**The effect of smoke-free policies in military settings on tobacco smoke exposure and smoking behaviour: a systematic review**

**ABSTRACT**

**Background:** Smoke-free legislation has been instrumental in reducing second-hand smoke (SHS) exposure in public places. However, the evidence of the impact of institutional smoke-free policies in settings such as healthcare and defence is weaker. Specifically, the literature on the effect of smoke-free policies in militarysettings has not yet been synthesised.

**Methods:** This review aimed to identify, critically appraise and synthesise the available evidence to evaluate the effect of defence smoke-free policies on SHS exposure. Eight electronic-databases (e.g. EMBASE, MEDLINE) were searched from inception to June 2020. We included English-language studies on smoke-free policies introduced in a defence setting, assessing their impact on SHS exposure (primary outcome) and healthcare utilisation, smoking behaviours and defence efficiency (secondary outcomes). Risk of bias was assessed using ROBINS-I. Synthesis without meta-analysis was conducted using vote counting of direction of effect.

**Results:** The search retrieved 4,503 citations of which eight met inclusion criteria; two controlled and six uncontrolled before-and-after studies. The evidence, albeit low-quality, from one study indicated reduced SHS exposure following the introduction of a defence smoke-free policy. For secondary outcomes the review found mixed results, with the quit rate being the one outcome favouring smoke-free policies. The cumulative confidence of evidence is uncertain and therefore reliable conclusions cannot be drawn from these studies.

**Conclusions:** A research gap exists for high-quality studies on the impact of defence smoke-free policies which should use comparators and, if possible, randomisation. Policymakers should introduce institutional smoke-free policies in defence settings within an evaluative framework to generate such evidence.

**KEY MESSAGES**

* There is good evidence that smoke-free legislation reduces second-hand smoke exposure and improves health outcomes.
* There is little context-specific evidence of the impact of smoke-free policies in institutional settings, including the military.
* This review found very low quality evidence, from eight before-and-after studies, which cannot determine the impact of defence smoke-free policies with any degree of certainty.
* A research gap exists for high-quality studies to investigate the impact of defence smoke-free policies which should use comparator groups and, if possible, randomisation.
* The evidence based on wider societal smoke-free measures offers a sound rationale to introduce smoke-free policies in defence.
* Any future defence smoke-free policies should be introduced within an evaluative framework so that the relevant evidence of their effect can be generated.

**INTRODUCTION**

Tobacco use is the leading cause of preventable premature mortality, responsible for approximately eight million deaths worldwide(1), and 16% of all deaths in England(2). Annually 1.2m deaths worldwide can be attributed to exposure to second-hand smoke (SHS)(1), whilst in England, 10,700 adult deaths were attributable to SHS in 2005(3). The World Health Organization (WHO) has stated that “*there is no safe level of exposure to second-hand tobacco smoke*”(4). Governments worldwide have responded to the health threats presented by tobacco with the introduction of a variety of tobacco control measures, including smoke-free legislation, with an international treaty laid down in the WHO Framework Convention for Tobacco Control(5). Good evidence now exists on the impact of smoke-free legislation in reducing SHS exposure and improving health outcomes(6–8).

The Department of Health published its Tobacco Control Plan for England 2017-22 with the aim of reducing the prevalence of smoking in adults from 15.5% (in 2017) to 12% by 2022(9). A key pillar of the plan is complementing the smoke-free legislation introduced in the Health Act 2006 with additional smoke-free policies(9). Public Health England defines smoke-free as “*the absence of smoking*”. Smoking is defined as *“smoking tobacco or anything which contains tobacco, or smoking any other substance, and includes being in possession of lit tobacco or of anything lit which contains tobacco, or being in possession of any other lit substance in a form in which it could be smoked*”(10).The NHS aims to take the lead by introducing a completely smoke-free estate(9).

The Ministry of Defence has contributed to the UK government’s approach with the publication of the Smoking and Tobacco Control Strategy for Defence in 2017(11). Its aim is *“to reduce smoking prevalence across the Whole Force to national prevalence levels by 2022 alongside a phased introduction of smoke-free working environments”*(11). The strategy has four broad policy objectives: preventing non-smokers from initiating smoking, promoting a coherent message around the benefits of not smoking, protecting defence personnel from SHS, and supporting existing smokers in quitting(11).

In 2020, 18% of regular service personnel smoked, with smoking prevalence particularly high in the British Army (23%), compared with Royal Navy (15%) and RAF (10%)(12). A particular organisational concern is that personnel who join the military as non-smokers start smoking whilst undertaking military training, and continue to smoke whilst in-service and upon leaving(13-15). This represents a significant disease burden both to the individual and the service, impairing cardiovascular and respiratory health and physical fitness (16-19), whilst recent studies have suggested an association between smoking and risk of musculoskeletal injuries (MSKI)(20,21). This impacts both deployability and employability, with MSKI being the leading reason for medical discharge(22).

The introduction of smoke-free environments across defence, above and beyond legislative measures is, therefore, an attractive policy option to contribute to reducing SHS exposure and smoking prevalence in the military. Other nations’ defence forces have adopted a similar strategy; in 2017 the New Zealand Defence Force (NZDF) announced that NZDF estate would be smoke-free by 2020(23), whilst the US Department of Defense banned smoking in recruit training in 1987(24).

In theory, the introduction of smoke-free policies for defence settings could lead to reduced SHS, reduced uptake of smoking, reduced consumption of smoke-tobacco products, increased rate of quitting and decreased prevalence of smoking. This would lead to a fall in tobacco-related disease burden and increased deployability of military personnel. This process is explained in the logic model in figure 1, adapted from the California Tobacco Control Program’s logic model(25).



**Figure 1: Logic model for smoke-free policies in defence settings**

**(adapted from California Tobacco Control Program’s logic model)**

However, previous attempts to introduce smoke-free policies have been unsuccessful(26) and at present only a few pilot sites, including the Army Foundation College, have introduced smoke-free policies(13). It is also unclear whether these policies will have a real impact on protecting non-smokers from the harmful effects of tobacco smoke by decreasing SHS or reducing the prevalence of smoking.

The evidence base for wider institutional smoke-free policies is limited. A 2016 Cochrane review (that did not include defence settings) found that institutional smoking bans did reduce the harm from SHS in hospital and prison settings but reduced active smoking only in hospital and university settings(27). However, the studies that contributed to this review were “*methodologically weak”* with the cumulative quality of evidence judged as low by the authors using the Grading of Recommendations Assessment (GRADE) approach, and emphasised the need for more robust studies to assess the impact of smoking bans in institutional settings(27). The National Institute for Health and Care Excellence (NICE) has also identified an evidence gap for smoke-free policies in UK healthcare settings, stating “*there was little evidence about the effect of policies on smoking cessation or staff absenteeism”*(28)*.*

Policymakers would, therefore, benefit from a systematic review of the current evidence on the likely impact of the introduction of smoke-free policies in defence settings. This review aims to locate, quality appraise and synthesise this evidence which could be used to direct new research and assist policy decisions with the following research questions:

What is the effect of smoke-free policies in defence institutions, above and beyond national smoke-free laws, on:

* the exposure of non-smokers to SHS?
* non-smokers’ utilisation of healthcare?
* non-smokers’ uptake of smoking?
* the smoking behaviours of smokers?
* smokers’ utilisation of healthcare?
* the efficiency of defence?

**METHODS**

We conducted a systematic review in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) Statement(29). The review’s primary outcome was non-smoker exposure to SHS, whilst the review’s secondary outcomes are contained in table 1. An *a priori* study protocol is available from PROSPERO(30).

**Eligibility Criteria**

The review’s eligibility criteria were developed using the PICOCSS (population, intervention, comparator, outcomes, study design, setting) framework(31) set out in table 1. Non-English language studies were excluded, and no restriction was placed on publication status and date.

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| **Table 1: PICOCSS Framework** | |
| **PICOCSS Component** | **Inclusion/Exclusion Criteria** |
| Population | Adult male and female serving military personnel and civilians working in defence settings, both smokers and non-smokers, aged ≥16. |
| Intervention | Introduction of a smoke-free policy in defence setting above and beyond smoke-free legislation, from partial site smoking bans, extending to whole site smoking bans, or even a complete smoking ban in a military cohort e.g. recruits. Studies that used smoke-free policies as a comparator against smoke-free policies plus smoking cessation measures were excluded, as this review is focused specifically on the effect of a population health policy and not individual-level interventions. |
| Comparator | No additional smoke-free policies above national legislation. |
| Outcomes | Primary outcome: Non-smoker exposure to SHS. This was chosen as the primary outcome as it covers the widest population in defence, not just smokers. Secondary outcomes: Non-smoker GP visits/hospitalisation for tobacco-related illnesses/injuries, smoker GP visits/hospitalisation for tobacco-related illnesses/injuries, uptake of smoking in non-smokers, total tobacco product consumption, prevalence of tobacco smoking and quit rate (measured either biochemically or self-reported), days of work lost to smoking, medical deployability, acceptability of smoke-free policies (for wider context) |
| Context | Presence of smoke-free legislation. |
| Study Design | Randomised control trials (RCTs), non-randomised trials, controlled before-and-after studies and interrupted time-series studies. |
| Setting | Any defence setting. |

**Search**

ASSIA, CINAHL, CENTRAL, DoPHER, EMBASE, MEDLINE, Open Grey and PsychINFO databases were searched from inception to June 2020. The search strategy was broadened through citation chaining, searching of authors’ files and hand searching of the key journals Tobacco Control, Nicotine and Tobacco Research, BMJ Military Health, Military Medicine and Military Medical Research. The Defence Public Health Unit and Public Health England were approached for further unpublished and grey literature.Synonyms for smoke-free (e.g. *smokefree, tobacco free, smoking ban*) and terms relating to defence (e.g. *military, army, navy*) were combined using the Boolean operator AND. The full search strategy is included in the online supplementary appendix.

**Study Selection**

A screening and selection tool was developed and piloted by two reviewers (TFH, AM) on the first thirty studies. Following this, single screening by one reviewer (TFH) was carried out for title and abstract screening. Two reviewers (TFH, AM) independently conducted full text-assessment with minor disagreements resolved by discussion, not by an independent assessor.

**Data Extraction**

The data collection tool was piloted on the first five studies with the tool being iteratively updated. One reviewer (TFH) then carried out data extraction with a second reviewer (AM) checking the compliance with the data extraction tool.Data items included year, author, journal, country, study design, study objectives, population (including key demographics, numbers, inclusion/exclusion criteria), setting, context, definitions of SHS exposure and smoking status, intervention, comparator, outcomes, analyses, adverse effects, length of and numbers lost to follow up, funding and conflict of interest. Following the pilot, result per outcome and participant flow through the study were added.

**Risk of Bias Assessment**

Risk of bias assessment was conducted by one reviewer (TFH) with the ROBINS-I tool using an intention-to-treat effect, with the second reviewer (AM) checking compliance with ROBINS-I (32). The full risk of bias assessment, including relevant confounders, is included in the online supplementary appendix.

**Synthesis**

Synthesis without meta-analysis (SWiM) was conducted due to the anticipation of considerable clinical, methodological and statistical heterogeneity using the SWIM guideline’s nine reporting items(33). The synthesis grouping was the broad intervention type: 24/7 prohibition of all tobacco products, whole-site smoking bans and partial site smoking bans. The summary measure was the direction of effect, which was synthesised using vote counting; for each outcome, the number of studies favouring the intervention was compared with the number not favouring the intervention. Certainty of evidence was assessed using the GRADE approach(34). The full synthesis methodology is included in the online supplementary appendix.

**Meta-Biases**

Publication bias was explored narratively. Outcome reporting bias was assessed by comparing studies’ reported outcomes with protocol outcomes (where available). If unavailable, the outcomes detailed in the studies’ methods section were compared with reported outcomes.

**Amendments to the Protocol**

There were five amendments made to the protocol whilst the review was carried out. These are: simplifying to the primary outcome to non-smoker exposure to SHS, inclusion of defence civilians, the identification of relevant confounders and co-interventions, grouping of studies for synthesis and investigation of meta-biases. Details and rationale for these changes are contained in the online supplementary appendix.

**RESULTS**

**Study selection**

The electronic database search produced 4490 records. Thirteen additional records were found through hand searching the authors’ files, key journals and citation chaining. Individual database results are included in the online supplementary appendix. After de-duplication 2787 titles and abstracts were screened. Twenty full-text articles were assessed, and eight studies were included. A PRISMA diagram of the study selection process is shown in figure 2.

**Diagram

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**Figure 2: PRISMA flow diagram detailing study selection**

**Study characteristics**

The characteristics of the included studies have been simplified and summarised in table 2.

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| **Table 2: Study Characteristics** | | | | | | | |
| **Study and**  **Study Design** | **Study Objective** | **Population**  (Size, service, demographics) | **Intervention** | **Comparator** | **Outcomes** | **Context**  Wider smoke-free legislation? | **Setting** |
| **Chiu et al. (2017)**(35)  CBA | Evaluate the effectiveness of a smoking restriction policy on Taiwanese military conscripts who smoked | n=1707  Taiwan Army Conscript Recruits  (smokers only)  100% male | Partial site smoking ban “*active smoking restrictions*” | Regular smoking restrictions | -Quit rate  -Daily cigarette consumption | Yes | Taiwan Army Training Regiment, Taiwan |
| **Cronan et al. (1989)**(36)  UBA | Determine the effects of three programs on smoking prevention and cessation during recruit training | n=238  US Navy Recruits  100% male | 24/7 prohibition of all tobacco products\* | No prohibition of tobacco products | -Smoking  -Prevalence  -Change in smoking status  -Daily cigarette consumption | No | US Navy Recruit Training Command, Navy Training Center, San, Diego, California, USA |
| **Derkenne et al. (2016)**(37)  UBA | Investigate resumption rates of tobacco abuse during and after a 7-week mission without using tobacco | n=52 (smokers only)  French Navy Submariners  100% male | 24/7 prohibition of all tobacco products | No comparator | -Quit rate | Yes | French Navy submarine patrol |
| **Hurtado and Conway (1996)**(38)  UBA | Describe changes in smoking status at the end of recruit training and at the end of the first year of enlistment | n=1511  US Navy Recruits (smokers)  100% male | 24/7 prohibition of all tobacco products | No comparator | -Quit rate | No | 3 US Navy Recruit Training Command sites, USA |
| **Patten et al. (1999)**(39)  UBA | Examine changes in smoking behaviour following treatment in the smoke-free Navy Alcohol Rehabilitation | n=404  Military patients  93.8% male  6.2% female | Whole-site smoking ban | No comparator | -Smoking initiation  -Prevalence  -Quit rate | No | US Navy Alcohol Rehabilitation Center (NARC), USA |
| **Santo et al. (2017)**(40)  UBA | Effect of smoke-free policy on: SHS exposure, tobacco use habits, cessation, health outcome, employee satisfaction with existing tobacco workplace policies, unintended policy effects | n=1210^  n=1147^  US active-duty personnel, service civilians, contactors  64.7%/67.6% male^  35.3%/32.4% female^ | Whole-site smoking ban | No comparator | -SHS exposure  -Tobacco product consumption  -Prevalence  -Quit rate  -Days of work lost | No | US Army Medical Campus, USA |
| **Williams et al. (1996)**(41)  UBA | Establish baseline prevalence of smoked and smokeless tobacco use prior basic training and 90 days following completion | n=3531  US Air Force recruits  61% male  39% female | 24/7 prohibition of all tobacco products | No comparator | -Smoking initiation  -Prevalence  -Quit rate | No | Lackland Air Force Base, San Antonio, Texas, USA |
| **Woodruff et al. (2000)**(42)  UBA | Examine the effect of a unique organisational smoking ban on female United States Navy recruits | n=5503  US Navy recruits  100% female | 24/7 prohibition of all tobacco products | No comparator | -Prevalence  -Quit rate | No | US Navy Recruit Training Command, Great Lakes, Illinois, USA |
| **Key:** CBA: Controlled before-and-after study, UBA: Uncontrolled before-after-study  \* 2 other intervention programmes (health education and health risk appraisal) not assessed in this review  ^ 2 independent samples 12 months apart, the male: female percentages are given for both samples: baseline/12-month follow-up | | | | | | | |

**Risk of bias within studies**

Seven studies were found to be at critical risk of bias, whilst one was found to have serious risk of bias(35). This is shown in figure 3, which was created using the *robvis* tool(43). The most influential domain affecting the overall risk of bias assessment was confounding; many of the studies did not consider confounding at all. Additionally, five studies were judged as having a critical risk of bias due to missing data.

The generalisability of the review’s findings is questionable given that only two of the primary studies were conducted in the presence of smoke-free legislation, with the remainder taking place in an earlier era of more light-touch tobacco regulations. Additionally, the primary studies were all set in relatively niche defence settings; basic training, a submarine, a military medical campus and a navy alcohol addiction centre, which may not apply to a *“whole force”* approach.

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**Figure 3: Summary of the risk of bias within included studies using ROBINS-I**

**Results of individual studies**

The results of individual studies by outcome have been simplified and summarised in an effect direction plot (table 3). The results displayed used the longest follow-up period from each study to capture the longest-term effect possible. Detailed results from individual studies are contained in the online supplementary appendix.

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| **Table 3: Effect Direction Plot**  Where multiple sub-groups contribute to an outcome then >70% of these are needed to consistently demonstrate a direction of effect.  Direction of effect in CBA based on difference between intervention and comparator, in UBA based on any change since baseline(44) | | | | | | | | |  |  |
| **Study risk of bias:** | Serious | Critical | | | | | | |  | **Key:**  CBA: controlled before & after study  UBA: uncontrolled before & after study  ▲Favours policy  ◄►No clear effect/conflicting findings  ▼Does not favour policy  NS:  never smokers  (sub-group)  FS:  former smokers  (sub-group)  \* tobacco-related illnesses/injuries  ^ Outcome length of follow-up |
| **Intervention type:** | Partial site ban | Whole-site ban | | 24/7 prohibition of all tobacco products | | | | |  |
| **Length of follow-up:** | 8 weeks | Outcome dependent | 1 year | 8 weeks | 6 months | 1 year | 19 weeks  (135 days) | Outcome dependent |  |
| **Study design:** | CBA | UBA | UBA | CBA | UBA | UBA | UBA | UBA |  |
| **Study:** | Chiu et al. (2017) | Patten et al. (1999) | Santo et al. (2017) | Cronan, Hervig and Conway (1989) | Derkenne et al. (2016) | Hurtado and Conway (1996) | Williams et al. (1996) | Woodruff, Conway and Edwards (2000) |  |
| **Outcome** |
| Non-smoker exposure to SHS (primary outcome) |  |  | ▲ |  |  |  |  |  |  |
| Non-smoker GP visits/hospitalisation\* |  |  |  |  |  |  |  |  |  |
| Uptake of smoking in non-smokers (initiation rate) |  | ▼  4 weeks^ |  | ◄►  ▲(NS)  ◄►(FS) |  |  | ▼ |  |  |
| Smoker GP visits/hospitalisation\* |  |  |  |  |  |  |  |  |  |
| Total tobacco product consumption | ▲ |  | ◄► | ▼ |  |  |  |  |  |
| Prevalence of tobacco smoking |  | ▼  1 year^ | ◄► |  |  |  | ▲ | ▲  8 weeks^ |  |
| Quit rate | ◄► | ▲  4 weeks^ | ▲ | ◄► | ▲ | ▲ | ▲ | ▲  20 weeks^ |  |
| Days of work lost to smoking |  |  | ◄► |  |  |  |  |  |  |
| Medical deployability of the population |  |  |  |  |  |  |  |  |  |

**Synthesis**

Studies have been grouped for SWiM into three broad intervention types: 24/7 prohibition of all tobacco products, whole-site smoking bans and partial site smoking bans.

There are two outcomes for which there is evidence that the 24/7 prohibition of tobacco products favoured the policy: smoking prevalence and quit rate. Two of two studies measuring prevalence found a reduction in smoking (100% (95%CI 34% - 100%)), whilst four of the five studies measuring the quit rate found current smokers quit after being exposed to the ban (80% (95%CI 38% – 96%)). There is evidence, from one of two studies that the ban did not favour the policy in preventing initiation of smoking (50% (95% CI 9.45% – 90.55%)), whilst the other study found no clear effect (36).

There are two outcomes for which there is evidence that whole-site smoking bans favoured the policy; non-smoker exposure to SHS and the quit rate. The only study that measured non-smoker exposure to SHS(40) found a reduction in seven-day exposure to SHS after one year of the policy (100% (95% CI 21% – 100%)). There is evidence from two of two studies that some smokers quit following the introduction of the whole-site ban 100% (95% CI 34% - 100%)). There is evidence from one of one study, that some non-smokers initiated smoking after the policy introduction (100% (95% CI 21% – 100%)) (not favouring the policy), although this could be an artefact of the uncontrolled before-and-after study design. There was no clear effect of the policy on total tobacco product consumption, the prevalence of smoking or days of work lost to smoking.

There was evidence that a partial site smoking ban had an effect on reducing total tobacco product consumption in one of one study (100% (95% CI 21% – 100%)). In contrast to the two intervention groups above, there was no clear effect on the quit rate. A daily cigarette reduction was seen in both the intervention and comparator group, but there was a difference in mean reductions between the two groups, favouring the intervention.

The confidence in cumulative evidence for defence smoke-free policies is very low, with the summary of effects being judged as very low-quality using the GRADE approach(34). The level of evidence was downgraded for both risk of bias in all studies and indirectness of the population (inpatients at alcohol rehabilitation centre) in one study(39). Causality cannot be attributed to the introduction of smoke-free policies; however, these studies do indicate a direction of effect, which requires confirmation with better-designed studies.

Publication bias may exist on the basis that all of the primary studies found outcomes that favoured the intervention, although in only three studies did all the outcomes favoured the policy. Outcome reporting bias may have been introduced, due to none of the included studies having published protocols with which to compare reported outcomes**.**

**DISCUSSION**

The main finding from this review is that the evidence from eight studies for smoke-free policies in defence settings is very low-quality. Reliable conclusions cannot be drawn from this review on the impact of defence smoke-free policies. For the primary outcome, there is very low-quality evidence from one study that the self-reported exposure to SHS reduced following the introduction of a whole-site smoking ban. For the secondary outcomes, the review found mixed results for the uptake of smoking amongst non-smokers. The review found no overall clear effect on the outcomes relating to smokers’ tobacco-use behaviours. The quit rate was the one outcome in which the majority of studies (six of eight) showed a direction of effect favouring smoke-free policies, but this could be an artefact of the study design, rather than showing a true effect. None of the studies evaluated the impact of defence smoke-free policies on medical deployability, which makes it difficult for policymakers to judge the impact of defence smoke-free policies on operational readiness.

This review has demonstrated a research gap on the impact of contemporary defence smoke-free policies on exposure to SHS and smoking behaviours of defence personnel.**.** Research in a wider variety of defence settings that includes the whole force population (including civilians), outside the relatively niche settings included in the studies of this review (basic training, submarines, medical settings), would be beneficial and increase the external validity of studies.

Such evaluation studies would benefit from including comparator groups, ideally with randomisation to account for confounding, secular changes and regression to the mean. A stepped wedge clustered randomised control trial could be incorporated into a phased roll-out of a smoke-free policy, with locations implementing the policy later in the roll-out being initially assigned to the control-arm(45). However, withholding smoke free initiatives for research purposes would be unethical due to a lack of genuine equipoise, given the overwhelming strong evidence on the harms of tobacco smoke(46). Methods used in natural experiments could be used instead (47). Given the difficulty in inferring causality without a control group; natural experiments researchers should adjust for confounding using methods like synthetic control groups or multiple regression analysis (47-48).

Longer-term effects could be investigated through the robust collection and then subsequent use of routine data in well-designed interrupted time series analysis studies (49). Future studies should aim to conduct more robust outcome measurements that would include biochemical and air quality measurements, a follow-up time of six or twelve months, an intention-to-treat analysis and blind follow-up data. Studies in defence settings should additionally use outcomes relevant to the operational effectiveness of defence. As discussed earlier, this should include medical deployability, but a multi-disciplinary approach involving both researchers and defence officials could help determine the most relevant outcomes of interest for defence.

The benefits of smoke-free policies on health, which are highly likely to be beneficial in defence settings, have been described extensively in the literature (6-8). This review does not provide any additional new context-specific evidence to inform policymakers on the particular impact of smoke-free policies in defence settings. The urgently needed introduction of smoke-free policies in defence settings also presents an opportunity to develop robust context specific evidence, using the best possible design appropriate for evaluating population-level interventions.

**Limitations**

The review has a number of methodological limitations. However, even with the use of perfect gold standard methods, such as the outlined in the ROBIS tool,(50) it is unlikely that the findings (given the limited number and quality of studies) would have changed drastically.

The review is limited by an English-language bias and a US-centric perspective due to six of studies being American. Additionally, the review did not conform to ROBIS gold standards with title and abstract screening, data extraction and risk of bias assessment not being done by two independent reviewers,(50) due to time and resource constraints.

The ROBINS-I tool is not specific to before-and-after studies; its authors have described it as “*adequate not great*” for before-and-after studies(51). Additionally, relevant confounders and co-intervention were not laid out in the protocol, which can be seen as reducing the transparency of the review(32). The ROBINS-I authors advised against including studies classed as having a “*critical risk of bias*” in a meta-analysis(32). However, a meta-analysis was not conducted and as there is often the need to synthesis “*best available evidence*”, as opposed to the theoretically best level of evidence in public health review,(31) these studies have been included in the synthesis.

This review is limited to studies evaluating the impact of defence smoke-free policies as outlined in the research questions; it did not include studies exploring facilitators and barriers to their implementation.

**CONCLUSIONS**

This systematic review aimed to evaluate the impact of militarysmoke-free policies on the health of defence populations. It has found very low-quality evidence, from eight before-and-after studies with weak methodologies, which cannot determine the policies’ impacts with any degree of certainty. This is consistent with the previous literature on the impact of institutional smoking bans(27). A research gap, therefore, exists for high-quality studies to investigate the impact of these policies. Whilst the specific evidence to support smoke-free policies in defence settings is limited, the wider evidence of societal smoke-free measures would still support the introduction of such policies. However, these should be introduced within a robust evaluating framework so that relevant evidence of effect can be generated in time.

**Reference:**

1. GBD 2017 Risk Factor Collaborators. Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks for 195 countries and territories, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet* 2018;392:1923–94 doi: [10.1016/S0140-6736(18)32225-6](https://doi.org/10.1016/S0140-6736(18)32225-6)

2. NHS Digital. *Statistics on Smoking, England* 2019. Available: https://files.digital.nhs.uk/D9/5AACD3/smok-eng-2019-rep.pdf [Accessed 15 July 2020]

3. Jamrozik K. Estimate of deaths attributable to passive smoking among UK adults: database analysis. *BMJ* 2005;330(7495):812 doi: [10.1136/bmj.38370.496632.8F](https://doi.org/10.1136/bmj.38370.496632.8F)

4. World Health Organization. *WHO Report on the Global Tobacco Epidemic* 2009. Available: http://whqlibdoc.who.int/publications/2009/9789241563918\_eng\_full.pdf?ua=1 [Accessed 07 July 2020]

5. World Health Organization. *WHO Framework Convention on Tobacco Control* 2020. Available: https://treaties.un.org/doc/Publication/MTDSG/Volume I/Chapter IX/IX-4.en.pdf [Accessed 07 September 2020]

6. Sims M, Mindell JS, Jarvis MJ, Feyerabend C, Wardle H, Gilmore A. Did smokefree legislation in England reduce exposure to secondhand smoke among nonsmoking adults? Cotinine analysis from the Health Survey for England. *Environ Health Perspect* 2012;120(3):425–30 doi: [10.1289/ehp.1103680](https://doi.org/10.1289/ehp.1103680)

7. Frazer K, Callinan JE, Mchugh J, van Baarsel S, Clarke A, Doherty K, et al. Legislative smoking bans for reducing harms from secondhand smoke exposure, smoking prevalence and tobacco consumption. *Cochrane Database Syst Rev* 2016;2:CD005992–CD005992. Available: https://pubmed.ncbi.nlm.nih.gov/26842828 [Accessed 05 July 2020]

8. Faber T, Kumar A, Mackenbach JP, Millett C, Basu S, Sheikh A, et al. Effect of tobacco control policies on perinatal and child health: a systematic review and meta-analysis. *Lancet Public Heal* 2017;2(9):e420–37 doi: [10.1016/S2468-2667(17)30144-5](https://doi.org/10.1016/S2468-2667(17)30144-5)

9. Department of Health. *Towards a Smokefree Generation: A Tobacco Control Plan for England* 2017. Available: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\_data/file/630217/Towards\_a\_Smoke\_free\_Generation\_-\_A\_Tobacco\_Control\_Plan\_for\_England\_2017-2022\_\_2\_.pdf [Accessed 25 May 2020]

10. Public Health England. *Smokefree mental health services in England Implementation document for providers of mental health services*. 2016. Available: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\_data/file/779497/SF\_MH\_services\_in\_England\_\_Guidance\_for\_Providers.pdf [Accessed 31 March 2021]

11. Ministry of Defence. *Smoking and Tobacco Control Strategy for Defence 2017-22* 2018. London: MOD

12. Ministry of Defence. *Freedom of Information Request Information FOI2020/05127* 2020. Available: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\_data/file/893727/Information\_regarding\_how\_many\_of\_those\_in\_the\_Armed\_Forces\_smoke\_\_\_2020\_05127.pdf [Accessed 15 August 2020]

13. Johnstone A and Martin-Bates A. Banning smoking at Army Foundation College, Harrogate: a military phase I training establishment’s experience of introducing a smoking ban. *BMJ Mil Health*Published Online First: 16 September 2020. doi: 10.1136/bmjmilitary-2020-001599

14. BBC. *Army bans smoking at Harrogate training college*. 2019. Available: https://www.bbc.co.uk/news/uk-england-york-north-yorkshire-49646705 [Accessed 12 July 2020]

15. Carter A. Policy Memorandum 16-001, Department of Defense Tobacco Policy. *Department of Defense* 2016; Available: https://www.med.navy.mil/sites/nmcphc/Documents/health-promotion-wellness/tobacco-free-living/INCOMING-CARTER-Tobacco-Policy-Memo.pdf [Accessed 20 June 2020]

16. Conway TL and Cronan TA. (1992). Smoking, exercise, and physical fitness. *Prev Med* 1992;21(6):723–734 doi: [10.1016/0091-7435(92)90079-w](https://doi.org/10.1016/0091-7435(92)90079-w)

17. Siddall AG, Bilzon JLJ, Thompson D, Greeves J, Izard R, and Stokes KA. Smoking status and physical fitness during initial military training. *Occup Med* 2017;67(3):205–210 doi: [10.1093/occmed/kqx006](https://doi.org/10.1093/occmed/kqx006)

18. Lynch P. Coronary Risk Profile of Young Soldiers with Coronary Heart Disease

*BMJ Military Health*1985;131:38-41 doi: [10.1136/jramc-131-01-09](http://dx.doi.org/10.1136/jramc-131-01-09)

19. Hoad NA, Clay DN. Smoking Impairs the Response to a Physical Training Regime: A Study of Officer Cadets. *BMJ Military Health*1992;138:115-117 doi: [10.1136/jramc-138-03-02](http://dx.doi.org/10.1136/jramc-138-03-02)

20. Bedno SA, Jackson R, Feng X, Walton IL, Boivin MR, Cowan DN. Meta-analysis of Cigarette Smoking and Musculoskeletal Injuries in Military Training. *Med Sci Sport Exerc* 2017;49(11):2191-2197 doi: [10.1249/mss.0000000000001349](https://doi.org/10.1249/mss.0000000000001349)

21. Munnoch K, Bridger RS. Smoking and injury in Royal Marines’ training. *Occup Med* 2007;11;57(3):214–6 doi: [10.1093/occmed/kql170](https://doi.org/10.1093/occmed/kql170)

22. Ministry of Defence. *Annual Medical Discharges in the UK Regular Armed Forces: 1 April 2014 to 31 March 2019* 2019. Available: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\_data/file/816158/20190708\_-\_MedicalDisBulletinFinal\_-\_O.pdf [Accessed 15 July 2020]

23. Hefler M. New Zealand to have world’s first smoke-free military by 2020. *Tob Control Blog* 2017. Available: https://blogs.bmj.com/tc/2017/05/31/new-zealand-to-have-worlds-first-smoke-free-military-by-2020/ [Accessed 05 May 2020]

24. Conway, TL. Tobacco use and the United States military: a longstanding problem. *Tobacco Control* 1998;7:219-221 doi: [10.1136/tc.7.3.219](http://dx.doi.org/10.1136/tc.7.3.219)

25. Roeseler A, Burns D. The quarter that changed the world. *Tob Control* 2010;1;19(Suppl 1):i3 LP-i15 doi: [10.1136/tc.2009.030809](http://dx.doi.org/10.1136/tc.2009.030809)

26. Nicol M. Top Armed Forces medical officer faces “Nazi” jibes after trying to stop his soldiers smoking in uniform. *Daily Mail* 2017; Available: https://www.dailymail.co.uk/news/article-4120664/Top-Armed-Forces-medical-officer-faces-Nazi-jibes-trying-stop-soldiers-smoking-uniform.html

27. Frazer K, McHugh J, Callinan JE, Kelleher C. Impact of institutional smoking bans on reducing harms and secondhand smoke exposure. *Cochrane Database Syst Rev* 2016;5:CD011856. Available: https://www.cochranelibrary.com/cdsr/doi/10.1002/14651858.CD011856.pub2/epdf/full [Accessed 05 July 2020]

28. National Institute for Health and Care Excellence. (2013). *Smoking: acute, maternity and mental health services. Public health guideline [PH48]* 2013. Available at: https://www.nice.org.uk/guidance/ph48/chapter/10-Gaps-in-the-evidence [Accessed 13 July 2020]

29. Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gøtzsche PC, Ioannidis JPA, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration. *BMJ* 2009; 21;339:b2700 doi: [10.1136/bmj.b2700](https://doi.org/10.1136/bmj.b2700)

30. Falconer Hall T, Siddiqi K. Evaluation of the impact of smoke-free policies in defence settings on exposure of military personnel to second-hand smoke: a systematic review. *PROSPERO* 2020;CRD42020198155. Available from: <https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42020198155>

31. Centre for Reviews and Dissemination. *Systematic Reviews: CRD’s guidance for undertaking reviews in health care* 2009. Available from: https://www.york.ac.uk/media/crd/Systematic\_Reviews.pdf [Accessed 23 May 2020]

32. Sterne JAC, Hernán MA, Reeves BC, Savović J, Berkman ND, Viswanathan M, et al. ROBINS-I: a tool for assessing risk of bias in non-randomised studies of interventions. *BMJ* 2016;355:i4919 doi: [10.1136/bmj.i4919](https://doi.org/10.1136/bmj.i4919)

33. Campbell M, McKenzie JE, Sowden A, Katikireddi SV, Brennan SE, Ellis S, et al. Synthesis without meta-analysis (SWiM) in systematic reviews: reporting guideline. *BMJ* 2020;368:l6890 doi: [10.1136/bmj.l6890](https://doi.org/10.1136/bmj.l6890)

34. Schünemann HJ, Higgins JPT, Vist GE, Glasziou P, Akl EA, Skoetz N and Guyatt GH*.* Chapter 14: Completing “Summary of findings” tables and grading the certainty of the evidence. In J.P.T. Higgins, J. Thomas, J. Chandler, M. Cumpston, T. Li, M.J. Page and V.A. Welch, (Eds). *Cochrane Handbook for Systematic Reviews of Interventions* 2019;Version 6.0. Available: https://training.cochrane.org/handbook/current/chapter-14 [Accessed 07 July 2020].

35. Chiu Y-L, Lo H-C, Lai C-H, Hwang S-L, Lin F-G, Huang S-J, Jiang S-H, Li S-R, Tzeng, Y-M, Fang W-H. and Kao, S. Effectiveness of a smoking restriction policy on smoking behaviour in the military. *Addict Behav* 2017;67:53–57 doi: [10.1016/j.addbeh.2016.12.006](https://doi.org/10.1016/j.addbeh.2016.12.006)

36. Cronan T, Hervig LK, Conway TL. Evaluation of smoking interventions in recruit training. *US NAvy Medical Research and Development Command* 1989. Available at: https://apps.dtic.mil/dtic/tr/fulltext/u2/a191940.pdf [Accessed 20 July 2020]

37. Derkenne C, Bylicki O, Darléguy A, Garnier M, Baert P, Lamblin A. Tolerance and Effectiveness of Forced and Prolonged Smoking Cessation Among French Submariners. *Mil Med* 2016;181(5):445–50 doi: [10.7205/MILMED-D-15-00177](https://doi.org/10.7205/milmed-d-15-00177)

38. Hurtado SL and Conway TL. Changes in Smoking Prevalence following a Strict No-Smoking Policy in U.S. Navy Recruit Training. *Military Medicine* 1996;161(10):571-576 doi: https://doi.org/10.1093/milmed/161.10.571

39. Patten CA, Martin JE, Hofstetter CR, Brown SA, Kim N, Williams C. Smoking cessation following treatment in a smoke-free Navy Alcohol Rehabilitation program. *J Subst Abuse Treat* 1999;16(1):61–9 doi: [10.1016/S0740-5472(98)00016-6](https://doi.org/10.1016/S0740-5472(98)00016-6)

40. Santo TJ, Ellis S, Rivera LO, Vasquez LE, Francis MM, Jin WK, et al. A Tobacco-Free Medical Campus Policy is Associated With Decreased Secondhand Smoke Exposure and Increased Satisfaction Among Military Medical Employees: Results of a Mixed-Methods Evaluation. *Mil Med* 2017;182(5):e1724–32 doi: [10.7205/MILMED-D-16-00153](https://doi.org/10.7205/milmed-d-16-00153)

41. Williams L, Gackstetter G, Fiedler E, Hermesch C and Lando H. Prevalence of Tobacco Use among First-Term Air Force Personnel before and after Basic Military Training. *Mil Med* 1996;161(6):318-323 doi: [10.1093/milmed/161.6.318](https://doi.org/10.1093/milmed/161.6.318)

42. Woodruff S, Conway T, Edwards C. Effect of an eight week smoking ban on women at US Navy recruit training command. *Tob Control* 2000;9(1):40–6 doi: [10.1136/tc.9.1.40](http://dx.doi.org/10.1136/tc.9.1.40)

43. McGuinness LA, Higgins JPT. Risk-of-bias VISualization (robvis): An R package and Shiny web app for visualizing risk-of-bias assessments. *Res Synth Methods* Published Online First: 26 April 2020. doi: [10.1002/jrsm.1411](https://doi.org/10.1002/jrsm.1411)

44. Thomson HJ, Thomas S. The effect direction plot: visual display of non-standardised effects across multiple outcome domains. *Res Synth Methods* 2013;4(1):95–101 doi: [10.1002/jrsm.1060](https://doi.org/10.1002/jrsm.1060)

45. Haynes L, Service O, Goldacre B, Torgerson D. Test, Learn, Adapt: Developing Public Policy with Randomised Controlled Trials. *Cabinet Office* 2020. Available: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\_data/file/62529/TLA-1906126.pdf [Accessed 12 August 2020]

46. Bonell CP, Hargreaves J, Cousens S, Ross D, Hayes R, Petticrew M and Kirkwood BR. Alternatives to randomisation in the evaluation of public health interventions: design challenges and solutions. *J Epidemiol Community Health* 2011;65(7)582-587 doi: [10.1136/jech.2008.082602](http://dx.doi.org/10.1136/jech.2008.082602)

47. Craig P, Katikireddi SV, Leyland A and Popham F. Natural Experiments: An Overview of Methods, Approaches, and Contributions to Public Health Intervention Research. *Annu Rev Public Health* 2017;38(1),39–56 doi: [10.1146/annurev-publhealth-031816-044327](https://doi.org/10.1146/annurev-publhealth-031816-044327)

48. Abadi A, Diamond A and Hainmueller J. Synthetic Control Methods for Comparative Case Studies: Estimating the Effect of California’s Tobacco Control Program. *Journal of the American Statistical Association* 2010;105(490),493–505 doi: [10.1198/jasa.2009.ap08746](https://doi.org/10.1198/jasa.2009.ap08746)

49. Kontopantelis E, Doran T, Springate DA, Buchan I, Reeves D. Regression based quasi-experimental approach when randomisation is not an option: interrupted time series analysis. *BMJ* 2015;350:h2750 doi: [10.1136/bmj.h2750](https://doi.org/10.1136/bmj.h2750)

50. Whiting P, Savović J, Higgins JPT, Caldwell DM, Reeves BC, Shea B, et al. ROBIS: A new tool to assess risk of bias in systematic reviews was developed. *J Clin Epidemiol* 2016;69:225–34 doi: [10.1016/j.jclinepi.2015.06.005](https://doi.org/10.1016/j.jclinepi.2015.06.005)

51. National Collaborating Centre for Method and Tools. *Spotlight on Methods and Tools: ROBINS-I* [Video] 2017. Available: https://www.youtube.com/watch?v=HgZKQo28QSc [Accessed 23 July 2020]