Ogbera[51]	2007	0	1	0	1	0	0	1	0	0	1	4	Moderate
Otu[52]	2013	0	0	0	1	1	0	1	0	1	0	4	Moderate
Sjoberg[53]	2007	0	0	0	1	0	0	1	0	0	1	3	Poor
Tait[54]	2007	1	1	0	1	0	0	0	0	0	0	3	Poor
Unachukwu[55]	2007	0	1	1	1	1	0	0	0	0	0	4	Moderate
Wallymahmed[56]	2005	1	1	0	1	0	0	1	0	0	0	4	Moderate
Williams[57]	1985	1	0	0	1	0	0	1	0	0	0	3	Poor
Pressure ulcer-related													
Alja'afreh[58]	2013	0	1	1	0	0	0	0	0	0	0	2	Poor
Allcock[59]	1994	1	1	1	1	0	0	1	0	0	0	5	Moderate
Amlung[60]	2001	1	1	1	1	1	0	0	0	0	0	5	Moderate
Barczak[61]	1997	1	1	1	1	1	0	0	0	0	1	6	Moderate
Barrois[62]	1995	1	1	0	1	1	0	0	0	0	1	5	Moderate
Barrois[63]	2008	1	1	0	1	1	0	1	0	1	1	7	Good
Bours[64]	1999	1	1	1	1	1	1	0	0	0	1	7	Good
Bours[65]	2002	1	1	1	1	1	1	0	0	0	1	7	Good
Brito[66]	2013	1	1	1	1	1	0	0	0	0	1	6	Moderate
Charlier[67]	2001	1	1	1	0	0	0	1	0	0	1	5	Moderate
Clark[68]	1992	1	1	0	1	1	0	1	0	0	0	5	Moderate
Cole[69]	2004	1	1	1	0	1	0	1	0	0	0	5	Moderate
da Silva Cardoso[70]	2010	1	1	1	1	1	0	0	0	0	0	5	Moderate

Continued

Table 2 Continued

Author	Year	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Question 7	Question 8	Question 9	Question 10	Total score†	Quality category‡
Dealey[71]	1991	1	1	0	1	0	0	0	0	0	0	3	Poor
Dealey[72]	1994	1	1	1	1	1	0	1	0	0	0	6	Moderate
Ek[73]	1982	1	1	0	1	0	0	0	0	0	0	3	Poor
Gallagher[74]	2008	1	1	1	1	1	1	1	0	0	1	8	Good
Galvan-Martinez[75]	2012	1	1	1	0	1	1	1	0	0	1	7	Good
Gawron[76]	1994	1	1	1	1	1	1	1	0	0	1	8	Good
Gethin[77]	2005	1	1	1	1	1	0	1	0	0	1	7	Good
Gosnell[78]	1992	1	1	1	1	1	1	1	0	1	0	8	Good
Groeneveld[79]	2004	1	1	1	1	1	1	1	0	0	1	8	Good
Gunningberg[80]	2005	1	1	1	1	1	1	1	0	0	1	8	Good
Gunningberg[81]	2006	1	1	1	1	1	1	1	0	0	1	8	Good
Gunningberg[82]	2008	1	1	1	1	1	1	1	0	0	1	8	Good
Gunningberg[83]	2013	1	1	1	1	1	0	0	0	0	1	6	Moderate
Hopkins[84]	2000	1	1	1	1	1	0	0	0	0	0	5	Moderate
House[85]	2011	1	1	1	0	1	0	0	0	0	0	4	Moderate
Inan[86]	2012	1	1	1	1	1	0	1	0	1	1	8	Good
Jenkins[87]	2010	1	1	1	1	1	0	0	0	0	0	5	Moderate
Lahmann[88]	2006	1	1	1	1	1	0	1	0	0	1	7	Good
Langemo[89]	1990	1	1	1	0	1	0	0	0	0	0	4	Moderate
Lepisto[90]	2001	1	1	1	0	1	0	0	0	0	0	4	Moderate
Meehan[91]	1990	1	1	1	1	1	0	0	0	1	0	6	Moderate
Meehan[92]	1994	1	1	1	1	1	0	0	0	1	0	6	Moderate
Nyquist[93]	1987	1	1	1	1	1	0	0	0	0	0	5	Moderate
O'Brien[94]	1998	1	1	1	1	1	0	0	0	0	0	5	Moderate
Pearson[95]	2000	1	1	1	1	1	0	1	0	0	0	6	Moderate
Soldevilla[96]	2006	1	1	0	1	1	0	1	0	0	0	5	Moderate
Thoroddsen[97]	1999	0	1	0	1	1	1	1	0	0	1	6	Moderate
Tubaishat[98]	2011	1	1	1	1	1	1	1	0	0	1	8	Good
Tubaishat[99]	2013	1	1	1	0	1	1	1	0	0	1	7	Good
Uzun[100]	2007	1	1	1	1	1	0	1	0	1	1	8	Good
Vanderwee[101]	2007	1	1	1	1	1	1	0	0	0	1	7	Good
Vanderwee[102]	2011	1	1	1	1	1	1	0	0	1	1	8	Good
Vangilder[4]	2008	1	1	1	1	1	0	0	0	1	1	7	Good
Vangilder[103]	2010	1	1	1	1	1	0	0	0	1	1	7	Good
Wann-Hansson[104]	2008	1	1	1	1	1	0	1	0	1	1	8	Good
Whittington[105]	2004	1	1	1	1	0	0	0	0	0	0	4	Moderate
Young[106]	2002	1	1	1	1	1	1	1	0	0	1	8	Good
Zhao[107]	2010	1	1	1	1	1	0	1	0	0	1	7	Good
Total (n)		65	65	53	69	52	17	46	0	20	39	426	
Total (%)		83.3	83.3	67.9	88.5	66.7	21.8	60.0	0	25.6	50.0	54.6	

*Please see online supplementary table S3 for descriptions of each question; score: 1, 'yes'; 0, 'no' or 'not reported'.
†Total score, total agreed study quality score from the methodological assessment performed (total possible score is 10).
‡Quality category, total study quality score was classified as either 'poor' (total score=0–3), 'moderate' (total score=4–6) or 'good' (total score=7–10) study quality score.
Author, primary author of included study; Year, year included study was published.

Amputation prevalence ranges were 0.03–1.5%. The prevalence ranges were different for subgroups of condition-related foot disease disorders and risk factors reported. Prevalence ranges for foot wounds included: 0.7–4.2% for all-cause foot wounds; 0.01–7.0% for diabetes-related foot wounds and 0.3–13.5% for pressure ulcer-related foot wounds. Prevalence ranges for foot infections included: 0.09–0.5% for all-cause foot infection, 0.05–6.4% for diabetes-related foot infections and pressure ulcer-related foot infections was not reported. Prevalence ranges for collective foot disease included: 0.2–1.2% for all-cause foot disease, 0.2–11.9% for diabetes-related foot disease and pressure ulcer-related foot infections was not reported. Prevalence ranges for PAD included: 0.3–36.0% for all-cause PAD and 0.01–0.4% for diabetes-related PAD. Prevalence ranges for PN included: 0.2% for all-cause PN and 0.003–2.8% for diabetes-related PN. Again prevalence was greater in prospectively designed studies for all condition-related foot disease or risk factors investigated in general inpatient populations, with the exception of collective foot disease and PN.

Meta-analyses

Four foot disease disorders met the prespecified minimum for meta-analysis calculation of three eligible studies with similar study designs. Tables 3–6 report the pooled prevalence estimates from the meta-analyses calculations for pressure ulcer-related foot wounds, diabetes-related foot wounds, diabetes-related foot infections and diabetes-related foot disease. Table 3 reports a pooled prevalence estimate for pressure ulcer-related foot wounds based on 14 included studies reporting sample sizes ranging from 60 to 37 307 and study quality scores from 4 to 8. The pooled prevalence estimate was 4.6% (95% CI 3.7% to 5.4%, p<0.001; I^2=95.3%, p<0.001). Examination of scatterplots revealed a bias between higher reported pressure ulcer-related foot wound prevalence and those studies using an unbiased, reliable outcome measure (figure S1).

Table 4 reports a pooled prevalence estimate for diabetes-related foot wounds based on six included studies reporting sample sizes ranging from 624 to 5188 and study quality scores from 4 to 6. The pooled prevalence estimate was 2.4% (95% CI 1.5% to 3.4%, p<0.001; I^2=94.2%, p<0.001). Examination of scatterplots revealed sources of bias between higher reported diabetes-related foot wound prevalence and those studies either reporting smaller sample sizes, having lower study quality or studies conducted in developing countries (figure S2).

Table 5 reports a pooled prevalence estimate for diabetes-related foot infections based on three included studies reporting sample sizes ranging from 827 to 5188 and study quality scores from 4 to 5. The pooled prevalence estimate was 3.4% (95% CI 0.2% to 6.5%, p<0.05; I^2=97.0%, p<0.001). Scatterplots were not evaluated due to the limited number of included studies.

Table 6 reports a pooled prevalence estimate for diabetes-related foot disease based on three included studies reporting sample sizes ranging from 810 to 5188 and study quality scores from 4 to 5. The pooled prevalence estimate was 4.7% (95% CI 0.3% to 9.2%, p<0.05; I^2=97.8%, p<0.001). Scatterplots were not evaluated due to the limited number of included studies.

DISCUSSION

Principal findings

This study is the first systematic review to investigate the prevalence of foot disease in representative general inpatient populations. The prevalence of foot disease disorders in general inpatient populations ranged from

Table 3 Pooled random-effects estimates for *pressure ulcer-related foot wound* prevalence expressed as % (95% CI)

Study	Sample size	Prevalence estimates	95% CI	Percentage weighting	Study quality score
Barrois *et al*[63]	37 307	3.7	3.5 to 3.9	9.86	7
Brito *et al*[66]	473	4.7	2.8 to 6.5	6.59	6
Gallagher *et al*[74]	672	3.0	1.7 to 4.3	8.05	8
Gethin *et al*[77]	506	3.0	1.5 to 4.4	7.59	7
Gunningberg[80]	612	8.8	6.8 to 11.4	5.89	8
Gunningberg[81]	369	4.6	2.5 to 6.7	6.04	8
Gunningberg and Stotts[82]	632	6.5	4.6 to 8.4	6.53	8
Gunningberg *et al*[83]	16 466	6.7	6.3 to 7.1	9.71	6
House *et al*[85]	60	5.0	−0.5 to 10.5	1.88	4
Lahmann *et al*[88]	16 728	3.2	2.9 to 3.5	9.81	7
Tubaishat *et al*[98]	302	7.8	4.7 to 10.9	4.29	8
Tubaishat and Aljezawi[99]	295	3.0	1.1 to 4.9	6.54	7
Vanderwee *et al*[101]	5947	4.4	3.9 to 4.9	9.55	7
Wann-Hansson *et al*[104]	535	3.0	1.5 to 4.4	7.67	8
Pooled estimate		4.6	3.7 to 5.4	p<0.001	
I^2		95.3%		p<0.001	

Table 4 Pooled random-effects estimates for *diabetes-related foot wound* prevalence expressed as % (95% CI)

Study	Sample size	Prevalence estimates	95% CI	Percentage weighting	Study quality score
Asumanu *et al*[40]	966	4.3	3.1 to 5.6	14.60	5
Hurd and Posnett[43]	3099	1.1	0.7 to 1.5	18.99	6
Mahé *et al*[45]	624	0.5	−0.1 to 1.0	18.40	6
Mohammad Akther *et al*[47]	5188	1.1	0.8 to 1.3	19.22	5
Ogbera *et al*[51]	1327	2.7	1.8 to 3.6	16.84	4
Unachukwu *et al*[55]	827	7.0	5.3 to 8.8	11.95	4
Pooled estimate		2.4	1.5 to 3.4	p<0.001	
I^2		94.2%		p<0.001	

0% to 13%, while the prevalence of a major risk factor for foot disease ranged from 0% to 36%. Meta-analyses could only be calculated for four condition-related foot disease disorders. These pooled prevalence estimates indicated that 4.6% (95% CI 3.7% to 5.4%) of all inpatients had a pressure ulcer present on their foot, 4.7% (0.3% to 9.2%) had collective diabetes-related foot disease, 2.4% (1.5% to 3.4%) had diabetes-related foot wounds and 3.4% (0.2% to 6.5%) had diabetes-related foot infections. Additional findings from this review suggested up to 1.2% of all inpatients had been hospitalised for the primary reason of foot disease. However, this systematic review also revealed large variations in reported prevalence and study quality within each foot disease disorder or risk factor of interest. These variations appear to have been the major contributors to the high statistical heterogeneity reported in the pooled prevalence estimates from this review.

Strengths and weaknesses

The findings of this systematic review should be viewed in the context of several consistent limitations observed in the included studies of this review. First, most included studies reported foot disease disorders or risk factor as an additional outcome and no included studies reported CIs or sample size calculations for foot disease findings. Second, most included studies reported a condition-related (such as diabetes-related), rather than an all-cause, foot disease disorder or risk factors in a general inpatient population. Third, study quality scores varied considerably depending on the study design and foot disease disorder or risk factor investigated. Fourth, all-cause and diabetes-related foot disease disorder or risk factor findings were predominately reported from retrospective studies. Lastly, while studies reporting pressure ulcer-related foot disease were all prospective and mostly of high quality, a large proportion reported only pressure ulcers on the heel. Overall, these limitations impact on the capture, precision and heterogeneity of findings and indicate included studies are likely to have under-reported foot disease disorder and risk factor prevalence.

The authors are also cognisant of limitations in the methodology used to perform this systematic review. First, this review used broad inclusion criteria for foot disease disorders, risk factors and general inpatient population definitions, and this may have contributed to the heterogeneity of findings. Second, the original search strategy was performed by only one author and did not initially identify studies reporting pressure ulcer-related foot wounds on specific anatomical locations of the foot. However, the authors believe this was addressed by conducting a broad initial search strategy, an extensive additional pressure ulcer-related search strategy, hand searching references of all included studies, citation searching all included studies and contacting external content experts to identify any remaining relevant studies. Third, only one author extracted data. However, a second author checked all data extraction finding and reported very high percentage agreement with the original data extraction findings. Fourth, the tool used to assess the methodological quality of included studies had not been tested for reliability and validity. However, the tool reported substantial inter-rater reliability agreement between blinded authors in this study, had high face validity and aligned with items

Table 5 Pooled random-effects estimates for *diabetes-related foot infection* prevalence expressed as % (95% CI)

Study	Sample size	Prevalence estimates	95% CI	Percentage weighting	Study quality score
Asumanu *et al*[40]	966	3.3	2.2 to 4.4	33.42	5
Mohammad Akther *et al*[47]	5188	0.6	0.4 to 0.8	34.82	5
Unachukwu *et al*[55]	827	6.4	4.7 to 8.1	31.76	4
Pooled estimate		3.4	0.2 to 6.5	p=0.037	
I^2		97.0%		p<0.001	

Table 6 Pooled random-effects estimates for *diabetes-related foot disease* prevalence expressed as % (95% CI)

Study	Sample size	Prevalence estimates	95% CI	Percentage weighting	Study quality score
Asumanu *et al*[40]	966	8.3	6.6 to 10.0	32.66	5
Daultrey *et al*[42]	810	4.9	3.4 to 6.4	33.05	4
Mohammad Akther *et al*[47]	5188	1.1	0.8 to 1.3	34.28	5
Pooled estimate		4.7	0.3 to 9.2	p=0.038	
I^2		97.8%		p<0.001	

reported to provide best practice methodological quality assessments for observational studies.[108] Lastly, the pooled prevalence estimates calculated in this review reported very high statistical heterogeneity, and some may argue the value of reporting such heterogeneous findings.[29] However, the authors used conservative random-effects meta-analyses models weighted on total sample size in an attempt to account for heterogeneity.[29] Furthermore, the authors consider the reporting of heterogeneous pooled prevalence estimates, with the clear cautionary notes provided by the authors on interpretation, provide considerable additional value and transparency to the existing literature available in this field.[29]

Interpretations of findings

The most consistent deficiency in study quality identified in this review was that no studies reported CIs for foot disease or risk factor prevalence findings. This was most probably related to very few studies investigating a foot disease disorder or risk factor as their primary outcome of interest.[24 32 36 37 41 42 47 49 50 52 83 106 107] Most studies reported foot disease or risk factors as an additional aim to the primary study aim of investigating the prevalence of a larger condition, such as the total pressure ulcer or diabetes prevalence. This lack of focus on foot disease may have led to an under-reporting of prevalence findings as suggested in other similar studies.[5 30 31] Furthermore, 7 of the 15 study cohorts that were investigated primarily for a foot disease disorder or risk factor were retrospective studies.[24 36 49 50 52] Retrospective studies have been found to also considerably underreport prevalence compared with prospectively designed studies utilising validated outcome measures,[5 30 31] and this also seemed to be the case in this review. Only eight study cohorts were prospectively investigated for the primary reason of identifying a foot disease disorder or risk factor;[32 37 40 42 47 83 106 107] however, only one used an unbiased method of measurement.[37] This particular study investigated PAD using a reliable and validated non-invasive ankle brachial index method.[37] With nearly all studies either retrospective in design or investigating a foot disease disorder or risk factor as an additional outcome, it could be hypothesised that the pooled prevalence estimates reported in this review are likely to underestimate the actual burden of foot disease in inpatient populations.

Foot wounds were by far the most identified and reported foot disease disorder arising from this systematic review. Yet, only three studies reported on all-cause foot wound prevalence.[24 34 35] A large retrospective study by Currie *et al*[24] investigating foot disease disorders and risk factors when they were the primary reason for admission was the only study with the primary aim of investigating all-cause foot wounds and reported a foot wound prevalence of 0.7%. The other two studies were prospective studies and reported all-cause foot wound prevalence of 1.6%[34] and 4.2%,[35] respectively. However, the primary aims of these prospective studies were to investigate wound prevalence, and thus, identifying foot wounds was one of several additional aims investigating different wound locations.[34 35] Limitations in study numbers and quality calls into question the precision of all-cause foot wound prevalence estimates and meant pooled estimates could not be calculated.

In contrast, the study numbers and quality were sufficient to perform meta-analyses on diabetes-related foot wound and pressure ulcer-related foot wound prevalence. The increased numbers of studies reporting these two condition-related areas is perhaps not unexpected considering aspects of diabetes and pressure ulcer management are commonly utilised internationally as key performance indicators of hospital care quality.[4 109–112] Foot wounds are major contributors to poor outcomes in both these conditions.[4 38 63 101 110] The pooled prevalence estimates for diabetes-related foot wounds (2.4%) and pressure ulcer-related foot wounds (4.6%) from this review indicate these foot wounds do contribute considerable burdens on the hospital inpatient system. While there were more studies investigating these two condition-related foot wounds in general inpatient populations again both pooled prevalence estimates had very high heterogeneity. This may be attributed to only 'moderate' study quality scores being eligible for inclusion in the calculation of the diabetes-related foot wound pooled prevalence estimate. However, this was not the case for the pressure ulcer-related foot wound pooled prevalence estimate where overall included study quality scores were 'good'. Interestingly, the only factor identified in the scatterplots to bias pressure ulcer-related foot wound prevalence findings was the bias of the investigators themselves. This suggests in studies where investigators or data collectors investigated participants from their own hospitals pressure ulcer prevalence were

under-reported. As this was the only factor identified to bias pressure ulcer-related foot wound prevalence from this review, it is therefore plausible, that the variation in pressure ulcer-related foot wound prevalence is largely affected by the quality of care provided by the individual hospital. Thus, this would support the ongoing use of unbiased pressure ulcer prevalence as a key performance indicator of hospital care quality.[4 82 101]

It was apparent that most studies reporting pressure ulcer-related foot wounds did not exclude wounds of diabetes origin, and conversely, most studies reporting diabetes-related foot wounds did not exclude wounds of pressure ulcer-related origin. This potential cross-contamination suggests studies reporting pressure ulcer-related foot wounds may inadvertently be a combination of the prevalence of pressure ulcer-related and diabetes-related foot wounds. Furthermore, literature reports stage 1 pressure ulcers make up to 50% of the total pressure ulcer burden.[63 82 101] Stage 1 pressure ulcers are defined as non-blanchable erythema without skin loss or a 'pre-pressure ulcer'.[63 82] This suggests the real pressure ulcer-related foot wound prevalence in those inpatients with skin loss may make up only 50% of the 4.6% pooled prevalence estimate reported from this review. Thus, it could be hypothesised that the real pressure ulcer-related wound prevalence may be closer to 2.4% pooled prevalence estimate findings for diabetes-related foot wounds. Again considering the high likelihood of cross-contamination of these two large condition-related foot wound types, this hypothesis may extend to the suggestion that pressure ulcer-related foot wounds with skin loss could be a useful surrogate marker for all-cause foot wound prevalence and a potential indicator of foot care quality. However, these hypotheses need to be interpreted with much caution until further investigations support its use in this capacity.

Foot infection was the other major foot disease disorder included in this review and was typically reported to affect existing foot wounds.[47 51 55] The retrospective analysis by Currie *et al*[24] was the only study primarily investigating all-cause foot infection prevalence and reported a rate of 0.5%. Another retrospective study to primarily investigate foot infection reported a rate of 0.1%; however, this study only investigated foot osteomyelitis (bone infection).[36] The remaining five cohorts reported diabetes-related foot infections.[24 40 47 55 56] The prospective pooled prevalence estimate for diabetes-related foot infection was 3.4% (0.2–6.5); yet, statistical heterogeneity was again high and needs to be interpreted with caution. This is particularly the case considering the pooled prevalence estimate for diabetes-related foot infection was higher than for diabetes-related foot wounds. However, the findings from the three studies used to calculate the diabetes-related foot infection pooled prevalence estimate each individually found higher diabetes-related foot wound prevalence than they did for diabetes-related foot infection prevalence.[40 47 55]

The aforementioned study by Currie *et al*[24] was also the only study to primarily investigate all-cause collective foot disease prevalence in a general inpatient population. This retrospective study analysed the proportion of foot disease that were the primary reason for admission from over 300 000 hospitalisations recorded in a Welsh national hospital discharge data set.[24] Interestingly, even though the retrospective study design used in this large study make significant under-reporting likely,[5 30 31] it still identified that collectively foot disease was the primary reason for admission in 1.2% of hospitalisations.[24] Foot disease was also collectively reported in 11 other study cohorts with prevalence ranging from 0.2% to 11.9%. However, a pooled prevalence estimate of 4.7%[40 43 45 47 51 55] could only be calculated for diabetes-related foot disease and this was again a heterogeneous finding. One factor that may have influenced these high heterogeneous findings was the different synonyms and inclusion criteria used to define collective foot disease disorders between studies. The terms varied between 'foot disease',[40] 'foot problems',[42 53] 'diabetic foot'[38 41] and an aggregation of different foot disease disorders.[24 47 49] The inconsistency of terms, definitions and the specific foot disease disorders included within these collective 'foot disease' groups appears to be a major contributing factor in the heterogeneity of these findings. It is recommended that a formal international consensus process is undertaken to determine an agreed foot disease definition so as to allow clinicians and researchers to compare homogeneous 'foot disease' outcomes in future.

The major risk factors for foot disease included in this study were PAD, PN and foot deformity. PAD was the most reported risk factor in 10 cohorts. Two 'moderate-to-good' quality prospective studies of all-cause PAD using similar gold standard non-invasive vascular outcome measures reported similar 29.6% and 36.0% prevalence findings.[32 37] In contrast, other PAD studies were either retrospective in design or reported PAD using a non-valid or reliable method. However, the methodological deficiencies of these studies translated to poorer study quality scores and much lower PAD prevalence ranges of 0.01–0.5%. Thus, using the most robust study quality evidence available, it could be hypothesised that PAD is present in approximately one-third of general inpatient populations.[32 37] PN was reported in six cohorts with the only study reporting all-cause PN prevalence (0.2%) again the retrospective study by Currie *et al*.[24] All other studies reported diabetes-related PN prevalence ranging from 0.003% to 2.8% in general inpatient populations.[24 40 44 48 52] The only study to primarily investigate diabetes-related PN identified that 2.8% of all inpatients had diabetes-related PN using a validated tool.[40] However, with only one retrospective study reporting all-cause PN and all other studies reporting condition-related PN, these low reported PN prevalence rates could again be considered to under-report the actual all-cause PN prevalence in

inpatients. Foot deformity was not identified by this review. Unfortunately, there were insufficient studies of satisfactory quality to enable the calculation of a pooled prevalence estimate for any risk factor. Therefore, until further studies are conducted, the best estimate of the proportion of general inpatient populations with a major risk factor for foot disease appears to be up to 36%.[32 37]

Lastly, amputation prevalence was reported in 10 included study cohorts identified by this review ranging from 0.03% to 1.5%.[24 33 36 40 46 48 55 50] The only study primarily investigating all-cause amputation in this context was again the retrospective study by Currie *et al*[24] suggesting 0.1% prevalence in general inpatient populations. Most remaining studies reported diabetes-related amputation rates which ranged between 0.04% and 1.5%.[24 33 40 46 48 55 50] Unfortunately, there were insufficient studies to calculate a pooled prevalence estimate. However, this prevalence range may not be exhaustive and needs to be interpreted with caution, as amputation was a secondary aim of this review and only reported from studies that also reported foot disease or risk factors.

Implications for clinicians, researchers and policymakers

While reviews have been investigating the inpatient burden of major organ disease for some time, such as heart disease,[113–115] this appears to be the first review to determine more precise estimates for foot disease in general inpatient populations. This review has identified that foot disease is present in considerable proportions of the general inpatient population. Primary findings indicate 1 in 20 inpatients had foot disease and 1 in 3 inpatients had a major risk factor for foot disease. This review also supports existing evidence suggesting foot disease is present in large proportions of discrete inpatient populations, such as patients with diabetes[1–3] and pressure ulcers.[4 82 101] Furthermore, additional findings indicate 1 in every 100 inpatients had been hospitalised because of foot disease and up to 1.5% of all inpatients were in hospital to have an amputation procedure. Although pooled prevalence estimates in this review had high heterogeneity, they are the most precise prevalence estimates to date to quantify the burden of foot disease present in general inpatient populations. Overall findings from this review appear to be very likely an underestimate of this burden.

With such a considerable proportion of foot disease present in inpatient populations, it is perhaps surprising that more research has not been conducted to primarily investigate this potentially considerable burden. However, this review does highlight the need for clinicians, researchers and policymakers to better understand and address this seemingly under-recognised burden in inpatient populations. It is recommended that future studies in this field should be prospective in design, have a primary aim to investigate foot disease in inpatient populations and use unbiased, reliable and validated foot disease and risk factor outcome measures. Furthermore, it is recommended the findings of this review should inform policy to more precisely address this under-recognised yet considerable burden of foot disease in inpatient populations.

CONCLUSIONS

This is the first known systematic review to synthesise the literature on foot disease in inpatient populations and provides the best estimates to date of this burden. Findings from this review indicate up to 36% of all inpatients had a major risk factor for foot disease, 5% had foot disease and up to 1% were in hospital because of foot disease. Owing to the high heterogeneity of included studies, these estimates need to be interpreted with caution; however, they are more likely to under-report the inpatient foot disease burden. This review highlights the urgent need for further research to more robustly quantify, and address, what appears to be a considerable burden of foot disease present in general inpatient populations.

Author affiliations
[1]School of Clinical Sciences, Queensland University of Technology, Brisbane, Queensland, Australia
[2]Institute of Health and Biomedical Innovation, Queensland University of Technology, Brisbane, Queensland, Australia
[3]Allied Health Research Collaborative, Metro North Hospital & Health Service, Brisbane, Queensland, Australia
[4]Wound Management Innovation Cooperative Research Centre, Brisbane, Queensland, Australia
[5]Queensland Research Centre for Peripheral Vascular Disease, College of Medicine and Dentistry, James Cook University, Townsville, Queensland, Australia
[6]Podiatry Service, Kirwan Community Health Campus, Townsville Hospital and Health Service, Townsville, Queensland, Australia
[7]Department of Podiatry, West Moreton Hospital & Health Service, Ipswich, Queensland, Australia
[8]Centre for Musculoskeletal Research, Griffith Health Institute, Griffith University, Gold Coast, Australia

Acknowledgements The authors wish to warmly acknowledge the work of the independent research assistant and the external content experts for their very kind assistance. The authors also wish to recognise the ongoing support provided to this work by Queensland Health, Wound Management Innovation Cooperative Research Centre, the Australian Government's Cooperative Research Centres Program and Queensland University of Technology.

Contributors PAL conceived and designed the study, carried out the literature searches, quality assessments, data extraction, statistical analysis and drafted the manuscript. SEH conceived and designed the study, assisted with the literature searches, quality assessments, data extraction, statistical analysis, contributed to discussion and reviewed/edited the manuscript. MEF conducted quality assessments, contributed to discussion and reviewed/edited the manuscript. SDJ conducted data extraction, contributed to discussion and reviewed/edited the manuscript. SSK, MCK and LFR conceived and designed the study, contributed to discussion and reviewed/edited the manuscript.

Funding This work was supported by grant funding from Queensland Health (Queensland Government, Australia) and the Wound Management Innovation Cooperative Research Centre (Australia).

Competing interests None declared.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement No additional data are available.

REFERENCES

1. Boulton AJM, Vileikyte L, Ragnarson-Tennvall G, *et al*. The global burden of diabetic foot disease. *Lancet* 2005;366:1719–24.
2. Lazzarini PA, Gurr JM, Rogers JR, *et al*. Diabetes foot disease: the Cinderella of Australian diabetes management? *J Foot Ankle Res* 2012;5:24.
3. Moxey PW, Gogalniceanu P, Hinchliffe RJ, *et al*. Lower extremity amputations—a review of global variability in incidence. *Diabet Med* 2011;28:1144–53.
4. Vangilder C, Macfarlane GD, Meyer S. Results of nine international pressure ulcer prevalence surveys: 1989 to 2005. *Ostomy Wound Manage* 2008;54:40–54.
5. Wraight PR, Lawrence SM, Campbell DA, *et al*. Retrospective data for diabetic foot complications: only the tip of the iceberg? *Intern Med J* 2006;36:197–9.
6. Kaminski M, Frescos N, Tucker S. Prevalence of risk factors for foot ulceration in patients with end-stage renal disease on haemodialysis. *Intern Med J* 2012;42:e120–8.
7. Global Lower Extremity Amputation Study Group. Epidemiology of lower extremity amputation in centres in Europe, North America and East Asia. *Br J Surg* 2000;87:328–37.
8. Ephraim PL, Dillingham TR, Sector M, *et al*. Epidemiology of limb loss and congenital limb deficiency: a review of the literature. *Arch Phys Med Rehabil* 2003;84:747–61.
9. Lazzarini PA, O'Rourke SR, Russell AW, *et al*. What are the key conditions associated with lower limb amputations in a major Australian teaching hospital? *J Foot Ankle Res* 2012;5:12.
10. Dillingham TR, Yacub JN, Pezzin LE. Determinants of postacute care discharge destination after dysvascular lower limb amputation. *PM R* 2011;3:336–44.
11. Lavery LA, Houtum WHV, Armstrong DG. Institutionalization following diabetes-related lower extremity amputation. *Am J Med* 1997;103:383–8.
12. Armstrong DG, Wrobel J, Robbins JM. Guest editorial: are diabetes-related wounds and amputations worse than cancer? *Int Wound J* 2007;4:286–7.
13. Tapp RJ, Shaw JE, Courten MPD, *et al*. Foot complications in Type 2 diabetes: an Australian population-based study. *Diabet Med* 2003;20:105–13.
14. Prompers L. *Diabetic foot disease in European perspective: results from the Eurodiale study*. PhD Thesis, Maastricht University, 2008. http://pub.maastrichtuniversity.nl/33a72da3-d773-4f20-9873-c6321b89b99a (accessed 19 Dec 2014).
15. Freeman A, May K, Frescos N, *et al*. Frequency of risk factors for foot ulceration in individuals with chronic kidney disease. *Intern Med J* 2008;38:314–20.
16. Wraight PR, Lawrence SM, Campbell DA, *et al*. Creation of a multidisciplinary, evidence based, clinical guideline for the assessment, investigation and management of acute diabetes related foot complications. *Diabet Med* 2005;22:127–36.
17. Reed T Jr, Veith FJ, Gargiulo NJ III, *et al* System to decrease length of stay for vascular surgery. *J Vasc Surg* 2004;39:395–9.
18. Lynch EA, Hillier SL, Stiller K, *et al*. Sensory retraining of the lower limb after acute stroke: a randomized controlled pilot trial. *Arch Phys Med Rehabil* 2007;88:1101–7.
19. Eckstein HH, Niedermeier HP, Noppeney T, *et al*. Certification of vascular centers—a project of the German Society of Vascular Surgery. *Eur J Vasc Endovasc Surg* 2006;32:279–85.
20. Korzets A, Ori Y, Rathaus M, *et al*. Lower extremity amputations in chronically dialysed patients: a 10 year study. *Isr Med Assoc J* 2003;5:501–5.
21. Oates KR. A survey of malignant disease in Zaire. *Fam Pract* 1986;3:102–6.
22. Memmel H, Kowal-Vern A, Latenser BA. Infections in diabetic burn patients. *Diabetes Care* 2004;27:229–33.
23. Reed JF III. An audit of lower extremity complications in octogenarian patients with diabetes mellitus. *Int J Low Extrem Wounds* 2004;3:161–4.
24. Currie CJ, Morgan CL, Peters JR. The epidemiology and cost of inpatient care for peripheral vascular disease, infection, neuropathy, and ulceration in diabetes. *Diabetes Care* 1998;21:42–8.
25. Moher D, Liberati A, Tetzlaff J, *et al*. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Med* 2009;6:e1000097.
26. Wagner FW Jr. Amputations of the foot and ankle. Current status. *Clin Orthop Relat Res* 1977;122:62–9.
27. Wagner FW Jr. The dysvascular foot: a system for diagnosis and treatment. *Foot Ankle* 1981;2:64–122.
28. Woodbury MG, Houghton PE. Prevalence of pressure ulcers in Canadian healthcare settings. *Ostomy Wound Manage* 2004;50:22–4, 6, 8.
29. Kirkwood B, Sterne J. *Essential medical statistics*. 2nd edn. Oxford, UK: Blackwell Publishing Ltd., 2003.
30. Moffitt TE, Caspi A, Taylor A, *et al*. How common are common mental disorders? Evidence that lifetime prevalence rates are doubled by prospective versus retrospective ascertainment. *Psychol Med* 2010;40:899–909.
31. Firth J, Nelson EA, Hale C, *et al*. A review of design and reporting issues in self-reported prevalence studies of leg ulceration. *J Clin Epidemiol* 2010;63:907–13.
32. Antonopoulos S, Kokkoris S, Stasini F, *et al*. High prevalence of subclinical peripheral artery disease in Greek hospitalized patients. *Eur J Intern Med* 2005;16:187–91.
33. Donnan PT, Leese GP, Morris AD. Hospitalizations for people with type 1 and type 2 diabetes compared with the nondiabetic population of Tayside, Scotland: a retrospective cohort study of resource use. *Diabetes Care* 2000;23:1774–9.
34. Gottrup F, Henneberg E, Trangbaek R, *et al*. Point prevalence of wounds and cost impact in the acute and community setting in Denmark. *J Wound Care* 2013;22:413–20.
35. Gruen RL, Chang S, MacLellan DG. The point prevalence of wounds in a teaching hospital. *Aust N Z J Surg* 1997;67:686–8.
36. Henke PK, Blackburn SA, Wainess RW, *et al*. Osteomyelitis of the foot and toe in adults is a surgical disease: conservative management worsens lower extremity salvage. *Ann Surg* 2005;241:885–92.
37. Lacroix P, Aboyans V, Voronin D, *et al*. High prevalence of undiagnosed patients with peripheral arterial disease in patients hospitalised for non-vascular disorders. *Int J Clin Pract* 2008;62:59–64.
38. Morgan CL, Peters JR, Dixon S, *et al*. Estimated costs of acute hospital care for people with diabetes in the United Kingdom: a routine record linkage study in a large region. *Diabet Med* 2010;27:1066–73.
39. Ajayi EA, Ajayi AO. Pattern and outcome of diabetic admissions at a federal medical center: a 5-year review. *Ann Afr Med* 2009;8:271–5.
40. Asumanu E, Ametepi R, Koney CT. Audit of diabetic soft tissue infection and foot disease in Accra. *West Afr J Med* 2010;29:81–5.
41. Chijioke A, Adamu AN, Makusidi AM. Mortality patterns among type 2 diabetes mellitus patients in Ilorin, Nigeria. *J Endocrinol Metab Diab S Afr* 2010;15:79–82.
42. Daultrey H, Gooday C, Dhatariya KK. Increased length of inpatient stay and poor clinical coding: audit of patients with diabetes. *JRSM Short Rep* 2011;2:83.
43. Hurd T, Posnett J. Point prevalence of wounds in a sample of acute hospitals in Canada. *Int Wound J* 2009;6:287–93.
44. Leichter SB, Hernandez C, Fisher A, *et al*. Diabetes in Kentucky. *Diabetes Care* 1982;5:126–34.
45. Mahé E, Langlois G, Baron G, *et al*. Results of a comprehensive hospital-based wound survey. *J Wound Care* 2006;15:381–4.
46. Masson EA, MacFarlane IA, Power E, *et al*. An audit of the management and outcome of hospital inpatients with diabetes: resource planning implications for the diabetes care team. *Diabet Med* 1992;9:753–5.
47. Mohammad Akther J, Ali Khan I, Shahpurkar VV, *et al*. Evaluation of the diabetic foot according to Wagner's classification in a rural teaching hospital. *Br J Diabetes Vasc Dis* 2011;11:74–9.
48. Mottini G, D'Avola D, Dimbelolo JC, *et al*. A hospital survey of the clinical features of diabetes in Congo. *Diabetes Nutr Metab* 2003;16:236–42.
49. Nason GJ, Strapp H, Kiernan C, *et al*. The cost utility of a multi-disciplinary foot protection clinic (MDFPC) in an Irish hospital setting. *Ir J Med Sci* 2013;182:41–5.
50. Ogbera AO, Fasanmade O, Ohwovoriole AE, *et al*. An assessment of the disease burden of foot ulcers in patients with diabetes mellitus attending a Teaching Hospital in Lagos, Nigeria. *Int J Low Extrem Wounds* 2006;5:244–9.

51. Ogbera AO, Chinenye S, Onyekwere A, *et al*. Prognostic indices of diabetes mortality. *Ethn Dis* 2007;17:721–5.
52. Otu AA, Umoh VA, Essien OE, *et al*. Profile, bacteriology, and risk factors for foot ulcers among diabetics in a tertiary hospital in Calabar, Nigeria. *Ulcers* 2013;2013:820468.
53. Sjoberg L, Yearwood R. Impact of a category-3 hurricane on the need for surgical hospital care. *Prehosp Disaster Med* 2007;22:194–8.
54. Tait C, Gibson E. Chronic wound audit: evaluation of a tissue viability service. *Br J Nurs* 2007;16:S14, S16, S18 passim.
55. Unachukwu C, Babatunde S, Ihekwaba AE. Diabetes, hand and/or foot ulcers: a cross-sectional hospital-based study in Port Harcourt, Nigeria. *Diabetes Res Clin Pract* 2007;75:148–52.
56. Wallymahmed ME, Dawes S, Clarke G, *et al*. Hospital in-patients with diabetes: increasing prevalence and management problems. *Diabet Med* 2005;22:107–9.
57. Williams DR. Hospital admissions of diabetic patients: information from hospital activity analysis. *Diabet Med* 1985;2:27–32.
58. Alja'afreh M, Mosleh SM. Pressure ulcers in Jordan: a snapshot survey of a tertiary public hospital. *Br J Nurs* 2013;22:S10, S12, S14–6.
59. Allcock N, Wharrad H, Nicolson A. Interpretation of pressure-sore prevalence. *J Adv Nurs* 1994;20:37–45.
60. Amlung SR, Miller WL, Bosley LM. The 1999 National Pressure Ulcer Prevalence Survey: a benchmarking approach. *Adv Skin Wound Care* 2001;14:297–301.
61. Barczak CA, Barnett RI, Childs EJ, *et al*. Fourth national pressure ulcer prevalence survey. *Adv Wound Care* 1997;10:18–26.
62. Barrois B, Allaert FA, Colin D. A survey of pressure sore prevalence in hospitals in the greater Paris region. *J Wound Care* 1995;4:234–6.
63. Barrois B, Labalette C, Rousseau P, *et al*. A national prevalence study of pressure ulcers in French hospital inpatients. *J Wound Care* 2008;17:373.
64. Bours GJ, Halfens RJ, Lubbers M, *et al*. The development of a national registration form to measure the prevalence of pressure ulcers in The Netherlands. *Ostomy Wound Manage* 1999; 45:28.
65. Bours GJJ, Halfens RJG, Abu-Saad HH, *et al*. Prevalence, prevention, and treatment of pressure ulcers: descriptive study in 89 institutions in The Netherlands. *Res Nurs Health* 2002;25:99–110.
66. Brito PA, de Vasconcelos Generoso S, Correia MITD. Prevalence of pressure ulcers in hospitals in Brazil and association with nutritional status—a multicenter, cross-sectional study. *Nutrition* 2013;29:646–9.
67. Charlier C. Prevalence, incidence and risk: a study of pressure ulcers at a rural base hospital. *Prim Intention* 2001;9:12.
68. Clark M, Cullum N. Matching patient need for pressure sore prevention with the supply of pressure redistributing mattresses. *J Adv Nurs* 1992;17:310–16.
69. Cole L, Nesbitt C. A three year multiphase pressure ulcer prevalence/incidence study in a regional referral hospital. *Ostomy Wound Manage* 2004;50:32–40.
70. da Silva Cardoso JR, Blanes L, Augusto Calil J, *et al*. Prevalence of pressure ulcers in a Brazilian hospital: results of a cross-sectional study. *Ostomy Wound Manage* 2010;56:52–7.
71. Dealey C. The size of the pressure-sore problem in a teaching hospital. *J Adv Nurs* 1991;16:663–70.
72. Dealey C. Monitoring the pressure sore problem in a teaching hospital. *J Adv Nurs* 1994;20:652–9.
73. Ek A. A descriptive study of pressure sores: the prevalence of pressure sores and the characteristics of patients. *J Adv Nurs* 1982;7:51–7.
74. Gallagher P, Barry P, Hartigan I, *et al*. Prevalence of pressure ulcers in three university teaching hospitals in Ireland. *J Tissue Viability* 2008;17:103–9.
75. Galvan-Martinez IL, Narro-Llorente R, Lezama-de-Luna F, *et al*. Point prevalence of pressure ulcers in three second level hospitals in Mexico. *Int Wound J* 2014;11:605–10.
76. Gawron CL. Risk factors for and prevalence of pressure ulcers among hospitalized patients. *J Wound Ostomy Continence Nurs* 1994;21:232–40.
77. Gethin G, Jordan-O'Brien J, Moore Z. Estimating costs of pressure area management based on a survey of ulcer care in one Irish hospital. *J Wound Care* 2005;14:162–5.
78. Gosnell DJ, Johannsen J, Ayres M. Pressure ulcer incidence and severity in a community hospital. *Decubitus* 1992;5:56–62.
79. Groeneveld A, Anderson M, Allen S, *et al*. The prevalence of pressure ulcers in a tertiary care pediatric and adult hospital. *J Wound Ostomy Continence Nurs* 2004;31:108–20.
80. Gunningberg L. Are patients with or at risk of pressure ulcers allocated appropriate prevention measures? *Int J Nurs Pract* 2005;11:58–67.
81. Gunningberg L. EPUAP pressure ulcer prevalence survey in Sweden: a two-year follow-up of quality indicators. *J Wound Ostomy Continence Nurs* 2006;33:258–66.
82. Gunningberg L, Stotts NA. Tracking quality over time: what do pressure ulcer data show? *Int J Qual Health Care* 2008;20:246–53.
83. Gunningberg L, Hommel A, Baath C, *et al*. The first national pressure ulcer prevalence survey in county council and municipality settings in Sweden. *J Eval Clin Pract* 2013;19:862–7.
84. Hopkins B, Hanlon M, Yauk S, *et al*. Reducing nosocomial pressure ulcers in an acute care facility. *J Nurs Care Qual* 2000;14:28–36.
85. House S, Giles T, Whitcomb J. Benchmarking to the international pressure ulcer prevalence survey. *J Wound Ostomy Continence Nurs* 2011;38:254–9.
86. Inan DG, Oztunç G. Pressure ulcer prevalence in Turkey: a sample from a university hospital. *J Wound Ostomy Continence Nurs* 2012;39:409–13.
87. Jenkins ML, O'Neal E. Pressure ulcer prevalence and incidence in acute care. *Adv Skin Wound Care* 2010;23:556–9.
88. Lahmann NA, Halfens RJ, Dassen T. Pressure ulcers in German nursing homes and acute care hospitals: prevalence, frequency, and ulcer characteristics. *Ostomy Wound Manage* 2006;52:20–33.
89. Langemo DK, Olson B, Hanson D, *et al*. Prevalence of pressure ulcers in five patient care settings. *J Enterostomal Ther* 1990;17:187–92.
90. Lepistö M, Eriksson E, Hietanen H, *et al*. Patients with pressure ulcers in Finnish hospitals. *Int J Nurs Pract* 2001;7:280–7.
91. Meehan M. Multisite pressure ulcer prevalence survey. *Decubitus* 1990;3:14–17.
92. Meehan M. National pressure ulcer prevalence survey. *Adv Wound Care* 1994;7:27.
93. Nyquist R, Hawthorn PJ. The prevalence of pressure sores within an area health authority. *J Adv Nurs* 1987;12:183–7.
94. O'Brien SP, Wind S, van Rijswijk L, *et al*. Sequential biannual prevalence studies of pressure ulcers at Allegheny-Hahnemann University Hospital. *Ostomy Wound Manage* 1998;44(3A Suppl):78S–89S; discussion 89S.
95. Pearson A, Francis K, Hodgkinson B, *et al*. Prevalence and treatment of pressure ulcers in northern New South Wales. *Aust J Rural Health* 2000;8:103–10.
96. Soldevilla J, Torra J, Verdu J, *et al*. Epidemiology of chronic wounds in Spain: results of the first national studies on pressure and leg ulcer prevalence. *Wounds* 2006;18:213–26.
97. Thoroddsen A. Pressure sore prevalence: a national survey. *J Clin Nurs* 1999;8:170–9.
98. Tubaishat A, Anthony D, Saleh M. Pressure ulcers in Jordan: a point prevalence study. *J Tissue Viability* 2011;20:14–19.
99. Tubaishat A, Aljezawi M. The prevalence of pressure ulceration among Jordanian hospitalised patients. *J Wound Care* 2013;22:305.
100. Uzun O, Tan M. A prospective, descriptive pressure ulcer risk factor and prevalence study at a university hospital in Turkey. *Ostomy Wound Manage* 2007;53:44–56.
101. Vanderwee K, Clark M, Dealey C, *et al*. Pressure ulcer prevalence in Europe: a pilot study. *J Eval Clin Pract* 2007;13:227–35.
102. Vanderwee K, Defloor T, Beeckman D, *et al*. Assessing the adequacy of pressure ulcer prevention in hospitals: a nationwide prevalence survey. *BMJ Qual Saf* 2011;20:260–7.
103. VanGilder C, MacFarlane GD, Harrison P, *et al*. The demographics of suspected deep tissue injury in the United States: an analysis of the International Pressure Ulcer Prevalence Survey 2006–2009. *Adv Skin Wound Care* 2010;23:254–61.
104. Wann-Hansson C, Hagell P, Willman A. Risk factors and prevention among patients with hospital-acquired and pre-existing pressure ulcers in an acute care hospital. *J Clin Nurs* 2008;17:1718–27.
105. Whittington KT, Briones R. National prevalence and incidence study: 6-year sequential acute care data. *Adv Skin Wound Care* 2004;17:490–4.
106. Young J, Nikoletti S, McCaul K, *et al*. Risk factors associated with pressure ulcer development at a major western Australian teaching hospital from 1998 to 2000: secondary data analysis. *J Wound Ostomy Continence Nurs* 2002;29:234–41.
107. Zhao G, Hiltabidel E, Liu Y, *et al*. A cross-sectional descriptive study of pressure ulcer prevalence in a teaching hospital in China. *Ostomy Wound Manage* 2010;56:38–42.
108. von Elm E, Altman DG, Egger M, *et al*. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE)

statement: guidelines for reporting observational studies. *J Clin Epidemiol* 2008;61:344–9.
109. Organisation for Economic Co-operation and Development (OECD). *Health care quality indicators: primary care [data online]*. Paris, France: OECD, 2013. http://stats.oecd.org/index.aspx?DataSetCode=HEALTH_STAT (accessed 5 Aug 2014).
110. Jeffcoate WJ, van Houtum WH. Amputation as a marker of the quality of foot care in diabetes. *Diabetologia* 2004;47:2051–8.
111. Jeffcoate WJ, Margolis DJ. Incidence of major amputation for diabetes in Scotland sets a target for us all. *Diabetes Care* 2012;35:2419–20.
112. Baharestani MM, Black JM, Carville K, *et al*. Dilemmas in measuring and using pressure ulcer prevalence and incidence: an international consensus. *Int Wound J* 2009;6:97–104.
113. Giel R, Dijk S, van Weerden-Dijkstra JR. Mortality in the long-stay population of all Dutch mental hospitals. *Acta Psychiatr Scand* 1978;57:361–8.
114. Boekeloo BO, Becker DM, LeBailly A, *et al*. Cholesterol management in patients hospitalized for coronary heart disease. *Am J Prev Med* 1988;4:128–32.
115. Sagmeister M, Gessner U, Oggier W, *et al*. An economic analysis of ischaemic heart disease in Switzerland. *Eur Heart J* 1997;18:1102–9.

BMJ Open

Prevalence of foot disease and risk factors in general inpatient populations: a systematic review and meta-analysis

Peter A Lazzarini, Sheree E Hurn, Malindu E Fernando, Scott D Jen, Suzanne S Kuys, Maarten C Kamp and Lloyd F Reed

BMJ Open 2015 5:
doi: 10.1136/bmjopen-2015-008544