Perkins *et al. Crime Sci (2017) 6:11*
DOI 10.1186/s40163-017-0073-1

Crime Science

SYSTEMATIC REVIEW

Open Access

Personal security alarms for the prevention of assaults against healthcare staff

Chloe Perkins[1], Deirdre Beecher[2], David Colas Aberg[3], Phil Edwards[1] and Nick Tilley[3*]

Abstract

Background: Personal security alarms have been used to try to reduce violence against healthcare staff, some of whose members face relatively high risks of assault. This systematic review focused on the effect of alarms in reducing the incidence and/or severity of assaults.

Methods: Electronic databases, including Cochrane Library, Ovid MEDLINE(R); CINAHL Plus (EBSCO); PubMed; PsycINFO (OvidSP) PsycEXTRA; Applied Social Sciences Index and Abstracts (ProQuest) (1987 to current); Criminal Justice Abstracts (EBSCOhost); Psychology and Behavioural Science Collection (EBSCOhost); Social Policy and Practice (OvidSP) Sociological Abstracts; ProQuest theses and dissertations, were searched. Study designs eligible for inclusion were randomised controlled trials, interrupted time series and controlled before-after studies that assessed the impact of personal security alarms on assaults. Searches were undertaken for studies of healthcare staff in all settings (i.e. including staff working in confined spaces such as hospitals and also field personnel such as community health workers). Workplace violence between colleagues (lateral violence and bullying) and other uses of personal alarms (e.g. fall alarms for the elderly, domestic violence prevention) were excluded. Search results were screened by title, abstracts and keywords for possible inclusion. Full text reports for all potentially relevant studies were obtained and independently assessed for final inclusion. The primary outcome was physical assaults (recorded or self-reported). Secondary outcomes included increased confidence or self-efficacy in violence prevention (recorded or self-reported).

Main results: No studies were found that met all inclusion criteria. Four reported associations of personal alarms (and other variables) with risks of assault in healthcare settings. These were described narratively.

Conclusions: Healthcare workers in emergency departments, psychiatric units and geriatric facilities face much higher risks of assault than those in other healthcare settings. Alarm systems vary widely. Alarm systems form one of a range of measures, which may interact with one another, that are used to reduce the risks of assault. Given this complexity and diversity, prior to field trials EMMIE orientated efficacy trials are recommended to try to establish whether alarms can be introduced and operated in ways that can contribute to reducing assaults in specific high-risk settings. In relation to findings relating to any given intervention, EMMIE refers to effects produced, mechanisms activated to produce the effects, moderators or contexts relevant to the activation of mechanisms, implementation issues that arise, and economic costs and benefits.

Keywords: Violence against healthcare workers, Alarms, EMMIE, Systematic review, Crime prevention, What Works Centre for Crime Reduction

Background

Violence against healthcare staff is a major problem. An international review found that a third of nurses have been assaulted and injured (Spector et al. 2014). In a 2010 survey, between 5 and 8% of frontline National Health Service (NHS) staff reported being physically assaulted by patients or other service users in the previous 12 months (Ipsos MORI 2010). Such assaults against NHS staff have increased. According to NHS Protect figures, a total of 70,555 physical assaults on NHS staff were reported in

*Correspondence: n.tilley@ucl.ac.uk
[3] Department of Security and Crime Science, University College London, 35 Tavistock Square, London WC1H 9EZ, UK
Full list of author information is available at the end of the article

the year 2015–2016 resulting in 1740 criminal sanctions; this represents an increase in total assaults of 4% from 67,864 in the year 2014–2015 and an increase of 17% from a total of 60,385 in the year 2004–2005 (NHS Protect 2017a). Nurses are four times more likely to experience assaults than any other NHS worker, with student nurses and those in psychiatric and learning disability areas at highest risk (Wells and Bowers 2002). One quarter of assaults are reported in acute wards and 69% in those for mental health problems and learning disability. Globally, nurses working in some departments face much higher levels of violence than those in others. The proportions experiencing violence in geriatric wards (45.9%), emergency departments (49.5%), and psychiatric departments are substantially higher than those in a general sample of nurses (23.4%) (Spector et al. 2014). The source of these physical assaults against nurses have been found to be predominantly patients, accounting for 64%, with a further 30% being carried out by the family or friends of patients and the remaining 11% is lateral violence from nurses, physicians or staff (Spector et al. 2014).

The Crime Survey of England and Wales identifies occupational groups at most risk of violence. The 2014–2015 Survey estimated that 1.3% of employed adults of working age had experienced one or more incident of violence at work over 12 months. It found workers in protective service occupations (e.g. police officers) to be at greatest risk with 9.2% experiencing one or more incident. Next came health and social care associate professionals, such as most nurses, of whom 6.1% suffered one or more incident—over four times the overall rate (Health and Safety Executive 2017b). Those working in protective services and health have consistently been reported, over a number of years as being at high risk.

In 2000, the Home Office estimated the total average cost of each common assault at £540, which includes the physical and emotional impact, victim services, lost output and the police court and prison costs (the average for more serious incidents of violence against the person, excluding homicide, rising to £19,000) (Office 2017). Impacts of violence on staff include pain, time away from work, depression and low self-esteem; impacts on the NHS include loss of personnel for significant amounts of time and resignations (NHS 2003). Violence and abuse against staff present substantial costs to the NHS through additional staff training, security, staff absenteeism, poor staff retention, and legal fees. Direct financial costs of £69 million per annum have been attributed to physical and non-physical violence and aggression in the NHS (National Audit Office 2003). The cost of physical assaults during 2007–2008 was estimated at £60 million (NHS 2007).

The high risk of assaults for NHS staff is suggested to be due to factors including: inadequate security, staff shortages, night-shift patterns, and the intensity of interactions with patients (Oztunc 2006). Other contributory factors reported include: patient mental health, patients under the influence of alcohol or other drugs, waiting time and delays, problems understanding information, anxiety caused by practical issues (e.g. transport and parking), and an increase in expectations of standards of service which may not be met (Ipsos MORI 2010; Rew and Ferns 2005).

Interventions

Scoping literature searches revealed many studies that identified the problem of assaults against staff in the healthcare setting, and many studies that estimated the prevalence of such attacks and the exposure of healthcare staff to violence. However, there is a paucity of primary research into interventions to prevent violence. Interventions to prevent violence against healthcare staff may be broadly classified as:

- Environmental (e.g. staffing numbers; CCTV; fixed emergency alarms; personal security alarms; security guards; police officers in A&E; making building access more secure for staff; ambient environments, proper lighting and calming décor; facilities for children, e.g. play area);
- Practices and policies (e.g. legislation such as the Criminal Justice and Immigration Act 2008; 'zero tolerance' approach policies);
- Staff skills (e.g. NHS conflict resolution training; verbal techniques; prevention and recognition strategies; staff attitudes, knowledge and skills) (Anderson et al. 2010).

Key measures identified by NHS Protect to tackle violence in healthcare settings include (Business plan 2014): establishment of NHS Serious Incident Reporting System (SIRS) and Physical Assault Reporting System (PARS); conflict resolution training (NHS Protect 2013); use of the powers under the Criminal Justice and Immigration Act 2008 (CJIA) to tackle nuisance or disturbance behaviour (sections 119–120 make an offence of causing a nuisance or disturbance on NHS premises, and provide power of removal); and guidance on the prevention and management of challenging behaviours in NHS settings. A 2003 report from the National Audit Office identified a variety of security measures in place across NHS trusts; panic alarm systems (in 85% of trusts); closed-circuit television (CCTV) (in 92% trusts); security staff (40%); police presence (20%) and other measures (17%) including restricted access, security screens in reception areas

and mobile phones for lone workers (National Audit Office 2003). Of the two most widely used security measures, CCTV has been reviewed previously (Farrington et al. 2007; Welsh and Farrington 2009) and considered as part of the What Works in Crime Reduction series (College of Policing 2015), while the use of personal alarms, has received less attention. Personal alarms were therefore, selected for further study as the focus of this review.

The use of personal security alarms in healthcare settings

Personal security alarms are used across NHS trusts. A Health & Safety Commission report (Commission HaS 1997) outlined three types of alarm system:

- *Panic button systems* are part of an internal alert system, which often comprise hardwired buttons placed in locations where there is a high risk of violence. Their activation triggers an alarm on a monitoring console. These may be useful in treatment and consulting rooms, where their location is known only to members of staff (Commission HaS 1997). Clear procedures on when and by whom they should be activated should be set out and include a predetermined response plan. Portable panic attack devices may also be linked to an internal system providing similar locational alerts on a monitoring console.
- *Personal security alarms* range from simple 'shriek' devices, designed to shock or disorientate an attacker to give victims time to get away, to a component in a monitored system (as above). Simple audible alarm devices are not based on the expectation that they will produce assistance from third parties. Rather, they are primarily intended to create a distraction to allow the worker time to get away from a potentially violent situation. NHS Protect also recommend that the personal alarms are discarded after activation to divert the assailant's attention to silencing it (NHS Protect 2017b). Some experts advise personal audible alarms are more suitable for outdoor use due to the potential risk of escalating a situation indoors and their use now is more limited. It has been suggested that alarm systems that rely on the use of whistles or screams are ineffective and dangerous in in-patient or psychiatric settings and coded, silent alarms triggering a response (as with a panic button) are more desirable in this setting. Personal security alarm or noise devices have been highly recommended for field personnel (e.g. community health workers) (Occupational Health & Safety Agency for Healthcare 2005).
- *Complex personal alarm systems* include personal alarms linked to fixed detection systems e.g. by radio or infra-red. Components may include panic buttons (linked to switch board and/or police) and portable personal devices (linked to central system with location information). *Lone worker devices* may also be included under this category.

Lone workers are a particular category of potentially at risk workers, prevalent in healthcare and other occupations, who work independently (often in a mobile capacity such as community healthcare providers but also independently or alone within buildings) without close supervision (Health and Safety Executive definition). NHS Protect specifically defines lone working as:

> *"any situation of location in which someone works without a colleague nearby; or when someone is working out of sight or earshot of another colleague" (p5 NHS Protect 2017b)*

Working alone is generally taken to increase a worker's vulnerability, and the proportion of lone workers injured through physical assault is estimated to be 9% higher than for non lone workers (NHS Protect 2017b) and is thought to result in a greater severity of assault (NHS Protect 2015). Lone worker devices or applications are covered by British Standard 8484:2016, a bench mark standard, which Lone Worker Devices must reach for certification and which forms the basis for a police response. Guidance on lone workers and violence from the Health and Safety Executive, further reports the most popular equipment used by lone workers to be:

- Mobile phones or other communication devices, to call for help if needed and report their whereabouts and schedule to others, and
- Personal alarms, which can help staff feel more confident about their safety (Health and Safety Executive 2017a).

Alarms are seldom the sole means by which attempts are made to prevent violence against staff in healthcare settings. The contexts in which alarms are used vary in terms of the other violence prevention methods in use, clinical specialism, whether lone working is a factor and population served. This review will draw together all studies that examine the use of any personal alarm interventions implemented to address the risks of violence and assault.

For this review we searched for studies in electronic databases and the grey literature primarily relevant to NHS or healthcare settings. However, to estimate the effectiveness of all categories of personal security alarms in healthcare settings, we broadened our searching to include evaluations in any other settings. We searched for studies in *any* settings which may include both mobile and

field personnel (e.g. paramedics and community health workers) and those working in confined spaces (e.g. hospitals, mental health units, and GP surgeries) and did not restrict searches so that other high risk occupations could be included if relevant studies were found (such as transport workers and lone workers). In practice, we found none in non-health occupational settings, which is why this review is confined to alarms in healthcare contexts.

EMMIE framework

This systematic review was conducted in support of the *What Works Centre for Crime Reduction*, hosted by the UK College of Policing. One aim of the UK College of Policing is to promote and facilitate evidence-based policing, defined as:

> *"a method of making decisions about 'what works' in policing: which practices and strategies accomplish police missions most cost-effectively" (Sherman 2013) (p. 377).*

Systematic reviews of the research literature lie at the heart of the 'what works' movement. The results of this review will be incorporated in an online toolkit devised by researchers at the UCL Jill Dando Institute of Security and Crime Science. To help structure the toolkit, the consortium produced the 'EMMIE' framework for assessing five dimensions of evidence (Johnson et al. 2015). The EMMIE acronym refers to:

- Effect size (how effective is the intervention?).
- Mechanism (how does the intervention work?).
- Moderators (in which contexts does the intervention work?).
- Implementation (what is needed to implement the intervention?).
- Economics (how much might the intervention cost?).

These dimensions encapsulate the types of evidence studies might provide which could inform improved decision-making (Sidebottom et al. 2017) and were designed to give consideration to a broader range of issues, pertinent to crime prevention practitioners and policymakers (Johnson et al. 2015). This approach to the systematic review in practice required a broader extraction of data, in addition to the more traditional estimates of effect, to uncover evidence across these dimensions and to reveal research and knowledge gaps in the primary studies and the evidence base.

Objectives

The systematic review was conducted to evaluate the evidence underpinning the use of personal security alarms with the aim of reducing the incidence of assaults against healthcare and other high-risk staff. Were sufficient numbers of well-designed controlled evaluations identified, we intended to include estimates of the effects on the defined outcomes of interventions using personal security alarms. We intended to describe: participant characteristics, setting, recruitment methods, theoretical basis used in designing interventions, intervention implementation, delivery, and outcomes.

Information speaking to the EMMIE framework was extracted from the evaluation studies (Johnson et al. 2015). For each study we intended to describe the setting, theoretical basis for the intervention, characteristics, and outcomes. We planned to summarise costs of the programmes where economic data were available.

Methods

Criteria for considering studies

Broad search strategies were used in order to include evaluations of personal alarms in all settings that may be relevant to healthcare. Studies had to report on programmes where there had been controlled evaluation of personal alarms.

Types of studies

Experimental study designs were to provide evidence of effects, and included controlled-before-after studies, controlled interrupted time series, controlled trials and randomised controlled trials that assessed the impact of personal security alarms on measured outcomes.

Types of participants/populations

Inclusion criteria

- Primary populations of interest were healthcare staff in all settings (i.e. including staff working in confined spaces such as hospitals as well as field personnel such as community health workers);
- Secondary populations of interest included work place violence in other settings with high risk of violence (such as some council departments, local housing association offices, or public transport providers).

Exclusion criteria

- Workplace violence between colleagues, lateral violence and bullying was excluded as 94% of physical assaults are carried out by patients, and family and friends of patients (64% by patients and 30% by family and friends) (Spector et al. 2014). Further to this, it was anticipated that lateral violence may have different causal pathways and mechanisms.

Types of interventions

Personal security alarms (to include mobile and fixed panic buttons, monitored and passive personal alarms), excluding medical personal alarms (e.g. fall alarms for elderly).

Types of outcome measures

Primary outcome measures The primary outcome variable was a reduction in physical assaults (recorded or self-reported), with studies of any duration included.

Secondary outcome measures The secondary outcome variables included other recorded or self-reported measures such as non-physical assaults, staff pain, time away from work, depression and low self-esteem, feelings of safety or insecurity, changes in working practices, increased confidence or self-efficacy in violence prevention.

Other data We have extracted data from studies on mechanism, moderators, implementation and economics.

Search methods for identification of studies

Our search methods comprised four parts: first, we searched electronic bibliographic databases for published work (see below for electronic databases searched); secondly, we searched the grey literature for unpublished work; thirdly, we searched trials registers for ongoing and recently completed trials; finally, we screened reference lists of published studies. The sources searched were chosen based on their coverage of the topic.

Electronic databases

In order to reduce publication and retrieval bias our search was not restricted by language, date or publication status. We searched the following databases between March and August 2016:

1. Cochrane Library (to March 2016).
2. CINAHL Plus (EBSCO) (1937 to 16/08/2016).
3. Global Health (OvidSP) (1910 to 2016 Week 32, 16/08/2016).
4. ISI WOS: SCI-EXPANDED (1970) & CPCI-S (1990) (to 16/08/2016).
5. Northern Light conference abstracts (2016 week 32, 16/08/2016).
6. Ovid MEDLINE(R), Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations, Ovid MEDLINE(R) Daily and Ovid OLDMEDLINE(R) (1946 to 16/08/2016).
7. PROSPERO (to March 2016).
8. PsycEXTRA (OvidSP) (1908 to March 2016).
9. PsycINFO (OvidSP) (1806 to 16/08/2016).
10. PubMed (Present to 18/08/2016).
11. Social Policy and Practice (OvidSP) (to 16/08/2016).
12. Applied Social Sciences Index and Abstracts (ProQuest) (1987 to 16/08/2016).
13. Criminal Justice Abstracts with Full Text (EBSCOhost) (to 16/08/2016).
14. ProQuest International bibliography of the social sciences (1951 to 16/08/2016).
15. ProQuest theses and dissertations (to 16/08/2016).
16. ProQuest Sociological Abstracts (1952 to 16/08/2016).
17. National Criminal Justice Reference Service Abstracts Database ProQuest (to 16/08/2016).

Other sources

We searched the following websites and publications for additional reports and other grey literature to cover the same search period:

1. Open Grey (http://www.opengrey.eu/) (to March 2016).
2. Campbell Systematic Reviews (http://www.campbellcollaboration.org/lib/?go=monograph) (to 16/08/2016).
3. NICE (National Institute for Health and Care Excellence) (http://www.evidence.nhs.uk/) (to 16/08/2016).
4. TRIP (https://www.tripdatabase.com/index.html) (to March 2016).
5. Google Scholar (to August 2016).

We also performed internet searches, using the Google search engine, to trace grey literature and organisations related to prevention of violence to health service staff. The Ovid MEDLINE(R) search strategy in Appendix 1 was adapted as necessary to search all other listed sources including the internet search. A specialist in criminology grey literature at Rutgers (Phyllis Schultze) conducted searches on our behalf. A collaborator at the College of Policing (Lynn O'Mahony) conducted further searches on our behalf of the National Police Library Catalogue and POLKA (the Police Online Knowledge Area).

Data collection and analysis

Selection of studies

All studies identified through the search process were first exported to the EndNote bibliographic database in order to identify and remove duplicate records (this commonly occurs where the same record is found in more than one database). Once de-duplication had been carried out, the remaining records were imported into EPPI-Reviewer 4 software for screening and coding. This allowed the team to manage coding tasks, assess inter-rater reliability, and share the results (within the consortium and externally). Two review authors independently examined the titles, abstracts, and keywords of electronic records for eligibility according to the inclusion criteria. Results of this initial screening were cross-referenced between two review authors, and full-texts obtained for all potentially relevant reports of studies. Full-texts of potentially eligible studies went through a secondary screening by each reviewer for final inclusion in the

review, with disagreements resolved by discussion. Reference lists of all relevant studies were screened for further eligible studies.

Data extraction and management

Data were coded in EPPI Reviewer, and relevant data extracted using a standardised data coding set (Appendix 2).

Assessment of risk of bias in included studies

A review of quality assessment tools for non-randomised studies identified six tools that were considered to be useful for systematic reviews (Deeks et al. 2003). For this review, we intended to use a modified framework of one of these tools from the 'Effective Public Health Practice Project' (Thomas 2003). We intended to assess the methodological quality of the study designs and describe each included study against the following criteria: allocation to intervention/control; confounders; blinding; data collection methods; attrition; fidelity; and follow up.

Data synthesis and analysis

Descriptive analysis We intended to describe all studies that met the inclusion criteria (see Appendix 2 for standardised data extraction sheet), including:

1. Study design.
   Study design; quality.
   Data collection methods, modes, and techniques; validity of tools.
   Statistical and other analyses.

2. Participants.
   Health care occupations.
   High risk occupations.

3. Components of intervention.
   Country, city.
   Setting.
   Theoretical basis used in programme design; postulated mediators.
   Inputs.
   Comparator (if a controlled evaluation).

4. Outcomes.
   Primary outcomes (e.g. reduction in physical assaults, recorded or self-reported).
   Secondary outcomes (e.g. time away from work, non-physical assaults).

5. EMMIE framework.
   Effects.
   Mechanisms.
   Moderators.
   Implementation.
   Economics.

Statistical analysis

Where estimates of effect were available, we intended to use statistical software (Stata version 14) to conduct a meta-analysis. If the included studies were sufficiently similar (i.e. comparable participants, interventions, and outcomes) we intended to pool the results using a fixed or random-effects meta-analysis, with standardised mean differences (SMDs) for continuous outcomes and odds ratios for binary outcomes, and calculate 95% confidence intervals for each outcome. The 95% confidence intervals indicate a range within which we can be 95% certain that the true effect lies (Schünemann et al. 2011). A fixed effect meta-analysis would be used if it could be assumed that each study is estimating the same intervention effect (the true effect of intervention is fixed across studies) and that differences in the results are due to chance. A random-effects meta-analysis would be used to pool effect estimates across studies where they are assumed to vary and follow some distribution across studies. A random effects meta-analysis considers the different effect estimates as if they were random where there is lack of knowledge about why intervention effects differ between studies (Deeks et al. 2011). Heterogeneity (variability) among the study effect estimates was to be assessed using a Chi squared test at a 5% significance level and the I-squared (I^2) statistic, the percentage of between-study variability that is due to true differences between studies (heterogeneity) rather than due to sampling error. We planned to consider an I^2 value greater than 50% to reflect substantial heterogeneity and use a random-effects meta-analysis if there was evidence of heterogeneity. We intended to conduct sensitivity analyses in order to investigate possible sources of heterogeneity due to study quality. Sensitivity analysis could include repetition of the meta-analysis substituting alternative decisions or subgroups (such as adequate vs. inadequate allocation concealment; low vs. high attrition) to determine if the findings are robust in terms of the decision-making process of the meta-analysis used to generate them (Deeks et al. 2011). In the absence of sufficient homogeneity, we planned to present tables of the quantitative results instead of pooling study results in a meta-analysis. Details of each programme were to be presented in a table of study characteristics.

Results

Results of the search

Records from all searches were imported, screened and coded using the EPPI Reviewer 4 software. Initial screening was shared between three review authors (DB, DCA, CP), who screened the titles, abstracts and keywords of 7922 records for potential eligibility according to the inclusion criteria. This screening resulted in the exclusion of a total of 7710 records. The review authors identified a total of 212 records to be assessed for eligibility using the full text reports. After reviewing the full text of all potentially relevant studies, no studies were identified that met the inclusion criteria, the numbers of records excluded are shown in Fig. 1.

Expanding the review

Through the search process, four studies were identified that provided some evidence relating to violence and the use of personal security alarms. These studies did not meet the study design inclusion criteria but were considered to be the most relevant studies available. The full text reports for these four studies were coded in detail in EPPI Reviewer and are qualitatively described. The focus of the review then became to determine what might be inferred from the studies available and what research gaps remain regarding the use of personal alarms. Given the paucity of available studies assessing the effects of personal alarms, consideration is given to how further studies can be devised to aid policy makers and practitioners to decide if, when, where and how to implement the use of personal alarms to reduce violence.

Description of studies on personal alarm use

Four studies were identified which provided some measure of associations between personal alarm use and violence (Gale et al. 2002; Gerberich et al. 2005; Landau and Bendalak 2008; Farrell et al. 2014). None was based in the UK, with one each in New Zealand, USA, Australia and Israel. All were based in healthcare settings, with two studies reporting on samples of registered nurses

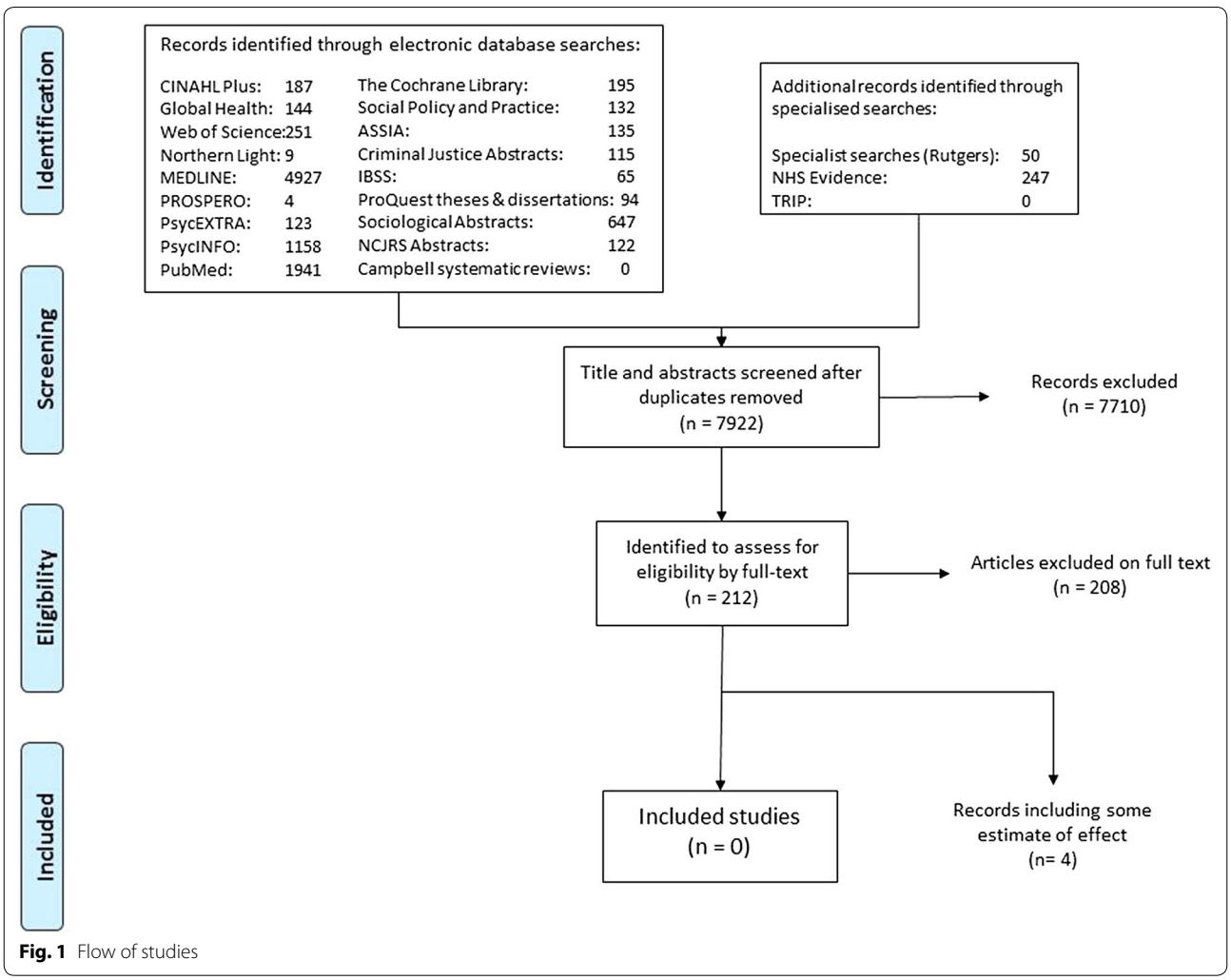

Fig. 1 Flow of studies

(Gerberich et al. 2005; Farrell et al. 2014), one study conducted on staff in psychiatric units (Gale et al. 2002) and a further on all personnel in emergency wards (Landau and Bendalak 2008). None of these evaluated the use of personal alarms in a controlled way, and of these studies, three used a cross sectional design (Gale et al. 2002; Farrell et al. 2014; Landau and Bendalak 2008) with the remaining study (Gerberich et al. 2005) employing a survey with a nested case control study design. Response rates for these studies varied from low (30%; Farrell et al. 2014) to high (78.5%; Landau and Bendalak 2008) with Gale et al. (2002) and Gerberich et al. (2005) reporting moderate response rates (55% and 66–68% respectively).

Gerberich et al. (2005) looked at the use of panic buttons and personal alarms but grouped the use of personal alarms with mobile telephones (distinguishing between whether this was owned by the employee or provided by the employer). Farrell et al. (2014) did not look individually at the use of personal alarms either, instead referring to the provision of 'personal protective equipment', which was not clearly defined but was said to include personal duress alarms. Gale et al. (2002) measured the use of both personal alarms (referred to as pocket alarms) and panic buttons, while Landau and Bendalak (2008) looked only at the availability of panic buttons to staff. Three of the four studies used self-reported experiences of violence, which risk recall and reporting bias (Gerberich et al. 2005; Farrell et al. 2014; Landau and Bendalak 2008). Farrell et al. (2014), however, asked participants to report on their last four working weeks to reduce any impact of recall bias and Gerberich et al. (2005) focused on particular months in part to avoid recall problems. Gale et al. (2002) used violent events reported to psychiatric unit managers as their measures of violence but noted that the reporting procedures for events varied between units and the use of managers may have led to reporting bias.

Gale, 2002

A study in New Zealand used a cross-sectional survey design to determine associations between a number of risk factors and preventative measures and experiences of violence. An anonymous postal survey was sent to the managers of all 219 psychiatric units in New Zealand and completed questionnaires were received from 119 (response rate 55%). Questionnaires covered information on the unit, the number of reported cases of events over the last 12 months (outcomes included property damage, attempted assaults, physical attack, sexual harassment and stalking) and the provision of preventative measures (including staff training, use of hazard sheets, pocket alarms and panic buttons).

One hundred and eleven respondents reported the use of preventative measures. Of these 45% provided staff with personal alarms and 41% made panic buttons available to staff. Study authors compared unit rates for outcome measures to risk/preventative factors using the Mann–Whitney U test. They reported that the use of pocket alarms was associated with a higher level of attempted assault ($p = 0.0001$) and attack ($p = 0.0001$) and the use of panic buttons had no significant association with risk of violence. However, the temporal order of alarm use and assault risk was not considered in the research.

Gerberich, 2005

An initial screening survey was undertaken of 6300 currently active nurses in Minnesota who had been working for at least 12 months, and were selected randomly from a 1998 licensing database (response rate 78%). A nested case control study was conducted using follow up questionnaires to a sub-set of respondents to evaluate environmental exposures and physical assault. Four hundred and seventy-five cases were identified as nurses who reported at least one incident of physical assault within the preceding 12 months. Follow up questions enquired about conditions during the month when the assault took place (or for the first event if there had been multiple incidents). Responses were received for 324 cases, a response rate of 68%. Controls were randomly selected (1425) and also asked about conditions during researcher-specified months included in the study period before they reported any physical assaults. Responses were received from 946 control subjects, a response rate of 66%.

Multiple logistic regression was used to explore the relationship between exposures (including environmental and personal protection factors) and physical violence. Exposures were classified as follows:

- General characteristics of staff and their duties—included work experience (years licensed, years in department), average patient contact hours per shift, average number of nurses and staff in immediate work environment during most commonly worked shift; primary area/department worked; main patient population; primary activity;
- Environmental design (features of the hospital environment)—including lighting, accessibility of exits, physical barriers blocking vision;
- Environmental protection (security features in the hospital environment for staff protection)—included the presence of video monitors, metal detectors,

security alarm/panic button, controlled access, security personnel, or escort/body guard; and
- Personal protection (individual protection factors)—included whether or not staff had access to a cellular telephone or personal alarm (and whether this was their own or provided by employer) and whether staff carried personal protection.

This study reported:

a. That of environmental factors, when lighting was less bright than daylight odds of assault were doubled (fully adjusted OR 2.15; 95% CI 1.58–2.83);
b. That the presence of a security alarm or panic button (vs none) was associated with increased risk of assault (fully adjusted OR 1.56; 95% CI 0.96–2.39); and
c. That risk was substantially lower among nurses who provided their own cellular telephones or portable alarms (fully adjusted OR 0.30; 95% CI 0.15–0.71) but that if these were provided by the employer that there was no difference (fully adjusted OR 1.01; 95% CI 0.70–1.54). Authors suggested the reduced risk was not due to the availability of the alarm or telephone.

The study also reported the nurses were at greatest risk when working in nursing home/long-term care/rehabilitation; emergency departments; and psychiatric/behavioural departments. These findings accord with those reported earlier in this review.

Farrell, 2014

Questionnaires were sent to a random sample of 5000 registered nurses and midwives in Victoria, Australia to explore their experiences of patient and visitor assault (PVA). The response rate was 30%. The survey asked respondents about their experience of any kind of assault (including verbal, physical and threat of harm) in the previous 4 weeks, the presence of 'protective' factors in the workplace and their importance in managing workplace violence. 36% of respondents reported that they had experienced a patient or visitor assault (PVA) in the previous 4 weeks, which included verbal abuse (90% of victims), physical abuse (45% of victims) and threat of harm (27% of victims). Of these respondents, 46% reported repeat victimization (with three or more instances of PVA) with patients being responsible for around two and a half times more incidents of PVA than visitors were.

Binary logistic regression analysis was undertaken to identify any association between covariates and outcome (PVA). The reported results found a number of 'protective factors' against PVA. These included:

- A high standard of patient facilities (to reduce fears, frustration and anxiety; adjusted OR 0.63; 95% CI 0.48–0.84),
- The provision of personal protective equipment such as mobile phones and personal duress alarms (adjusted OR 0.73; 95% CI 0.56–0.97),
- Sufficient staffing levels (adjusted OR 0.70; 95% CI 0.52–0.92), and
- Effective policy enforcement by management (adjusted OR 0.56; 95% CI 0.43–0.74).

As found in Gerberich et al. (2005) and previously noted in this review, the healthcare setting was also found to be critical to PVA occurrence. Farrell et al. (2014) reported that personnel in accident and emergency (Adjusted OR 4.27; 95% CI 2.47–7.39), aged care (adjusted OR 3.33; 95% CI 2.22–5.00) and psychiatric or mental health departments (adjusted OR 4.09; 95% CI 2.41–6.95) were significantly more likely to be assaulted in comparison to other settings. Staff shift patterns were also reported to impact on the likelihood of PVA, with higher risk of PVA being attributed to those on rotating rosters compared to non-rotation (adjusted OR 2.15; 95% CI 1.58–2.92) and night duty when compared to day duty (adjusted OR 1.86; 95% CI 1.25–2.78).

Landau, 2008

Three thousand self-report questionnaires were distributed in the emergency wards of Israel's 25 general hospitals to all personnel (to permanent medical and nonmedical staff, and staff from other wards attending patients in the emergency wards at the time of questionnaire distribution). The response rate was 78.5% (2356 completed questionnaires). A General Exposure to Violence Index (GEVI) was devised, based on participants' reports of exposure to violence in the preceding 12 months. A multiple regression model was used to explain the GEVI, using 15 independent variables, including professional characteristics (e.g. average weekly hours, position, length of time in department, participation in violence training workshops), personal characteristics (e.g. country of origin, gender, age) and hospital features (e.g. size and availability of an emergency button).

This study used routine activity theory (Cohen and Felson 1979; Felson et al. 2016) (RAT) as its theoretical framework. RAT's starting point is that for a crime to occur a 'suitable target' (in this case a healthcare staff member), a 'motivated offender' (such as an angry, frustrated or mentally unbalanced patient or visitor) and absence of a 'capable guardian' (one source of which might be an alarm system) must converge in time and

Table 1 Summary of effects in studies found

Study	Design	Device	Outcome	Reported measure	Association
Gale et al. (2002)	Cross sectional survey of managers of psychiatric units in NZ	Pocket alarms	Unit reported physical assaults (property damage, attempted assault, sexual harassment, stalking)	Unit rates of risk factors compared using Mann–Whitney U test	Associated with increased risk of assault ($p = 0.0001$)
		Panic buttons			No significant association with risk of violence
Gerberich et al. (2005)	Nested case control study, survey of Minnesota Nurses	Security alarm/panic button	Self-reported physical and nonphysical violence events during the study period	Adjusted odds ratio and 95% CI	1.56 (0.96–2.39)
		User owned mobile telephone/personal alarm			0.30 (0.15–0.71)
		Employer provided mobile telephone/personal alarm			1.01 (0.70–1.54)
Farrell et al. (2014)	Survey of nurses and midwives in Victoria, AU	Provision of personal protective equipment (such as mobile phones and personal duress alarms)	Occurrence of patient and visitor assault, based on self-reported experiences of PVA over most recent 4 working weeks	Adjusted odds ratio and 95% CI	0.73 (0.56–0.97)
Landau and Bendalak (2008)	Survey of personnel in EDs in Israel	Access to an emergency button (guarding)	General Exposure to Violence Index (GEVI) based on self reported type and frequency of victimisation to violence during preceding year	Multiple regression analysis	Close to significant effect ($p = 0.078$) on respondents exposure to violence. Unavailability related to higher risk of victimisation

space. If alarms are an effective source of guardianship the likelihood of victimization will be higher for those without access to an emergency button as a protective device.

The lack of availability of an emergency button was related to an almost statistically significant higher risk of victimization ($p = 0.078$). "*Respondents without an emergency button, tended to be more victimized*" (referring to the GEVI, based on self reported type and frequency of victimisation to violence in the preceding year).

Discussion

In the discussion, information has been drawn together from the available studies that have been highlighted in the results section, and additional evidence gathered and synthesised (from sources including further relevant literature and expert opinion, see Appendix 4) to speak to the EMMIE framework, on the effects, mechanisms, moderators, implementation and economics of personal alarm use.

Effects

It seems apparent that none of the studies found are able to provide clear measurements of effect of personal alarms on assaults against healthcare staff (see Appendix 3: Characteristics of studies; Table 1: Summary of effects). At best, these studies provide some evidence of association; however the direction of this association differs between studies. One study (Gale et al. 2002) found that the use of pocket alarms was associated with an increased risk of assault ($p = 0.0001$), while there was no significant association between panic alarms and risk of violence. Conversely, three studies (Gerberich et al. 2005; Farrell et al. 2014; Landau and Bendalak 2008) report that the use of personal protective equipment (mobile phone or personal alarm) and access to an emergency button may be associated with some decreased risk of assault. However, Gerberich et al. (2005) found that the association between personal protective equipment and assault disappeared when the equipment was provided by employers (rather than employee owned), and therefore this association cannot be attributed to the protective equipment alone.

While the searches conducted for this review focused on intervention based studies, none of the studies introduced the use of personal alarms as an intervention. The studies found do not deal with the temporal order of a personal alarm intervention and outcome measures and therefore cannot provide evidence of causality. The studies additionally were not conducted in a controlled way and lack appropriate comparison groups. These studies provide some useful insight into factors that could be further investigated but do not provide evidence to inform us on the effectiveness of personal alarms to reduce assaults against healthcare staff. Studies are at best suggestive but do not allow us to conclude anything with regard to effect and causation; they raise only possibilities.

Mechanism

Personal security alarms may send a deterrent message to potential offenders, while also improving staff confidence and decreasing fear. A report from the National Institute for Health and Care Excellence (NICE) (2006) suggested that personal security and fixed alarms along with communication devices are a useful way of preventing violent behaviour and protecting staff where it occurs, but no research relevant to this was identified through searches undertaken as part of this review.

The use of a passive (unmonitored) audible alarm is primarily intended to disarm and disorientate an offender giving the victim time to get away. To be effective it is suggested that the noise emitted needs to be greater than 130 dB (ideally around 138 dB) and sounds continuously, to avoid similarity to other more frequently heard car alarms (Personal Alarms 2016), although no research studies supporting this contention in healthcare settings were uncovered in the course of this review.

Personal safety alarms are often designed to be discreet and hidden either to enable the user to create a moment of surprise or disorientation in the potential attacker to allow time to get away, or to call covertly for physical assistance to de-escalate a situation. While it has been reported that audible alarms should not be used in indoor or enclosed environments due to the risk of escalating a potentially violent situation, there is no evidence to establish whether triggering of a silent (covert) or audible personal alarm (overt) can have any subsequent effect on the outcome in terms of occurrence or severity of an assault. Evidence from available studies did not allow us to elicit any findings on whether a situation is more likely to be de-escalated or escalated in particular settings as a result of an alarm being triggered overtly or covertly.

Research conducted into the costs and benefits of monitored quick-response pendant alarms (linked to police control rooms) to reduce repeat victimization for domestic violence has highlighted a number of preventative mechanisms that may be activated from their use (Farrell et al. 1993). While recommendations around the use of personal alarms in domestic violence situations may have changed, these mechanisms describing how personal alarms may work could also apply to their use in other contexts, and are described as:

1. Direct incapacitation—response to alarm activation prevents assault;

2. Indirect incapacitation—alarm activation leads to arrest of offender preventing further assaults during detention;
3. Specific deterrence—potential offenders are aware of personal alarm and as a result do not offend;
4. General deterrence—potential offenders aware of a scheme to equip staff with personal security alarms and therefore avoid offending as a result (Farrell et al. 1993).

In terms of the four studies identified in this review, only Landau and Bendalak (2008) suggested a mechanism to explain how personal alarms might act to reduce assaults. The authors developed hypotheses to test the likelihood of victimisation against 15 independent variables based on routine activity theory. The authors' third hypothesis on guarding, suggested that the likelihood of an individual being victimized will be reduced if they are exposed to greater levels of guardianship as this decreases opportunities for victimization. The authors specifically identified the access to an emergency button as a protective device that serves to increase guardianship. In their specific setting (emergency department wards in Israel) they found a near statistically significant association between the lack of access to an emergency button and an increased likelihood of being victimized. While this study does not provide a rigorous test for the suggested mechanism, and does not control for other factors, the authors do highlight that it demonstrates the importance of environmental and situational factors in applying interventions to reduce assaults as implied by routine activity theory.

Moderators

Reported variations in rates of assaults in different healthcare settings suggest there may be different processes and pathways in terms of violence and therefore potentially different requirements for violence prevention in different settings. Gerberich et al. (2005) and Farrell et al. (2014) both reported higher rates of assault in elderly care, psychiatric and emergency department settings. NHS Protect note similar variations in rates of assaults across different sectors, with figures for 2015/2016 reporting assault rates per 1000 staff to be 21 for the acute sector, 54 for the ambulance sector and 191 for the mental health sector (NHS Protect 2017a). The healthcare setting (e.g. whether community, ambulance, acute, secure wards, in patient or emergency) and patient population (e.g. geriatric, adult, paediatric or mental health) have been shown to be strong moderating factors. If preventive intervention efforts are targeted across whole healthcare sectors, it seems likely that any effects will be diluted due to the differences between settings (e.g. community and ward settings) and it also seems likely that the ways in which alarms might work might differ. Different settings are therefore likely to require different alarm systems, and research is needed to identify those systems with the most potential for success.

A related critical condition for personal alarms to prevent violence against healthcare staff may concern the source of the violence, in particular whether assaults are due to unintentional 'medical reasons' present at the time of the incident or whether they are criminally motivated. This was only alluded to in the highlighted studies, and is intrinsically linked to the healthcare setting and primary patient population. NHS Protect reported that 25% (17,851) of total reported assaults (70,555) in 2015–2016 did not involve any medical factors (NHS Protect 2017a). The ambulance sector reported the highest proportion of assaults determined as having no medical factors at 75% with the victim wishing to report the incident to police in 50.7% of cases. This was very different in acute and mental health sectors where 26.7 and 21.9% of reported assaults respectively had no medical factors involved and with only 4.9 and 2.8% of assaults with victim wishing to report to police (Dixon 2010). It is reasonable to conjecture that any preventive mechanisms of alarm systems will vary by the distribution of sources of violent behaviour, which might thereby be expected to moderate the outcomes produced.

Different types of alarms may be required to reduce assaults in these different scenarios. Personal audible alarms are unlikely to deter offenders from committing assaults when they are not in control of their actions, while they may be more effective in deterring offenders in a community setting who have no medical factors. In circumstances where medical factors contribute to assault, access to a personal or fixed alarm as a component in a monitored system and which trigger immediate assistance may be able to prevent or reduce severity of assaults. There is a range of different types of personal alarms available as discussed previously in this review and these should be considered to ensure the most appropriate technology is implemented for each setting.

In addition to the different clinical settings having an impact on the potential for effectiveness of personal alarms, the studies highlight diverse other underlying factors that may be having a moderating impact at the same time. Farrell et al. (2014), noted staffing shift patterns and rotations (higher risk implied for those working nights and in rotating shift patterns), along with the standard of patient facilities and experience of nursing staff to be a factor in risk of assault. Gerberich et al. (2005) similarly pointed to ambient lighting being as

bright as daylight as having a significant and positive effect on the risk of violence. Jason Pott[1] (also see Appendix 4) however, noted that depending on who manages the hospital (e.g. a private finance initiative) the Trust may not have control over such environmental factors. Where possible, such factors which may be moderators of the intervention, should also be considered when implementing a scheme.

Implementation

There is some overlap in the moderating factors and issues that should be considered in implementing a personal alarm intervention but there is little mention of the specifics required to implement such an intervention successfully, in the studies found. However, in discussion with Jason Pott (see Appendix 4), a Lead Research Nurse in a London emergency department, he clearly felt that the practical implementation of any intervention would require careful consideration:

> *"The Emergency Department is a complex and stressed environment where patients are not in control and are 'at the mercy of staff'. [Waiting] time is a major factor, in addition to intoxication and pain… there are a number of flash points which can trigger aggression… Any intervention has to be considered to terms of its practical application within the ED."*

In arguing that the particular attributes of emergency departments need to be considered in implementing an alarm scheme if it is to be effective, Pott is suggesting that these attributes will be important in shaping how any given alarm system will work through in practice to produce its consequences. In other words, the emergency department context (and by extension the particular attributes of any other healthcare setting) are important as implementation factors because they function as moderators, conditioning any effects brought about by an alarm system.

A further factor mentioned by Pott but not explicitly considered in any of the highlighted studies, includes the use of publicity in deterrence and how this may impact a personal alarm intervention (whether or not if the public and potential offenders are aware of the use alarms this would increase deterrence). Indeed, there is extensive literature on the use of publicity to increase deterrence, and it has been shown to increase the success of crime reduction interventions (Laycock 1991; Bowers and Johnson 2003, 2005). Publicity may therefore comprise a key condition for alarms to maximise their potential preventive outcome.

However, Jason Pott noted that in his experience in the NHS, implementation of policies or interventions with good publicity does not always translate well into practice on the ground (e.g. the zero tolerance of aggression in the NHS).

> *"[zero tolerance] Policies are only partially implemented (i.e. physical aggression, but not verbal aggression). The zero tolerance message does not seem to be delivered on the 'shop floor'; it seems to be a 'headline' policy and doesn't deter those individuals who are most likely to offend against NHS staff. There is also poor implementation and support for the policy…"*

So, publicity may be a key contextual condition for alarms to produce violence-reducing outcomes but the practical implementation of publicity is evidently partial and it clearly cannot have its possible moderating influence if not put in place.

Pott's personal experience of implementation of personal alarms in an emergency department was also that they are often in practice patchily operated. For example he notes that alarms were often misplaced, not handed over at shift changes and were not effectively deployed. Here, the system might be effective if operated as intended but cannot be if in practice, it is not used. Monitored fixed alarms including locational information on activation might provide the best opportunity to diffuse a potentially assaultive situation.

The zero tolerance policy to aggression in the NHS has been highly publicised in order to act as a deterrent to offenders by increasing the perceived risk of apprehension. Publicising the implementation of alarms could do the same, although with publicity there is also the potential to increase the fear of crime or violence. A strategic approach e.g. to specifically publicise the success of an intervention is more likely to reassure the public while at the same time increase the perceived risk of apprehension to offenders (Bowers and Johnson 2005). Careful implementation of an alarm intervention that considers the setting, engages the commitment of staff and management to apply it in practice, and includes appropriate policy and publicity to support it, could increase the deterrence effect.

Economics

There was no mention of costs in the four studies highlighted in this review. The costs of violence to the NHS, have been noted previously in this review as being £69 million per annum for physical and non-physical violence and aggression (National Audit Office 2003), with

[1] Involvement of NHS staff was an important part of the development of this review. Jason Pott, a Lead Research Nurse in the Emergency Department of the Royal London Hospital, was approached for advice during development of this review as NHS staff involvement was considered important.

the cost of physical assaults during 2007–2008 being estimated at £60 million (NHS Security Management Service 2007). There are significant impacts for the NHS of violence against staff, which were mentioned previously. These include, pain, time away from work, depression and low self-esteem, which in turn will mean loss of NHS personnel for significant periods of time, high staff turnover and resignations. Violence against staff represents substantial costs to the NHS and should therefore justify appropriate levels of investment in order to reduce its occurrence.

Research needs in the future

The risks of assault from patients in particular, but also from their family and friends, are high and costly in some health care settings. It is therefore important the decision-makers have informed guidance on cost-effective preventive strategies.

A range of measures can be and have been used to try to reduce the problem, of which alarms form a part. Alarm systems themselves differ widely from one another. Such alarm systems work in different ways and, as found where alarms are used as a preventive measure for other crime problems, they often depend on the availability and inclination of others to respond and take further action and those inclinations to respond are apt to change over time. Given the diversity of contexts where health staff are at risk, the variations in alarm system, and the varying range of other preventive measures in place alongside alarms it would have made little sense to aggregate findings from field trials. There is too much heterogeneity and complexity.

Prior to undertaking further primary studies, a useful starting point for future research would be to undertake wider consultation with healthcare staff, as well as professionals from the security industry and organisations specialising in personal safety training, consultancy and conflict management, to assess a cross-section of issues that may affect the implementation of any personal alarm intervention and ascertain the conditions believed necessary for them to produce their intended outcomes. Following this, rather than moving straight to field trials to meet the obvious evidence gap, it might be prudent first to undertake a series of EMMIE informed efficacy trials. Efficacy trials are designed to test theory by creating conditions in which measures conjectured to have the potential to bring about their intended effects have their best chance of doing so (Loudon et al. 2015; Godwin et al. 2003). In contrast field trials aim to find out if the measures are effective in practice in real everyday conditions. EMMIE informed efficacy trials would explicate the underlying theory of how alarms could produce reductions in assaults in the varying conditions present in the different types of settings in which healthcare staff members are at high risk of assault.

The underlying theory would specify the preventive mechanisms that alarms could activate, and the type of alarm system and complementary conditions that would be needed if the preventive mechanisms were to be activated. In particular, trials to address the different categories and mechanisms of alarms (audible or silent), and their intended outcome (to reduce the severity of assaults or deterrence) should be considered. Experimenters would then work closely with those managing and working within the trial sites to operationalize the system in the theoretically specified ways. They would track both the capital and maintenance costs involved in the system, note implementation hurdles encountered and how they were overcome, and focus on the details of the expected short and long-term changes in levels of assault in experimental as against matched comparison sites. Long-term tracking is advocated given the possibility that staff and patient turnover and adaptation to the alarm system may change the way in which the alarm system operates over time.

Assuming that the trial produced promising findings, subsequent trials could then relax the artificial conditions imposed by the efficacy trial to try to discern whether and how alarms might be applied cost-effectively in packages of measures to reduce violence in healthcare settings.

Conclusion

There is a clear and urgent need for preventative measures to reduce violence experienced by NHS personnel. There is evidence of substantial variations in risk across different healthcare sectors, primary patient populations and clinical conditions. The literature discusses a wide range of preventative measures aimed at reducing assaults. There are also diverse types of alarm system available to address the problem. Additionally, different assault reduction interventions, including alarms, may interact with one another. In this complex and diverse field, decision makers need to be able to make informed choices to select measures that will work cost-effectively in their setting. So far, however, little research or evidence has emerged to estimate their effectiveness, or to address the different ways in which different systems may be effective in varying settings.

There is a strong need to build a knowledge base that is fit for purpose and therefore in the short term, the authors suggest EMMIE-focused efficacy trials to try to gauge the potential preventive benefits from alarms as a prelude to future field trials. Further, if the findings of the efficacy trials are positive, to ascertain whether their routine deployment in high-risk settings could be recommended as a cost-effective option.

Authors' contributions
The topic for this review was selected in consultation with the College of Policing. All authors, with the exception of NT, contributed to the search strategy, data extraction, and analyses. CP and NT drafted the final manuscript. All authors read and approved the final manuscript.

Authors' information
Chloe Perkins is a postdoctoral researcher in the Faculty of Epidemiology and Population Health at the London School of Hygiene and Tropical Medicine. Her interests include environmental exposure modelling and assessment. Deirdre Beecher is Senior Metadata Specialist with Cochrane. Her interests include search methods, and metadata management and vocabulary building. David Colas Aberg is a Ph.D. student and Research Assistant in the Department of Security and Crime Science, University College London. His research interests include bone mechanics and the diagnoses of accidental and non-accidental bone traumas in children. Phil. Edwards is an Associate Professor in Epidemiology and Statistics at the London School of Hygiene and Tropical Medicine. His research interests are in the epidemiology of unintentional injury, particularly injuries caused within the transportation system. He has evaluated the effects on road safety and crime of reduced street lighting in the UK. Nick Tilley is a professor in the Department of Security and Crime Science, University College London. His research interests include evaluation methodology, the international crime drop, situational crime prevention and policing.

Author details
[1] Faculty of Epidemiology and Population Health, London School of Hygiene & Tropical Medicine, London, UK. [2] Cochrane Central Executive Team/IKMD, London, UK. [3] Department of Security and Crime Science, University College London, 35 Tavistock Square, London WC1H 9EZ, UK.

Acknowledgements
The authors would like to thank Rachel Armitage and Saskia Garner for reviewing an earlier version of this paper. Their comments led to substantial improvements. This project is part of the University Consortium for Evidence-Based Crime Reduction and was funded by College of Policing and the Economic and Social Research Council (ESRC); RC Grant Reference: ES/L007223/1. The views and opinions expressed herein are those of the authors and do not necessarily reflect those of the College of Policing or ESRC.

Stakeholder involvement
Jason Pott, Lead Research Nurse in the Emergency Department of the Royal London Hospital, provided advice to the investigative team in the review development (Appendix 4). In our experience, user input is particularly valuable in considering outcomes of interest to users, and identifying preferred methods of disseminating results to user groups.

Competing interests
The authors declare that they have no competing interests.

Consent for publication
Not applicable.

Ethics approval and consent to participate
Does not apply. As a review of summary data from previously conducted research, no humans (or their tissues) participated as subjects in this research.

Funding
The research reported here was funded by the Economic and Social Research Council (ESRC) Grant ES/L007223/1 and the College of Policing.

Appendix 1: Search strategy

Ovid MEDLINE(R), Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations, Ovid MEDLINE(R) Daily and Ovid OLDMEDLINE(R)

1. Aggression/
2. violence/or workplace violence/
3. Verbal abuse.mp.
4. Physical abuse.mp.
5. Dangerous Behavior/
6. anger/or frustration/or hostility/
7. (language adj3 (menacing or discrimin* or insult* or abuse or threat*)).ab,ti.
8. (workplace adj3 (disturb* or violence)).ab,ti.
9. (violen* or aggress* or hostil* or fight* or abuse* or accident* or assault*).ab,ti.
10. ((physical or verbal) adj3 (attack* or threat* or abuse* or violence or aggression or insult*)).ab,ti.
11. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10
12. ((personal or fixed or portable or emergency) adj3 (alarm* or device*)).ti,ab.
13. ((staff or employee*) adj3 (safe* or protect* or secur*)).ti,ab.
14. risk management/or safety management/ or security measures/
15. Rape/pc [Prevention & Control]
16. Sex Offenses/pc [Prevention & Control]
17. ((panic or alarm or help or SOS) adj3 (bell* or button*)).ti,ab.
18. ((warning or security or alert*) adj3 device*).ti,ab.
19. 12 or 13 or 14 or 15 or 16 or 17 or 18
20. 11 and 19.

Notes:
[mp.=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier].

Appendix 2: Standardised data extraction

Text was coded from included studies under the following data extraction categories:

Study design
- Meta-analysis;
- RCT;
- Controlled interrupted time series;
- Controlled before and after;
- Before/after not controlled;
- Cross sectional;
- Case study;
- Qualitative;
- Commentary.

Study length
- Dates of before period;
- Dates of after period.

Study setting
- Country;
- Healthcare setting (e.g. community based, emergency or inpatient hospital department);
- Other.

Study aims

Effect

Methods
Participants
Intervention (e.g. fixed alarm, personal alarm)
Comparator/control
Outcome measures
Quality of evidence. To include description and treatment of bias and confounding

- Matching of intervention and control areas (e.g. the comparability of the settings; whether controls are likely to be affected by the intervention);
- Blinding of data collection and analyses;
- Lengths of data collection time period pre- and post-intervention;
- Control of confounders (e.g. was there an assessment of the distribution of confounders between intervention and control groups?);
- Adjustment for time trends;
- Any other potential sources of bias (regression to the mean);
- Selective reporting of results by study authors.

Results—where in full text and quantitative results
- Difference between groups (include CI);
- Interpretation.

Mechanism

Were any of these mechanisms mentioned?

- Increasing risk;
- Reducing reward;
- Removing excuses;
- Increasing effort;
- Other;
- Specific deterrence;
- General deterrence.

Were any mentioned mechanisms tested?

Were any intermediate outcome measures taken to assess the activation of the causal mechanism(s) judged to underpin the intervention?

Moderators

Country of implementation

Setting of intervention (e.g. hospital ED, inpatient department, community setting)

Setting characteristics

Was the intervention implemented in isolation? (Standalone/package/unclear)

What type of technology was used?

Implementation (what is needed to implement the use of intervention)

Implementation factors mentioned

Implementation factors stated to be necessary for success

Who is responsible for deciding eligibility/location of intervention sites?

Who is responsible for setting up, operating and maintaining the intervention?

Obstacles to implementation

Resources required

Any personnel requirements (training, monitoring of system).

Economics

Cost of programme set up

Annual running costs

Cost of a personal alarm

Cost of assaults prevented

Cost of personnel/hours

Direct and indirect benefits

Benefit cost ratio/cost benefit analysis.

Appendix 3: Characteristics of studies

Gale, 2002 (New Zealand)

Methods	Cross sectional survey questioning provision of preventative measures and reported violence
Participants	Managers of the 219 psychiatric units in New Zealand
Interventions	No intervention
Outcomes	Reported incidents over the last year of: property damage, attempted assault, physical attack, sexual harassment and stalking over last 12 months
Notes	The use of pocket alarms and panic buttons were surveyed, and analysed (Mann–Whitney U test) to look for associations with reported outcomes

Gerberich, 2005 (USA)

Methods	Survey with nested case–control study, multiple logistic regression to explore risk factors (environmental and personal protection factors) for physical violence
Participants	6300 Minnesota nurses (selected randomly from licensing database), nested case control included full questionnaires from 310 cases and 946 control subjects
Interventions	No intervention
Outcomes	Self-reported cases of assault in the previous 12 months
Notes	Survey included question on the use of mobile telephones and personal alarms (either their own or provided by employer) and occupational violence experience

Farrell, 2014 (Australia)

Methods	Cross sectional survey. Binary logistic regression analysis to determine how protective factors were associated with occurrence of PVA (patient and visitor assault)
Participants	Random sample of nurses and midwives registered with Nurses Board of Victoria
Interventions	No intervention
Outcomes	Prevalence of PVA from self reported assaults, over four most recent working weeks PVA defined as "any incident where an employee is abused, threatened or assaulted in circumstances arising out of, or in the course of their employment, where. . .a person to believe that they are in danger of being physically attacked, and may involve an actual or implied threat to safety, health or wellbeing. . . . Neither intent nor ability to carry out the treat is relevant; the key issue is that the behaviour creates a risk to health and safety"
Notes	Participants responded giving their experiences of PVA over their four most recent working weeks also provided information on 'protective factors' including personal protective equipment (e.g. personal duress alarms)

Landau, 2008 (Israel)

Methods	Cross sectional survey with multivariate regression to determine contribution of various factors to explanation of violence against emergency ward personnel
Participants	3000 questionnaires distributed to all types of staff in emergency wards of all 25 general hospitals in Israel
Interventions	No intervention
Outcomes	Self reported violent incidents during the course of their work, in the previous year—used to generate a GEVI (General Index of Exposure to Violence)
Notes	Multivariate regression used to determine contribution of various factors (professional characteristics, personal characteristics, hospital structure including availability of an emergency button) to violence (GEVI)

Appendix 4: Stakeholder interview

Involvement of NHS staff was an important part of the development of this review. Jason Pott, Lead Research Nurse in the Emergency Department of the Royal London Hospital, provided advice during its development. He was selected as a known contact with expertise and experience in the NHS. He told us that violence against staff is multifaceted and he believes a broad approach would be most effective in prevention.

> *"The Emergency Department is a complex and stressed environment where patients are not in control and are 'at the mercy of staff'. [Waiting] time is a major factor, in addition to intoxication and pain... there are a number of flash points which can trigger aggression... Any intervention has to be considered to terms of its practical application within the ED."*

Jason estimates that physical assaults on staff occur weekly in the ED at Royal London and verbal assaults occur daily. There is a pervasive culture that this is the accepted norm and particularly in ED, while tolerance may be lower in inpatient and outpatient settings. It is a uniquely high stress/risk environment (the Royal London ED has 14–16 nurses for 450 patients per day, and up to 50 patients in the department at one time). Factors making assaults likely include high emotions and anxiety

(for patients or relatives) and aggressive language is commonly used and accepted.

> *"The system that is implemented needs to be whole system…there needs to be agreement from all stakeholders on how all parties will uphold an approach. Inconsistency weakens all the members of the team and prevents the public from seeing the zero tolerance approach. Red-carding from A&E is almost unheard of, and those who are removed are rarely physically violent, but are chronic patients with complex needs which is more concerning."*

Jason commented on the range of interventions that have been proposed to reduce violence against NHS staff.

Environmental factors

CCTV this is widely implemented and has its usefulness but requires monitoring and is often under resourced. There would be resistance from nursing staff to have these and they could not be used in cubicles where risk is highest, to protect patient privacy.

Fixed emergency alarms in the past, personal security alarms have been issued to ED staff at the Royal London, but these were often forgotten, misplaced, and handover after each shift was inefficient. Fixed call alarms in cubicles might be a better solution (current 'arrest' alarms do not provide location information).

Security guards are well utilised in the Royal London ED. They are effective and engage well with staff but are anxious about clinical issues and their role in restraint of patients. This makes them cautious when considering removing patients. Security staff are only able really to act under instruction of the clinical staff which requires resources to manage.

Police officers police presence in the ED was an effective policy but cannot be resourced. Some clinical staff feel poorly supported by the police in real situations.

Building access most EDs have worked hard to lock down departments and the new emergency department at Royal London has restricted access doors. This is an ongoing struggle and is impossible to police because patients often arrive with other people and this needs to be tolerated.

Ambient environments, lighting and calming décor décor is challenging and if hospitals are managed through a PFI then the Trust does not have control of the decoration. Lighting is always well lit, possibly aggressively so.

Practices and policies

NHS Security Incident Reporting System (SIRS) is an electronic tool to report security incidents on the premises to *NHS Protect*, to aid in detecting and preventing crime in a national, regional and sector specific context.

Jason told us there is a strong feeling that violence and aggression in Emergency Departments remains underreported. Verbal aggression is almost never reported to the police; and where reported there is often a resistance to arrest anyone, or at least there is inconsistent treatment of offenders. There have been accounts of police reluctance to take patients who may have mental/physical health issues. There is also some reluctance from ED staff to report anything but the most serious cases to the police, due to the resources required to report and give statements (i.e. to maintain patient care in a busy ward they cannot afford staff to be away from patients for 40 min to report an incident). Incidents may be reported but are often not escalated to the police. Reporting needs to be supported at different managerial levels, allowing for whether a patient's ill health is a contributory factor.

'Zero tolerance' policies policies are only partially implemented (i.e. physical aggression, but not verbal aggression). The zero tolerance message does not seem to be delivered on the 'shop floor'; it seems to be a 'headline' policy and doesn't deter those individuals who are most likely to offend against NHS staff. There is also poor implementation and support for the policy: the core 'quality' indicators, upon which EDs are judged, include things such as admission/discharge times, times for triage from ambulance, patient satisfaction; while violence against staff is not included.

Staff skills

The NHS provides compulsory 1 day *Conflict Resolution* training to all front-line staff. The training includes components of self-defence, personal awareness, conflict avoidance techniques, 'proportional force' and reinforcement that staff should not expect to be hit. It costs around £250 to send a nurse on the 1 day course. In addition all ED staff have 'de-escalation' and breakaway training.

Publisher's Note

Received: 30 October 2017 Accepted: 18 November 2017
Published online: 28 November 2017

References

Anderson, L., FitzGerald, M., & Luck, L. (2010). An integrative literature review of interventions to reduce violence against emergency department nurses. *Journal of Clinical Nursing, 19*(17–18), 2520–2530.

Bowers, K. J., & Johnson, S. D. (2003). *Reducing burglary initiative: The role of publicity in crime prevention*. London: Home Office.

Bowers, K. J., & Johnson, S. D. (2005). Using publicity for preventive purposes. In N. Tilley (Ed.), *Handbook of crime prevention and community safety* (pp. 329–354). Devon, UK: Willan Publishing.

Cohen, L. E., & Felson, M. (1979). Social change and crime rate trends: A routine activity approach. *American Sociological Review, 44*(4), 588–608.
College of Policing. (2015). Crime Reduction Toolkit: CCTV 2015. Retrieved from http://whatworks.college.police.uk/toolkit/Pages/Intervention.aspx?InterventionID=1.
Commission HaS. (1997). *Violence and aggression to staff in health services: guidance on assessment and management (2nd ed)*. Norwich: Commission HaS.
Deeks, J., Dinnes, J., D'Amico, R., Sowden, A., Sakarovitch, C., & Song, F. (2003). Evaluating non-randomised intervention studies. *Health Technology Assessment, 7,* 27.
Deeks, J. J., Higgins, J. P., & Altman, D. G. (2011). Chapter 9: Analysing data and undertaking meta-analyses. In J. P. Higgins & S. Green (Eds.), *Cochrane handbook for systematic reviews of interventions*. Lisa Bero: The Cochrane Collaboration.
Dixon, D. (2016). A five year analysis of physical assaults against NHS staff in England: SIRS/RPA violence report 2010–2015.
Farrell, G., Buck, W., & Pease, K. (1993). The merseyside domestic violence prevention project: Some costs and benefits. *Studies on Crime and Crime Prevention, 2,* 21–33.
Farrell, G. A., Shafiei, T., & Chan, S.-P. (2014). Patient and visitor assault on nurses and midwives: An exploratory study of employer 'protective' factors. *International Journal of Mental Health Nursing, 23,* 88–96.
Farrington, D. P., Gill, M., Waples, S. J., & Argomaniz, J. (2007). The effects of closed-circuit television on crime: Meta-analysis of an English national quasi multi-site evaluation. *Journal of Experimental Criminology, 3,* 21–38.
Felson, M., & Eckert, M. (2016). *Crime and Everday Life* (5th ed.). Uitgever: SAGE Publications, Inc.
Gale, C., Pellett, O., Coverdale, J., & Paton, Simpson G. (2002). Management of violence in the workplace: A New Zealand survey. *Acta Psychiatrica Scandinavica, 412,* 41–43.
Gerberich, S. G., Church, T. R., McGovern, P. M., Hansen, H., Nachreiner, N. M., Geisser, M. S., et al. (2005). Risk factors for work-related assaults on nurses. *Epidemiology, 16*(5), 704–709.
Godwin, M., Ruhland, L., Casson, I., MacDonald, S., Delva, D., Birtwhistle, R., et al. (2003). Pragmatic controlled clinical trials in primary care: The struggle between external and internal validity. *BMC Medical Research Methodology, 3*(1), 28.
Health and Safety Executive. (2017a). Work-related violence: Lone workers: Health and Safety Executive. Retrieved June 20, 2017, from http://www.hse.gov.uk/violence/conclusions.htm#a2.
Health and Safety Executive. (2017b). Violence at work. Health and Safety Executive.
Home Office. (2017). *Research Study 217: The economic and social costs of crime*. London: Home Office.
Ipsos MORI. (2010). *Violence against frontline NHS staff—research for COI on behalf of the NHS Security Management Service*. London: Ipsos MORI.
Johnson, S. D., Tilley, N., & Bowers, K. J. (2015). Introducing EMMIE: An evidence rating scale to encourage mixed-method crime prevention synthesis reviews. *Journal of Experimental Criminology, 11*(3), 459–473.
Landau, S. F., & Bendalak, Y. (2008). Personnel exposure to violence in hospital emergency wards: A routine activity approach. *Aggressive Behavior, 34*(1), 88–103.
Laycock, G. (1991). Operation identification or the power of publicity? *Security Journal, 2,* 67–71.
Loudon, K., Treweek, S., Sullivan, F., Donnan, P., Thorpe, K. E., & Zwarenstein, M. (2015). The PRECIS-2 tool: designing trials that are fit for purpose. *British Medical Journal, 350,* 2147.
National Audit Office. (2003). *A safer place to work. Protecting NHS Hospital and ambulance staff from violence and aggression*. London: Office NA.
NHS Counter Fraud and Security Management Service. (2003). *Protecting your NHS—a professional approach to managing security in the NHS*. London: NHS.
NHS Protect. (2013). *Conflict resolution training: Implementing the learning aims and outcomes*. London: NHS Protect.
NHS Protect. (2014). *Business plan 2014–2015*. London: NHS Protect.
NHS Protect. (2015). *Lone worker estate mapping exercise*.
NHS Protect. (2017a). Reported physical assaults on NHS staff figures: NHS Business Services Authority. Data on reported physical assaults against NHS staff in England between 2004–2005 and 2015–2016 is available on this page. Retrieved February 1, 2017, from https://www.nhsbsa.nhs.uk/crime-prevention/nhs-protect-statistics.
NHS Protect. (2017b). A guide for the better protection of lone workers in the NHS.
NHS Security Management Service. (2010). Cost of violence against NHS staff. A report summarising the economic cost to the NHS of violence against staff 2007/2008.
(NICE) NIfHaCE. (2006). *Violence: The short-term management of disturbed/violent behaviour in in-patient psychiatric settings and emergency departments*. London: NIfHaCE.
Occupational Health & Safety Agency for Healthcare. (2005). *Preventing violent and aggressive behaviour in healthcare: A literature review*. Vancouver, Canada.
Oztunc, G. (2006). Examination of incidents of workplace verbal abuse against nurses. *Journal of Nursing Care Quality, 21*(4), 227–232.
Rew, M., & Ferns, T. (2005). A balanced approach to dealing with violence and aggression at work. *British Journal of Nursing, 14*(4), 227–232.
Schünemann, H. J., Oxman, A. D., Vist, G. E., Deeks, J. J., Glasziou, P., & Guyatt, G. H. (2011). Chapter 12: Interpreting results and drawing conclusions. In J. P. Higgins & S. Green (Eds.), *Cochrane handbook for systematic reviews of interventions (version 5.1.0 ed.)*. Lisa Bero: The Cochrane Collaboration.
Sherman, L. (2013). The rise of evidence-based policing: Targeting testing and tracking. *Crime and Justice, 42*(1), 337–451.
Sidebottom, A., Tompson, L., Thornton, A., Bullock, K., Tilley, N., Bowers, K. J., et al. (2017). Gating alleys to reduce crime: A meta-analysis and realist synthesis. *Justice Quarterly.* http://dx.doi.org/10.1080/07418825.2017.1293135
Spector, P., Zhou, Z., & Che, X. (2014). Nurse exposure to physical and non-physical violence, bullying and sexual harassment: A quantitative review. *International Journal of Nursing Studies, 51,* 72–84.
Suzy Lamplugh Trust. (2016). Personal alarms 2016. Retrieved February 12, 2016.
Thomas, H. (2003). *Quality assessment tool for quantitative studies*. Toronto: McMaster University.
Wells, J., & Bowers, L. (2002). How prevalent is violence towards nurses working in general hospitals in the UK? *Journal of Advanced Nursing, 39*(3), 230–240.
Welsh, B. C., & Farrington, D. P. (2009). Public area CCTV and crime prevention: An updated systematic review and meta-analysis. *Justice Quarterly, 26*(4), 716–745.