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Servicemembers and veterans with major traumatic limb loss from Vietnam war and OIF/OEF conflicts: Survey methods, participants, and summary findings

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Abstract—Care of veterans and servicemembers with major traumatic limb loss from combat theaters is one of the highest priorities of the Department of Veteran Affairs. We achieved a 62% response rate in our *Survey for Prosthetic Use* from 298 Vietnam war veterans and 283 servicemembers/veterans from Operation Iraqi Freedom/Operation Enduring Freedom (OIF/OEF) who sustained major traumatic limb loss. Participants reported their combat injuries; health status; quality of life; and prosthetic device use, function, rejection, and satisfaction. Despite the serious injuries experienced, health status was rated excellent, very good, or good by 70.7% of Vietnam war and 85.5% of OIF/OEF survey participants. However, many health issues persist for Vietnam war and OIF/OEF survey participants (respectively): phantom limb pain (72.2%/76.0%), chronic back pain (36.2%/42.1%), residual-limb pain (48.3%/62.9%), prosthesis-related skin problems (51.0%/58.0%), hearing loss (47.0%/47.0%), traumatic brain injury (3.4%/33.9%), depression (24.5%/24.0%), and posttraumatic stress disorder (37.6%/58.7%). Prosthetic devices are currently used by 78.2% of Vietnam war and 90.5% of OIF/OEF survey participants to improve function and mobility. On average, the annual rate for prosthetic device receipt is 10.7-fold higher for OIF/OEF than for Vietnam war survey participants. Findings from this cross-conflict survey identify many strengths in prosthetic rehabilitation for those with limb loss and several areas for future attention.

Key words: benefits, combat, limb loss, OIF/OEF, prosthetic devices, traumatic amputation, veterans, Vietnam war, wounded servicemembers, wounded warriors.

INTRODUCTION

The Department of Veterans Affairs (VA) was established to care for battle-injured veterans and their dependents. Restoring function to those with limb loss is one of the VA's highest priorities. Only 2 to 7 percent of servicemembers serving in prior conflicts returned to Active

Abbreviations: ADL = activity of daily living, DOD = Department of Defense, OIF/OEF = Operation Iraqi Freedom/Operation Enduring Freedom, PTSD = posttraumatic stress disorder, TBI = traumatic brain injury, VA= Department of Veterans Affairs.

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Duty after major limb loss [1–2]. A recent Department of Defense (DOD) Rehabilitation Directive is facilitating the return of servicemembers with major traumatic limb loss from Operation Iraqi Freedom/Operation Enduring Freedom (OIF/OEF) to their highest possible functional level so that major limb loss does not prevent them from maximizing their career options in either the military or civilian sectors [3–5]. The DOD's Amputee Patient Care Programs at Walter Reed Army Medical Center, Washington, DC; Brooke Army Medical Center, San Antonio, Texas; and Naval Medical Center, San Diego, California, offer state-of-the-art rehabilitation, prostheses, assistive technologies, and training to restore function for servicemembers with limb loss to the extent possible [6]. The goal of early rehabilitation for servicemembers with traumatic limb loss in center-based comprehensive rehabilitation programs is to restore function and quality of life to the fullest extent possible and provide state-of-the-art prostheses, wheeled mobility, and other assistive devices.

The mortality among servicemembers injured in combat decreased from 24 percent in the Vietnam war to approximately 20 percent in OIF/OEF. This is largely attributed to changes in protective gear and equipment, immediate battlefield triage, and forward surgical teams linked to comprehensive care [7–8]. The total number of servicemembers with traumatic limb loss from the Vietnam war is estimated at 3.4 percent of battle injured or 5,283 individuals [9]. This compares with 2.6 percent of battle injured with limb loss or nearly 1,000 individuals to date in OIF/OEF.*

Following limb loss, adjusting to life with a prosthesis and other mobility technologies is a complex rehabilitation process. Each day, individuals with limb loss balance issues of pain and physical and psychological limitations with decisions about activities of daily living (ADLs), use of prostheses, adaptive devices, and wheeled mobility. Over time, those with limb loss select and use prosthetic devices and other technologies that maximize their function and conserve their time. Some Vietnam war veterans with major traumatic limb loss are now interested in trying new, technologically advanced, or specialty prosthetic devices to improve their function and increase their participation in recreational activities, while some OIF/OEF servicemembers and veterans are simplifying the number of prosthetic devices they use on a regular basis to minimize prosthetic burden.

It is important to forecast shifts in prosthetic use and associated costs since the VA prosthetic limb distribution policy allows veterans with limb loss to receive any prosthesis requested if it is deemed medically and functionally indicated.† Therefore, the purpose of this article is to summarize findings from Vietnam war veterans and OIF/OEF veterans and servicemembers with traumatic limb loss who completed the *Survey for Prosthetic Use* (**Appendix 1** , available online only) and to identify issues of importance to servicemembers, veterans, and the agencies caring for them.

METHODS

Survey Participants

Our goal was to include all eligible OIF/OEF servicemembers with traumatic limb loss and an equivalent number of Vietnam war veterans, oversampling to include all those with unilateral upper-limb loss and multiple limb loss. We enrolled 298 veterans from the Vietnam war and 283 servicemembers and veterans from OIF/OEF [10]. A glossary of study terms and definitions is located at the end of this issue [11].

Vietnam War Participants

We identified veterans aged 50 to 80 who sustained major traumatic limb loss in the Vietnam war combat theater (1961–1973) and received service-connected disability benefits for limb loss using VA Compensation and Pension Mini Master files in Austin, Texas. We searched on the following diagnosis codes: veterans with traumatic, combat-related upper-limb loss (5,120–5,156); lower-limb loss (5,160–5,173); and multiple limb loss (5,104–5,111) [10]. From the roster of 2,531 Vietnam war veterans with major limb loss, we selected 501 individuals: all with major unilateral upper-limb loss (96), all with multiple limb loss (73), and a random sample of 332 individuals with unilateral lower-limb loss. We verified participant

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†Downs, Fred (Veterans Health Administration). Conversation with: Gayle Reiber (VA Puget Sound Health Care System, Seattle, WA). 2008 Mar 12.

contact information for these 501 veterans through the VA Corporate Data Warehouse. Survey exclusion criteria included amputation to only fingers or toes, being cognitively unable to respond to the survey, no valid contact information, or being deceased.

OIF/OEF Participants

We identified all servicemembers from the OIF/OEF conflicts (January 2000–January 2008) with major traumatic limb loss from the Madigan Army Medical Center M-2 database, Tacoma, Washington; the VA Compensation and Pension file; and the Veterans Health Administration Health Eligibility Center database of discharged OIF/OEF veterans. Survey inclusion criteria for this cohort included major traumatic limb loss in the OIF/OEF combat theater and being at least 1 year following limb loss. Exclusion criteria included being cognitively unable to respond to the survey, no valid contact information, amputation to only fingers or toes, or being deceased. We identified 541 servicemembers and veterans who were 1 year since limb loss by February 21, 2007; of these servicemembers and veterans, 110 had unilateral upper-limb loss, 317 had unilateral lower-limb loss, and 114 had multiple limb loss. We verified participant contact information through the VA Corporate Data Warehouse and other Federal sources.

Survey Development and Content

A group of rehabilitation and surgery clinicians and researchers developed the *Survey for Prosthetic Use* (**Appendix 1**, available online only) to address key issues for veterans and servicemembers with major upper- and lower-limb loss. The survey used conventional survey methodology [12–14].

Demographic and Lifestyle Variables

The survey's demographics and lifestyle variables included age at the time of the survey, sex, race, employment in military and nonmilitary positions, and current military status (Active Duty, National Guard/Reserves, in rehabilitation, or discharged). Lifestyle questions included marital status and whether participants had children.

Combat-Associated Injuries

Participants reported their combat-associated injuries including the date and site(s) of limb loss. Upper-limb loss categories included partial hand, wrist disarticulation, transradial, elbow disarticulation, transhumeral, shoulder, or forequarter. Lower-limb loss categories included partial foot, ankle disarticulation, transtibial, knee disarticulation, transfemoral, hip, and transpelvic. Participants also reported their number of pre- and post-amputation-related surgeries.

In addition to limb loss, participants specified other combat injuries: injury to limb(s) without limb loss, head injury, eye injury, hearing loss, chest injury, abdominal injury, burns, and other combat injuries. Participants assessed the extent each combat injury affected current quality of life from 0 (does not affect at all) to 10 (strongly affects).

Participants with upper-limb loss reported cumulative trauma disorder (worn-limb syndrome) that may result from overuse of the nonamputated limb. Related conditions include carpal tunnel syndrome, cubital tunnel syndrome, tendonitis, arthritis, stiff or painful joints, and ganglion cysts. We assessed upper-limb function on 23 ADLs, including eating, dressing, housekeeping, community activities, automobile operation, use of tools, and sporting activities. Participants indicated whether they performed each ADL (1) using their prostheses, (2) using a one-arm technique, (3) assisted by another person, or (4) not at all.

Participants with lower-limb loss reported joint arthritis, stiff joints, heel pain, plantar fasciitis, and heterotrophic ossification. We grouped physical function into seven mutually exclusive graded levels: 1 = cannot walk, need assistance to transfer; 2 = cannot walk, does not need assistance to transfer; 3 = household walker; 4 = community walker; 5 = walk with varying speeds; 6 = low-impact activities, such as golf; and 7 = high-impact activities, such as basketball or skiing.

Health Status and Comorbidity

Self-reported health information used questions on health status from the previously validated 36-Item Short Form Health Survey [15–16]. We assessed the presence or absence of 15 comorbid conditions, including chronic back pain, phantom limb pain, residual-limb pain, arthritis, migraines, posttraumatic stress disorder (PTSD), depression, and traumatic brain injury (TBI).

Prosthetic and Assistive Devices and Services

We measured the number and type of prosthetic devices ever and currently used and the frequency of daily prosthetic use. Participants reported on the number and types of prostheses ever received as follows: prostheses

received during their first year post limb loss and all prostheses received from 1 year post limb loss to the present. We summarized prosthetic devices and prototype devices into major groups defined by the degree of technology and level of limb loss. We grouped upper-limb prostheses into three categories: advanced technology (myoelectric, microprocessor-type devices, or hybrid [mix of electronic and body-powered parts]), mechanical (body-powered with no batteries needed), and cosmetic (nonfunctional).

Four prosthetic types are available for participants with limb loss at or proximal to the knee (knee, transfemoral, hip, or pelvis): specifically, advanced technology (microprocessor-type device requiring recharging or hybrid), mechanical (not requiring recharging), specialty (recreational, athletic, or high-impact use), or waterproof (shower or swimming leg).

For limb loss distal to the knee (transtibial, ankle, or foot), the five prosthetic types available are advanced technology (hybrid), mechanical (prostheses not requiring recharging and/or vacuum-assisted system with pump or suction device [considered mechanical as these systems are largely vacuum sockets with mechanical feet]), specialty (recreational, athletic, or high-impact use), waterproof (shower or swimming leg), and cosmetic (nonfunctional limb for foot or ankle only).

We classified data on cosmetic devices by limb-loss level. We included cosmetic device data for those with foot or ankle limb loss since these devices were used for ambulation and/or balance. We excluded cosmetic devices at more proximal lower-limb loss sites that were not used for ambulation from the functional limb analysis but included them in the cost analysis reported elsewhere [17].

Participants identified the number and type of prosthetic devices they wore out and the average time for replacement. For prostheses rejected because of dissatisfaction, we noted the number and type of device(s) as well as the reasons for discontinuation. We reported on abandonment of all prostheses. We collected data on current assistive technology use (walkers, canes, crutches, car modifications, wheelchairs, terminal upper-limb devices, etc.). We asked participants what assistive technology they anticipated using in the next 3 years.

We determined the source of prosthetic care (DOD, VA, private, or multiple sources) as well as satisfaction with devices and providers. We adapted questions on prosthetic and assistive device use from the Houghton Scale [18]. We adapted questions on prosthesis satisfaction from the Orthotic and Prosthetic User's Survey (OPUS) and the Prosthetic Evaluation Questionnaire (PEQ) [19–20]. We collected current overall prosthetic satisfaction only for participants using prostheses. They rated their prosthetic satisfaction from 0 (not at all satisfied) to 10 (completely satisfied).

Prosthetic and rehabilitation experts, including members of our Expert Panel (**Appendix 2**, available online only), reviewed the survey for content validity before we piloted it on 24 men and women with traumatic or combat-related limb loss. After refinements to the survey questions, we piloted the survey on 6 of the 9 servicemembers with major traumatic limb loss from the Desert Storm conflict. A generic version of the *Survey for Prosthetic Use*, including both upper- and lower-limb loss sections, is available in **Appendix 1** (available online only).

Data Collection

Each eligible veteran or servicemember with major traumatic limb loss received a mailed letter of invitation; an eligibility checklist; and an information statement with the study purpose, key study personnel, and human subjects contact information. If we received no response within a month, we mailed a second copy of the survey; and if we received no response in another month, we placed telephone calls. Participants could select from three survey response methods: toll-free telephone call with knowledgeable staff available at participant's convenience; mailed hardcopy; or Internet by a secure, password-protected Web site with data-entry range checks, missing value alerts, error message alerts, and drop-down menus.

We entered data collected by telephone and mail into the Web site. We reviewed all surveys for missing or noncongruous data. Staff contacted participants to resolve these and other issues identified in the data quality review. We telephoned participants with major traumatic limb loss reporting no current prosthetic use to collect information on reasons prostheses were abandoned and on their use of wheelchairs.

Expert Panel

A group of experts in limb loss and prosthetic care from the VA, DOD, academic, and private-practice settings, as well as veterans and servicemembers with limb loss from the Vietnam war and OIF/OEF, served on the study's Expert Panel (**Appendix 2**, available online

only). This group met by telephone multiple times and in person for 3 days in Seattle, Washington, in June 2008. Expert Panel members advised study staff on prosthetics, function, limb loss, transition probability, and cost issues. Members of the Expert Panel participated as authors on articles in this issue. Survey findings discussed by the investigative team and Expert Panel are the basis for recommendations for improved prosthetic and rehabilitation care and are presented elsewhere in this issue [21].

Statistical Methods

We used the American Association for Public Opinion Research guidelines to determine survey response rates [22]. The numerator is the number of participants with major traumatic limb loss who completed a survey divided by the number of eligible veterans and servicemembers (those who completed the survey, declined participation, and did not respond). We excluded deceased veterans and servicemembers and those with no contact information from the computation (**Figure 1**). We compared responders and nonresponders to assess potential bias using data available in the Mini Master Compensation and Pension file for the Vietnam war and OIF/OEF participants.

Person-level analysis for both conflicts is grouped into the following three categories: unilateral upper-limb loss, unilateral lower-limb loss, and multiple limb loss. We created a variable to summarize limb loss and ambulation-related pain and a variable to summarize mental health issues. The sum of positive responses to three dichotomized pain questions (phantom limb, residual limb, and back) is the pain summary. The sum of three dichotomized mental health questions (depression, PTSD, and TBI) is the mental health summary. We described categories for evaluation of upper-limb loss and the mutually exclusive 1 to 7 scale for evaluation of lower-limb physical function earlier.

We computed prosthetic device receipt, replacement, and rejection from the time of limb loss to the date of the survey. The numerator for each, divided by years since limb loss, yields an annual rate. We compared annual rates for participants from both conflicts.

The prosthetic satisfaction analysis excluded 65 Vietnam war and 27 OIF/OEF participants who abandoned or never used prostheses, including individuals using wheeled mobility. We also excluded 3 Vietnam war and 5 OIF/OEF participants with incomplete satisfaction data from this analysis; thus, prosthetic satisfaction data is on 230 Vietnam war and 251 OIF/OEF participants.

Univariate, bivariate, and multivariate analyses used SAS 9.2 (SAS Institute, Inc; Cary, North Carolina) and Stata 9.2 (StataCorp; College Station, Texas). For univariate analyses, we based statistical significance on chi-square (categorical data), Mann-Whitney *U*-test (ordinal data),

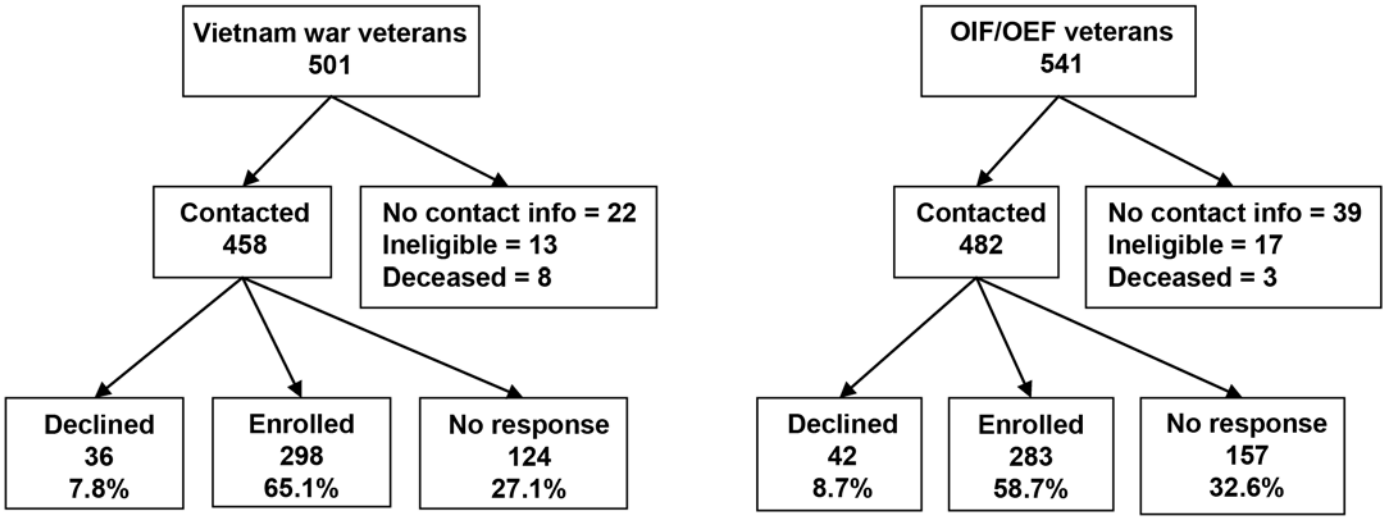


Figure 1.
Survey enrollment for Vietnam war and Operation Iraqi Freedom/Operation Enduring Freedom (OIF/OEF) survey participants with major traumatic limb loss.

Student *t*-test (continuous data), and Fisher exact test if cell numbers were ≤5. We used a two-sided test for significance with the *p*-value set at $p \leq 0.05$.

RESULTS

Survey Response

Figure 1 shows participant flow. We mailed surveys to 501 Vietnam war veterans with major traumatic limb loss. No valid contact information was available for 22 veterans, and 21 did not meet eligibility criteria. There are 298/458 Vietnam war participants for a response rate of 65.1 percent. For the 541 OIF/OEF servicemembers and veterans identified who were 1 year following limb loss, 39 had no valid contact information and 20 did not meet eligibility criteria. We had a 58.7 percent (283/482) response rate. The response rate for all participants is 61.8 percent.

The survey response method differed by conflict. **Figure 2** shows that 64.8 percent of veterans from the Vietnam war cohort preferred the mail-out/mail-back method compared with 26.5 percent of the OIF/OEF cohort. The survey was completed on our Web site by 23.1 percent of Vietnam war and 40.3 percent of OIF/OEF veterans and servicemembers. Telephone completion was used by 12.1 percent of Vietnam war and 33.2 percent of OIF/OEF veterans and servicemembers ($p < 0.001$).

Participant Demographics

The mean age for the Vietnam war cohort was 60.7 years, 100.0 percent were male, and 81.1 percent were Caucasian. In contrast, the mean age for the OIF/OEF cohort was 29.3 years, 96.8 percent were male, and 73.2 percent were Caucasian (**Table 1**). Of the Vietnam war cohort, 74.8 percent are married or living together and 87.0 percent have children; of the OIF/OEF cohort, 60.6 percent are married or living together and 48.0 percent have children. In the Vietnam war cohort at the time of limb loss, 7.0 percent were officers and 93.0 percent were enlisted servicemembers, compared with 11.0 percent officers and 89.0 percent enlisted servicemembers for the OIF/OEF cohort (data not shown). No Vietnam war veterans in our survey reported being on Active Duty compared with 20.5 percent of the OIF/OEF cohort. An additional 8.5 percent of OIF/OEF servicemembers indicated they still receive DOD rehabilitation care even though they are ≥1 year following limb loss. Full- or part-time employment (military and other employers) of Vietnam war and OIF/OEF survey participants is 78.7 and 53.6 percent, respectively. We did not classify volunteer work as employment in this survey. In the OIF/OEF cohort, an additional 22.6 percent are students.

	Vietnam War (n = 298)		OIF/OEF (n = 283)	
	Number	Percent	Number	Percent
→	193	64.8	75	26.5
→	69	23.1	114	40.3
→	36	12.1	94	33.2

Figure 2.
Method of survey response of Vietnam war and Operation Iraqi Freedom/Operation Enduring Freedom (OIF/OEF) cohorts by mail, Web site entry, or telephone interview.

Combat Injuries and Amputations

The location(s) of limb loss in participants from both conflicts shows a similar distribution (**Figure 3**) with the exception of slight increases in transradial (below elbow) and partial-foot levels in OIF/OEF servicemembers and veterans. The 298 Vietnam war participants lost 378 limbs and the 283 OIF/OEF participants lost 351 limbs. The number of years (mean ± standard deviation) since initial limb loss is 38.6 ± 4.0 years for the Vietnam war cohort compared with 3.1 ± 1.2 years for the OIF/OEF cohort. The most common types of limb loss included transtibial lower-limb loss, transfemoral lower-limb loss, and transradial upper-limb loss. Other articles in this issue present detailed findings for these groups [23–25].

Figure 4 shows the mean frequency of limb salvage surgery before and following surgical amputation. Preamputation, more limb-salvage procedures were performed in those with unilateral lower-limb loss. On average, postamputation surgery was more frequent in those with multiple limb involvement (mean 2.5 surgeries for Vietnam war and 5.5 for OIF/OEF, $p < 0.001$) and those with unilateral lower-limb loss (mean 2.3 surgeries for Vietnam war and 5.6 for OIF/OEF). Overall, across all limb levels, significantly more surgical procedures followed limb loss in OIF/OEF than in Vietnam war participants ($p < 0.001$).

Table 1.
Vietnam war and Operation Iraqi Freedom/Operation Enduring Freedom (OIF/OEF) survey participant demographics by site of major traumatic limb loss.

Demographic	Vietnam War				OIF/OEF			
	Unilateral Upper Limb	Unilateral Lower Limb	Multiple Limb	Total	Unilateral Upper Limb	Unilateral Lower Limb	Multiple Limb	Total
Participants	47	178	73	298	50	172	61	283
Age (yr, mean ± SD)	60.3 ± 2.4	60.8 ± 3.3	60.7 ± 2.6	60.7 ± 3.0	30.2 ± 6.0	29.4 ± 6.1	28.1 ± 4.6	29.3 ± 5.8*
Sex (%)								
Male	100.0	100.0	100.0	100.0	96.0	97.7	95.1	96.8
Female	0.0	0.0	0.0	0.0	4.0	2.3	4.9	3.2
Race/Ethnicity (%)								
American Indian/Alaska Native	0.0	0.6	2.8	1.0	4.0	5.9	3.3	5.0
Asian	0.0	0.6	1.4	0.7	0.0	0.6	5.0	1.4
Black/African American	6.5	11.8	4.2	9.1	14.0	8.2	10.0	9.6
Hispanic or Latino	8.7	5.6	8.3	6.8	20.0	7.1	5.0	8.9
Native Hawaiian or Pacific Islander	0.0	0.6	1.4	0.7	0.0	1.2	0.0	0.7
White/Caucasian	82.6	80.3	81.9	81.1	60.0	75.9	76.7	73.2
Other	2.2	0.5	0.0	0.6	2.0	1.1	0.0	1.2
Marital Status (%)								
Married/Living Together	76.6	73.7	76.4	74.8	58.0	61.2	61.0	60.6*
Divorced/Separated	19.1	19.4	19.4	19.4	14.0	10.0	3.4	9.3
Widowed	0.0	4.0	0.0	2.4	0.0	0.0	0.0	0.0
Never Married	4.3	2.9	4.2	3.4	28.0	28.8	35.6	30.1
Have Children (%)	81.0	90.0	85.0	87.0	48.0	49.0	46.0	48.0*
Current Military Status (%)								
Active Duty	0.0	0.0	0.0	0.0	14.0	21.5	23.0	20.5
In Rehabilitation	0.0	0.0	0.0	0.0	6.0	7.0	14.8	8.5
Medical Discharge	76.6	83.2	84.7	82.5	70.0	57.5	50.8	58.3
Discharge	23.4	16.8	15.3	17.5	8.0	10.5	9.8	9.9
National Guard/Reserves	0.0	0.0	0.0	0.0	2.0	3.5	1.6	2.8
Current Employment Status (%)								
Employed	78.7	79.7	76.4	78.7	44.0	56.7	52.5	53.6
Student	0.0	0.0	0.0	0.0	34.0	22.2	14.7	22.6
Retired†	21.3	20.3	23.6	21.3	20.0	19.3	27.9	21.3
Other	0.0	0.0	0.0	0.0	2.0	1.8	4.9	2.5

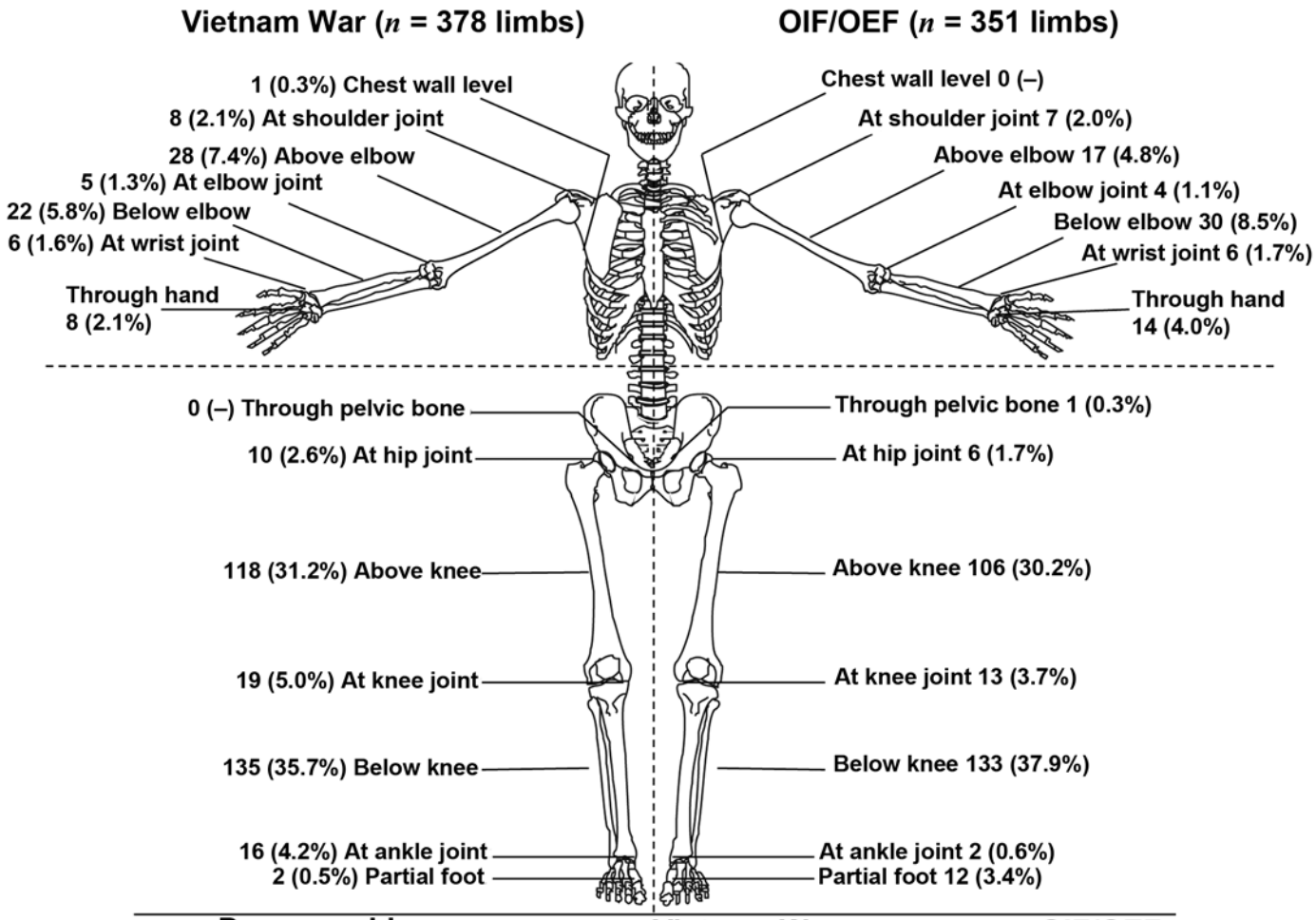
*$p < 0.001$.
†Not employed after amputation.
SD = standard deviation.

We assessed participants' other combat injuries. After limb loss, the most common combat injury is hearing loss (47%) in participants from both conflicts, followed by trauma to nonamputated limbs (33% of Vietnam war and 45% of OIF/OEF cohort, $p < 0.001$), and head injuries (13% of Vietnam war and 34% of the OIF/OEF cohort, $p < 0.001$) (**Figure 5**).

Health Status and Comorbidity

Self-rated overall health status at the time of the survey was rated as excellent, very good, or good by 70.7 percent of Vietnam war veterans and 85.5 percent of the OIF/OEF cohort. The highest self-reported health status among members of both conflicts is reported by those with multiple limb loss (**Table 2**). Quality of life assessment is presented elsewhere [26].

The major chronic health problems identified by Vietnam war and OIF/OEF participants, respectively, include chronic back pain (36.2% vs 42.1%), phantom limb pain (72.2% vs 76.0%), and residual-limb pain (48.3% vs 62.9%). We stratified the pain summary for prosthetic users and nonusers to determine if pain was strongly associated with prosthetic use. For those with upper-limb loss in both conflicts, the mean pain summary



Demographics	Vietnam War	OIF/OEF
Veterans and Servicemembers	298	283
Involved Limbs	378	351
Years Since Limb Loss (mean ± SD)	38.6 ± 4.0	3.1 ± 1.2
Unilateral Upper Limb	47	50
Unilateral Lower Limb	178	172
Multiple Limb	153	129

Figure 3.
Frequency of highest level of limb loss by involved limbs for Vietnam war and Operation Iraqi Freedom/Operation Enduring Freedom (OIF/OEF) cohorts. SD = standard deviation.

was higher in those not using a prosthesis. For those with unilateral lower- and multiple limb loss, findings are mixed (**Table 2**). Arthritis was reported by 64.4 percent of Vietnam war and 25.8 percent of OIF/OEF participants; migraine headaches were present in 11.4 percent of Vietnam war and 21.9 percent of OIF/OEF participants. **Table 2** shows the frequency of three mental health conditions in Vietnam war and OIF/OEF participants, respectively: TBI (3.4% vs 33.9%), depression (24.5% vs 24.0%), and PTSD (37.6% vs 58.7%).

Functional Capability

Table 3 shows the ability to perform ADLs with and without prostheses for participants with unilateral and bilateral upper-limb loss. Even though OIF/OEF prosthetic device users are, on average, 36 years younger than

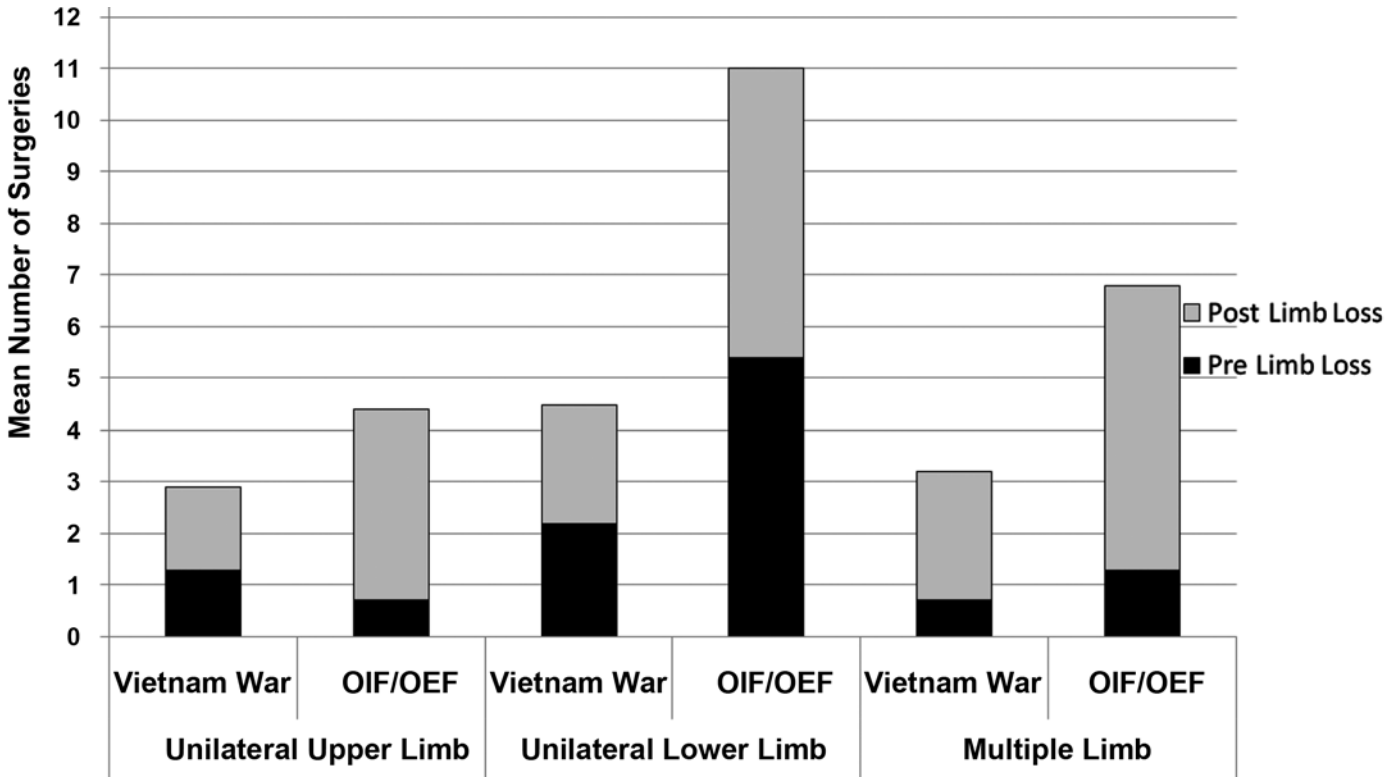


Figure 4.
Mean number of pre and post limb-loss surgeries, excluding debridement, for servicemembers and veterans from Vietnam war and Operation Iraqi Freedom/Operation Enduring Freedom (OIF/OEF) by level of limb loss.

Vietnam war prosthetic device users, among those with unilateral upper-limb loss, a prosthesis is used to perform some or all ADL's in 70.2 percent of Vietnam war and 76.0 percent of OIF/OEF veterans and servicemembers. In those with bilateral upper-limb loss, 50.0 percent of Vietnam war and 85.7 percent of OIF/OEF participants use prostheses for some or all their ADLs.

We assessed ambulatory function using seven mutually exclusive categories for participants with unilateral lower-limb loss (**Table 3**). In Vietnam war veterans with unilateral lower-limb loss using prostheses, 1.2 percent do not walk (levels 1 and 2), 62.9 percent walk in households or communities (levels 3–5), and 20.2 percent engage in low- or high-impact activities (levels 6 and 7). In contrast, in the OIF/OEF cohort using prostheses, 0.6 percent do not walk (levels 1 and 2), 41.9 percent walk in households and communities (levels 3–5), and 51.7 percent engage in low- and high-impact activities (levels 6 and 7).

Prosthetic Device Use, Replacement, and Rejection Among Prosthetic Users

Unilateral Upper-Limb Prostheses

Table 4 describes prosthetic use and excludes 4.0 percent of Vietnam war and 2.1 percent of OIF/OEF participants who never received, replaced, or rejected any prostheses. We computed the number of prosthetic devices ever received by device type for each participant. In Vietnam war veterans with unilateral upper-limb loss, only 8 have received a myoelectric prosthesis. The majority received mechanical (body-powered) prostheses. On average, over their 39 years of prosthetic experience, they received 5.3 prostheses for a mean rate of 0.14/year. In comparison, their OIF/OEF counterparts with unilateral upper-limb loss received significantly more ($p < 0.001$) prostheses at a rate of 1.59/year (this includes multiple myoelectric prostheses, mechanical [body-powered] prostheses, and a sports or specialty prosthesis). Thus, on an annual basis, the OIF/OEF unilateral upper-limb

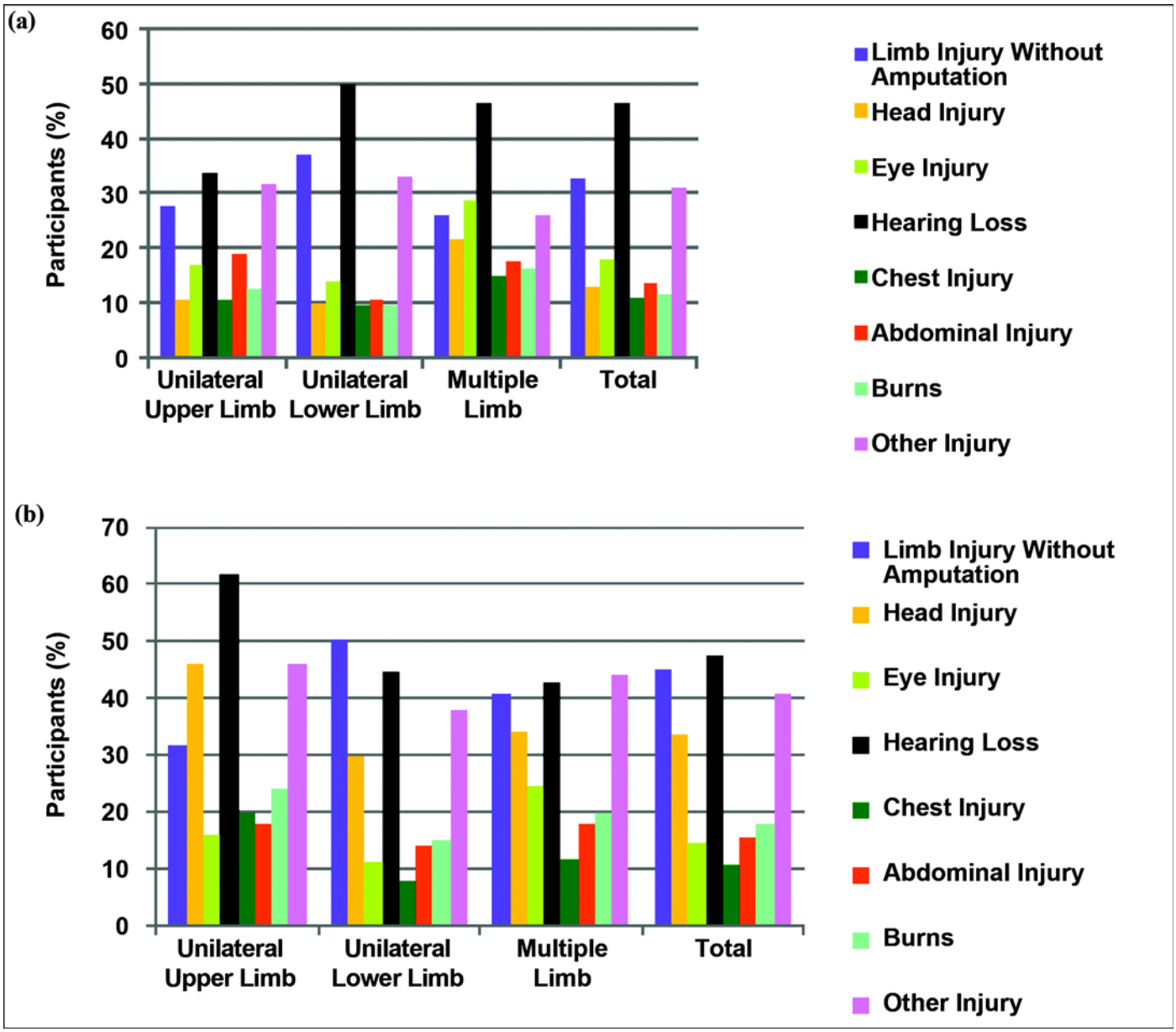


Figure 5.
Combat-associated injuries by type of major traumatic limb loss for **(a)** Vietnam war and **(b)** Operation Iraqi Freedom/Operation Enduring Freedom (OIF/OEF) survey participants.

group received 11.3-fold more prostheses than the Vietnam war group.

Vietnam war participants with unilateral upper-limb loss have worn out and replaced only an average of 3 prostheses for a rate of 0.08/year compared with 0.29/year in OIF/OEF participants ($p < 0.01$), a 3.6-fold increase in annual prosthetic device replacement for the OIF/OEF group.

The average number of prostheses rejected by Vietnam war participants with upper-limb loss is 0.03/year compared with 0.59/year for OIF/OEF participants ($p < 0.001$), for an annual rejection rate 19.7-fold higher in the OIF/OEF group. Thus, on average each OIF/OEF veteran or servicemember with unilateral upper-limb loss has set aside a myoelectric/advanced device and a mechanical device. This issue is further addressed elsewhere [23].

Table 2.
Current health and comorbidity in Vietnam war and Operation Iraqi Freedom/Operation Enduring Freedom (OIF/OEF) survey participants by site of major traumatic limb loss (cross-conflict comparisons).

Demographic	Vietnam War				OIF/OEF			
	Unilateral Upper Limb	Unilateral Lower Limb	Multiple Limb	Total	Unilateral Upper Limb	Unilateral Lower Limb	Multiple Limb	Total
No. of Participants	47	178	73	298	50	172	61	283
Health Status: Excellent, Very Good, or Good (%)	63.8	68.0	81.9	70.7	82.0*	84.8†	90.2	85.5†
Chronic Back Pain (%)	29.8	44.9	19.2	36.2	40.0	50.0	21.3	42.1
Phantom Pain (%)	66.0	74.7	69.9	72.2	82.0†	76.7	68.9	76.0†
Residual-Limb Pain (%)	31.9	53.4	46.6	48.3	68.0	61.6	62.3	62.9
Mean Pain Summary Score‡								
Using Prosthesis	1.21	1.75	1.34	1.58	1.79§	1.86	1.57	1.79*
Not Using Prosthesis	1.43	1.64	1.39	1.51	2.25*	2.30	1.00*	2.04§
Total Pain Summary Score	1.28	1.73	1.36	1.57	1.90†	1.88	1.52	1.81§
Arthritis (%)	55.3	71.9	52.1	64.4	26.0†	29.7†	14.8†	25.8†
Migraine Headaches (%)	10.6	13.5	6.9	11.4	34.0§	19.2	19.7*	21.9†
Traumatic Brain Injury (%)	6.4	2.3	4.1	3.4	32.0§	34.9†	32.8†	33.9†
Depression (%)	19.2	27.5	20.6	24.5	26.0	25.0	19.7	24.0
Posttraumatic Stress Disorder (%)	27.0	45.5	24.7	37.6	68.0†	63.4†	37.7	58.7†
Mean Mental Health Summary Score¶								
Using Prosthesis	0.49*	0.75	0.46*	0.66	1.18†	1.22†	0.93§	1.15†
Not Using Prosthesis	0.64	0.75	0.57	0.66	1.50*	1.40	0.60	1.30§
Total Mental Health Summary Score	0.53	0.75	0.49	0.65	1.26†	1.23†	0.90§	1.17†

*$p < 0.05$.
†$p < 0.001$.
‡Pain Summary = chronic back pain, phantom pain, residual-limb pain.
§$p < 0.01$.
¶Mental Health Summary = traumatic brain injury, depression, and posttraumatic stress disorder.

Unilateral Lower-Limb Prostheses

Table 4 shows that Vietnam war veterans with unilateral lower-limb prostheses received an average of 10.6 prostheses since limb loss for a rate of 0.28/year compared with a mean of 6.9 prosthetic devices for a rate of 2.60/year for OIF/OEF veterans and servicemembers ($p < 0.01$). Annual receipt of prostheses is 9.3-fold higher in the OIF/OEF than in the Vietnam war cohort. Since limb loss, unilateral lower-limb prosthetic replacements average 7.30 (0.19/year) for the Vietnam war group and 1.62 (0.56/year, $p < 0.01$) for the OIF/OEF group, nearly a 3-fold difference. Annual rates of limb rejection are 0.05/year for the Vietnam war group and 0.75/year for the OIF/OEF group ($p < 0.01$), a 15-fold annual increase. Additional details are reported elsewhere [24].

Multiple Limb Prostheses

Table 4 shows the total mean prosthetic devices received for the Vietnam war cohort with multiple limb loss is 13.5 for a rate of 0.34/year compared with 10.8 in the OIF/OEF cohort at an annual rate of 4.77/year; thus, a 14-fold annual increase exists in prosthetic device receipt for those with multiple limb loss in the OIF/OEF cohort. Mean prosthetic device replacement in this group is 0.21/year for the Vietnam war group and 0.51/year for the OIF/OEF group, for a 2.4-fold higher annual replacement in the OIF/OEF group. Prosthetic device rejection in Vietnam war participants with multiple limbs is 0.09/year compared with OIF/OEF participants who reported 1.79/year for an approximately 20-fold excess rejection rate by the OIF/OEF group. Additional details are reported elsewhere [25].

Prosthetic Satisfaction Issues

Among those using prostheses, overall prosthetic satisfaction, reported on a scale from 0 (low) to 10 (high), is significantly higher in the OIF/OEF cohort than in the Vietnam war cohort (7.5 vs 7.0, respectively, $p < 0.01$)

Table 3.
General prosthetic device function and use by site of major traumatic limb loss and conflict.

Participant	Vietnam War	OIF/OEF
Unilateral Upper Limb (*n*)	47	50
Prosthesis Currently Used to Perform (%)		
Majority of Daily Tasks	13 (27.7)	18 (36.0)
Minority of Daily Tasks	20 (42.5)	20 (40.0)
Total	33 (70.2)	38 (76.0)
Prosthesis Not Currently Used (%)	14 (29.8)	12 (24.0)
Bilateral Upper Limb (*n*)	6	7
Prosthesis Currently Used to Perform (%)		
Majority of Daily Tasks	1 (16.7)	5 (71.4)
Minority of Daily Tasks	2 (33.3)	1 (14.3)
Total	3 (50.0)	6 (85.7)
Prosthesis Not Currently Used	3 (50.0)	1 (14.3)
Unilateral Lower Limb (*n*)	178	172
Functional Level: Prosthesis Currently Used (%)		
1–2: Do Not Walk	2 (1.2)	1 (0.6)
3: Household Walker	15 (8.4)	10 (5.8)
4: Community Walker	34 (19.1)	23 (13.4)
5: Varying Speed Walker	63 (35.4)	39 (22.7)
6: Low-Impact Activities	29 (16.3)	44 (25.6)
7: High-Impact Activities	7 (3.9)	45 (26.1)
Total	150 (84.3)	162 (94.2)*
Prosthesis Not Currently Used (%)	28 (15.7)	10 (5.8)†
Multiple Limb (involves lower limb) (*n*)	67	54
Functional Level: Prosthesis Currently Used (%)		
1–2: Do Not Walk	5 (7.4)	0 (0.0)
3: Household Walker	4 (6.0)	7 (13.0)
4: Community Walker	12 (17.9)	12 (22.2)
5: Varying Speed Walker	19 (28.4)	11 (20.4)
6: Low-Impact Activities	5 (7.4)	10 (18.5)
7: High-Impact Activities	2 (3.0)	10 (18.5)
Total	47 (70.1)	50 (92.6)†
Prosthesis Not Currently Used (%)	20 (29.9)‡	4 (7.4) †
Total (*n*)	298	283
Prosthesis Currently Used (%)	233 (78.2)	256 (90.5)*
Prosthesis Not Currently Used (%)	65 (21.8)	27 (9.5)*

*$p < 0.001$.
†$p < 0.01$.
‡$p < 0.05$.

(**Table 5**). Across all limb-loss levels, 80 percent of Vietnam war and 88 percent of OIF/OEF participants are satisfied with their prostheses, and 85 and 88 percent, respectively, report a good prosthetic device fit. The group least satisfied with their device fit is the Vietnam war cohort with unilateral upper-limb loss (74%) in contrast with highest satisfaction (97%) in the OIF/OEF cohort ($p < 0.01$). Interest in changing their current prostheses to another type is reported by 41 percent of Vietnam war and 45 percent of OIF/OEF participants.

The most common prosthetic device problems for Vietnam war and OIF/OEF participants are prostheses that are not pain-free to wear (45% and 39%, respectively) and skin problems (51% and 58%, respectively). Sweating inside their socket is a problem for 67 percent of Vietnam and 62 percent of OIF/OEF participants. Significantly more of the OIF/OEF cohort than the Vietnam war cohort with unilateral lower-limb loss are bothered with skin problems ($p < 0.05$) (**Table 5**). A minority of participants from both conflicts (11% and 12%, respectively) have difficulty wearing their prostheses due to poor socket fit. A detailed analysis of satisfaction by source of prosthetic devices is presented elsewhere [27].

DISCUSSION

This is the first article that compares prosthetic device use and satisfaction in veterans and servicemembers with major traumatic limb loss from the Vietnam war and OIF/OEF conflicts [28–29]. Excellent, very good, or good health status is reported by 70.7 percent of Vietnam war and 85.5 percent of the OIF/OEF participants ($p < 0.001$). Of interest is that the highest health status is reported by participants from both conflicts with multiple limb loss: 81.9 percent in Vietnam war and 90.2 percent in OIF/OEF participants. This may be related to their close brush with death and that they are happy to be alive, regardless of physical and psychological effects. Overall, 93 percent of Vietnam war and 97 percent of OIF/OEF participants using prostheses report that they can cope with their prostheses, and 94 percent of participants from both conflicts report adjusting to life with a prosthesis. Lower levels of adjustment are reported by unilateral upper-limb loss participants from both conflicts. The experience of the Vietnam war participants suggests a very good long-term prognosis for their OIF/OEF counterparts.

Table 4.
Prosthetic device use, replacement, and rejection in Vietnam war and Operation Iraqi Freedom/Operation Enduring Freedom (OIF/OEF) survey participants by type of major traumatic limb loss.

Prosthetic Device	Vietnam War				OIF/OEF			
	Unilateral Upper Limb	Unilateral Lower Limb	Multiple Limb	Total	Unilateral Upper Limb	Unilateral Lower Limb	Multiple Limb	Total
No. of Participants	47	178	73	298	50	172	61	283
Never Received Prosthesis (%)*	0.0	5.1	4.1	4.0	2.0	1.7	3.3	2.1
Currently Using Wheelchair and No Prosthesis (%)	6.4	8.9	22.9	11.9	0.0	2.4	3.4	2.2
Mean No. of Prosthetic Devices Ever Received by Type								
Myoelectric/Advanced	0.38	0.15	0.57	0.29	2.06	0.86	2.86	1.50
Mechanical (body-powered)	4.72	9.14	12.61	9.26	1.76	4.39	5.90	4.25
Sports/Specialty	0.21	1.31	0.30	0.88	0.84	1.67	2.02	1.60
Total	5.3	10.6	13.5	10.4	4.7	6.9	10.8	7.3
Mean Time Since Limb Loss (yr)	39.10	38.20	39.20	38.60	3.37	3.14	2.54	3.05
Mean Rate of Prosthetic Receipt	0.14	0.28	0.34	0.27	1.59	2.60	4.77	2.88
Rate Ratio of OIF/OEF to Vietnam	—	—	—	—	11.3	9.3	14.0	10.7
Mean No. of Prosthetic Devices Replaced by Type								
Myoelectric/Advanced	0.50	0.26	0.55	0.43	0.28	0.38	0.55	0.41
Mechanical (body-powered)	2.96	6.73	7.99	6.43	0.39	1.35	0.74	1.05
Sports/Specialty or Cosmetic	0.78	3.28	1.83	2.80	0.52	0.35	0.35	0.38
Total	3.06	7.30	8.19	6.82	0.94	1.62	1.37	1.44
Annual Rate of Worn-Out Prosthetic Devices	0.08	0.19	0.21	0.18	0.29	0.56	0.51	0.50
Rate Ratio of OIF/OEF to Vietnam	—	—	—	—	3.6	2.9	2.4	2.8
Mean No. of Prosthetic Devices Rejected by Type								
Myoelectric/Advanced	1.00	0.21	0.35	0.40	1.00	0.65	0.92	0.82
Mechanical (body-powered)	1.18	1.96	3.32	2.18	0.78	1.58	2.65	1.69
Sports/Specialty	0.00	0.36	1.00	0.37	0.36	0.56	0.84	0.58
Total	1.30	1.96	3.46	2.22	1.84	2.10	3.81	2.42
Annual Rate of Rejected Prosthetic Devices	0.03	0.05	0.09	0.06	0.59	0.75	1.79	0.94
Rate Ratio of OIF/OEF to Vietnam	—	—	—	—	19.7	15.0	19.9	15.7

*These persons are excluded from remainder of this table.

A remarkable 20.5 percent of OIF/OEF participants with major limb loss returned to Active Duty given the opportunities afforded by the DOD and the rehabilitation paradigm shift. Other indicators of good adjustment in participants from both conflicts are the high proportion who married, had children, are employed, or are attending school. Despite the high prevalence of physical and psychological limitations, the vast majority of these combat-injured servicemembers and veterans report good health status and adjustment following limb loss. These findings are consistent with other published articles [30–32]. OIF/OEF participants can carefully review the findings in the Vietnam war participants to gauge their adjustment in 36 years.

Psychosocial reactions to traumatic limb loss begin with shock, followed by denial; anxiety; distress; depression; acute grief; acknowledgement, along with feelings of hostility and frustration mixed with a willingness to participate in rehabilitation activities; early acceptance; and finally, reorganization and reframing [33]. People with traumatic limb loss more often use avoidance as a coping strategy than do those with limb loss from disease. This is consistent with the finding by others that people who have not had adequate warning or preparation tend to react with denial [34–35].

Table 5.
Satisfaction with prosthetic devices and sockets for survey participants currently using prostheses by type of limb loss and cohort.

Survey Data	Vietnam War*				OIF/OEF†			
	Unilateral Upper Limb	Unilateral Lower Limb	Multiple Limb	Total	Unilateral Upper Limb	Unilateral Lower Limb	Multiple Limb	Total
No. of Participants	33	150	50	233	38	162	56	256
Mean Prostheses Satisfaction (0–10)	6.5	7.1	6.7	7.0	6.3	7.6	7.9	7.5‡
Prosthesis Satisfaction (%)								
I am satisfied with my prosthesis	74	80	86	80	88	89§	86	88§
My prosthesis fits well	74	86	86	85	97‡	86	89	88
I want to change this current prosthesis to another type	23	41	49	41	44	43	50	45
My prosthesis is pain-free to wear	67	49	65	55	50	63‡	61	61
I am bothered with skin problems	40	54	49	51	44	63§	52	58
I am bothered with smells from my prosthesis	23	33	37	33	29	36	43	37
Socket Satisfaction (%)								
I am happy with the comfort and fit of my socket	69	73	80	74	76	73	89	77
I am bothered with sweating inside my socket	62	68	69	67	70	57	71	62
I cannot wear my prosthesis because my socket fits poorly	17	8	14	11	13	13	11	12
Coping and Adjustment (%)								
I can cope with my prosthesis	87	94	94	93	94	98	95	97
I have adjusted to life with a prosthesis	77	98	94	94	88	96	91	94

*n = 241 (81%).
†n = 256 (90%).
‡$p < 0.01$.
§$p < 0.05$.
OIF/OEF = Operation Iraqi Freedom/Operation Enduring Freedom.

A literature review on psychosocial adjustment to lower-limb loss identified that factors associated with positive limb loss adjustment include increasing time since limb loss, greater social support, higher satisfaction with prostheses, active coping attempts, lower amputation level, lower pain summaries, and an optimistic personality disposition. Factors associated with limited adjustment include high rates of depression leading to greater activity restriction, increased feelings of vulnerability, poorer self-rated health, body-image anxiety, and social discomfort [36–39]. Dougherty et al. found that a higher health status outlook in servicemembers with more extensive limb loss is related to surviving their near brush with death and feelings of having a second chance at life [25].

In general, OIF/OEF participants trend to more frequent amputation-related surgical procedures. The highest numbers of pre- and postamputation surgeries were in the OIF/OEF group with unilateral lower-limb loss (mean of 5.4–5.6 surgical procedures for pre and post major amputation, respectively) and the multiple limb loss group (mean of 5.5 surgeries following the definitive amputation). Increases in preamputation procedures are related to advances in limb salvage, vascular repair, and free-tissue transfers. In previous conflicts, amputations were typically performed earlier and above the zone of injury. Current amputation surgery focuses on preserving limb length and joints in the zone of injury. Therefore, after an initial open, length-preserving amputation, more surgical procedures are required. Increases in postamputation surgery are also related to differing treatment guidelines between conflicts, greater opportunity to manage wounds in operating rooms rather than at the bedside, and the resolution

of heterotopic bone ossification common in the OIF/OEF cohort [40].

Hearing loss is present in 47 percent of servicemembers and veterans with traumatic limb loss from both conflicts. Gondusky and Reiter reported hearing loss to be the most common single injury, affecting 25 percent of Marines in OIF through 2004. Hearing loss is often concurrent with TBI [41]. According to the Veterans Benefits Administration Annual Benefits Reports, auditory dysfunction (hearing loss and tinnitus) were the most prevalent reasons for new service-connected conditions in fiscal year 2008 and, overall, the most prevalent service-connected conditions affecting over 1 million veterans [42]. These communication disorders are reported to affect social, vocational, and psychological function and are commonly associated with depression [43–44]. In our survey, we found no significant association between hearing loss and depression in participants from either conflict.

Limb injury in limbs not undergoing amputation is the next most prevalent injury and is reported by 33 percent of Vietnam war and 45 percent of OIF/OEF participants ($p < 0.001$). One reason for the increase in the OIF/OEF cohort may be exposure of more body-surface areas to harm by the current mechanisms of injury (e.g., blast injuries and explosive devices vs gunshot wounds). Head injuries, also prevalent in our study population, are reported by 13 percent of Vietnam war and 34 percent of OIF/OEF participants ($p < 0.001$). Implications of this finding are discussed later with the mental health issues.

Chronic healthcare issues identified by study participants with traumatic limb loss are persistent pain (back, phantom limb, and residual-limb pain), skin problems, and psychological issues [45–48]. We were unable to conduct a comprehensive pain inventory as part of this survey; thus, we did not collect important dimensions of pain, such as the specific frequency, intensity, and duration for each type of pain. Prevalence of back pain was reported by 36.2 percent of the Vietnam war cohort compared with 42.1 percent of the OIF/OEF cohort. Edhe et al. reported back pain prevalence was 52 percent in a study of people with limb loss from a VA and Level III trauma center, while Ephraim et al. reported a 62 percent prevalence [49–50]. The prevalence of back pain in people with limb loss is considerably higher than the 15 to 25 percent reported in the general population [51].

Phantom pain is reported by 72.2 percent of Vietnam war and 76.0 percent of OIF/OEF participants without limb loss. These findings are consistent with other studies of limb loss that reported prevalence of phantom pain ranging from 59 to 79 percent [45,49–50,52]. Von Korff et al. categorized phantom pain intensity using the Chronic Pain Grade [53]. Phantom pain distribution in their study population was no pain (2%), Grade I or Grade II pain (low disability, low to high intensity, 73%), and Grade III or Grade IV pain (high disability, moderate to severe intensity, 25%) [49]. In Ehde et al., phantom pain was rated as 4.6 ± 3.3 (mean ± standard deviation) on a scale of 0 (not bothersome) to 10 (as bothersome as it could be) [49].

Residual-limb pain is reported by 48.3 percent of the Vietnam war and 62.9 percent of the OIF/OEF participants. Pain summary scores were not significantly higher among participants using prostheses compared with those who used wheeled mobility or no prostheses. In Edhe et al., residual-limb pain intensity on a scale of 0 to 10 was 5.4 ± 2.7, with 38 percent of limb loss participants scoring their residual-limb pain intensity as severe [49]. In other studies of individuals with traumatic limb loss, 68 to 74 percent report residual-limb pain [49–50].

Our findings indicate that current approaches to pain management do not adequately address the issue from the participants' perspective, consistent with reports by others [54–56]. Even though pain prevalence is high, it may still be under-reported. The tendency of veterans and servicemembers not to complain, endure hardships, and follow the orders of their high-ranking healthcare providers may influence the extent to which they report their pain. Innovative pain control research is ongoing at Walter Reed Army Medical Center, Washington, DC, and VA facilities, including mirror-box therapy, virtual reality, acupuncture, and more invasive pain management procedures [28,57–58]. The high prevalence of continued pain in these combat-injured individuals with limb loss needs to be communicated to rehabilitation and primary care providers to better manage pain burden. Clark et al. identify a need to develop alternative strategies to assess pain in servicemembers with cognitive impairment and to develop a standardized method of assessing pain outcomes [57]. The VA Health Services Research and Development Service recently released a systematic review of pain in patients with polytrauma that further addresses these issues [59].

Arthritis is reported by 64.4 percent of Vietnam war and 25.8 percent of OIF/OEF participants. Posttraumatic degenerative arthritis from injuries to joints on nonamputated limbs takes years to develop and is more common

in individuals with traumatic limb loss and contralateral limb involvement. Kulkarni et al. reported the prevalence of osteoarthritis in British male veterans on the amputated limb was 61 percent compared with 23 percent on the nonamputated limb. They found a 3-fold increased risk for osteoarthritis in those with transfemoral limb loss compared with transtibial limb loss [60]. Norvell et al.'s study of veterans with traumatic limb loss (mean age 63), identified that the prevalence of contralateral knee pain was 50 percent in those with transfemoral limb loss, 36 percent in transtibial limb loss, and 20 percent in controls without limb loss. At the transfemoral level, there was a 3.3-fold (95% confidence interval 1.5–6.3) increase in prevalence of knee pain compared with age- and sex-matched veterans without limb loss [61]. Gait abnormalities and physiologic loads may involve mechanisms contributing to osteoarthritis and pain in those with limb loss [61].

Skin problems related to prostheses use are a problem for 51 percent of Vietnam war and 58 percent of OIF/OEF participants. As expected, a significant correlation existed between sweating inside the socket and skin issues. Participants reported that skin problems interfere with good prosthetic device and socket fit and increased the frequency of reported pain. Skin issues are reported in other studies of people with limb loss [34,62–68]. Dillingham et al. reported a 25 percent prevalence of skin and wound problems among community-based participants with trauma-related limb loss [69]. Future research is needed on modifications to prosthetic materials, construction, and wicking moisture in order to reduce skin breakdown and infections.

Mental health issues for participants include TBI, depression, and PTSD. In the Vietnam war cohort with traumatic limb loss, 3.4 percent self-reported TBI compared with 33.9 percent in the OIF/OEF cohort. In our survey population, we stratified by head injury and found that among those with head injury, a statistically significant increase exists in TBI compared with those with no head injury for both conflicts. Recognition, diagnosis, and coding for TBI have improved since 2003, improving the accuracy of TBI prevalence. PTSD prevalence is not significantly higher, given head injury, and depression, which is higher in those with head injury, is not statistically significant. A U.S. Army Brigade Combat Team reported a 10 to 20 percent TBI prevalence rate [70]. The higher prevalence in our OIF/OEF cohort is not surprising given the extensive trauma sustained by these veterans and servicemembers.

Depression is present in 24.5 percent of the Vietnam war and 24.0 percent of the OIF/OEF participants. This is similar to the 20 to 30 percent prevalence in individuals with limb loss reported in other studies [36,46–47,71–72]. PTSD is present in 37.6 percent of Vietnam war and 58.7 percent of OIF/OEF participants ($p < 0.05$). The combination of depression and PTSD is reported to yield higher levels of symptomatic distress and result in higher rates of suicidal behavior than depressed patients without PTSD. Patients with both conditions experience greater role impairment and slower recovery than those with PTSD alone [73]. Both conditions are independently associated with higher healthcare use and costs [74–75]. OIF/OEF participants have a higher burden of mental health issues than that reported by Vietnam war participants. Mental health issues may effect rehabilitation and recovery processes, so continued programs focusing on psychological adjustment post-limb loss are indicated.

The mean mental health summary score, which adds the presence of TBI, depression, and PTSD, is nearly 2-fold higher in OIF/OEF than in Vietnam war participants. Hoge et al. described mental health issues among 424,451 servicemembers returning from deployment between May 1, 2003, and April 30, 2004. The baseline predeployment prevalence of mental health conditions was 8.5 percent [76]. Following deployment, 19.1 percent of servicemembers from OIF met the risk criteria for a mental health concern: 11.3 percent from OEF and 8.5 percent from other locations. Among servicemembers returning from deployment, Hoge et al. reported the prevalence of PTSD at 9.8 percent for OIF, 4.7 percent for OEF, and 2.1 percent for deployment to other locations [76]. Depression and other mental health issues affect rehabilitation and recovery processes, so continued programs focusing on psychological adjustment post-limb loss are recommended [77]. A recent VA systematic review on individuals with TBI and PTSD further addresses these issues [78].

The success of rehabilitation efforts is evidenced by the striking ambulatory and functional ability reported by the OIF/OEF cohort, with 50 percent performing low- or high-impact activities, compared with 20 percent for the Vietnam war cohort (who are on average 30 years older). A high percentage of participants from both conflicts also achieved household to community ambulatory function even though they did not perform low- or high-impact

level activities. Ambulatory function in Vietnam war participants with unilateral lower-limb loss is also very good with 87 percent reporting they still ambulate 40 years after their initial limb loss. Their success with function is helpful in projecting future function in the OIF/OEF participants.

Prosthetic device use patterns shifted over the last 10 years because of a higher level of expected functioning, the availability of a wider variety of prosthetic devices, and higher levels of prosthetic device turnover. Durable prostheses are required to meet performance demands of both discharged veterans and the high percentage of OIF/OEF servicemembers with limb loss who return to Active Duty. The OIF/OEF cohort aggressively advocates for prostheses for different physical activities. Recent advances in prosthetic device development include more sophisticated components, stronger sources of power, and electronic controls [63]. As a result of the higher expectations and the more technologically advanced prostheses, demand for related rehabilitation services will increase.

Currently, 78.2 percent of Vietnam war and 90.5 percent of OIF/OEF participants use prostheses. The OIF/OEF group received prosthetic devices at higher annual rates since limb loss than the Vietnam war group: 11.3-fold higher for unilateral upper-limb loss, 9.3-fold higher for unilateral lower-limb loss, and 14.0-fold higher for multiple limb loss. Even though the OIF/OEF cohort was surveyed only 3 years since their limb loss, their annual replacement rates across unilateral upper-, unilateral lower-, and multiple limb loss are 3.6-fold, 2.9-fold, and 2.4-fold, respectively, higher than in the Vietnam war cohort at the same limb-loss level. It is important to recognize that the first year following limb loss is a time of rapid adjustment; thus, there is greater exposure to more prosthetic devices. This is true for both Vietnam war and OIF/OEF participants.

Previous prosthetic device replacement was based on a 3- to 5-year turnover rate. In the OIF/OEF group, replacement is more frequent because of higher functional demands; dissatisfaction with their current prosthesis; different applications for prostheses; and new prosthetic materials with varying strength, flexibility, and durability. These materials are more compliant and flexible, which likely improves short-term satisfaction and function, but these prostheses may not as durable as the earlier, more rigid prosthetic materials and designs. Therefore, prostheses using newer materials may not last as long as the older laminated prostheses.

Rejection of prosthetic devices (due to dissatisfaction) is higher in the OIF/OEF than the Vietnam war cohort. Specifically, the annual rejection rate for those with unilateral upper-limb loss is 19.7-fold higher, for unilateral lower-limb loss is 15.0-fold higher, and for multiple limb loss is 19.9-fold higher. The availability of new types of prosthetic devices and the higher expectations of OIF/OEF servicemembers and veterans may explain the higher rejection rates. Again, receipt of devices is highest in the first months following limb loss. Many servicemembers and veterans are provided with an opportunity to adjust to life with limb loss using several prosthetic devices. As they gain experience and adapt to living with prostheses, preferences for specific prostheses develop, and the prostheses with inferior performance or requiring more effort are set aside and no longer used. Experience with and provision of multiple prostheses is part of the rehabilitation process. Many types of prosthetic devices are successfully used by a majority with limb loss to conduct their varied activities. The high rejection rates identified indicate that a more judicious approach to initial prosthetic device provision may be warranted.

Van der Linde et al. reviewed 40 studies and did not find clinical agreement with different prostheses and satisfactory functioning [79]. Several studies have found that disuse and reduced daily functioning were due to dissatisfaction with the current prostheses but did not detail the reasons behind abandonment [80–81]. A study of 396 adults with lower-limb loss found 15 percent abandoned their prostheses after 5 years [82]. Ease of use and restoration of ambulation significantly predicted continued use of the prostheses. A study of 44 older individuals with lower-limb loss found gait problems, fatigue, poor device performance, and fear of falling to be associated with lower prosthetic device use [83]. Additional reasons for rejecting prostheses by limb-loss level are found elsewhere [23–25,84].

Reasons for total abandonment of all prostheses included dissatisfaction with a previous prosthesis, preference for using no prosthetic device in those with upper-limb loss, and transitions to wheelchairs for those with lower- or multiple limb loss. Those who abandoned prostheses because of dissatisfaction with the devices may suffer reduced function and worse quality of life as a consequence. Our survey identified key issues associated

with prosthetic device dissatisfaction that may help to correct these problem areas. Opportunities may also exist to improve function by trying other types of prosthetic devices that improved performance in other studies [85–86].

Unilateral upper-limb loss resulted in no prosthetic use for 29.8 percent of Vietnam war and 24.0 percent of OIF/OEF veterans and servicemembers [23]. A greater proportion of the OIF/OEF group with unilateral upper-limb loss use a prosthetic device to perform the majority of daily tasks. This is also noted for those with bilateral upper-limb loss.

Only 4.0 percent of Vietnam war and 2.1 percent of OIF/OEF participants never used a prosthetic device. Some veterans and servicemembers who use wheelchairs indicated they used a prosthesis to transfer, for cosmetic reasons, or for only brief periods, as it was too painful to ambulate with their prosthetic devices.

Satisfaction with their current prostheses is high in both cohorts. Despite this, over 40 percent of all survey participants indicate a willingness to change their current prosthesis to another type. The Gallup survey of 167 OIF/OEF servicemembers with limb loss found 69 percent were satisfied with their prostheses at a mean of 1 year postamputation, but this study did not delineate satisfaction by the type of limb loss or by the type of prosthetic device, or give specific reasons for dissatisfaction [87]. Dillingham et al.'s study of Persian Gulf veterans with limb loss indicated 43 percent were satisfied with the comfort of their prostheses [2]. Other studies report issues with satisfaction (comfortable fit, changing sizes of residual limb, etc.) and identify strategies to address these issues, including newer prosthetic device design [88–89]. Further research is needed to improve satisfaction with prosthetic devices.

Strengths of this survey are inclusion of veterans and servicemembers with major limb loss from two military conflicts. Standardized questions on prostheses, function, satisfaction, and quality of life were asked of both groups. Our study staff used multiple sources for the survey roster, including electronic VA databases, DOD records, and the Internet. Servicemembers and veterans, including those on Active Duty from OIF/OEF, are highly mobile and challenging to contact. Surveys and invitation letters may not have reached all potential survey participants. Despite these challenges, our 61.8 percent response rate compares favorably with other studies (typical response rates 47%–59%) of combat-injured veterans and servicemembers [90–91].

Our survey included pictures of prosthetic types and assistive devices to help participants with recall. We asked participants to remember only prostheses received by major category (such as electrically assisted vs traditional body-powered). We compared data for the entire target population with our enrolled population and found little evidence of selection bias in either conflict cohort. We compared site of limb loss and sex between the original survey roster and survey participants. The only significant difference in responses by level of limb loss or sex was a higher response rate in the Vietnam war group with multiple limb loss.

Potential limitations of this survey include the fact that veterans and servicemembers who responded may be functioning at a higher level than those who did not respond. The results of our survey may have limited generalizability to the overall civilian population with limb loss. Participants in this survey experienced major traumatic limb loss associated with other combat-associated injuries that are more extensive than usually observed in U.S. civilian populations with traumatic limb loss. Recall, particularly for the Vietnam war veterans, may be impaired. Other studies of prosthetic device use in non-combat-associated limb loss populations report similar prosthetic issues and reasons for dissatisfaction as found in our survey [92–93].

CONCLUSIONS

OIF/OEF servicemembers and veterans with traumatic limb loss are a high-profile group with a high public relations focus. Attention to the care these veterans and servicemembers receive is a national priority as they continue to transition to VA care. Some veterans in the VA system from previous conflicts and with medically indicated limb loss may request the same advanced technology prostheses and rehabilitation care provided to the OIF/OEF cohort. It is necessary to plan for the future demand on the VA in terms of prosthetic use, continued rehabilitation, and costs to guide future prosthesis-related services and economic decisions.

The findings from the survey represent the largest across-conflict comparison of prosthetic device use and satisfaction for veterans and servicemembers with major traumatic limb loss. Many advances are evident in restoring function through appropriate rehabilitation care and use of prostheses. Issues still remain in management of phantom, residual-limb, and back pain; skin problems;

and improvement of satisfaction with prosthetic devices. The planned VA paradigm shift for those with limb loss described earlier will target personnel and resources to address these important issues for our veterans and servicemembers [94].

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