Posttraumatic stress disorder and hypertension in Australian veterans of the 1991 Gulf War

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A B S T R A C T

Objective: Military veterans experience a high prevalence of psychopathologies such as posttraumatic stress disorder (PTSD). Relationships between physical and psychological health are increasingly recognised. This study investigated associations between PTSD and hypertension in male Australian Gulf War veterans.

Methods: In 2000–02, 1456 veterans underwent medical and psychological assessments. Medical practitioners rated self-reported medical conditions as probable diagnoses, possible, unlikely or non-medical. The Composite International Diagnostic Interview (CIDI) assessed psychological symptomatology present in the 12 months preceding evaluation, and lifetime prevalence. Odds of hypertension among those with and without PTSD were calculated for each timeframe using logistic regression.

Results: Analysis was restricted to the 1381 veterans for whom CIDI and medical data were available. Hypertension was considered probable in 100 subjects (7.2%). Adjusted odds ratios of hypertension were 2.90 (95% CI 1.19–7.09) amongst veterans with PTSD in the past 12 months and 2.27 (95% CI 1.01–5.10) for lifetime prevalence, compared with those without PTSD. Hypertension was over seven times more likely amongst veterans with PTSD alone than those with no mental illness in the past 12 months.

Conclusions: Veterans with a history of PTSD had increased odds of having hypertension. Given the array of disabling psychosocial associations of PTSD, and the numerous potential clinical sequelae of hypertension, co-existence of these conditions may have implications for prevention and management at the individual, clinical, and public health policy and practice level. Early identification of PTSD in military samples may help to ameliorate longer-term adverse physical health outcomes.

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Introduction

A growing body of literature supports an association between psychological state and physical health. However few studies have considered posttraumatic stress disorder (PTSD) and hypertension, despite the fact that plausible theories suggest potential mechanistic links between the two conditions. For instance, PTSD has numerous neuroendocrine manifestations [1–4], including sympathetic nervous system overactivity. It has been hypothesised that this may be associated with long-term alterations in baroreceptors that regulate blood pressure [1,5], and that PTSD may pose a risk of hypertension by this mechanism. Furthermore, behavioural factors may mediate associations between PTSD and hypertension [5] — elevated alcohol intake is common in military populations [6] and amongst people with PTSD [1] and is also a known risk factor for hypertension in males [7,8].

A systematic review [9] investigating PTSD and specific physical diagnoses identified little published material in this field, and reported that there were inconsistent findings for many conditions, including hypertension. Many papers that have examined associations between PTSD and blood pressure have considered factors such as autonomic reactivity and acute blood pressure lability following re-exposure to a traumatic stimulus [1]. Others have not primarily considered hypertension, but rather focused on non-specific cardiovascular symptoms [10–12], used broad diagnostic categories encompassing several conditions including hypertension [10], or reported on investigations such as electrocardiogram abnormalities consistent with various cardiovascular diagnoses [13,14]. Amongst studies that have examined specifically for relationships between PTSD and hypertension, associations have been reported in both veteran [15–17] and civilian [18–20] populations. Others have reported no such association with hypertensive cardiovascular diseases [21].

Definitions of hypertension varied between studies. Measures of PTSD also differed — some studies have not specified diagnostic timeframes and very few have compared the different effects of comorbid psychopathologies on odds of hypertension [17,18]. To our knowledge, no study has considered associations between hypertension and PTSD present over more than one timeframe.

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Prevalence of [22], and morbidity arising from, PTSD is high amongst veterans of armed conflict. PTSD in veterans is associated with numerous adverse health outcomes including poorer self-rating of general health [10,12], increased physical symptomatology [10–12,23,24] and complaints of sexual dysfunction [25], increased clinical consultations and utilisation of healthcare services [12,15], psychosocial impairment including work absenteeism [12,15], adverse health behaviours [26], and higher adjusted all-cause mortality rates [27]. Such findings indicate that, notwithstanding the human suffering generated, PTSD also poses a significant economic burden in terms of individual and societal costs and direct and indirect healthcare expenditures. Such costs are likely to be magnified in the presence of co-existing physical disorders. For instance, healthcare costs amongst Australian veterans of the Vietnam war with PTSD were 60% higher than average, with a large proportion of these expenses due to medical costs of associated physical conditions [28]. Hypertension is also common amongst both veterans and the wider community. With numerous potential clinical sequelae, it accounted for 7.6% of the total burden of disease in Australia in 2003 [29]. Thus co-existing physical and psychological disorders may have profound individual, clinical, and public health implications.

Gulf War veterans have a higher prevalence of PTSD than non-deployed military comparison groups [30]. To our knowledge, an investigation into the prevalence of PTSD and co-existing hypertension in Gulf War veterans has not yet been reported. Examining these associations in veterans of such recent deployments is warranted, particularly given the younger age of these veterans. This study sought to investigate the relationship between PTSD and hypertension in male Australian Gulf War veterans using two temporal measures of psychopathology, PTSD symptomatology present in the past 12 months and lifetime prevalence. We also investigated whether the relationship between PTSD and hypertension was influenced by the presence of other comorbid psychological disorders and whether it differed from the relationship between other psychological disorders and hypertension.

Methods

Study population

Details of recruitment and of demographic and service characteristics of study participants have been reported previously [31–33]. In brief, 1456 (80.5%) eligible Australian Gulf War veterans participated, of whom 1424 were males, in addition to a military comparison group (n = 1588, 56.8%) who were in active service during the Gulf War period but not deployed there. Participants completed a postal questionnaire and underwent medical assessment. Ethics approval was obtained from the Monash University, Department of Veterans’ Affairs and Department of Defence Human Research Ethics Committees [31,32].

The current analysis includes only Gulf War veterans (veterans) and is restricted to males due to the small number of female veterans (n = 38) of this conflict.

Postal questionnaire

The postal questionnaire assessed multiple domains including sociodemographic and military service details, recent health symptoms, and medical problems or conditions that had ever been diagnosed or treated by a medical doctor. Stressful military events and experiences encountered during a veterans’ military career were assessed using the 44-item Military Service Experience (MSE) questionnaire [31,34]. The MSE score represents the total number of selected potentially stressful military experiences reported by each subject.

The self-administered Alcohol Use Disorders Identification Test (AUDIT), a screening instrument devised by the World Health Organization, was used to assess alcohol intake and behaviours [35]. Scores of 8 or more are generally considered indicative of harmful/hazardous alcohol use and possible alcohol dependence [35], and defined AUDIT caseness in this analysis. Whilst the original instrument explores alcohol-related behaviours in the preceding year, our modified version considered the preceding three month period, since we were not interested in the prevalence of AUDIT caseness as such but, rather, the relationship between current alcohol abuse and current hypertension.

Clinical assessment

Assessment [36] included measurement of height, weight, waist and hip circumferences [37], and blood pressure. During review, medical doctors assessed the likelihood of self-reports of having been diagnosed or treated for selected conditions by a doctor. Using specific criteria, including whether confirmatory investigations had been performed, treatment initiated, specialist referral made, and whether such management was consistent with standard medical practice, these self-reports were classified as either probable, possible, unlikely or non-medical diagnoses [32]. Subjects were assigned to the ‘probable’ category if the condition was diagnosed by a doctor, perhaps with specialist referral, and investigated and treated in a manner consistent with the level of intervention expected from conventional medical practice for the condition. This method was adopted to improve classification of the self-reported diagnoses. We have previously reported that fewer than 10% of all self-reported conditions were subsequently deemed unlikely or non-medical [32]. For the purpose of this analysis, physician assessment of the likelihood of a subject having hypertension was used as the basis for classifying subjects as hypertensive (those for whom a diagnosis of hypertension was considered probable) or not hypertensive (those who did not report hypertension, and those who reported having hypertension but the diagnosis was considered possible, unlikely or non-medical). Blood pressure measurements were not used to assign hypertension status, as the isolated reading collected in this study was not considered sufficiently diagnostic [8].

Body mass index (BMI) was classified as underweight/normal <25 kg/m², overweight 25 kg/m² to <30 kg/m² and obese ≥30 kg/m² [38]. As waist circumference ≥102 cm is generally used to define abdominal obesity amongst males in many Caucasian populations, [39] this cut-off was used to dichotomise waist circumference in the current analysis.

Subjects were evaluated for any history of affective, anxiety, somatic or substance use disorders, using the Composite International Diagnostic Interview (CIDI): the CIDI-Auto 2.1. [40]. This structured interview evaluates the probable presence or absence of psychological disorders, consistent with Diagnostic and Statistical Manual of Mental Disorders, 4th edition (DSM-IV) diagnostic criteria [31]. The CIDI assessed for symptoms consistent with diagnostic criteria present over two timeframes: in the 12 months prior to the interview (referred to herein as ‘current’) and over one’s lifetime. CIDI-defined psychological disorders were categorised dichotomously, as present or absent over the specified time period. This analysis considered three groups of CIDI-defined diagnoses: PTSD, ‘other psychological disorders’ (affective disorders and/or any DSM-IV anxiety disorders other than PTSD) and no mental illness (no PTSD, no affective disorder and no other anxiety disorder). Whilst the CIDI also allows diagnosis of other conditions such as somatic disorders, they were not included in this analysis as our principal hypothesis was that PTSD is associated with hypertension, and that this association differs from that of affective and other anxiety disorders. Moreover, the prevalence of conditions other than depression, PTSD and other anxiety disorders was very low in this population [31]. All psychological diagnoses referred to herein are CIDI-defined.
Statistical analyses

Data were analysed using Stata 10.0 [41]. Separate analyses were conducted for current PTSD prevalence and lifetime prevalence. For socio-demographic, military service, clinical and psychological variables, univariate analyses were used to test for differences between veterans who did and did not have PTSD, and for differences between those with and without hypertension. Chi-square tests were used for categorical variables and t-tests for continuous measures.

Logistic regression models were fitted for each timeframe, to investigate the odds of comorbid hypertension amongst those with and without PTSD. Unadjusted associations were examined; odds ratios (OR) were also computed after adjusting for socio-demographic, military and clinical confounding factors, as well as comorbid psychological disorders, and are reported as adjusted odds ratios (AOR) [42]. Adjustment was undertaken for characteristics of military service as it was hypothesised that such factors may have influenced the nature of the experience and exposures, which in turn may have influenced likelihood of PTSD. Heterogeneity of the effect of PTSD on hypertension across levels of socio-demographic, military, clinical and comorbid psychological measures was assessed via interaction terms added to the logistic regression models. Adjusted odds of hypertension amongst those with PTSD and/or other psychological disorders compared with referent groups (no mental illness, PTSD alone, other psychological disorder alone), were also calculated.

Results

Of 1424 male veterans who participated in the study, 1419 (99.6%) underwent the medical assessment and CIDI data were available for 1381 veterans (97.0%). This analysis is restricted to the 1381 males for whom both CIDI and medical data were available.

Psychological diagnoses

Prevalence of current PTSD was 5.1% (n = 71) as has previously been reported [31] and the lifetime prevalence was 6.6% (n = 91).

Psychological morbidity and comorbidity was common. Overall, 17% of veterans (n = 243) had some form of current psychological disorder (at least one of PTSD, affective disorder or anxiety disorder other than PTSD), and lifetime prevalence of any such condition was 27% (n = 367).

Approximately a third of veterans with current PTSD (31%, n = 22) and lifetime prevalence of PTSD (36%, n = 30) also had both a comorbid affective disorder and anxiety disorder other than PTSD in the same timeframe.

Prevalence of hypertension and its relationship with clinical and socio-demographic variables

Data regarding hypertension status was available for all but four subjects. High blood pressure diagnosed or treated by a doctor was reported by 156 veterans, and a diagnosis of hypertension was considered probable in 100 subjects (7.2%). Of the remaining 56 veterans who reported a history of hypertension, the diagnosis was assessed as possible in 27 (1.9%), unlikely in 19 (1.4%), non-medical in five (0.4%), and was not validated in five subjects.

Those with hypertension were older (mean age 41.3 years vs. 37.7 years respectively, p < 0.0001) and reported higher educational attainment (p = 0.043) than those without the condition. Employment or marital status, military service type (Navy or Army/Air Force), and number of psychological stressors experienced during service were not significantly associated with having hypertension. Military rank at the time of service differed between those with and without hypertension (p = 0.041), with more hypertensive subjects being officers (26%) and fewer in non-supervisory roles (24%) than those without hypertension (17.7% and 34.1% respectively).

Hypertension was strongly associated with both BMI (p < 0.0001) and waist circumference (p < 0.001), but not with smoking status, pack year history of smoking, or alcohol consumption behaviours. There were no significant differences in prevalence of current affective disorders or current anxiety disorders other than PTSD by hypertension status. Both current PTSD (p = 0.014) and lifetime PTSD (p = 0.047) differed significantly by hypertension status. Additionally, significantly more of those with hypertension had a lifetime history of anxiety disorders other than PTSD (n = 19, 19%) than those without hypertension (n = 145, 11.4%).

Socio-demographic, lifestyle, military, clinical and psychological characteristics associated with PTSD

Table 1 shows that a greater proportion of those with current or lifetime PTSD had a comorbid affective disorder or a comorbid anxiety disorder other than PTSD compared with those without PTSD over the corresponding time period. Lifestyle factors also differed significantly by PTSD status for both timeframes, however anthropometric indices did not.

Socio-demographic patterns amongst those with and without PTSD were similar for both temporal measures — compared with those with no PTSD over the corresponding timeframe, a greater

Table 1

| Psychological comorbidity, anthropometric indices and lifestyle factors in male Australian Gulf war veterans with and without 12 month and lifetime PTSD.

<table>
<thead>
<tr>
<th>CIDI-defined PTSD in past 12 months</th>
<th>CIDI-defined PTSD ever</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Present</strong></td>
<td><strong>Absent</strong></td>
</tr>
<tr>
<td><strong>N = 71</strong></td>
<td><strong>n (%)</strong></td>
</tr>
<tr>
<td><strong>Mean age in years at interview (s.d.)</strong></td>
<td></td>
</tr>
<tr>
<td>38.1 (6.7)</td>
<td>38.0 (6.4)</td>
</tr>
</tbody>
</table>
| **Comorbid psychological disorders**
| **Any affective disorder** | | |
| Present | Absent | Present | Absent |
| 43 (60.6) | 101 (7.7) | 68 (74.7) | 219 (17.0) |
| 28 (39.4) | 1209 (92.3) | 23 (25.3) | 1071 (83.0) |
| **Any anxiety disorder other than PTSD**
| Present | Absent | Present | Absent |
| 28 (39.4) | 106 (8.1) | 37 (40.7) | 129 (10.0) |
| 43 (60.6) | 1204 (91.9) | 54 (59.3) | 1161 (90.0) |
| **Anthropometric measures**
| **BMI** | | |
| Underweight/normal | Overweight | Obese | Waist circumference ≥102 cm |
| 20 (28.2) | 279 (21.3) | 23 (25.3) | 276 (21.4) |
| 31 (43.7) | 681 (52.0) | 43 (47.2) | 669 (51.9) |
| 20 (28.2) | 350 (26.7) | 25 (27.5) | 345 (26.7) |
| 24 (33.8) | 423 (32.3) | 29 (31.9) | 418 (32.4) |
| **Behavioural habits**
| **Smoking status** | | |
| Current | Former | Never | Pack-years of smoking |
| 29 (41.4) | 333 (25.5) | 36 (40.0) | 326 (25.3) |
| 19 (27.1) | 404 (30.9) | 25 (27.8) | 398 (30.9) |
| 22 (31.4) | 571 (43.6) | 29 (32.2) | 564 (43.8) |
| <0 | 0–<10 | 10–<20 | ≥20 |
| 22 (31.8) | 574 (44.2) | 29 (34.1) | 567 (44.4) |
| 19 (29.2) | 292 (22.5) | 24 (28.2) | 287 (22.5) |
| 9 (13.8) | 234 (18.0) | 13 (15.3) | 230 (18.0) |
| 15 (23.1) | 198 (15.2) | 19 (22.3) | 194 (15.2) |
| 36 (52.2) | 466 (35.6) | 42 (47.2) | 460 (35.7) |

| a Variation in denominator for each variable as different numbers of subjects completed each question/component of assessment.
| b Comorbid psychological diagnoses in past 12 months, and comorbid psychological diagnoses present ever for PTSD symptoms present ever.
| c Denotes significant differences between those with and without PTSD overall for this variable, at the 0.05 significance level.

proportion of those with PTSD were not engaged in full-time or part-time employment (p < 0.001 for both timeframes); fewer were married or in de facto relationships (p = 0.059 for current PTSD and p = 0.025 for lifetime PTSD) and fewer had attained higher tertiary educational qualifications, although differences in academic achievements were not statistically significant.

Military service characteristics were similar amongst veterans with and without PTSD for both temporal measures. There were no significant differences in type of military role between those with and without PTSD. The MSE score differed by PTSD status for both timeframes (current PTSD chi-square = 90.85, lifetime PTSD chi-square = 97.54, p = 0.001 for both) — the majority of subjects with PTSD reported experiencing over fifteen psychological stressors during the course of their military careers. Conversely, less than 25% of those without PTSD experienced this number of stressors.

### Association between PTSD and hypertension

Table 2 reports the prevalence of hypertension and the unadjusted and adjusted odds ratios of hypertension amongst those with current and lifetime PTSD. The adjusted odds of hypertension in those with current PTSD were almost three times greater than those without current PTSD. Compared with those without a lifetime history of PTSD, having a lifetime history of PTSD was significantly associated with hypertension after controlling for socio-demographic and military variables; addition of co-morbid psychological disorders to the model had little effect.

The assessment of constancy of the effect of PTSD on hypertension across levels of socio-demographic, military or other psychological variables revealed no statistically significant interaction terms, indicating that these variables do not modify the effect of PTSD and hypertension. Notably, there were no significant interactions between PTSD and other psychological diagnoses present in either timeframe, suggesting that the association between PTSD and hypertension did not differ based on the presence or absence of these psychological comorbidities.

### Difference between association of PTSD and hypertension and other psychological disorders and hypertension

Table 3 shows the adjusted odds of hypertension for different comparisons of psychological disorders. For current psychological disorders, those with PTSD alone had over seven times greater odds of hypertension than those with no current psychological disorders. No other comparisons were significantly different for current psychological disorders, nor for lifetime prevalence of psychopathology.

### Discussion

Our study has found that Australian veterans of the 1991 Gulf War who have a history of current PTSD were more likely to have hypertension than those without current PTSD and those with no current mental illness, even after adjusting for several socio-demographic, lifestyle, clinical and military service variables. The presence of current psychological comorbidities did not differentially modify this association between current PTSD and hypertension. Veterans with lifetime PTSD were more likely to have hypertension than those without lifetime PTSD. Notably, for both current and lifetime prevalence of psychopathology, in the absence of PTSD, other psychological disorders were not associated with hypertension.

Overall these findings suggest that the association of PTSD with hypertension is different from that of other psychological disorders, and also differs from that of psychological comorbidity. Moreover, the timeframe of PTSD symptomatology influences the association with hypertension.

The finding that current PTSD is associated with an increased risk of hypertension adds to the growing body of research showing a relationship between PTSD and poor physical health [43,44]. Although the exact mechanisms underlying this relationship are not yet to be elucidated, psychophysiological symptoms are prominent in the clinical picture of PTSD. It is widely accepted that the pathophysiology of PTSD is characterised by dysregulation of several systems thought to be involved in the stress response, including the hypothalamic-pituitary-adrenal (HPA) axis, the locus caeruleus, the moderating influence of the prefrontal cortex on the amygdala, and noradrenergic neural networks [45]. The disorder is characterised by chronic and persistent hyperarousal and physiological hyperreactivity, features that would plausibly contribute to hypertension. The fact that only current PTSD is associated with hypertension in comparison to veterans with no mental illness, and not lifetime PTSD, which is a more heterogeneous group and includes some people with a past history of PTSD ever present or in de facto relationships (p = 0.059 for current PTSD and p = 0.025 for lifetime PTSD), raises the possibility that other psychological conditions may differentially influence the association of PTSD with hypertension.

Table 3

<table>
<thead>
<tr>
<th></th>
<th>12 month diagnoses of hypertension (AOR (95% CI))</th>
<th>Lifetime diagnoses of hypertension (AOR (95% CI))</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTSD + other psychological disorders vs no mental illness</td>
<td>1.93 (0.70–5.30)</td>
<td>2.03 (0.87–4.72)</td>
</tr>
<tr>
<td>PTSD alone vs no mental illness</td>
<td>7.11 (2.03–24.94)</td>
<td>2.58 (0.51–12.91)</td>
</tr>
<tr>
<td>Other psychological disorders alone vs no mental illness</td>
<td>1.34 (0.70–2.27)</td>
<td>1.02 (0.28–3.82)</td>
</tr>
<tr>
<td>PTSD + other psychological disorders vs PTSD alone</td>
<td>0.27 (0.06–1.24)</td>
<td>0.79 (0.14–4.46)</td>
</tr>
<tr>
<td>Other psychological disorders + PTSD vs other psychological disorders alone</td>
<td>1.45 (0.47–4.41)</td>
<td>1.98 (0.79–4.94)</td>
</tr>
</tbody>
</table>

AOR = adjusted odds ratio 95% CI = 95% confidence interval.

### Other psychological disorders

- Affective disorder and/or other anxiety disorders other than PTSD.
- No mental illness = no PTSD, no affective disorder, no other anxiety disorders.

### Notes

- Adjusted for age, occupation, education, marital status, service branch, MSE score, military rank, BMI, waist circumference, pack years of smoking and AUDIT case status.

- Model adjusted for socio-demographic and military service variables as per model a), and comorbid other psychological disorders as per model b).

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of the disorder but no active pathology, is perhaps best explained by trajectories of recovery. Those who no longer meet criteria for the diagnosis presumably also do not continue to suffer from the same physiological dysregulation that characterises PTSD.

The differential associations between PTSD plus comorbid other psychological disorders and hypertension when compared with those with no PTSD for the two timeframes (Table 2) is difficult to explain. These results may suggest that the effects of multiple psychological disorders on the odds of hypertension may vary based on duration and chronicity of symptomatology or presence or absence of current active mental illness, or that comorbid psychological disorders antagonise the effect of PTSD on hypertension. Symptoms severity (and thus the magnitude of the physiological response) may also have differed between those with PTSD alone and those with PTSD plus other disorders amongst these veterans for the two timeframes – this is unmeasured in our study as symptom severity is not captured in the CIDI.

Our findings of higher prevalence of hypertension amongst those with PTSD compared with those without PTSD are broadly consistent with findings in Croatian civilians following the conflict [46] as well as American [19] and Canadian [20] civilians.

Also consistent with existing studies of American World War II veterans [16] and Australian Vietnam era veterans [15] were our findings of increased adjusted odds of hypertension amongst those with lifetime PTSD compared with those without lifetime PTSD. However, our findings regarding lifetime prevalence of psychopathology differ slightly from a large population-based US survey that examined associations of CIDI-defined lifetime PTSD and lifetime depression with self-reported hypertension in the past 12 months [18]. That study reported significant adjusted associations between hypertension and PTSD alone and PTSD plus depression, but not depression alone, compared with those with no mental illness [18]. Discrepant findings may be due to use of different study populations, which included women in the civilian study, and adjustment for a different number and range of potential confounders in the two studies.

Our findings differ from those of a study of US veterans of the Iraq and Afghanistan conflicts [17], which reported significantly greater adjusted odds of hypertension amongst male veterans with psychological diagnoses excluding PTSD than veterans with no mental illness. Direct comparison of our results with their finding of significantly elevated odds of hypertension amongst males with PTSD (with or without other psychological diagnoses), compared with those with no mental illness, is not possible, as the psychological timeframe used in the US study was unclear and the sample was based on help-seeking veterans. Moreover, the nature of the conditions included in the ‘other mental health diagnoses’ differed from our study.

Consistent with earlier research, we also found that smoking status and alcohol consumption were associated with PTSD. The findings are consistent reports that smokers with PTSD tend to smoke greater quantities than smokers without PTSD [5]. However, we found no significant difference in the pack year history of smoking between those with and without PTSD, perhaps because non-smokers were included in this analysis. Interestingly, neither smoking nor alcohol behaviours were significantly associated with hypertension. This may be due to the relative infrequency of hypertension in our sample.

Our study has several strengths. Psychological disorders were assessed by trained clinical psychologists using a validated instrument. Previous studies have only assessed asingle temporal association or effects of temporality of various disorders on hypertension risk. Moreover, we have adjusted for a range of socio-demographic and military service variables and considered the independent effects of other psychological disorders. Medical practitioner assessment of the likelihood of the diagnosis of self-reported doctor diagnosed or treated hypertension and the definition of cases was limited to probable hypertension. Measurement of height, weight and waist circumference were standardised.

There are some limitations to this study that should be acknowledged. Whilst overall our findings suggest an association between PTSD and hypertension, it is not possible to infer causation or directionality. We did not consider individual affective or other anxiety disorders, or other conditions also assessed by the CIDI, such as somatic disorders, as the small numbers would have precluded meaningful analysis. Our analysis was limited to self-reported hypertension that was assessed by medical doctors to ascertain likelihood of diagnosis, but not confirmed by repeated measurements of blood pressure or a validity study. We did not consider other physical diagnoses as our primary hypothesis was that hypertension and PTSD may be linked secondary to shared pathophysiological and behavioural aetiologies. We did not consider severity, nature or duration of PTSD symptoms, which may perhaps confer differential risk. As veterans were assessed approximately 10 years after returning from the Gulf War, responses regarding military service exposures and psychological symptoms experienced may have been subject to recall bias.

Overall, the results of our study indicate that Australian Gulf War veterans with current PTSD are at increased risk of having hypertension, and moreover, the effect of current PTSD appears different from and independent of that of other psychological disorders. Whilst of obvious relevance to military populations, in whom prevalence of PTSD is high largely secondary to combat-related exposures, this issue is also pertinent to the general community. Population-level studies have reported prevalence of current PTSD (present in the preceding 12 months) of 1.33% [47] in the Australian population. Preliminary analyses of a more recent Australian survey [48] suggest somewhat higher rates, more consistent with those reported in US [22] and Canadian [49] populations. If the current findings are extrapolated to the general population, therefore, it is clear that the relationship between hypertension and PTSD has significant implications for the broader health sector.

Indeed, our findings are of considerable clinical and public health significance, particularly as these outcomes were demonstrated in a relatively young veteran population. Defence forces around the world are increasingly paying attention to the early identification of mental health problems following deployment, with particular reference to PTSD. Similarly, primary care providers are increasingly being expected to identify PTSD and other mental health conditions in civilian health settings. The current findings highlight an increased importance for these initiatives. It is no longer solely a question of identifying mental health disability; it is also about the potential for early identification and amelioration of what may become significant physical health problems later in life. There is great potential for effective identification and intervention in a younger population to deliver substantial longer-term savings in both economic terms and human suffering. These findings also add an additional dimension to the politics of conflict, by demonstrating that there may be considerable physical and psychological consequences, with likely attendant social manifestations, evident some time after deployment. Further research is required to elucidate the causal pathways and directionality of such associations, and to examine for similar relationships amongst veterans of other conflicts and non-military personnel.

**Conflicts of interest**

There are no conflicts of interest.

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