

BMJ Open Is the introduction of violence and injury observatories associated with a reduction in violence-related injury in adult populations? A systematic review and meta-analysis

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ABSTRACT

Objective The aim of this study was to summarise the results from existing studies reporting on the effectiveness of the introduction of violence and injury observatories (VIOs).

Design This is a systematic review and meta-analysis study.

Data sources We searched multiple electronic databases including but not limited to PubMed, PsycINFO, SCOPUS, Cochrane Collaboration, Campbell Collaboration and Web of Knowledge.

Eligibility criteria We included non-randomised controlled trials, quasi-experimental designs, prospective and retrospective cohort studies, controlled before-and-after studies and cross-sectional studies. We sought to include studies performed in any country and published in any language. The primary outcome was homicide, while the secondary outcome was assault.

Data extraction and synthesis We searched a number of databases, supplemented by searches in grey literature including technical reports. Searches comprised studies from January 1990 to October 2018.

Results Of 3105 potentially relevant unique citations from all literature searches, 3 empirical studies and 4 technical reports met our inclusion criteria. Studies were conducted in the UK (n=3), Colombia (n=2), Brazil (n=1) and Uruguay (n=1). Subgroup analyses according to the two types of models implemented, the VIO and the injury surveillance system (ISS), provided evidence for an association between implementing the VIO model and a reduction in homicide count in high-violence settings (incidence rate ratio (IRR)=0.06; 95% CI 0.02 to 0.19; four studies), while the introduction of ISS showed significant results in reducing assault (IRR=0.80; 95% CI 0.71 to 0.91; three studies).

Conclusion This systematic review provides the best evidence available for the effectiveness of the introduction of VIOs and ISSs in reducing violence outcomes in adults in high-violence settings. The implementation of VIOs should be considered in high-violence communities where reduction in homicide rates is desired.

PROSPERO registration number CRD42014009818.

Strengths and limitations of this study

- This is the first systematic review to assess the impact of violence and injury observatories (VIOs) and injury surveillance systems targeting violence reduction among an adult population.
- This review incorporated a range of search approaches among a number of databases, without language restriction, to ensure a comprehensive strategy in evaluating the evidence.
- There is a paucity of studies on the effectiveness of VIOs in reducing violence in adult populations, thus limiting conclusions on evidence.

INTRODUCTION

The WHO reports that 1.6 million people die annually from violence, officially recognising violence as a global health issue.¹ South Africa's homicide burden is seven times the global average.² Interpersonal violence is the third leading cause of premature death in South Africa (approximately 4.4% of all years of life lost), according to the 2010 Global burden of disease study estimates which use vital registration data.³ Mortuary data record significantly more homicides, which suggests a greater disease burden contribution of interpersonal violence.⁴

An observatory is a specialised informational repository and knowledge-building centre, housing cross-referenced databases with advanced analytical and research capacities.⁵ A violence and injury observatory (VIO) is primarily a tool to improve knowledge regarding security to produce targeted and effective interventions. It may be employed as a diagnostic tool measuring the degree of violence in a defined region over time and may additionally serve to monitor and evaluate the impact of measures adopted.

To date, there has been no systematic review of the literature to present a succinct review of the evidence. We therefore sought to summarise the evidence from existing studies on the contribution of VIOs towards violence prevention in adult populations.

Observatories for violence and injury

The model relies on collaboration between data stakeholders, government and non-government actors within the violence prevention and safety cluster.

The observatory seeks to collate and integrate all violence and injury-related data and not limit itself to a clinical perspective, but rather incorporates a public health approach which considers a broader contextual understanding of the data with regard to forensics (unnatural deaths), violence-related crimes, victim of crime surveys (unreported crimes), emergency medical services (EMS) violent incident data, structural correlates of violence (census data) and, finally, non-fatal trauma cases through hospital clinical database.

As described in detail previously,^{6,7} key functions of an observatory include

1. Observatory function 1: collection, integration and storage of secondary data and information.
2. Observatory function 2: data analysis.
3. Observatory function 3: reporting on and disseminating information and knowledge.

Historical background of the VIO model

Between 1993 and 1996, the mayoral administration of Cali, the third most populous city in Colombia, instituted a programme of development, security and peace, referred to as DESEPAZ.⁸ This programme applied a public health perspective to issues of violence prevention and intervention, influenced by the mayor's background in epidemiology, and would establish the framework for the first ever observatory dedicated to the theme of violence and injury.⁸ The information was subsequently validated, supplemented and used in weekly meetings of the city's Security Council, whose primary focus was citizen security issues; however, the council also sought to improve the coordination and efficiency in the use of resources.⁸

Following a thorough review of the data, further statistical analysis led to subsequent policy planning and coordinated intervention efforts by civil authorities.⁸ Concurrently, structural interventions to improve police functioning through the provision of pay increases, educational opportunities and housing construction incentives were implemented.⁹ These initiatives would provide the initial framework for later developments with the VIO model.

In the area of international violence prevention approaches, there has been a growing interest on the part of governments, municipalities, research centres, civil society organisations and international organisations in creating observatories or analytical tools for security-related problems, including, but not limited to, school violence, domestic violence, drug use and social and gender violence.¹⁰ Table 1⁷ provides a sample of VIOs found globally.

METHODS

This review protocol¹¹ has been published in the PROSPERO International Prospective Register of systematic reviews (<http://www.crd.york.ac.uk/PROSPERO>), registration number 2014: CRD42014009818.

CRITERIA FOR CONSIDERING STUDIES FOR THIS REVIEW

Type of studies

We included non-randomised controlled trials (RCTs), quasi-experimental designs, prospective and retrospective cohort studies, controlled before-and-after studies and cross-sectional studies. Studies performed in general or specific populations and in hospitals or clinics were included. Additionally, we sought to include studies performed in any country and published in any language.

Types of participants

Participants for this study included adults ≥ 18 years of age who are located within the catchment areas of the observatory study sites.

Types of interventions/exposures

For purposes of the systematic review, we have used the term 'observatory' to denote a surveillance system that collects data from multiple sources, for example, crime

Table 1 A sample of violence and injury observatory locations and websites found globally

Observatory name	Location	Website
Central-American Observatory of Violence	El Salvador	http://www.ocavi.com
Centre for Crime and Public Safety Studies	Belo Horizonte, Brazil	http://www.crisp.ufmg.br/
CISALVA Institute	Cali, Colombia	http://prevencionviolencia.univalle.edu.co
Departmental Observatory for Violence Towards Women France	Île-de-France, France	http://www.seine-saint-denis.fr/-Observatoire-departemental-des-.html
National Observatory on Violence and Crime	Uruguay	http://www.minterior.gub.uy/webs/observatorio
Observatory for Safety and Peaceful Coexistence of the Juárez Municipality	Juárez, Mexico	www.observatoriodejuarez.org

data from policing sources and injury data from clinical and forensic sources, whereas injury surveillance systems (ISSs) almost exclusively focus on the use of injury data alone from clinical sources. We included observatories/ISSs that address violence prevention and whether these reduce violence in adult populations. All surveillance systems that focus specifically on the collection of violence and injury data were included in this review.

Types of comparisons

Controlled populations were extracted as presented in the respective articles. Control data were drawn from preintervention figures as specified by the authors. Where no data were supplied or documented, we extrapolated preintervention information from cities with a similar population size and make-up within the surrounding regions.

Types of outcome measures

Violence is defined as the intentional threat or use of physical force against oneself, another person or a group or community that results in injury, death, psychological harm, maldevelopment or deprivation.¹² The outcome measures are based on the Organisation of American States (OAS) regional system of standardised indicators in peaceful coexistence and citizen security,¹³ as they represent the largest member organisation of crime and violence observatories worldwide, and included measures obtained by administrative record or surveys.

Primary outcomes

Primary outcomes included murder/homicide, suicide, transit death, unintentional injury death, sexual violence and intrafamily/family/domestic violence.¹³

Secondary outcomes

Secondary outcomes included aggravated assault, crime victimisation and the perception of insecurity, fear or risk.¹³

Patient and public involvement

Patients and/or the public were not involved in this research.

SEARCH METHODS FOR IDENTIFICATION OF STUDIES

The search of databases and grey literature was performed by AJ with the help of the University of Cape Town Health Sciences' librarian, to identify all relevant studies available at October 2018, regardless of language or publication status. Peer-reviewed journal articles and grey literature (postgraduate theses, unpublished, internal or non-reviewed papers and technical reports) were also searched. Search terms included combinations of keywords relating to violence and crime, and prevention and control. See online supplementary table 1 for the complete strategy.

Database

We searched the following electronic databases: PubMed, Sociological Abstracts and International Bibliography

of the Social Sciences and Education Resources Information Centre via Proquest, PsycINFO and Cumulative Index to Nursing and Allied Health Literature and Humanities International via EBSCOhost, SCOPUS, Cochrane Collaboration, Campbell Collaboration, Social Care Online, National Criminal Justice Reference Service, Web of Knowledge and Regional databases of the WHO. The searched Spanish databases included Spanish National Research Council, Epistemonikos, Evidence-informed policy network, Universidad de La Rioja, Red de Revistas Científicas de América Latina, el Caribe, España y Portugal, Scientific Electronic Library Online and the Virtual health library.

Furthermore, the following websites were searched for relevant literature: websites of the WHO Violence Prevention Alliance (<http://www.who.int/violenceprevention/en/>), Blueprints for Violence Prevention (<http://www.colorado.edu/cspv/blueprints>), the Community Guide (<http://www.thecommunityguide.org/violence/index.html>), Centres for Disease Control and Prevention (<http://www.cdc.gov/ViolencePrevention/index.html>), The World Bank (<http://www.worldbank.org>), the Juarez violence and injury observatory (<http://observatoriodejuarez.org/dnn/ENGLISH.aspx>) and the Medical Research Council (MRC) burden of disease research unit (<http://www.mrc.ac.za/bod/bod.html>).

In addition, the following conference proceedings were searched for relevant abstracts: International Conference on Crime Observatories, United Nations Congress on Crime Prevention and Criminal Justice, Global Violence Reduction conference, Annual Meeting of Violence Prevention Alliance and the International Society for Violence and Injury Prevention international conference. We used both text words and medical subject headings terms. The terms were used in varying combinations. Reviewers also searched reference lists of the relevant studies identified.

DATA COLLECTION AND ANALYSIS

Selection of studies for inclusion

Review authors used a screening guide developed by AJ to ensure that inclusion criteria are consistently applied. Two review authors (AJ and DB), working independently, screened the titles and abstracts of all studies identified through the English literature searches for eligibility. MC and FF completed the same process for the Spanish language studies. Full texts of potentially eligible studies were obtained by AJ. The two authors (AJ and DB) independently assessed the full text of each article for eligibility and compared their results. Again, this was repeated by MC and FF for the Spanish language studies. Discrepancies were resolved through discussion and consensus, consulting a third author (MEE) to resolve any persistent disagreements. All reviewers documented the reasons for all studies excluded from the systematic review.

Data extraction and management

Two authors independently extracted descriptive and outcome data for each included article using a standardised data collection form, resolving any discrepancies by discussion and consensus, failing which a third author (MEE) would arbitrate.

Review Manager V.5.1 statistical software (<http://ims.cochrane.org/RevMan>) was used by AJ, while DB cross-checked the data entered to ensure that there were no data entry errors. References were managed using Mendeley V.1.19.3.

Incidence rate ratios (IRRs) were calculated from the extracted data.

Assessment of risk of bias in included studies

Two reviewers assessed all included studies using the Effective Public Health Practice Project (EPHPP) questionnaire, which is a quantitative study assessment tool to identify methodological issues.¹⁴ The criteria used to assess the risk of bias in RCTs were random sequence generation; allocation concealment; blinding of participants and study personnel; blinding of outcome assessors; incomplete outcome data; selective outcome reporting; other sources of bias and overall risk of bias, in accordance with the methods used by the Cochrane Collaboration and the EPHPP tool. The criteria used for risk of bias assessment for non-randomised studies include selection bias (dealing with confounding, adjustment and comparability of groups); performance bias (in terms of the fidelity of the interventions); detection bias (regarding unbiased and correct assessment of outcomes, including blinding of assessors); attrition bias (with regard to completeness of sample, follow-up and data); and reporting bias (with regard to publication biases and selective reporting of results).¹⁴ Studies were scored as having low, high or unclear risk of bias. Any disagreements between the two authors in the assessment of risk of bias were resolved in discussion and consensus and the consultation of a third author where necessary.

Data synthesis including assessment of heterogeneity

Data analysis was managed using STATA statistical software.¹⁵ Meta-analyses using the metan routine (metan logirr selogirr) were conducted by combining IRRs defined as the incident rate of violence outcomes (homicide or assault) before and after the introduction of a VIO or ISS. The random effects model was used. Heterogeneity was assessed by examining types of participants, interventions and outcomes in each study. Statistical heterogeneity was assessed using the χ^2 test and quantified with the I^2 statistic.¹⁶ Where heterogeneity was apparent, findings are discussed as a narrative summary.

Subgroup analyses

Subgroup analyses examining the VIO model (comprising aggregated data from regional clinical centres and mortuaries for homicide data) versus the ISS model (public hospital data) were performed.

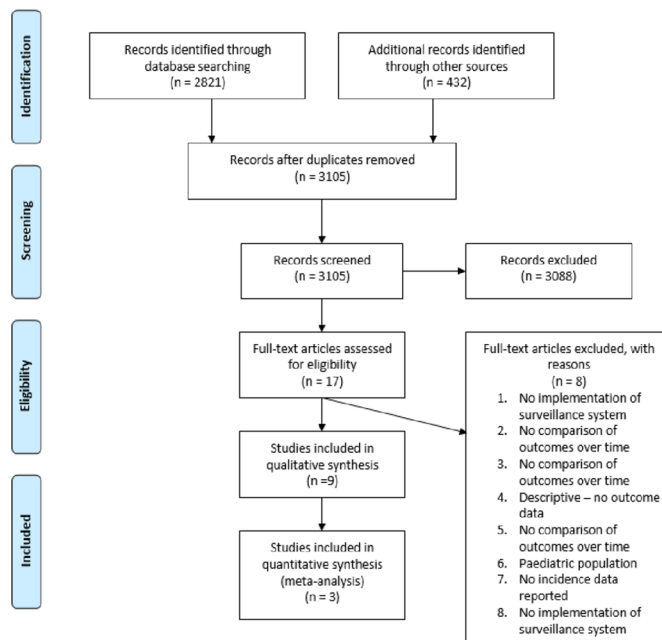


Figure 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram for studies from English databases.

Assessment of quality of evidence

We used the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach to assess the quality of evidence for the contribution of the observatory towards violence prevention.¹⁷ The GRADE approach specifies four levels of quality ranging from high to very low, with the highest quality rating denoting a confidence that the true effect lies close to the estimate of the effect. Quality was rated according to an a priori identification of potential participant-centred outcomes, including benefits and harms.¹⁷ Two authors independently assigned the grade scores and compared results as per the process for the recording of previous aspects of the study. Discrepancies were resolved by consensus discussion between the two primary reviewers (AJ and DB), with arbitration by a third reviewer (MEE) as necessary.

Sensitivity analyses

We performed sensitivity analyses to determine the effect, if any, of type, and quality assessment of publication on outcome.

RESULTS

Description of included studies

The study selection process identified 3105 potentially relevant unique citations from all literature searches (figures 1 and 2 detail the results from English and Spanish databases, respectively). Of the 21 studies deemed potentially eligible for inclusion, 9 English language studies and 7 Spanish technical reports met the inclusion criteria. Three studies were conducted in the UK, with the remaining studies taking place in Colombia, Brazil,

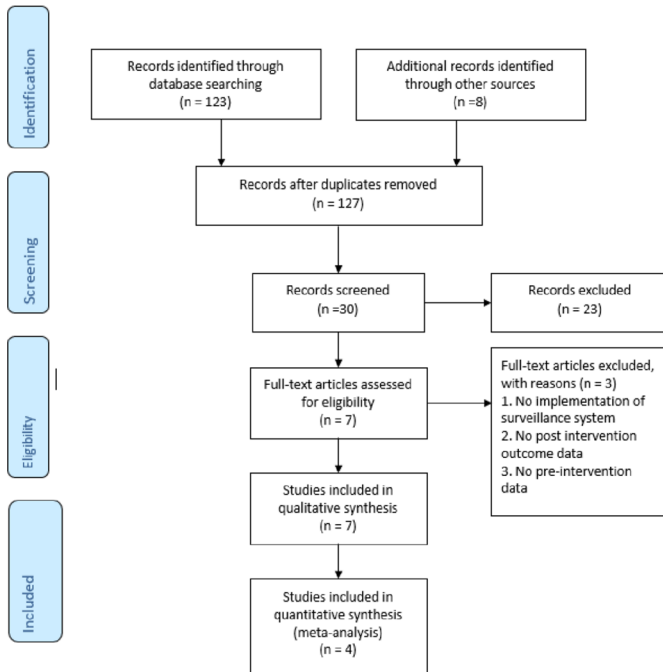


Figure 2 Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram for studies from Spanish (n=3)/Portuguese (n=1) databases.

Mexico and Uruguay. Data from technical reports were used in the five studies arising from South America. All studies were published after 1990. No studies were RCTs. Control data were reported in all the empirical studies in the form of preintervention figures. None of the technical reports had control data, and thus estimates were extrapolated from World Bank open data.¹⁸

Details of studies included in the review are presented in [table 2](#). Reasons for the 10 studies excluded from the systematic review are detailed in [table 3](#).

Meta-analysis across all studies was not possible, given the heterogeneity in both the model and the nature of outcome reported. Subgroup analyses were thus conducted according to the two types of models implemented ([table 4](#)): three empirical studies used assault count as an outcome, while four technical reports used homicide rate. One technical report,¹⁹ initially deemed eligible for meta-analysis, was considered an outlier after closer inspection, and subsequently, excluded from the meta-analysis; instead, it is discussed in a narrative review below. The quality assessment of the included studies is described in [table 5](#).

Overall effect of violence interventions

The pooled crude IRR for the seven violence intervention studies was 0.18 (95% CI 0.05, 0.71) ([figure 3](#)). Heterogeneity was observed across studies (I² statistic 100%).

Subgroup analysis by model of surveillance system indicates an effectiveness for the introduction of a VIO in reducing homicide (IRR 0.06; 95% CI 0.02, 0.19) (four studies, n=44 043 495). In the three studies employing an ISS model, the pooled IRR for the association between the intervention and assault count was 0.80 (95% CI 0.71, 0.91). Sensitivity analyses for language of publication, region and type of report rendered identical results.

Narrative review

Among the six studies included in this review but not included in the meta-analysis, there was no control group

Table 2 Description of the included studies

Author	Country	Setting	Dates	Type of intervention	Outcome	Population size
Arnetz <i>et al</i> 2011 ²⁰	USA	Hospital staff population	2003–2008	ISS	Patient violence report	7 867
Boyle <i>et al</i> 2012 ³¹	England, UK	Public hospital	2001–2011	ISS	Assault count	156 260
Escobedo 2009 ³²	Colombia	National	1995–2006	VIO	Homicide rate	36 823 538
Da Cruz 2010 ³³	Brazil	City	2003–2009	VIO	Homicide rate	2 265 852
Florence <i>et al</i> 2011 ³⁰	Wales, UK	Public hospital	2000–2007	ISS	Assault count	293 507
Franco <i>et al</i> 2012 ³⁴	Colombia	City	1994–2007	VIO	Homicide rate	1 630 009
Garrib <i>et al</i> 2011 ²¹	South Africa	Rural population	2000–2007	DSS	Homicide count	142 859
Gutierrez-Martinez <i>et al</i> 2007 ⁸	Colombia	Municipality	2002–2004	VIO	Homicide count	2 498 089
Hernandez and Hernández 2014 ¹⁹	Mexico	City	2008–2011	VIO	Homicide rate	1 309 272
Mberu <i>et al</i> 2015 ²²	Kenya	Urban informal settlement	2003–2012	DSS	Assault count	56 479
Quigg <i>et al</i> 2011 ²⁹	England, UK	Public hospital	2003–2010	ISS	Assault count	316 210
Ventura and Maciel 2012 ³⁵	Uruguay	National	2005–2012	VIO	Homicide rate	3 324 096
Ward <i>et al</i> 2002 ²³	Jamaica	Public hospital	1998–1999	ISS	Violence-related injuries	575 158
Zhang <i>et al</i> 2014 ²⁴	China	National	2004–2010	ISS	Assault count	1 286 312 905

DSS, demographic surveillance system; ISS, injury surveillance system; VIO, violence and injury observatory.

Table 3 Description of the excluded studies

Author	Reason for exclusion
Biroscaak <i>et al</i> 2006 ³⁶	No comparison of outcomes over time
Luz <i>et al</i> 2011 ³⁷	No comparison of outcomes over time
Clinton-Sherrod <i>et al</i> 2010 ³⁸	No outcome data
Costa Rica 2016 ³⁹	No post intervention data reported
González <i>et al</i> 2018 ⁴⁰	No implementation of surveillance system
London <i>et al</i> 2002 ⁴¹	No comparison of outcomes over time
Odihambo <i>et al</i> 2013 ⁴²	No incidence data reported
Peru 2016 ⁴³	No preintervention data reported
Stone <i>et al</i> 1999 ⁴⁴	Paediatric population
Zavala-Zegara <i>et al</i> 2012 ⁴⁵	No implementation of surveillance system

and thus a statistical effect could not be determined. An additional limitation to these studies, including Arnetz *et al*,²⁰ Gutierrez-Martinez *et al*,⁸ Garrib,²¹ Mberu,²² Ward *et al*,²³ and Zhang *et al*,²⁴ was the lack of preintervention data. Furthermore, Mberu *et al*,²² and Garrib *et al*,²¹ used data from demographic surveillance systems which were data collection tools whose primary focus was not violence-related injuries or outcomes. In the Arnetz 2011 study, the ISS implemented was limited to a large metropolitan multisite hospital system (six hospitals) whose sole focus was the recording of violence incidents that resulted in injuries to patients or hospital employees, thus limiting the generalisability of the results.

With regard to the study setting, each of the six studies had divergent settings. Arnetz *et al*,²⁰ had a focus of violence among the hospital staff population within several regional hospital, while Ward *et al*,²³ was set in a single public hospital. Zhang *et al*,²⁴ focus was national, while Gutierrez-Martinez *et al*,⁸ focused on six municipalities within Colombia. Mberu *et al*,²² looked at an urban slum population on the outskirts of Nairobi, Kenya, while Garrib *et al*,²¹ was set in a northern KwaZulu Natal rural population in South Africa.

In terms of one of the primary outcomes, homicide count, only Garrib *et al*,²¹ and Gutierrez-Martinez *et al*,⁸ reported this outcome of these six included studies which did not undergo meta-analysis. Furthermore, when considering the secondary outcome, assault count, only Mberu *et al*,²² and Zhang *et al*,²⁴ reported this outcome.

Finally, with regard to study design, the lack of a control group was a consistent feature for all six studies.

DISCUSSION

This systematic review provides the best evidence to support the effectiveness of violence surveillance systems in reducing violence-related outcomes in adult populations. This effect was consistent across the introduction of VIOs in reducing mortality and ISSs on lowering assault outcomes. Additionally, this review highlights the paucity of studies evaluating VIOs/ISSs, the lack of rigorously designed studies, publication biases among the South American and European literature and the political context of study locations.

The remarkable reduction of 82% in violence-related outcomes after the implementation of a VIO may be explained by the purposeful sharing and communication of violence-related data between violence prevention stakeholders within a given setting. The Cardiff model which advocates for the sharing of violence-related data between clinical (including EMS) and policing services has demonstrated effectiveness in reducing violence outcomes where implemented.²⁵ The VIOs incorporate this data sharing principle which it extends to other violence prevention stakeholders in its target area including emergency service providers (policing, fire and rescue and clinical), local and provincial government actors, and non-government organisations and researchers working in violence prevention. This whole of society approach is grounded in using the appropriate data from multiple sources to strengthen and improve the monitoring and evaluating of violence. In working closely with the policing serves, interventions to reduce violence may be consistently evaluated and supported or removed using an evidence-based approach to policy. The

Table 4 Studies included in the meta-analysis

Author	Country	Outcome	Focus of intervention	Type of intervention	Preintervention data period (years)	Population size	Effect Size (IRR) (95% CI)
Boyle <i>et al</i> 2012 ³¹	England, UK	Assault count	Public hospital	ISS	2000–2007	156 260	0.91 (0.87 to 0.95)
Col TR 2009 ³²	Colombia	Homicide rate	National (Colombia)	VIO	1994	36 823 538	0.05 (0.05 to 0.05)
Da Cruz 2010 ³³	Brazil	Homicide rate	City (Belo Horizonte)	VIO	2002	2 265 852	0.16 (0.14 to 0.18)
Florence <i>et al</i> 2011 ³⁰	Wales, UK	Assault count	Public hospital	ISS	2000–2003	293 507	0.72 (0.66 to 0.78)
Franco 2012 ⁴⁶	Colombia	Homicide rate	City (Medellin)	VIO	1993	1 630 009	0.01 (0.01 to 0.01)
Quigg <i>et al</i> 2011 ²⁹	England, UK	Assault count	Public hospital	ISS	2003–2004	316 210	0.78 (0.75 to 0.81)
Ventura and Maciel 2012 ³⁵	Uruguay	Homicide rate	National (Uruguay)	VIO	2004	3 324 096	0.19 (0.16 to 0.23)

IRR, incidence rate ratio; ISS, injury surveillance system; VIO, violence and injury observatory.

Table 5 Bias assessment of included studies

Study ID	Bias
Arnetz <i>et al</i> 2011 ²⁰	Selection bias with all cases originating from violence experienced by patients and staff within multisite hospital system (six hospitals)
Boyle <i>et al</i> 2012 ³¹	Study design was non-randomised natural experiment, with withdrawals and dropouts not reported and no blinding noted
Escobedo 2009 ³²	Technical report with no control population
Da Cruz 2010 ³³	Technical report with no control population
Florence <i>et al</i> 2011 ³⁰	Non-randomised study design, with withdrawals and dropouts not reported and no blinding noted
Franco <i>et al</i> 2012 ³⁴	Technical report with no control population
Garrib <i>et al</i> 2011 ²¹	Observational study design with no population data available for rural population. Injury estimates reported.
Gutierrez-Martinez <i>et al</i> 2007 ⁸	Interrupted time series study design, non-randomised with no control population. Withdrawals and dropouts not reported and no blinding noted.
Hernandez and Hernández 2014 ¹⁹	Technical report with no control population
Mberu <i>et al</i> 2015 ²²	Interrupted time series study design, non-randomised with no control population. Withdrawals and dropouts not reported and no blinding noted.
Quigg <i>et al</i> 2011 ²⁹	Six-year exploratory study using descriptive and time trend analyses. Non-randomised with no control population. Withdrawals and dropouts not reported.
Ventura and Maciel 2012 ³⁵	Technical report with no control population
Ward <i>et al</i> 2002 ²³	Observational study design. Non-randomised with no control population. Withdrawals and dropouts not reported and no blinding noted.
Zhang <i>et al</i> 2014 ²⁴	Observational study design. Non-randomised with no control population. Withdrawals and dropouts not reported and no blinding noted.

maintenance of violence data registries within VIOs allow for long-term violence trend analysis, violence prevention intervention development and evaluation, monitoring and evaluation of current violence trends, and through predictive analytics, the modelling of future violence trends. The collation and integration of violence-related data (from multiple sources) and violence prevention stakeholders (from diverse structures) are the core VIO

principles which promote the reduction of violence outcomes where VIOs are implemented.

Sensitivity analyses for language of publication, region and type of report rendered results identical to the subgroup analyses. Technical reports comprise aggregated data sourced from regional or national hospitals and mortuaries. The extraction of data from aggregated data sources may provide a more comprehensive view of the regional burden of violence compared with the extraction from a single study site in the form of a local public hospital. Outcomes were clearly defined and standardised in technical reports, whereas outcomes varied between empirical studies. Furthermore, the OAS in 2007 developed a list of 22 citizen security indicators which were standardised for collection in 19 countries and 2 cities in the central and South American region. This was done to address the regions lack of good quality and up-to-date statistical data. All participating regions have since then collected these indicators routinely and published them in their technical reports related to violence and injury.

We identified several technical issues within most of the included studies including the lack of control or preintervention data, the study designs were primarily observational and the lack of standardisation highlighted by the recording of disparate outcomes. One technical report, initially deemed eligible for inclusion into the meta-analysis, was later considered to be an outlier. The regional political context should be noted with regard

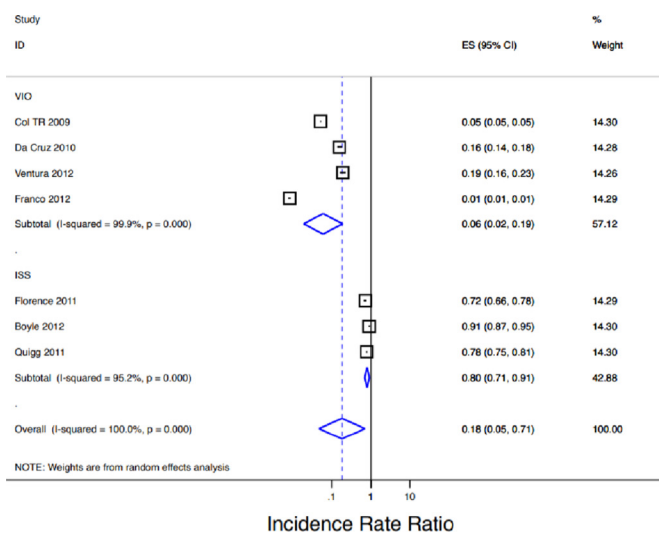


Figure 3 Violence outcome count after VIO implementation. VIO, violence and injury observatory; ISS, injury surveillance system.

Table 6 Homicides in Juárez, Mexico, 2007–2012

Year	Homicide count	Homicides per day
2007	319	Less than 1 murder per day
2008	1623	4.4 per day
2009	2754	7.5 per day
2010	3622	9.9 per day
2011	2086	5.7 per day
2012	797	2 per day

to this technical report.¹⁹ This technical report recorded the number of homicides taking place in Juárez, Mexico, from 2008 to 2012. The partial victory achieved in the war on drugs in Colombia had contributed towards a surge in drug-related violence in Mexico. Violence first began to surge in 2007 after the Sinaloan cartel attempted to take over Juárez's highly prized drug trafficking routes. Local enforcer gangs such as La Linea and the Aztecas fought a bitter war, often using unrestrained violence that targeted civilians and drove up the murder count. In 2007, Mexican president Felipe Calderón responded by launching a major offensive against drug-trafficking groups, sparking an explosion of violence that had gained the intensity of a regional war.²⁶ Calderón had fully militarised the conflict, sending thousands of troops and federal police into trafficking centres in what became a virtual military occupation of Ciudad Juárez. The result has been the much publicised, massive bloodshed, with more than 26 000 people killed since 2007, much of it taking place in the north of Mexico, near the US border.²⁷ Homicide counts from the Hernandez 2014 report details (table 6) the spike in homicides over this period from 2007 to 2012.¹⁹

With these extraneous (irregular) circumstances in mind, a decision was made by study authors to exclude this technical report from the subsequent meta-analysis. VIOs are by nature narrow in their scope and local in their implementation. Juárez experienced levels of violence that were provoked by activities at broader regional levels, with casualties comparable to those of ongoing wars in different regions of the world. The influence of transnational drug policy in the region influenced the levels of violence within Juárez, limiting the effectiveness of local interventions developed by the Juárez observatory. Additionally, according to the WHO typology of violence, this would be classified as collective violence, which refers to violence committed by larger groups of individuals and can be subdivided into social, political and economic

violence. The VIO mandate is limited to interpersonal violence which constitutes violence between individuals.

Ventura 2012, located in Uruguay, was the sole meta-analysis case to show a rise in homicide rate after the implementation of a VIO. Historically, one of Latin America's more peaceful countries with a homicide rate below the global average of 6.2 per 100 000 population (2012), 2012 saw the homicide rate in Uruguay increase from 5.9 to 7.9 per 100 000 population (table 7).²⁸ Officials from the Uruguayan Ministry of the Interior reported that a spate of gang shootouts and murders in Montevideo pointed to an increase in organised criminal activity in the country, which was attributed to warring drug gangs.²⁸

Drug traffickers from Colombia, Mexico and Bolivia are, according to the US State Department, are increasingly using Uruguay as a transit point for narcotics, reporting that criminal may be moving cocaine production operations to the country.²⁸ Additionally, the US Drug Enforcement Administration recently announced that it would reopen its office in Uruguay, 18 years after it was closed, highlighting the country's re-emergence in the international narcotics trade.²⁸

Comparison with previous systematic reviews and observational studies

To date, this is the first systematic review to assess the evidence of effect for VIO/ISS reduction of violence among adult populations. This review confirms the findings of previous observational studies, which have shown reductions in violence outcomes^{10 11} after the implementation of a VIO.

Strengths and weaknesses

One of the strengths of this review is that it incorporated a range of search approaches among a number of well-known databases, without language restriction, to ensure a comprehensive strategy in evaluating the evidence. In cases where English abstracts of publications in non-English journals deemed relevant, full-length foreign language articles were translated and assessed for inclusion in this review. The lack of evaluation of randomised controlled studies is a weakness generally noted in this type of research, which involve a prohibitive cost to run. Furthermore, the lack of controls, preintervention data, blinding and the reporting of withdrawals and dropouts were weaknesses identified within the included studies. A publication bias was noted in the South American literature which more often published data in regional technical reports, favouring this type of publication over peer-reviewed journal publication.

Table 7 Homicides in Uruguay, 2002–2012

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Homicide rate	6.9	5.9	5.8	5.7	6.1	5.8	6.6	6.7	6.1	5.9	7.9
Homicide count	231	197	194	188	203	194	221	226	205	199	267

Interpretation and mechanisms

The formation of an observatory allows for the collation and integration of violence-related data. Furthermore, it brings together relevant stakeholders from government; emergency services including medical, police and forensic; and non-government actors in the safety sector to promote a comprehensive understanding of the burden of violence-related injuries through data sharing. The observatory practices include monitoring and evaluation of violence-related injuries and crimes, and intervention development with stakeholders to promote violence reduction. Interventions may be applied at multiple levels including places, people or behaviour-based approaches. Examples of a 'place-based approach' would include interventions focused on geographical locations such as hot spot policing or disorder (broken windows) policing. Examples of a 'people-based approach' includes ones focused on individuals and groups and include interventions such as focused deterrence, cognitive-behavioural therapy or vocational training. Finally, examples of a 'behaviour-based approach' include the targeting of known risk factors for violence such as firearms, alcohol, drugs and gangs. These may be addressed through policy changes or interventions such as drug courts and treatment.

An alternate consideration of the mechanism it is that observatories are the 'outcome' of an intersectoral initiative by various stakeholders to act collectively against violence and it is this collective action that brings about the reduction with the observatory being a mediator on that causal pathway.

Clinical relevance

VIOs and ISSs remain a viable model for the surveillance of violence-related injuries and outcomes. This is consistent with the public health surveillance principles which have been applied successfully to other communicable and non-communicable diseases worldwide. Physicians should be encouraged to share their violence-related data with violence prevention stakeholders, as this provides a more complete picture of the local burden of violence-related injury. This is demonstrated with the advent of targeted policing and the Cardiff model which promotes data sharing between hospital emergency departments and local policing services, and has demonstrated both reductions in hospital admissions related to violence and reduced the number of violence-related crimes reported to the police.^{21 29}

CONCLUSION

This systematic review provides the best evidence available for the effectiveness of the introduction of VIOs and ISSs in reducing violence outcomes in adults in high-violence settings. The limitations of study design, political context of study locations and paucity of evaluative research in this field were noted in the process of conducting the review. Florence *et al*³⁰ and Boyle *et al*³¹ are two studies which provided rigorous study designs with control populations, which may serve as a standard to future research in this field. Additionally, this review has shown a publication bias in Latin

American research, which favoured publication in regional technical reports as opposed to peer-reviewed journals. It is hoped that this review will encourage further evaluative research in not only the other VIOs found across the world but also the over 100 differently themed observatories found globally, which may help us understand how observatories influence social change.

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