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## Ageing, limb-loss, and military veterans: A systematic review of the literature

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### *ABSTRACT*

The impact of losing a limb in military service extends well beyond initial recovery and rehabilitation, with long-term consequences and challenges requiring healthcare commitments across the life-course. This paper presents a systematic review of the current state of knowledge regarding the long-term impact of ageing and limb-loss in military veterans. Key databases were systematically searched including: ASSIA, CINAHL, Cochrane Library, Medline, Web of Science, PsycArticles/PsychInfo, ProQuest Psychology and ProQuest Sociology Journals, and SPORTSDiscus. Empirical studies which focused on the long-term impact of limb-loss and/or healthcare requirements in veterans were included. The search process revealed 30 papers relevant for inclusion. These papers focused broadly on four themes: 1) long-term health outcomes, prosthetics use, and quality of life; 2) long-term psycho-social adaptation and coping with limb-loss; 3) disability and identity, and; 4) estimating the long-term costs of care and prosthetic provision. Findings present a compelling

case for ensuring the long-term care needs and costs of rehabilitation for older limbless veterans are met. A dearth of information on the lived experience of limb-loss, and the needs of veterans' families calls for further research to address these important issues.

*KEY WORDS:* limb-loss; amputation; military veterans; life-course; healthcare

## Background

Limb loss as a consequence of military service has been thrust into the public consciousness and on to political agendas as a result of recent conflicts in Iraq and Afghanistan (Caddick and Smith 2014). The injuries produced by these conflicts have created a legacy that veterans and the societies they are part of will need to deal with for many years to come, throughout the life-course of limbless veterans (Edwards *et al.* 2015; Geiling, Rosen and Edwards 2012). For example, a Congressional report revealed that 1,645 American veterans lost a limb during the U.S.-led global war on terror<sup>1</sup>, whilst U.K. Defence Statistics indicated that 301 British veterans sustained an amputation through service in Iraq or Afghanistan<sup>2</sup>. The lifelong impact of traumatic limb-loss is also particularly relevant for older veterans who served in (among others) World War Two, Korea, Northern Ireland, Vietnam and the Falklands, and whose health issues may be exacerbated by age-related changes and comorbidities, including the long-term psychological consequences of war (Geiling *et al.* 2012; Hunt and Robbins 2001).

The research literature on limb-loss in veterans has increased rapidly in volume as a result of the conflicts in Iraq and Afghanistan (*e.g.*, Wool 2015). Indeed, most of the studies have appeared post-9/11, indicating a renewed interest in this issue among researchers. This increasing interest dovetails with (and is partially derived from) the political imperative to care for veterans who lose limbs as a result of service. In the U.K., the ‘Armed Forces Covenant’, which was enshrined in law in 2011, dictates that veterans and their families should not encounter disadvantage as a result of their service, and that where appropriate they should be entitled to special treatment (Ministry of Defence 2011). The Covenant explicitly states that those who have ‘given the most’ – including injured veterans – are to be given special consideration. Importantly, disadvantage experienced as a result of service may be

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<sup>1</sup> <https://fas.org/sgp/crs/natsec/RS22452.pdf>

<sup>2</sup>

[https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/449400/AnnexA\\_20150730\\_DAY-RELEASE\\_Quarterly\\_Afghanistan\\_Iraq\\_Amputation\\_Statistics.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/449400/AnnexA_20150730_DAY-RELEASE_Quarterly_Afghanistan_Iraq_Amputation_Statistics.pdf)

taken to include the age-related after-effects of service-related injury and amputation (Edwards *et al.* 2015).

Military personnel undergo amputations for a variety of reasons (Cifu 2010). Firstly, there are those whose injuries are ‘service attributable’, experienced as a result of combat or training accidents. These are the amputations for which military institutions are most directly accountable. Secondly, there are those who become injured whilst serving but ‘off-duty’, for example in motor vehicle accidents. Thirdly, some former personnel suffer chronic illness (such as diabetes) which results in amputation typically at ‘older’ ages (*e.g.*, >50 years old). Whilst acknowledging an abundance of literature in this third area of older veterans who undergo amputations late in life (most of which appears to emanate from the U.S. Veterans’ Administration (VA) healthcare system; *e.g.*, Kurichi *et al.* 2015; Littman *et al.* 2014), our focus in this systematic review is on the first group whose injuries are ‘service attributable’. It is this cohort which will have aged *with* limb-loss over many years and will have required significant healthcare input throughout their lifetime (Geiling *et al.* 2012).

#### *Definition of terms*

For the purpose of this review, the term ‘veteran’ refers to any former member of the Armed Forces who has served for more than a single day. This aligns with the U.K. government definition of a veteran, and is the most inclusive of any country. Whilst other countries’ definitions differ along the lines of deployment experience or length of service, the UK definition arguably provides the broadest scope for inclusion of research within our review. Some of the articles we reviewed did not state participants’ length of service, yet given the majority focused on traumatic limb-loss sustained on active-duty, they were self-evidently longer-serving than the minimum required for ‘veteran’ status.

‘Limb-loss’ or ‘Limbless’ refers to any individual who has undergone a ‘major’ amputation (*i.e.*, above the level of ankle or wrist) (Kurichi *et al.* 2007). This may include

those with multiple amputations (*e.g.*, a bilateral lower limb amputee), and those with amputations at different levels (*e.g.*, above knee or below knee; AK/BK). In relation to veterans, this may also include combat-related traumatic limb-loss (*e.g.*, as a result of blast injury or damage from projectiles), injuries sustained in training accidents or those acquired during the course of normal duties. Given the terms ‘ageing’, ‘older’, ‘elderly’ and ‘later life’ are often used inconsistently or left undefined, following previous reviews (*e.g.*, Cattan *et al.* 2005) we adopted any criteria used by the studies in this review.

### *Aims of the review*

In this paper, we systematically review the literature on ageing and limb-loss in military veterans in order to a) comment on the current state of knowledge regarding the long-term impact of limb-loss in veterans, b) explore avenues for developing research in this area, and c) highlight health and social care implications for older limbless veterans. Our aim is to extend the literature by providing a critical summary of the strengths, limitations, omissions, and biases of current knowledge (Jesson and Lacey 2006), thereby guiding future research in this area and stimulating informed policy reflection and decision making.

## **Methods**

### *Inclusion criteria*

*Participants*: older limbless military veterans. Excluded were younger (*e.g.*, Iraq/Afghanistan-era veterans). There were no restrictions on the type or cause of limb loss, other than meeting the above definition of ‘major’ limb loss and that the injury was sustained during the service person’s military career. *Comparators*: where available, studies were included which drew explicit comparisons between ‘older’ (*e.g.*, Vietnam-era) and ‘younger’ (*e.g.*, Iraq/Afghanistan-era) veterans. *Outcomes*: long term impact of limb loss, healthcare needs, and age-related complications or comorbidities associated with limb-loss. Excluded were

studies focused solely on short-term rehabilitation. *Study design*: empirically-based studies of any study design. Excluded were commentaries, reviews (*etc.*).

For the purpose of this review, we wanted to include all studies relating to the long-term effects of limb loss. Since the majority of service-related amputations happen to young military personnel in their mid-20's (Geiling *et al.* 2012), we included articles whereby participants were described as 'middle-aged' or older, thus ensuring that participants had been living with limb-loss for multiple decades at the time of study. For example, if ages were not stated explicitly, articles were included wherein date of publication or 'time since amputation' exceeded two decades from the end of the conflict in which participants were injured.

### *Search strategy*

Guidelines for systematically searching and selecting papers for review were followed (Centre for Reviews and Dissemination 2009). Key databases were searched including: ASSIA, CINAHL, Cochrane Library, Medline, Web of Science, PsycArticles/PsychInfo, ProQuest Psychology and ProQuest Sociology Journals, and SPORTDiscus. The search terms included were as follows:

- "aging" OR "ageing" OR "older" OR "elder\*" OR "later life"
- "veteran" OR "veterans" OR "ex-military" OR "ex-service" OR "ex-force\*" OR "army"
- "limbloss" OR "limb-loss" OR "limb loss" OR "limbless" OR "amput\*" OR "prothe\*" OR "artificial limb"

Given the large range of potential outcomes of interest, outcomes were not included in the search strategy. Rather, the above three search strings were used to capture *all* potentially relevant papers on older limbless veterans, with key outcomes highlighted during the initial phase of searching. Citation scanning was conducted for all papers included at the final stage.

A special issue in the *Journal of Rehabilitation Research and Development* – in which one of the searched-for articles was published – was searched, and the authors also searched their personal collections of articles.

*Selection of studies, data extraction, quality assessment and synthesis of results*

For screening, article titles and abstracts were scanned for relevance by one reviewer and checked against the inclusion criteria by five members of the review team and discrepancies resolved by discussion. All relevant articles were subsequently read by three reviewers and a standardized data extraction form used to record key findings from each study. This form was also used to capture details on the type of study, location, and sample characteristics including age, gender, type/cause of amputation, and (where relevant) conflict in which limb trauma originated.

Previous review studies (Bunn *et al.* 2008; Cattan *et al.* 2005; Wilson *et al.* 2016) as well as recognized assessment tools (CASP 2013; EPHPP 2010) were used to guide processes of quality assessment. For qualitative studies, judgments were based on the suitability of the research design and recruitment processes for addressing the study's aims, the rigour of data collection and analysis processes, and whether there was a clear statement of the study's findings (CASP 2013). For the quantitative studies, quality was determined by an overall assessment of the appropriateness of the study design and methods in relation to the study's aims and objectives (Cattan *et al.* 2005). Studies were judged accordingly – by the same three reviewers who completed data extraction – as strong, moderate, or weak according to their methodological quality, and any discrepancies were resolved by discussion.

The research we identified was grouped into a number of 'themes' based on the content and focus of individual articles. These themes were identified and agreed upon by five reviewers at a meeting of the review team. The themes provided categories and sub-headings for organizing the results and are as follows: a) Long-term health outcomes, prosthetics use,



and quality of life; b) Long-term psycho-social adaptation and coping with limb-loss; c) Disability and identity, and; d) Estimating the long-term costs of care and prosthetic provision. Included papers were too heterogeneous (*i.e.*, with regard to methodology, outcomes, and focus of the studies) to attempt a meta-analysis. Following guidelines on producing systematic reviews (CRD, 2009) and previous review studies (Cattan *et al.* 2005), a narrative synthesis (as opposed to meta-analysis or other methods of integration) was therefore chosen as the most suitable means of synthesizing findings from methodologically diverse studies.

## Results

The search process yielded an initial 1512 hits, which after screening resulted in a total of 6 articles relevant for inclusion (see figure 1). Citation scanning resulted in an additional 16 articles. Given that many papers that were deemed relevant reported age and time since amputation of their samples, but did not refer to ‘ageing’, ‘older’, or ‘elderly’ veterans, a larger number of papers were identified through citation scanning than through the initial keyword search. Hand searching a special issue of *Journal of Rehabilitation Research and Development* (JRRD) led to the discovery of an additional 7 articles. The authors’ personal collections of articles yielded one further study.

[insert figure 1 here]

A total of 21 studies were identified, with 1 study – the Veterans Administration’s (2010) *Survey for Prosthetic Use* – reported in 10 separate articles (of which 8 were published in a *JRRD* special issue). Nine out of the 21 studies were conducted in the U.S., with most of these (5/9) taking place within the VA healthcare system. Four studies were conducted in Iran, 1 in Nicaragua and 7 in the U.K. Most studies (15/21) were surveys of various long-term physical and psychological outcomes, three used qualitative or mixed methods (Foote *et al.* 2015; Machin and Williams 1998; Meyers 2014), and three (Blough *et al.* 2010; Edwards *et al.*

2015; Stewart and Jain 1999) used a form of economic modelling to estimate the long-term costs of caring for limbless veterans. The characteristics of all the studies are summarized in tables 1a and 1b.

[insert tables 1a and 1b here]

*Long-term health outcomes, prosthetics use, and quality of life*

The largest collection of studies identified for review (16/21) focused broadly on assessing long-term physical health outcomes (including pain and comorbidities) associated with limb-loss, levels of prosthetic utilization by older limbless veterans, and the impact of health outcomes and prosthetic use on quality of life (QoL). The largest of these studies was the VA's (2010) *Survey for Prosthetic Use*. This was a national survey comparing health outcomes, QoL, and use of prosthetics among 298 Vietnam veterans with combat-related traumatic limb-loss (mean age and time since amputation = 61 yrs and 39 yrs) and 283 of their younger Operation Iraqi Freedom/Operation Enduring Freedom (OIF/OEF) counterparts (mean age and time since amputation = 29 yrs and 3 yrs). It was noted that using prosthetic devices can improve functional ability, enhance mobility and safety, facilitate higher levels of activity, and can also reduce the risk of secondary comorbidities and problems resulting from overuse of intact limbs among limbless veterans (Gailey *et al.* 2010; Reiber *et al.* 2010). The survey aimed to document differences in health status and device-use between older and younger veterans, and to forecast changes in the use of prosthetic devices. It used a combination of validated and bespoke measurement tools, as well as analysis of medical records data.

Overall, findings from the survey revealed that health status (as measured on the SF-36 health questionnaire) was reported as good, very good, or excellent among 70.7% of Vietnam veterans and 85.5% of OIF/OEF veterans (Reiber *et al.* 2010). Compared with OIF/OEF veterans, fewer of the older Vietnam veterans (90.5% vs. 78.2%, respectively) were

current prosthetic users (Reiber *et al.* 2010). Findings on prosthetic use were further described with regard to the different types of amputation. Among lower-limb amputees, sole use of a wheelchair for mobility was more common in the Vietnam cohort compared with the OIF/OEF cohort, at 18% and 4%, respectively (Laferrier *et al.* 2010). Seventeen percent of the Vietnam lower-limb amputees reported abandoning use of all prosthetic devices, rising to 33% among bilateral lower-limb amputees, and 30% among upper-limb amputees (Laferrier *et al.* 2010; McFarland *et al.* 2010). Vietnam veterans reported more problems with their prosthetics and more pain when using them compared to OIF/OEF veterans (Berke *et al.* 2010). Other studies included in this review also revealed that prosthetic usage varied by type of amputation. For instance, a series of long-term follow-up studies of Vietnam veterans conducted by Dougherty (1999; 2001; 2003) revealed that 87.5% of unilateral AK amputees were current prosthetic users (average of 13.5 h/day) compared with just 22% of bilateral AK amputees (average of 7.7 h/day), thereby highlighting the significant additional impact of multiple compared to single limb-loss.

A high prevalence of comorbidities and pain was identified across the studies in this review. Most studies which assessed arthritis revealed prevalence rates of between 54% and 71% among older limbless veterans (Dougherty *et al.* 2014; Foote *et al.* 2015; Gailey *et al.* 2010; Kulkarni *et al.* 1998; Reiber *et al.* 2010), with one study of unilateral lower-limb amputees reporting a lower prevalence of 16.1% (Norvell *et al.* 2005). This compared with around 15% of OIF/OEF veterans reporting arthritis (Dougherty *et al.* 2010). Three papers (Dougherty *et al.* 2010; Gailey *et al.* 2010; McFarland *et al.* 2010), reported a higher incidence of cumulative trauma disorder (CTD; overuse injuries resulting from reliance on the intact limb) among Vietnam veterans, which compromised their ability to use prosthetics and reduced their prosthetic satisfaction levels relative to younger veterans. Coincident with the ageing process and the occurrence of comorbidities, some Vietnam veterans' prosthetics

therefore became too heavy, uncomfortable and painful to use, resulting in more abandonment of prosthetics (Lafferrier *et al.* 2010).

Pain was reported as so prevalent among limbless veterans that it was often under-evaluated (Berke *et al.* 2010). Prevalence rates of numerous types of pain are described in table 2. It was suggested by one study that phantom limb pain was often a persistent condition that stayed with the amputee for the remainder of life (Wartan *et al.* 1997). Another study described back pain and pain in contra-lateral (non-amputated) limbs as “disabling and progressive problems of long-term surviving amputees” and argued that such problems were as great as phantom pains but were often overlooked (Ebrahimzadeh and Fattahi, 2009; p. 1876). Eight papers reported the prevalence of mental health comorbidities among older limbless veterans (Dougherty *et al.* 2010, 2014; Ebrahimzadeh and Fattahi, 2009; Ebrahimzadeh and Hariri, 2009; Foote *et al.* 2015; Gailey *et al.* 2010; McFarland *et al.* 2010; Reiber *et al.* 2010). These studies reported rates of depression between 9.7% and 28% and PTSD between 15% and 46%.

[Insert table two here]

Despite the high prevalence of pain and comorbidities, QoL was reported as good, very good, or excellent in 72.8% - 79.7% of older limbless veterans (Epstein *et al.* 2010; Foote *et al.* 2015). One reason for this may be that veterans tended to deal with pain via silent acceptance or a ‘stiff upper lip’ approach to coping (Machin and Williams 1998). One study (Taghipour *et al.* 2009) reported significantly poorer QoL among limbless veterans compared to population norms. Among the factors related to poor QoL, Epstein *et al.* (2010) revealed that poorer self-reported QoL was significantly associated (in both Vietnam and OIF/OEF veterans) with the need for assistance with activities of daily living. Such assistance was required by one third of upper limb amputees in both older and younger veterans (McFarland *et al.* 2010). Among bilateral lower-limb amputees, Dougherty *et al.* (2010) noted that 33% of

Vietnam veterans (compared with just 6% of OIF/OEF veterans) could no longer walk. In addition, fewer Vietnam veterans were participating in ‘high impact’ activities such as skiing and basketball, compared with the younger cohort (see also, Reiber *et al.* 2010). In the only study to include qualitative analysis of older veterans’ QoL experiences, Foote *et al.* (2015) provided vivid descriptions of the effects of impairment and restrictions on activities caused by amputation and by not being able to walk long distances due to pain. Declining mobility with age was linked strongly to poorer QoL in the narrative of one veteran interviewed in Foote *et al.*’s study.

Other factors related to poorer QoL included a higher number of comorbidities, higher levels of pain, and mental health problems (Dougherty *et al.* 2010, 2014; Epstein *et al.* 2010; Foote *et al.* 2015; Hoaglund *et al.* 1983; Reiber *et al.* 2010). Several papers noted the impact of age-related changes, pain and declining mobility on veterans’ QoL (Dougherty 2001; Dougherty *et al.* 2010; Ebrahimzadeh and Fattahi 2009; Foote *et al.* 2015), with mental health problems such as depression and PTSD – endured for many decades in some cases – described as among the biggest reasons for poor QoL among older limbless veterans (Ebrahimzadeh and Fattahi 2009; Epstein *et al.* 2010; Foote *et al.* 2015).

Finally, several papers considered the long-term impact of limb-loss on employment and personal relationships (*e.g.*, Dougherty 1999; 2001; 2003; Dougherty *et al.* 2010; 2014; Foote *et al.* 2015; Reiber *et al.* 2010). In a long-term follow-up of bilateral above-knee amputees from Vietnam, Dougherty found that 70% of veterans were or had been employed outside the home since their injury. Reiber *et al.* (2010) similarly reported a 78.7% current employment rate among Vietnam veterans. The vast majority of veterans were also married and had had children (Dougherty 1999; 2001; 2003; Ebrahimzadeh and Fattahi 2009, Ebrahimzadeh *et al.* 2013). Accordingly, Dougherty (1999) argued that Vietnam veterans had lived ‘relatively normal lives’ within the context of their physical limitations and that,

contrary to media narratives, did not on the whole experience insurmountable emotional and physical scars. Indeed, Foote *et al.* (2015) suggested that older Vietnam veterans with limb-loss had continued to make major life transitions and experienced positive QoL, but that problems with pain, physical ailments exacerbated by ageing, and mental health problems could also adversely affect QoL, thus underscoring the importance of ongoing care and rehabilitation.

### *Psycho-social adaptation and coping in older limbless veterans*

Three studies (Desmond 2007; Desmond and MacLachlan 2006; Machin and Williams 1998) discussed coping and psycho-social adaptation among older limbless veterans. Desmond and MacLachlan (2006) surveyed coping strategies and psycho-social adaptation with a sample of elderly lower-limb amputees (mean age = 74 years) who were members of the British Limbless Ex-Servicemen's Association (Blesma). The term 'psycho-social adaptation' was not defined in this paper but was described in relation to an individual's ability to adapt to a range of challenges including impairments in physical functioning, prosthesis use, pain, changes in occupation, and alterations in body image and self-concept. The authors reported that problem solving and seeking social support were coping strategies associated with fewer depressive symptoms and greater psycho-social adaptation among older veteran amputees. Avoidant coping strategies (*e.g.*, denial, alcohol use) were associated with poorer psychosocial adjustment, echoing wider findings about the maladaptive use of avoidant coping strategies in adaptation to disability. Greater time since amputation was also positively related to adjustment, with the average length of time being 42.6 years among the Blesma veterans.

In a separate study, Desmond (2007) then explored coping and adjustment with upper limb amputees from the Blesma cohort. In this study, psychosocial adjustment was

conceptualized as ‘the absence of clinically elevated symptoms of anxiety and depression and evidence of positive adjustment to amputation and prosthesis use’ (p. 17). Findings broadly mirrored those of the earlier study, although the associations between seeking social support and adjustment were not evident. As Desmond argued, the findings of this and the previous study hold relevance for the care of older veterans, in particular the importance of promoting adaptive, problem-focused coping strategies designed to enhance long-term adjustment and QoL.

Machin and Williams (1998) also explored coping strategies in relation to phantom pains. They reported that veterans generally made little use of strategies such as problem solving or emotional support, preferring a ‘stiff upper lip’ approach to coping and a silent acceptance of pain. Many had also given up on medical assistance, making comments such as “I have had no success with treatments so far, so there is no point in even trying” (p. 293).

### *Disability and Identity*

One study by Meyers (2014) focused on the identity politics of disability and amputation amongst middle-aged veterans of Nicaragua’s civil war of the 1980’s. Meyers’ qualitative study drew upon interviews and participant observations conducted with opposing sides of the conflict in order to understand how each side positioned themselves with regard to the broader category of ‘disability’. For the ex-Contra rebels (politically marginalized following their defeat by the Sandinista regime), adopting the social identity of ‘disabled’ became a means of arguing for equal rights and the protection of disability benefits. On the other hand, the Sandinistas under the ‘Organization of Disabled Revolutionaries’ (ORD) sought to distance themselves from ‘other’ disabled people, preferring to emphasize their privileged status as ‘war heroes’. Their amputations were symbols of valor setting them apart from other disabled groups and protecting them from ‘stigmatized’ disabled identities. Sandinista veterans thereby

adopted an ambiguous relationship to other disabled people: choosing to set themselves apart yet occasionally being compelled to identify with wider disability movements in order to gain access to benefits and resources.

Meyers' findings showed that the political and military context in which veterans were injured was an important feature of their long-term adjustment to 'disability' and negotiations around personal and social identity. By highlighting matters of social identity, Meyers also situated the study of older veteran amputees within the wider literature on critical disability studies (*e.g.*, Meekosha and Shuttleworth 2009), which the literature on older veterans has otherwise yet to engage with. Indeed, one insight from Meyers' paper – mirroring the perspective of disability scholars more broadly (Meekosha and Shuttleworth 2009) – was that disabled and amputee veterans were not a homogenous group in terms of their social identities and experiences of disability, and that various 'intersecting' identities (particularly in relation to age, gender, race, and combat-era) were important in understanding their lives.

#### *Estimating the long-term cost of prosthetic provision for limbless veterans*

In line with the aims of this systematic review to evaluate the long-term impact of limb-loss, three papers considered the long-term financial burden of prosthetic device provision required to meet veterans' mobility needs (Blough *et al.* 2010; Edwards *et al.* 2015; Stewart and Jain 1999). Using Markov model analysis, Blough *et al.* (2010) projected the cost of prosthetic device provision for US veterans over 5 year, 10 year, 20 year and lifetime periods. Using the *Survey for Prosthetic Use* sample (see above), the authors contrasted the estimated the lifetime cost of provision for Vietnam veterans compared with OIF/OEF veterans. Given the greater number – and greater technological advancement – of prosthetics used by OIF/OEF veterans, the cost of provision for the younger cohort was significantly higher than the Vietnam cohort. Costs were also compared by type of amputation, with unilateral upper,



unilateral lower, bilateral upper, and multiple limb loss forming separate categories for analysis. Given that lower-limb prostheses were typically more expensive and complex than upper-limbs, costs were also highest in the ‘multiple limb loss’ category, such that the lifetime projected costs of provision for a single Vietnam and OIF/OEF multiple limb amputee were 750k and 3.4m US Dollars, respectively. This compared with lifetime costs for a unilateral upper limb amputee at 300k for Vietnam and 1.1m for OIF/OEF. Blough *et al.* asserted that future costs of prosthetic provision could be manageable for the VA and for the Department of Defence (DoD), but that their estimates were ‘conservative’ because of potential outliers and the cost of future emerging technologies.

In a similar study with U.K. veterans, Edwards *et al.* (2015) argued for the imperative of long-term planning to meet the prosthetic and rehabilitative needs of Iraq and Afghanistan veterans. Using a simplified version of Blough *et al.*’s (2010) Markov model, Edwards *et al.* estimated that the long-term (40 year) cost of rehabilitation and prosthetic provision for the entire UK veteran cohort of Iraq and Afghanistan was £288 million (USD 444 million) in 2015 currency. Prior to the conflicts in Iraq and Afghanistan, Stewart and Jain (1999) conducted a retrospective cohort study based on 98 British amputee veterans from previous conflicts in order to produce an estimate of lifetime costs. Extrapolating from their sample to the rest of the UK population of war amputees, the figure they produced was £69 million, which did not account for any related, hidden, or future costs and, according to the authors, was likely to be a significant under-calculation.

None of the cost-estimate studies were, however, able to account for variations in the cost of care provision through chronic disease, age-related changes (*e.g.*, in mobility), and comorbidities such as mental health problems that limbless veterans are likely to encounter ‘downstream’ (Geiling *et al.* 2012). As Geiling *et al.* (2012), in their commentary on the ‘medical costs of war in 2035’ put it, there was a need to consider the “secondary and tertiary

consequences in middle age [which] might include decreased mobility, weight gain, coronary artery disease, and diabetes mellitus” (p. 1237). Accordingly, Geiling *et al.* emphasised the need for early interventions – including prevention and treatment measures – to help mitigate the likely additional costs to society. Indeed, as Edwards *et al.* (2015) also cautioned, their estimates should be considered merely as “the start of a challenge to develop sustained rehabilitation and recovery funding and provision” (p. 2854), and that ongoing assessment of injured soldiers and their care would be required as the population ages.

#### *Quality of the literature on ageing and limb-loss in veterans*

The literature as a whole is over-reliant on the self-report survey method (17/21 studies). Whilst many of these were large, well designed surveys which included comparison groups, there are limitations associated with this dependence on survey methodology. For instance, 11 studies discussed the potential representativeness of their samples, including questions over the presence of selection bias and differences between respondents and non-respondents. In particular, evidence that some veterans self-medicated with alcohol to deal with phantom pain (Sherman *et al.* 1983) and avoided contact with clinicians when treatments were deemed ineffective (Machin and Williams 1998), could indicate that non-respondents had potentially more severe problems with mental health or alcohol use. It could also be argued that the use of a single 5-point scale to assess quality of life within the VA survey for prosthetic use (2010) was an overly simplistic measure for a complex, multi-faceted construct. Whilst 11 studies used validated measurement instruments (12 also incorporated bespoke measurement tools), only one study (Kulkarni *et al.* 1997) used medical assessments to determine the presence of comorbidities. There was also an absence of longitudinal follow-up studies which would have been able to determine the impact of limb loss over time or throughout the life course (Murrison 2011).

Of the studies based in full or part on qualitative methods (Foote *et al.* 2015; Machin and Williams, 1998; Meyers, 2014), only one (Meyers 2014) provided sufficient information on data collection and analysis procedures for methodological rigor to be assessed. This study was classified as strong, based on the quality and extent of data collection, well-documented relationship between researcher and participants, clearly articulated findings and implications, and good grounding in theory. With the exception of this paper, however, the literature on older limbless veterans lacked theoretical depth and engagement with critical social issues such as ageing and disability, identity, and independence (*e.g.*, Schwanen and Ziegler 2011). Overall, the quality of the literature on ageing and limb-loss in veterans may be categorized as weak-to-moderate. Despite an over-reliance on the self-report survey method, findings do appear consistent across the literature (see tables 1 and 2), and the measures used possessed some face validity. Accordingly, the literature reviewed can be considered useful for drawing some conclusions regarding the long-term impact of limb-loss on veterans, whilst also recognizing the need for further well-designed research studies (both quantitative and qualitative), and prospective, longitudinal studies.

## **Discussion**

### *Summary of results*

This systematic review makes a contribution to the existing literature on ageing and limb-loss in military veterans by analyzing the results of numerous studies, and by identifying key factors associated with the long-term impact of limb-loss. We were also able to identify the strengths, limitations, and omissions of this body of research. Key findings emphasize that, whilst limbless veterans are generally able to achieve a good quality of life, limb-loss is still a progressive and degenerative injury involving enduring experiences of pain, comorbidities, and sometimes mental health problems which undermine veterans' health, well-being and

quality of life. Furthermore, it is evident that approaches to coping, as well social and political context, exert an important influence on veterans' long-term adjustment and identity in relation to limb-loss. Finally, the literature highlights the substantial cost of caring for limbless veterans throughout the life-course and the financial commitments required to safeguard their long-term health and care needs.

#### *Comparison to other literature*

Only two prior reviews could be identified regarding the impact of limb-loss on veterans (Christensen *et al.* 2016; Robbins *et al.* 2009). One review (Robbins 2009) focused on long-term health outcomes associated with war-related amputation, but was not systematically conducted and the focus was solely on clinical outcomes. The other (Christensen *et al.* 2016) was a systematic review of the physical and social factors determining health-related quality of life (HRQoL) for veterans with lower-limb amputation. Whilst some of the included studies focused on long-term impact, this was therefore limited to the outcome of HRQoL in lower-limb amputees. As such, the present study remains the only systematic review to have captured the long-term impact of limb-loss in older veterans across a broad range of outcomes and studies.

Whereas the studies on coping and psycho-social adaptation among older limbless veterans focused predominantly on the physical impact of limb-loss, exploration of the long-term psychological effects of traumatic injury has been largely overlooked. Indeed, other research indicates that the psychological consequences of war trauma can be very long lasting, and that those with a physical disability may experience even greater distress as their injuries become more disabling through ageing (Burnell, Coleman and Hunt 2010; Hunt and Robbins 2001). It is unfortunate, therefore, that the literature on coping among older veterans shows a lack of engagement with the potential psychological consequences of traumatic limb-loss.

Within the wider literature on limb-loss (*e.g.*, Heavey 2013; Wool 2015) and ageing veterans (*e.g.*, Burnell *et al.* 2010; Hunt and Robbins 2001), there are numerous studies which explore the narratives and experiences of ageing and disability. Such studies show how the stories people tell about their lives help them assign meaning to their experiences, and how these meanings are themselves derived from cultural narratives about ageing and disability (Phoenix, Smith and Sparkes 2010; Smith and Sparkes 2008). This topic is largely ignored, however, within the research we describe in this review. The omission of narrative research from the literature on older limbless veterans is significant, particularly when considered in light of a rich body of work in narrative gerontology (*e.g.*, Kenyon, Bohlmeijer and Randall, 2010) which attests to the value of stories both for understanding and improving the lives of individuals, and in a broader sense for understanding history from the perspective of those who lived through significant events. Accordingly, we suggest that research with older limbless veterans may productively adopt a narrative approach to better understand the lived experience of war and limb-loss throughout the life-course.

#### *Strengths and limitations*

This review is limited by the lack of a protocol published prior to carrying out the study. Whilst the PRISMA checklist (Moher *et al.* 2009) was used during the write-up to ensure accuracy of reporting, the omission of a protocol from the study design limits transparency regarding any changes between protocol and systematic review. Furthermore, the limited quality of evidence in the studies reviewed inevitably restricts the conclusions that can be drawn, due in part to the questionable representativeness of some studies and the fact that the most isolated and severely disabled older veterans may not have been reached (Foote *et al.* 2015).

Strengths of this review include the broad inclusion criteria and wide search strategy which meant that a large number of diverse studies were able to be reviewed and synthesized.

We were therefore able to comprehensively identify all relevant studies across a number of different domains, and were able to highlight consistent findings regarding the long-term impact of limb-loss on older veterans.

#### *Implications for policymakers*

One clear strength of the literature is that a wide range of age-related changes and comorbidities have been identified among older limbless veterans, as has the potential impact of these various conditions on independence, mobility, health and quality of life. Amputation is not a static disability, but a “progressive deteriorating condition” that affects the health status of amputees over time (Ebrahimzadeh and Fattahi, 2009; p. 1873). It is important to note, therefore, that age-related changes may complicate the process of long-term recovery and capacity for prosthetic use, with subsequent healthcare implications for older veterans (McFarland *et al.* 2010). The findings of this systematic review indicate significant challenges regarding the long-term physical and mental health of limbless veterans. There is thus a compelling case to ensure that (very) long-term care requirements, including the cost of repairing and replacing prosthetic devices and of mental health care, are adequately considered when the future costs of care provision are estimated (Blough *et al.* 2010; Edwards *et al.* 2015; Geiling *et al.* 2012). In addition, given the majority of veterans were long-term prosthetic users, ensuring the continuation of healthcare staff trained in advanced prosthetic technology will be necessary to meet future care needs and to maintain expertise in the absence of current military conflict (Blough *et al.* 2010).

Several US papers included in this review also noted the influence of a ‘paradigm shift’ concerning the goals and purpose of rehabilitation for limbless veterans (Berke *et al.* 2010; Gailey *et al.* 2010; Laferrier *et al.* 2010; McFarland *et al.* 2010). This shift was described in terms of providing veterans with the opportunity to return to active duty (should they wish to), with 18-21% successfully returning at the time of the research compared to 2-

7% in previous eras (Lafferrier *et al.* 2010). In the U.K., research by Dharm-Datta *et al.* (2011) revealed that 63% of a sample of 52 limbless veterans had returned to work in the services, with 4 veterans able to re-deploy to Iraq or Afghanistan. However, the implications of this ‘paradigm shift’ in rehabilitation were not discussed. For example, veterans are undergoing rehabilitation for limb-loss in militarized settings such as the Walter Reed Army Medical Centre (U.S.) and Headley Court (U.K.). Yet, it is unclear to what extent a military-style rehabilitation and a return to military life may prepare limbless veterans for independent living in the long-term and a future civilian career post-service.

As part of the wider paradigm shift, Messinger (2010) examined how a sports-based model of rehabilitation might prepare veterans for a future post-limb-loss. Messinger identified a dominant sports-based approach to rehabilitation in military settings, whereby returning to high-impact activity such as running, hiking, skiing, and basketball was seen as symbolic of, if not constitutive of, recovery (Messinger, 2010). In the case study of an Iraq war veteran amputee Messinger presented, this model of rehabilitation – with its intense focus on the restoration of physical functioning – came into conflict with the veteran’s own wishes and desires in terms of intellectual development and preparation for a future career beyond the military. The sports program was “not elastic enough to encompass the alternative notions of rehabilitation and recovery” held by the veteran himself (Messinger, 2010; p. 299). More broadly, the use of sport for/as rehabilitation is epitomized in new initiatives such as the Invictus Games which offers an international, Olympic-style sporting competition for injured veterans. The narrative associated with such events centers on ‘battling back’ or ‘overcoming’ amputation through sport (Batts and Andrews, 2011). Notwithstanding the benefits that such sporting events may bring to limbless veterans (see Caddick and Smith 2014 for a review), one question that has yet to be answered is what happens to these veterans *after* the events,

when the limelight has disappeared and they begin to encounter the long-term challenges of limb-loss, as identified in this systematic review.

### *Implications for research*

One limitation of the literature is that much of the knowledge is concentrated in the U.S., and specifically on Vietnam veterans cared for within the VA healthcare system. Given that different conflicts tend to produce different kinds of traumatic injuries (such as the increase in ‘polytraumatic’ injuries and traumatic brain injuries which Iraq and Afghanistan veterans are now surviving; Dharm-Datta *et al.* 2011), it is uncertain to what extent knowledge based on Vietnam veterans will generalize to the current generation of limbless veterans as they age. Furthermore, differences in the ways care is organized across different national and cultural contexts means that findings might not transfer easily outside of the U.S. context. In the U.S., veterans’ healthcare is organized under the large, separately funded U.S. Department of Veteran Affairs. By contrast, in other countries such as the U.K., care for veterans is predominantly delivered by civilian providers and third sector organizations. More specifically, within the U.K. once a serviceperson leaves the armed forces, the responsibility for care passes from the Ministry of Defence to the National Health Service (NHS). Invariably the NHS care for veterans is supplemented or supported by third sector organizations such as Blesma, Help 4 Heroes, Combat Stress *etc.* Academics and policy makers in the U.K. and elsewhere should therefore adopt a cautious approach to extrapolating from U.S. findings, and should seek to expand the knowledge base on older limbless veterans in other national contexts.

There are further omissions from the literature. None of the papers in this systematic review considered the issue of social isolation as a potential long-term outcome associated with limb-loss in older veterans. This is despite the fact that social isolation has been identified as an important concern among older veterans (Ashcroft 2014) and among older



amputees in general (Briggs 2006; Murray 2005). Indeed, Murray (2005) suggested that reluctance to use a prosthetic limb may result in isolation among older amputees; a possibility that was not considered in the papers that dealt with prosthetic use. Additionally, the impact of traumatic limb-loss on families and social relationships was not explored in the studies reviewed. Yet, as Fossey and Hacker Hughes (2014) argued, the needs of family members – whilst poorly understood at present – should be taken into consideration as part of care planning and provision for limbless veterans. Future research with older limbless veterans should therefore consider the life-long impact of care-giving upon families, for example with regard to the financial and psychological impact of caring (Fossey and Hacker Hughes 2014; Griffin *et al.* 2009).

### **Conclusions**

This systematic review highlights the long-term impact of limb-loss in veterans and the associated need for ongoing rehabilitation and care throughout the life-course. The following recommendations are possible for researchers and policy makers. Firstly, it is important to understand the specific healthcare needs of older veterans, and to deal with the multiple comorbidities and age-related changes they are likely to encounter as they move throughout the life-course. These are the secondary and tertiary consequences of limb-loss and must be considered as part of the traumatic legacy of combat injury. Secondly, researchers should seek to explore older veterans' experiences of limb-loss in order to fully appreciate the long-term personal and social impact of amputation. The lives and experiences of family members should also form part of this research agenda. Thirdly, the issue of social isolation – reported to be a matter of concern among older amputees in general – should be given greater consideration in research with older limbless veterans. Finally, the clinical and academic interest in older limbless veterans in the U.S. context should be mirrored by other countries, particularly as part of government commitments to support those injured by conflict.

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Table 1a: Summary of papers from the VA (2010) *Survey for Prosthetic Use* study

Author(s)	Focus of article	Participants: age ( $M_{(age)}$ ), sex, etiology of limb-loss and time since limb loss ( $M_{(time)}$ )	Key findings
1(i) Berke <i>et al.</i>	Satisfaction with prosthetic care (sub-sample from VA cohort)	1. $N = 230$ Vietnam veterans with combat-related traumatic limb-loss (100% male, $M_{(age)} = 61$ yrs, $M_{(time)} = 39$ yrs)/ 2. $N = 251$ OIF/OEF veterans with combat-related traumatic limb-loss (97% male, $M_{(age)} = 29$ yrs, $M_{(time)} = 3$ yrs)	Vietnam veterans reported lower care satisfaction and pain-free prosthetic use compared with OIF/OEF veterans. Prosthetic-fit issues common across both groups.
1(ii) Blough <i>et al.</i>	Economic modelling and long-term projection of prosthetic device costs.	1. $N = 298$ Vietnam veterans with combat-related traumatic limb-loss (100% male, $M_{(age)} = 61$ yrs, $M_{(time)} = 39$ yrs). 2. $N = 283$ OIF/OEF veterans with combat-related traumatic limb-loss (97% male, $M_{(age)} = 29$ yrs, $M_{(time)} = 3$ yrs)	Average lifetime costs of prosthetic provision estimated up to 6.2-fold higher for OIF/OEF veterans compared to their older Vietnam counterparts.
1(iii) Dougherty <i>et al.</i>	Health outcomes and prosthetic use in multiple limb amputees (sub-sample)	1. $N = 73$ Vietnam veterans with combat-related traumatic limb-loss (100% male, $M_{(age)} = 61$ yrs, $M_{(time)} = 39$ yrs) 2. $N = 61$ OIF/OEF veterans with combat-related traumatic limb-loss (95% male, $M_{(age)} = 28$ yrs, $M_{(time)} = 3$ yrs)	Significantly more age-related comorbidities in Vietnam compared to OIF/OEF group.
1(iv) Epstein <i>et al.</i>	Factors associated with QoL.	1. $N = 298$ Vietnam veterans with combat-related traumatic limb-loss (100% male, $M_{(age)} = 61$ yrs, $M_{(time)} = 39$ yrs). 2. $N = 283$ OIF/OEF veterans with combat-related traumatic limb-loss (97% male, $M_{(age)} = 29$ yrs, $M_{(time)} = 3$ yrs)	Vietnam cohort reported worse overall QoL compared with OIF/OEF cohort. Higher number of comorbidities associated with worse QoL in both groups.
1(v) Gailey <i>et al.</i>	Prosthetic use and functional outcomes in unilateral lower-limb amputees (sub-sample)	1. $N = 178$ Vietnam veterans with combat-related traumatic limb-loss (100% male, $M_{(age)} = 61$ yrs, $M_{(time)} = 39$ yrs). 2. $N = 172$ OIF/OEF veterans with combat-related traumatic limb-loss (98% male, $M_{(age)} = 29$ yrs,	Compared with OIF/OEF veterans, Vietnam veterans had lower self-reported health, functional ability and QoL, used fewer prosthetics, and had a higher prevalence of arthritis and CTD.

		$M_{(time)} = 3$ yrs)	
1(vi) Laferrier <i>et al</i>	Factors influencing mobility and use of assistive technology (sub-sample)	1. $N = 245$ Vietnam veterans with combat-related traumatic lower limb-loss (100% male, $M_{(age)} = 61$ yrs, $M_{(time)} = 39$ yrs). 2. $N = 226$ OIF/OEF veterans with combat-related traumatic lower limb-loss (98% male, $M_{(age)} = 29$ yrs, $M_{(time)} = 3$ yrs)	Sole or supplementary use of wheelchair for mobility common in both groups, with more Vietnam veterans abandoning use of all prosthetics.
1(vii) McFarland <i>et al</i>	Satisfaction and prosthetic use in unilateral upper-limb amputees (sub-sample)	1. $N = 47$ Vietnam veterans with combat-related traumatic lower limb-loss (100% male, $M_{(age)} = 60$ yrs, $M_{(time)} = 39$ yrs). 2. $N = 50$ OIF/OEF veterans with combat-related traumatic lower limb-loss (98% male, $M_{(age)} = 30$ yrs, $M_{(time)} = 3$ yrs)	Higher prevalence of arthritis and CTD among Vietnam veterans compared with OIF/OEF veterans. Presence of comorbidities associated with reduced upper-limb activity in Vietnam veterans.
1(viii) Reiber <i>et al</i>	Health outcomes and prosthetic use.	1. $N = 298$ Vietnam veterans with combat-related traumatic limb-loss (100% male, $M_{(age)} = 61$ yrs, $M_{(time)} = 39$ yrs). 2. $N = 283$ OIF/OEF veterans with combat-related traumatic limb-loss (97% male, $M_{(age)} = 29$ yrs, $M_{(time)} = 3$ yrs)	Overall health reported as good in both groups but lower in Vietnam veterans than OIF/OEF. Vietnam veterans used fewer prosthetics, were less active, and had lower functional capabilities.
1(ix) Dougherty <i>et al</i> (2012)	Health outcomes, QoL and prosthetic use in bilateral AK amputees (sub-sample)	1. $N = 23$ Vietnam veterans with combat-related traumatic limb-loss (100% male, $M_{(age)} = 60.4$ yrs, $M_{(time)} = 39$ yrs). 2. $N = 10$ OIF/OEF veterans with combat-related traumatic limb-loss (100% male, $M_{(age)} = 27.2$ yrs, $M_{(time)} = 3$ yrs)	Self-reported health lower in Vietnam veterans compared to OIF/OEF veterans. QoL reportedly comparable between groups. Prosthetic use problematic, particularly in older veterans.
1(x) Dougherty <i>et al</i> (2014)	Health outcomes, QoL and prosthetic use in bilateral lower limb amputees (sub-sample; one AK and one BK).	1. $N = 13$ Vietnam veterans with combat-related traumatic limb-loss (100% male, $M_{(age)} = 61$ yrs, $M_{(time)} = 39$ yrs) 2. $N = 11$ OIF/OEF veterans with combat-related traumatic limb-loss (95% male, $M_{(age)} = 28$ yrs, $M_{(time)} = 3$ yrs)	Vietnam veterans reported lower functioning and use of prosthetics. Both groups reported similar QoL and a moderate-to-strong impact of dual AK/BK amputation on their lives.

Key: *AK* = above knee; *BK* = below knee; *CTD* = Cumulative trauma disorder; *OIF* = Operating Iraqi Freedom (Iraq); *OEF* = Operation Enduring Freedom (Afghanistan); *QoL* = Quality of life.

Table 1b: Summary of remaining studies included in systematic review

Author, year and location of study	Design and focus of study	Participants: age ( $M_{(age)}$ ), sex, etiology of limb-loss and time since limb loss ( $M_{(time)}$ )	Key findings
2 Desmond and MacLachlan (2006) UK	Cross-sectional. Coping strategies and long-term psycho-social adaptation to lower limb-loss.	$N = 796$ members of BLESMA with lower limb-loss (96% male, $M_{(age)} = 74$ yrs, $M_{(time)} = 42.6$ yrs). 82.8% of amputations reported as traumatic etiology.	Problem solving, seeking social support, and increasing time since amputation positively associated with adjustment to amputation.
3 Desmond (2007) UK	Cross-sectional. Coping strategies and long-term psycho-social adaptation to upper limb-loss.	$N = 138$ members of BLESMA with combat-related traumatic upper limb-loss (100% male, $M_{(age)} = 75$ yrs, $M_{(time)} = 50$ yrs).	Avoidant coping strategies associated with psychological distress and poorer adjustment.
4 Dougherty (1999) USA	Survey. Long-term outcomes for bilateral AK amputees from Vietnam War.	1. $N = 23$ Vietnam veterans with combat-related traumatic bilateral AK amputations (100% male, $M_{(age)} = 48$ yrs, $M_{(time)} = 28$ yrs). 2. $N = 145$ age and sex-matched controls	Decreased physical functioning among Vietnam amputees. Majority had been employed since injury, yet few were current prosthetic users.
5 Dougherty (2001) USA	Survey. Long-term outcomes for unilateral BK amputees from Vietnam War.	1. $N = 28$ Vietnam veterans with combat-related unilateral BK amputations 2. $N = 44$ Vietnam veterans with combat-related unilateral BK amputation plus $\geq 1$ other major injury (1 and 2; 100% male, $M_{(age)} = 48$ yrs, $M_{(time)} = 28$ yrs) 3. $N = 141$ age and sex-matched controls	Veterans with additional (secondary) injuries had worse health outcomes and made more use of psychological support services.
6 Dougherty (2003) USA	Survey. Long-term outcomes for unilateral AK amputees from	1. $N = 18$ Vietnam veterans with combat-related unilateral AK amputations 2. $N = 28$ Vietnam veterans with combat-related unilateral AK amputation plus $\geq 1$ other major	Both veteran groups had worse health outcomes than controls. Majority of veterans were currently employed and used prosthetics for on average

	Vietnam War.	injury (1 and 2; 100% male, $M_{(age)} = 48$ yrs, $M_{(time)} = 28$ yrs) 3. $N = 141$ age and sex-matched controls	13.5h/day.
7 Ebrahimzadeh and Fattahi (2009) Iran	Survey. Long-term clinical outcomes in unilateral AK amputees.	$N = 31$ veterans of Iran-Iraq War with combat-related unilateral AK amputation (100% male, $M_{(age)} = 43$ yrs, $M_{(time)} = 17$ yrs)	High prevalence of pain and psychological symptoms including PTSD.
8 Ebrahimzadeh and Hariri (2009) Iran	Survey. Long-term clinical outcomes in unilateral BK amputees.	$N = 96$ veterans of Iran-Iraq War with combat-related unilateral BK amputation (100% male, $M_{(age)} = 43$ yrs, $M_{(time)} = 17$ yrs)	High prevalence of pain and psychological symptoms including PTSD.
9 Ebrahimzadeh <i>et al.</i> (2013) Iran	Survey. Long-term clinical outcomes in veterans with hip disarticulation.	$N = 76$ veterans of Iran-Iraq war with combat-related hip disarticulation (96.1% male, $M_{(age)} = 44$ yrs, $M_{(time)} = 26.6$ yrs)	High prevalence of back pain, phantom pains and stump spasms. Lower QoL scores for pain and physical function compared to population norms. Sports participation associated with higher QoL.
10 Edwards <i>et al</i> (2015) UK	Economic modelling. Long-term cost of care for British veterans of Afghanistan.	$N = 265$ veterans of war in Afghanistan with combat-related traumatic limb-loss. Ages and time-since-injury not reported.	Long-term (40-year) cost of prosthetic provision for lower-limb amputee cohort estimated at £288 million (USD 444 million) in today's currency.
11 Foote <i>et al</i> (2015) USA	Survey and qualitative interviews. Long-term health and QoL among Vietnam veterans.	$N = 257$ Vietnam veterans with combat-related traumatic limb-loss. Age, sex, and time since amputation not reported. (Sub-sample of $n = 20$ for qualitative interviews)	High prevalence of pain and co-morbid arthritis. Interviews revealed that – even 40 years post-injury – mental health problems and ageing/pain-related comorbidities had a strong negative influence on QoL.
12 Hoaglund <i>et al</i> (1983) USA <sup>1</sup>	Survey. Prosthetic problems and needs in veterans with	1. $N = 133$ veterans with service-connected traumatic limb-loss (100% male, $M_{(age)} = 47$ yrs, $M_{(time)} = 21$ yrs).	High prevalence of 'moderate to severe intensity' residual limb pain, along with high prevalence of back pain, phantom

	lower-limb amputations.	2. $N = 42$ veterans with dysvascular disease-related limb-loss. (100% male, $M_{(age)} = 60$ yrs, $M_{(time)} = 2$ yrs).	pain, and prosthetic problems.
13 Kulkarni <i>et al</i> (1998) UK	Medical examination. Prevalence of osteoarthritis and osteopenia.	1. $N = 44$ World War Two veterans with combat-related unilateral lower limb loss (100% male, $M_{(age)} = 73$ yrs, $M_{(time)} = 47$ yrs).	High prevalence of hip OA on both amputated and non-amputated sides. AK amputees had significantly more OA (and of greater severity) than BK amputees.
14 Machin and Williams (1998) UK	Survey and semi-structured interviews. Phantom pain and coping strategies.	1. $N = 26$ World War Two veterans and members of Blesma (100% male, $M_{(age)} = 76.8$ yrs. $M_{(time)} = not\ reported$ ). All injuries described as traumatic and either combat or service-related.	A dominant 'stiff upper lip' approach to coping with phantom pain was identified, with little recourse to social support or medical assistance.
15 Meyers (2014) Nicaragua	Qualitative ethnographic. Disability and identity among veterans with limb-loss.	Participant numbers unstated. Participants described as male middle-aged veterans of Nicaraguan Civil War of 1980s with either combat-related amputations or loss of limb function.	Depending on social and political context, limbless veterans may identify as 'disabled' or as 'war wounded', and may distance themselves from, or alternatively align themselves with, 'other' disabled groups.
16 Norvell <i>et al</i> (2005) USA <sup>1</sup>	Survey and retrospective cohort design. Prevalence of knee pain and osteoarthritis.	1. $N = 62$ veterans with traumatic lower limb-loss (100% male, $M_{(age)} = 63$ yrs, $M_{(time)} = 31$ yrs). 2. $N = 94$ veterans without amputation (100% male, $M_{(age)} = 65$ yrs).	Higher prevalence of knee pain and knee OA in amputees compared with non-amputees. Prevalence of knee pain also higher in AK amputees than BK amputees, linked to gait abnormalities.
17 Sherman and Sherman (1983) USA <sup>1</sup>	Survey. Prevalence of phantom pain.	$N = 764$ veterans with combat or service-related amputations (100% male, $M_{(age)} = 51$ yrs, $M_{(time)} = 27$ yrs).	Persistence of phantom pain severe enough to cause at least occasional debilitation is the norm rather than exception for combat amputees. Veterans reported not being listened to when seeking treatment for phantom pains, and self-medicating with alcohol.
18 Sherman <i>et al</i>	Survey. Prevalence	$N = 2694$ veterans with combat or service-related	Very high prevalence of moderately

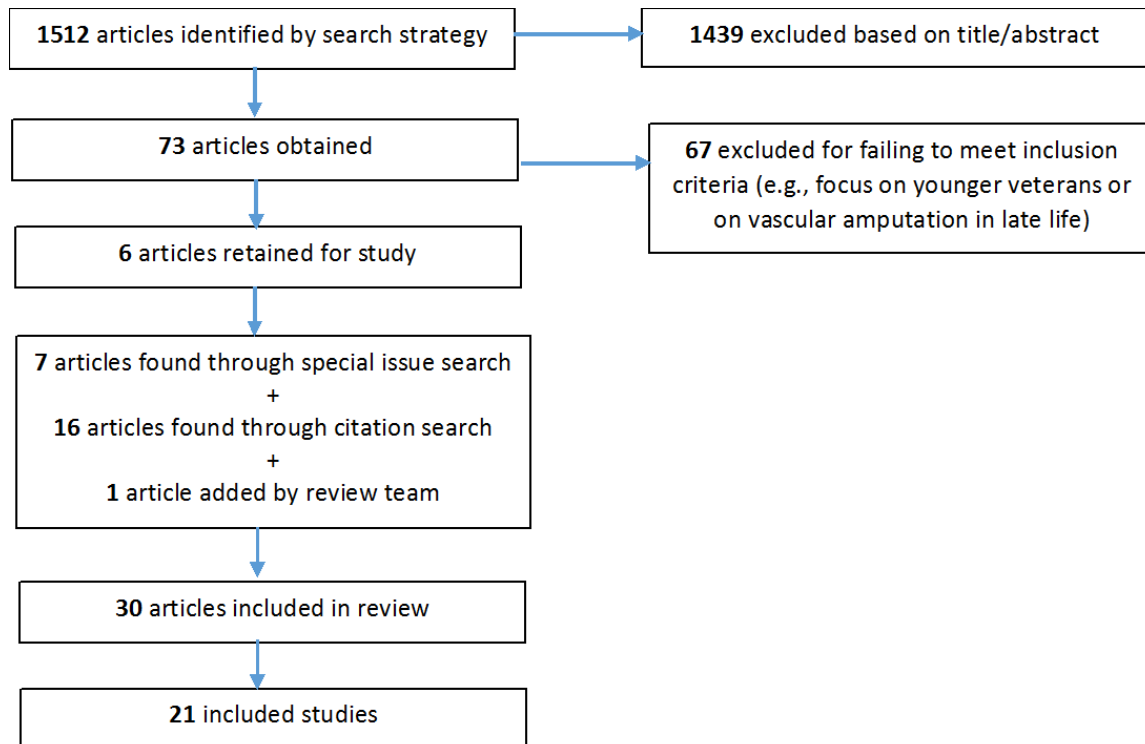
(1984) USA <sup>1</sup>	of phantom pain.	amputations (100% male, $M_{(age)} = 53$ yrs, $M_{(time)} = 28$ yrs).	intense phantom pain. Many have given up on treatments and have had poor experiences with clinicians.
19 Stewart and Jain (1999) UK	Epidemiological survey. Analysis of prosthetic costs over 50 year period.	$N = 98$ veterans with combat-related traumatic limb-loss (100% male, $M_{(age)} = 74$ yrs, $M_{(time)} = 48$ yrs)	50-year costs of prosthetic limb provision estimated at £69 million.
20 Taghipour <i>et al</i> (2009) Iran	Survey. Long-term QoL outcomes in lower-limb amputees	$N = 141$ veterans of Iran-Iraq war with combat-related traumatic lower limb-loss (100% male, $M_{(age)} = 45.2$ yrs, $M_{(time)} = 21.6$ yrs)	Poorer mental and physical HRQoL among amputees compared to population norms. Low back pain most important contributor to poorer HRQoL.
21 Wartan <i>et al</i> (1997) UK	Survey. Prevalence of phantom and stump pain.	$N = 590$ members of BLESMA with traumatic limb loss (100% male, $M_{(age)} = 73$ yrs, $M_{(time)} = 50$ yrs)	High prevalence of phantom limb pain and stump pain. Intensity of phantom sensations a significant predictor for time-course duration of phantom pain.

Key: <sup>1</sup>Study took place at USA Veterans Administration (VA). *AK* = above knee; *BK* = below knee; *BLESMA* = British Limbless Ex-Servicemen's Association; *CTD* = Cumulative trauma disorder; *OA* = Osteoarthritis; *OIF* = Operating Iraqi Freedom (Iraq); *OEF* = Operation Enduring Freedom (Afghanistan); *PTSD* = Post-traumatic stress disorder; *QoL* = Quality of life (Health-related = HRQoL).



Table 2: Prevalence of pain among older limbless veterans

<b>Type of pain</b>	<b>Average % pain prevalence identified in reviewed studies</b>	<b>No. of papers reporting prevalence statistics</b>
Phantom limb pain	17 – 90.8	14
Residual limb pain	32 – 92.2	10
Chronic back pain	8 – 76.6	9
Pain in contra-lateral (non-amputated) knee (lower-limb amputees)	38 – 79.4	4
Prosthetic-related pain	33 – 51	3
Hip pain on ipsilateral (amputated) side in lower-limb amputees	14.8	1
Knee pain on ipsilateral (amputated) side in BK amputees	13	1



*Figure 1: Flow diagram of identification of eligible studies*