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ORIGINAL ARTICLE

Near-repeat shootings in contemporary Sweden 2011 to 2015

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Abstract The concept of near-repeat patterns illustrates how crimes are clustered in space and time, with a crime event often shortly followed by another crime nearby. This study aims first to describe the frequency in shootings; second, to analyse the patterns of near-repeat shootings; and third, to validate a near-repeat calculator in the three largest cities in Sweden. Data were geocoded from three registries on shootings administered by the police departments in Stockholm, Gothenburg and Malmö from 2011 to 2015, and were analysed using a free near-repeat calculator. There were 948 shootings, 378 of which involved at least one injury or death (40%). The relative risk of firearm-perpetrated homicides was almost 2.5 times higher in Malmö compared to Stockholm, but almost half of the shootings occurred in Stockholm. Near-repeat patterns were found with a significantly increased risk of a new shooting in all three cities, but were weaker in Gothenburg.

Keywords Near-repeat · Shootings · Firearms · Guns · Gangs

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Introduction

Globally, there are more than 400,000 homicides per year of which about 41% are attributed to firearms. The proportion varies from 10% (Oceania) to 66% (Americas), with an overall rate of 13% in Europe (United Nations Office on Drugs and Crime 2013), while 17% of all Swedish homicides involve firearms (National Council for Crime Prevention 2011). In the Stockholm Programme of 2009, the EU member states stressed that firearms trafficking is a continuing security challenge for the EU (European Union 2010). Even though the overall level of violent crime in Sweden is low compared to many other countries (van Wilsem 2004), some trends deserve to be highlighted. First, there has been a decrease in homicides in Sweden since the 1990s; in the early 1990s saw about 100 homicides annually, but in the 2010s the number decreased to about 90 per year, even though the population had increased (National Council for Crime Prevention 2015a). This reduction is attributable to a reduction in child homicides (Hedlund et al. 2016), offenders with psychosis (Sturup and Lindqvist 2014), as well as alcohol-related homicides (Granath 2012). While homicides have dropped overall, there has been an average 2% yearly increase in males shot to death and an additional 4% yearly increase in males hospitalized due to firearms injuries (Sturup and Granath in review). There are indications that the increasing proportion of homicides committed with firearms can be linked to gang conflict and organized crime (National Council for Crime Prevention 2015a). In addition, it has been shown that there has been a substantial increase in shootings since 2006, and that the increase has largely taken place in some of the most disadvantaged neighbourhoods of the country (National Council for Crime Prevention 2015b). There is also a higher concentration of homicides linked to conflicts within the organized crime milieu in the three major metropolitan areas in Sweden as between 2002 and 2013, 18% of homicides in three major metropolitan areas were linked to organized crime, compared to 7% in less populated surrounding territories (National Council for Crime Prevention 2015a). In contrast to the increase in the number of males shot to death, the clearance rate in firearm-perpetrated homicides has decreased from about 95% in the early 1990s to about 50% after 2010 (Sturup and Granath in review). Another trend worth noting is that there has been a shift in the trend toward organized crime in Sweden (Rostami 2016a, b). With the entry of international outlaw motorcycle gangs (OMG) in the early 1990s, organized crime became one of the pillars of Swedish crime policy, particularly as a result of the Great Nordic Biker War, which began in 1994 and continued until 1997. In the late 1990s and early 2000s, Sweden witnessed newly emergent street gangs, which initially reflected OMG activity, but later became competitors, which resulted in several conflicts. The entry of new international OMGs has resulted in conflicts within the OMG sphere. Today the Swedish organized crime landscape is fragmented, with street-gang, OMGs and other territorial-based organized crime groups and several abiding conflicts resulting in shootings, explosive attacks and homicides (Swedish National Police 2013; Rostami 2016a, b; Sturup and Granath in review).

All in all, the research suggests a shift in Swedish homicides from a more domestic setting using sharp and blunt violence to a more public setting using firearms, with a corresponding decrease in clearance rate. A study of 264 homicides in Sweden from 2007 to 2009 also showed that cases involving young males shot to death in public settings is considerably less likely to be cleared than other cases, and that the police need new strategies when investigating such cases (Sturup et al. 2015). The changing nature of lethal violence in Sweden in combination with the lack of studies in Europe on shootings motivates the present study, which aims to further our knowledge on near-repeat patterns of shootings in the three Swedish cities.

The near-repeat principle

Near-repeat crimes refer to the spatio-temporal proximity of crime incidents, in other words, clustering in both time and place (Youstin et al. 2011). The concept rests on the assumption that after a crime is committed there is an elevated risk of another crime of the same type nearby and within a short time period (Townsley et al. 2003; Farrell 2005). Two mechanisms that can explain the phenomenon are called *flag* and *boost* (Pease 1998). Flag implies that the victim of an offence in some way shows visible signs of being a suitable crime target, which might then attract other offenders (Pease 1998). The boost mechanism, on the other hand, departs from the idea that specific offenders become aware of vulnerabilities when committing a crime, and that the same offenders return to another victim nearby to commit another crime (Pease 1998). Most evidence seems to point to the boost hypothesis as the main explanation, since near-repeat incidents (at least for burglary, for which there is the most research) are significantly more similar to each other than none-near-repeat incidents (Bowers and Johnson 2004; Bernasco 2008). In the case of shootings, less is known about the mechanisms that produce near-repeat patterns, and the boost account in particular appears a less likely explanation, but some tentative suggestions will be discussed below in the end of this section.

The existence of near-repeat patterns has been demonstrated not only for a number of crimes, most commonly for burglary (Wu et al. 2015; Hernandez 2013; Johnson 2013; Bernasco 2008; Short et al. 2009; Townsley et al. 2003; Hoppe 2016; Lindström and Martinez-Olsson 2016), but also for vehicle theft (Block and Fujita 2013; Lockwood 2012; Youstin et al. 2011) and street robberies (Haberman and Ratcliffe 2012; Youstin et al. 2011), in addition to less commonly studied phenomena such as maritime piracy (Marchione and Johnson 2013) and Iraqi insurgency attacks (Townsley et al. 2008). The exact distances and time periods with significantly increased risks of victimization vary between crime types and study sites, but can typically be found between 1 and 4 weeks and 100–400 m.

On the topic of shootings, several studies from the U.S. have examined near-repeat patterns (Ratcliffe and Rengert 2008; Youstin et al. 2011; Wells et al. 2011, 2012; Wyant et al. 2012), but no such studies have been conducted in Europe. Ratcliffe and Rengert (2008) examined over 3700 shootings in Philadelphia between August 2003 and September 2005. They used the spatial bandwidth of 400

feet (using Manhattan distances) and the temporal bandwidth of 2 weeks, and they reported a significantly increased risk of near-repeat shootings after a first shooting incident. The study also examined whether a policing initiative, Priority Corners, could prevent the near-repeat shootings, but they found no such effects. Wells et al. (2011) examined over 5700 shootings in Houston between January 2007 and August 2008 (see also Wells et al. 2012). The authors used the same near-repeat bandwidths as Ratcliffe and Rengert (2008) and also reported significant near-repeat patterns. The authors also evaluated a policing initiative called Crime Reduction Unit, but found no effect on near-repeat shootings in the ten-month-long intervention period compared to the ten months prior to the intervention. Youstin et al. (2011) examined almost 3000 shootings in Jacksonville between January 2006 and December 2008. The authors used a spatial bandwidth of 575 feet and examined time bandwidths of 14, 7, 4 and 1 day. The authors found significant near-repeat patterns, and the strongest relationships were found within the first day of a shooting. All in all, it appears that the research picture regarding the near-repeat phenomena in a U.S. setting is conclusive. Near-repeat patterns exist for shootings in the US, in particular within very short time and space frames.

Less is known on how to explain near repeats for shootings. As noted by Ratcliffe and Rengert (2008), it is however not surprising to find such patterns given the importance of projecting strength and responding to threats within some criminal sections of society. When someone has been shot, retaliation by the victim can happen unless too heavy injuries were sustained, in which case a relative or friend may retaliate instead. Some shootings are linked to open drug markets, and here a dispute occurring at the drug market may end up in the victim returning to retaliate (Ratcliffe and Rengert 2008). In the case of Sweden, shootings are far less common than in major US cities, but a plausible explanation for some near repeats may be longer chains of retaliation. Shootings are strongly tied to disadvantaged neighbourhoods with criminal networks (National Council for Crime Prevention 2015b), and after an initial shooting hitting neighbourhood A, there may be retaliation against neighbourhood B, which then strikes back at neighbourhood A yet again, thus producing a near repeat.

This study

It has been noted that there have been very few scientific studies on near-repeat shootings (Haberman and Ratcliffe 2012), that there have been no studies from Europe, and that all existing studies examine only one city or setting. Since gun violence is far more common in the U.S. than in Europe, and it is uncertain if lower rates of gun violence is less or more associated with near-repeat shootings, it is pertinent to ascertain whether near-repeat patterns may be identified in Sweden. By using registries from multiple regions, it is possible to examine differences between settings, thereby increasing our comparative understanding of the phenomenon of near-repeat shootings. This study aims to (1) describe the frequency of shootings in the three largest cities in Sweden; (2) study the pattern of near-repeat shootings and (3) validate a near-repeat calculator in a European setting.

Data and methods

Data

Data were collected from three registries of shootings (hereafter called the shooting registries) administered by the police departments in Stockholm, Gothenburg and Malmö between 1 January 2011 and 31 December 2015. Since 2011 the police have kept information on shootings in a registry in each region, but the registries have not been coordinated between the departments. Recently, an initiative to coordinate has been started within the Swedish police, and the registries will shortly be more comparable. Information on all shootings is collected in the registries for administrative and operational issues. The Malmö registry originally included soft air guns and similar firearms, but the Malmö police have excluded such weapons from the data used in the present study and the datasets should be fairly comparable. Local differences are, however, likely to exist, and some caution should be taken when interpreting the data, in particular relative to Malmö.[1]

The exact *x*-coordinates and *y*-coordinates were established in the vast majority of cases (over 88%); however, in 100 of the cases, only the street names were known, and in those cases the geocoding used the middle of the street (10.5%). In 10 cases (1.1%), the location was unknown, and those cases were therefore excluded from the near-repeat analysis. Incidents involving multiple victims were counted as one incident coded by the most severe injury: homicide (at least one death), injury (at least one injured victim, but no deaths) or no injuries.

Stockholm, Gothenburg and Malmö are the three largest cities in Sweden. Shooting data for Stockholm are gathered for the whole county which has a population of about 2162,000, but a separate analysis has been performed for Stockholm municipality with a population of circa 923,500. The population of the Gothenburg area, comprising Gothenburg, Mölndal and Partille municipalities, is about 648,500, while the Malmö police area comprises the Malmö and Burlöv municipalities, with a total of circa 335,500 residents.

Analytical strategy

The shootings are described using descriptive statistics of the raw data ($n = 948$) and in addition the raw numbers were converted to the number of incidents per 100,000 inhabitants to improve comparability. As slight differences between the registries cannot be ruled out, the comparative incidence analysis involves only incidents resulting in either homicide or injury, which increases the reliability and reduces the risk of biased between-city comparisons. The near-repeat analysis evaluated all incidents where the location could be identified and geocoded ($n = 938$). Data were analysed using a free near-repeat calculator available online (Ratcliffe 2009). The calculator uses the Knox method to analyse the *x*- and *y*-coordinates within a given time span by Monte Carlo simulations. Euclidian

[1] The serial shooter that operated in Malmö in 2003 to 2010 was apprehended before the observation period of this study and has not contributed with any shootings.

distances were used as the interpretation of such distances is more straight forward than Manhattan distances. The main analysis was performed for a temporal bandwidth of 14 days and spatial bandwidth of 100 m, mirroring Ratcliffe and Rengert (2008). An alternative bandwidth specification of 3 days and 500 m is reported in the appendix; due to the fairly low number of shooting incidents in each city, it was not viable to combine very short time spans (1 week or less) with small spatial distances (below 250 m). To control for potentially differing results due to the larger spatial resolution of the Stockholm data, which includes the whole county, the Stockholm data have been plotted in ArcGIS10 and clipped with a layer of Stockholm municipality. This results in a smaller number of shooting incidents ($n = 197$), which has been analysed separately.

Results

Description, density and spatial patterns of shootings

There were 948 shootings recorded in the registries over the five-year period, resulting in somewhat fewer than 200 shootings per year. Seventy-nine victims were killed in 71 lethal incidents, while 355 victims were injured in 316 incidents. All in all, 378 of the 948 incidents (39.9%) involved at least one injury or death. The incidents were rather evenly distributed over week, with shootings least common on Wednesdays (12%) and most common on Sundays (16%). Shootings were also slightly more common in the summers (June to August; 29%), compared to winters (December to February; 22%) (Table 1).

Table 1 Annual number of firearm-perpetrated incidents resulting in homicide or bodily injury from a total of 948 shootings in Stockholm, Gothenburg and Malmö between 1 January 2011 and 31 December 2015

	2011	2012	2013	2014	2015	Total	Mean	Rate[a]
Stockholm								[b]
Homicides	3	5	5	9	11	33	6.6	0.42
Body injury	26	21	19	24	36	126	25.2	1.14
Gothenburg								[c]
Homicides	1	2	7	4	7	21	4.2	0.66
Body injury	10	7	26	21	18	82	16.4	2.6
Malmö								[d]
Homicides	6	4	0	3	4	17	3.4	1.0
Body injury	28	21	23	22	14	108	21.6	6.5

The most severe injury is counted (i.e. in cases of homicide and injuries only the homicide is counted)

[a] Per 100,000 inhabitants

[b] Based on Stockholm municipality

[c] Based on Gothenburg, Mölndal and Partille municipalities

[d] Based on Malmö and Burlöv municipalities

The most shootings were registered in Stockholm County ($n = 403$), but for Stockholm municipality alone the number was substantially lower ($n = 197$). Malmö had more shootings than Stockholm municipality, and considering the lower population of Malmö the rate was substantially higher than in the other cities. As has been mentioned, there may be a between-city registry bias, but such problems should be very minor for the firearm-perpetrated homicide rate, and it was also higher in Malmö compared to Stockholm municipality (relative risk = 2.43) and somewhat higher compared to Gothenburg (relative risk = 1.55). This implies that the rate of firearm-perpetrated violence is substantially higher in Malmö than in the other two cities. The relative risk comparing Gothenburg and Stockholm was 1.57. Even though the population-adjusted risk of firearm-perpetrated homicides is higher in Malmö, 47% of the homicidal shootings in this study were registered in Stockholm County (33 of 71 cases, 19 of which occurred in Stockholm municipality).

As shown in Figs. 1, 2 and 3, all three cities areas where victims had been shot and injured tended to cluster together so that there are between two and seven (but see below regarding Malmö) adjacent areas with at least one shooting injury each, which then registers for above 0 injuries per square kilometre. There are also isolated areas with shooting injuries that are not adjacent to other areas with shooting injuries. The clustering appears to be the strongest in the city of Malmö, where such clusters are adjacent to each other too, creating one major cluster of 23 areas, which in turn is very close to another cluster of five areas, with yet another cluster of six areas located about one kilometre to the west. The major 23-area cluster actually comprises three different neighbourhood clusters with disadvantaged neighbourhoods and criminal network activity (Fosie, Rosengård, Södra innerstaden) but which are located close to each other. The close proximity in the city of Malmö of different disadvantaged neighbourhoods with their associated criminal networks has previously been pointed to as a potential reason for violence in the city (National Council for Crime Prevention 2012). In comparison with US studies, it cannot be ruled out that the relatively small size of Malmö, in particular if combined with the proximity of different disadvantaged neighbourhoods and their associated criminal networks to each other, may have an impact on results.

Near-repeat analysis

As shown in Tables 2, 3 and 4, the analyses of near-repeat patterns show significantly increased risks for a new shooting in all three cities. Although all three cities show evidence of near-repeat patterns, there are some differences between the cities. In part differences may be hypothesized to relate to the differing geographical units, with the Stockholm data comprising the entire county, although a separate analysis of Stockholm municipality resulted in similar results as the county-level analysis (Table 5).

Stockholm and Malmö registered a fourfold increase in risk within 100 m and 2 weeks of a shooting. No such pattern was found for Gothenburg; but for the 100 to 200-m spatial band, there was a 187% higher risk of a shooting within 2 weeks of an

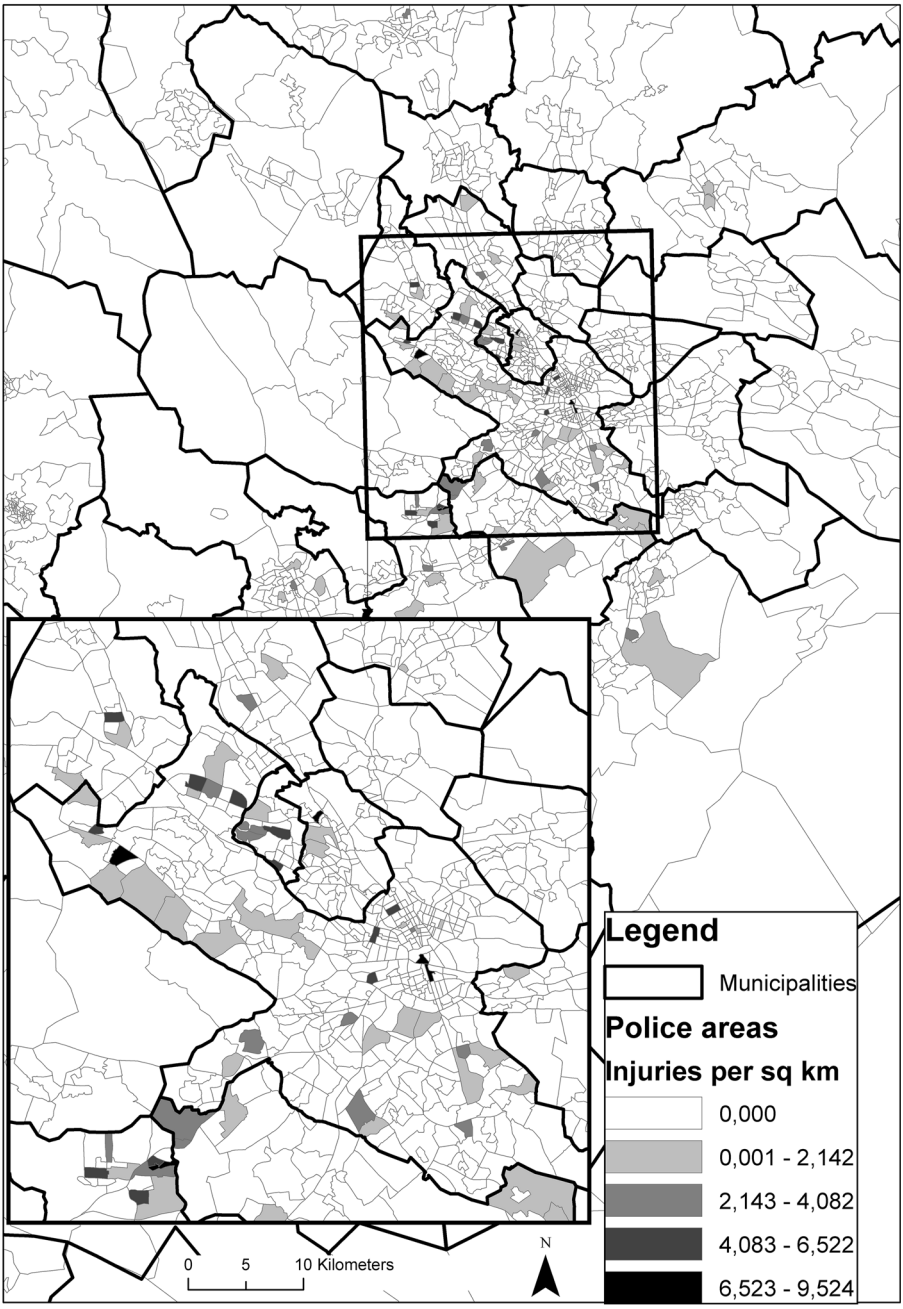

Fig. 1 Shootings resulting in injury or death in Stockholm 2011–2015

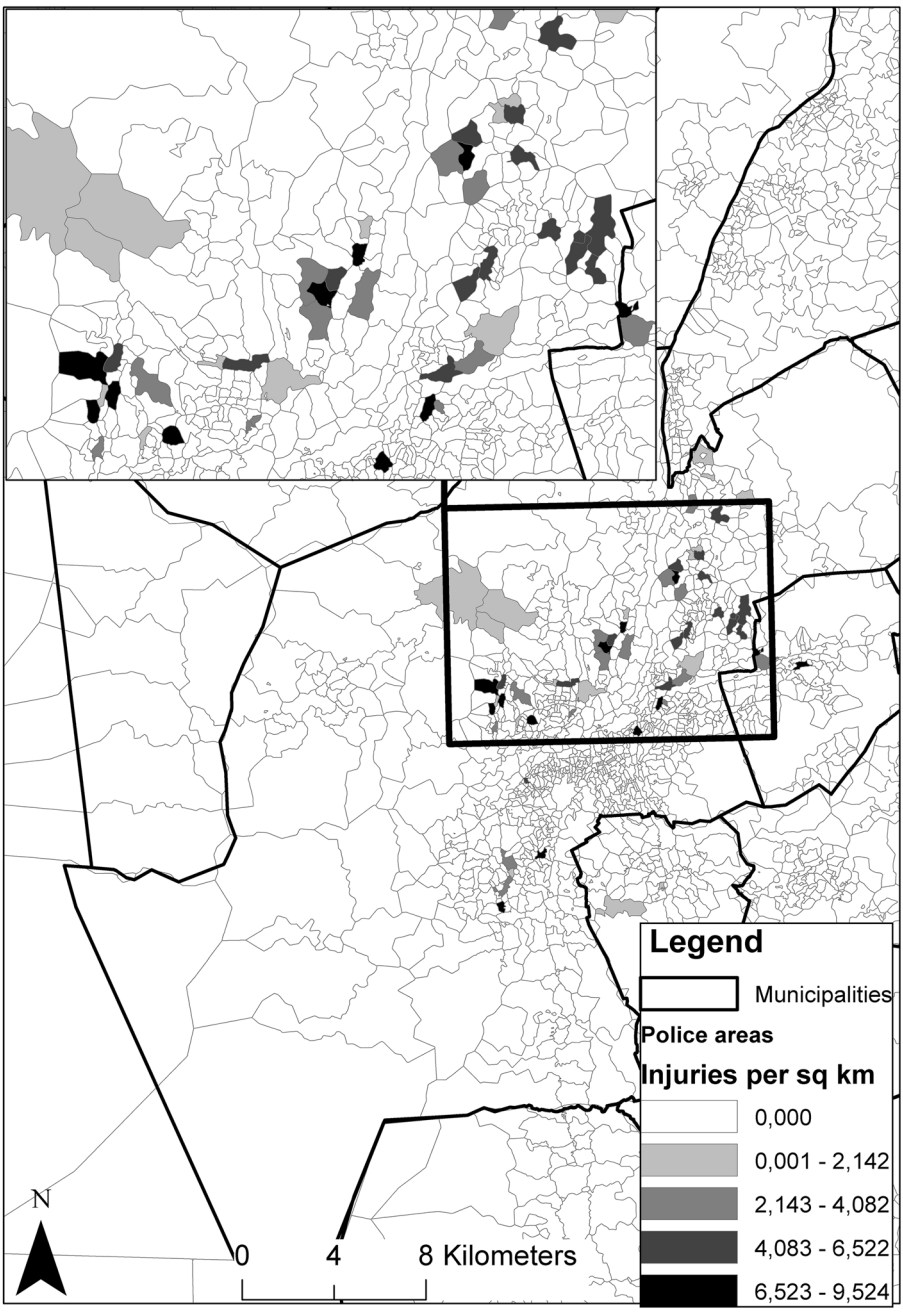

Fig. 2 Shootings resulting in injury or death in Gothenburg 2011–2015

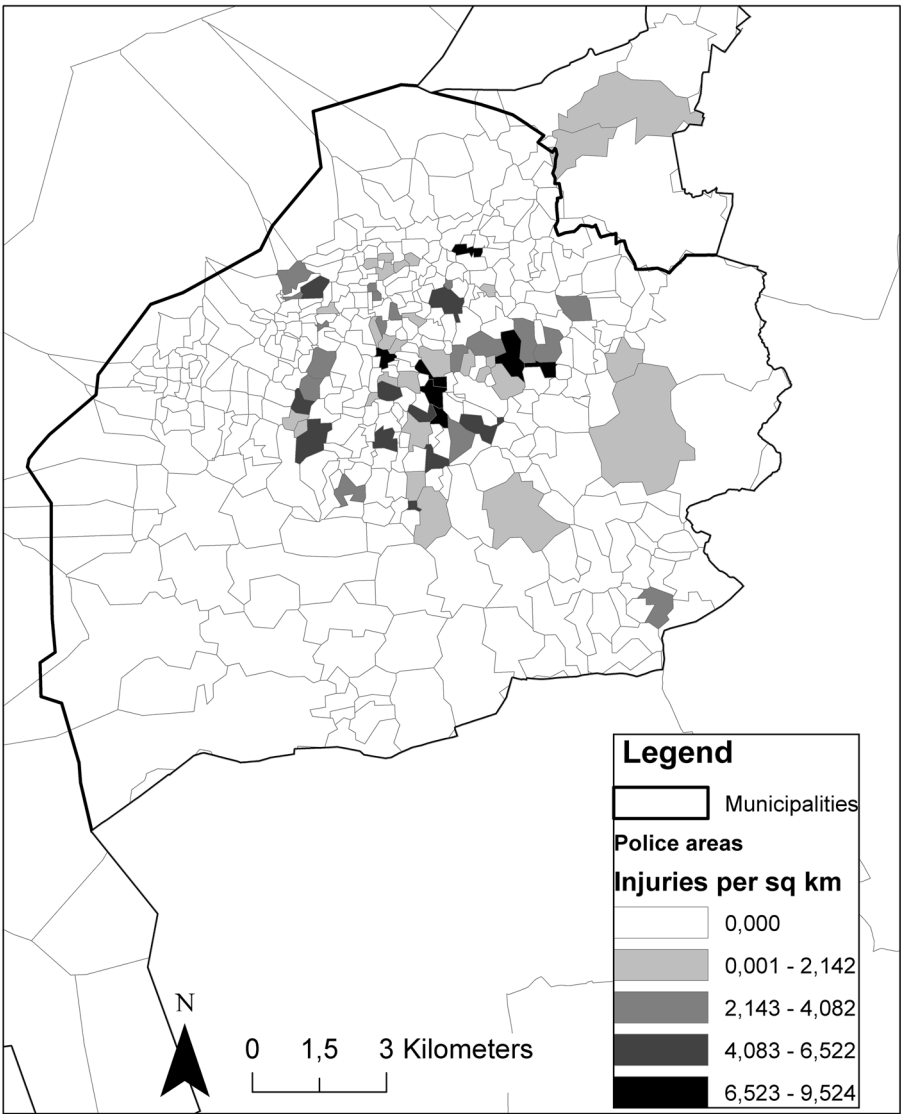

Fig. 3 Shootings resulting in injury or death in Malmö 2011–2015

incident. In the case of Stockholm, there were also significant near-repeat patterns between 200 and 300 m from a first incident within the first 2 weeks, and between 100 and 200 m after 3–4 weeks. For Malmö, the patterns were more clearly clustered, with significant near-repeat patterns within 100 m for up to 6 weeks, and between 100 and 200 m for the first 2 weeks.

Table 2 Observed-to-expected mean frequencies for shootings, with spatial band width of 100 m and temporal bandwidth of 14 days based on 403 shootings in Stockholm county between 2011 and 2015

	0–14 days	15–28 days	29–42 days	43–56 days	More than 56 days
Same location	3.53	3.40	3.57	3.84	0.83
1–100 m	4.03*	0.84	0.83	1.74	0.94
101–200 m	2.43	4.87*	2.49	1.68	0.87
201–300 m	2.67*	1.27	2.66*	3.16*	0.90
301–400 m	0.00	0.00	0.87	2.72*	1.01
401–500 m	1.68	1.37	2.06	1.05	0.96
501–600 m	2.26	1.10	1.14	1.15	0.97
601–700 m	0.69	1.41	1.40	0.72	1.00
701–800 m	1.12	1.10	0.00	1.72	1.00
801–900 m	1.19	1.21	0.00	0.00	1.03
901–1000 m	1.07	0.55	1.09	2.26	0.98
More than 1000 m	0.99	1.00	0.99	0.99	1.00*

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3 Observed-to-expected mean frequencies for shootings, with spatial band width of 100 m and temporal bandwidth of 14 days based on 231 shootings in Gothenburg between 2011 and 2015

	0–14 days	15–28 days	29–42 days	43–56 days	More than 56 days
Same location	5.68	5.58	0.00	0.00	0.86
1–100 m	0.00	1.29	2.50	1.42	0.98
101–200 m	2.87*	2.03	2.07	1.11	0.92
201–300 m	1.11	2.41	2.04	0.44	0.96
301–400 m	2.31	1.67	0.82	3.63*	0.92
401–500 m	1.38	1.17	1.53	1.71	0.97
501–600 m	0.49	2.13	2.25	1.73	0.96
601–700 m	1.12	0.82	1.65	1.74	0.98
701–800 m	2.18	1.62	0.57	1.23	0.97
801–900 m	1.94	1.54	1.03	0.57	0.98
901–1000 m	1.19	1.90	0.63	1.44	0.98
More than 1000 m	0.97	0.97	0.98	0.97	1.00*

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The alternative specification with a temporal bandwidth of 3 days and a spatial bandwidth of 500 m yields similar, but more consistent, results (see Appendix Tables 6, 7, 8 and 9). All three cities saw a threefold increase in relative risk within the first 3 days and 500 m from a shooting. In addition, there are several more significant over-representations; for instance, a significantly increased risk within 500 m and 10–12 days in Stockholm, within 500 m and 4–6 days in Malmö and between 1000 and 1500 m after 0–9 days in Gothenburg.

Table 4 Observed-to-expected mean frequencies for shootings, with spatial band width of 100 m and temporal bandwidth of 14 days based on 304 shootings in Malmö between 2011 and 2015

	0–14 days	15–28 days	29–42 days	43–56 days	More than 56 days
Same location	21.55*	3.13	4.58*	1.78	0.52
1–100 m	4.78*	2.64*	4.12*	0.88	0.85
101–200 m	3.24*	1.52	0.50	0.86	0.96
201–300 m	1.70	0.74	0.93	0.68	1.00
301–400 m	1.02	1.41	1.42	0.72	0.99
401–500 m	0.49	0.95	1.12	1.64	1.00
501–600 m	0.91	1.02	0.67	0.40	1.02
601–700 m	0.52	1.33	0.90	0.59	1.01
701–800 m	0.75	0.53	0.84	1.25	1.01
801–900 m	0.64	1.28	0.96	1.35	1.00
901–1000 m	1.00	0.99	0.75	1.30	1.00
More than 1000 m	0.97	0.99	1.00	1.00	1.00*

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5 Observed-to-expected mean frequencies for shootings, with spatial band width of 100 m and temporal bandwidth of 14 days based on 197 shootings in Stockholm municipality between 2011 and 2015

	0–14 days	15–28 days	29–42 days	43–56 days	More than 56 days
Same location	5.46	5.77*	6.07*	5.58	0.66
1–100 m	3.77*	0.00	1.30	2.50	0.93
101–200 m	0.00	4.26*	1.59	1.50	0.93
201–300 m	4.91*	1.59	1.58	2.37	0.88
301–400 m	0.00	0.00	0.65	1.80	1.03
401–500 m	2.28	1.82	2.30	0.85	0.94
501–600 m	3.03*	0.00	0.00	0.00	1.02
601–700 m	0.00	0.00	2.26	0.00	1.03
701–800 m	0.81	0.80	0.00	1.55	1.01
801–900 m	0.77	0.80	0.00	0.00	1.04
901–1000 m	0.00	1.01	1.02	0.00	1.04
More than 1000 m	0.97	1.00	0.99	0.99	1.00*

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Discussion

This Swedish multicity study of shootings illustrates clear patterns in near-repeat shootings in all three observed cities. There were significantly elevated risks of a near-repeat shooting within a relatively small distance and time period, but with some notable differences between cities. Stockholm and Malmö exhibited strong near-repeat patterns within the first 2 weeks and 100 m, while there was no such pattern in Gothenburg, but instead a significant over-representation within the first

2 weeks and at the distance of 100–200 m. The findings are largely in line with the findings from the U.S. setting (Ratcliffe and Rengert 2008; Wells et al. 2011; Youstin et al. 2011; Wells et al. 2011), although the effects appear to be larger in the present study. Both Ratcliffe and Rengert (2008) and Wells et al. (2011) note observed over expected ratios of about 1.3, while the present study notes values well over 2 for all three cities. It is not known whether this is related to the relatively much lower frequency of shootings in Sweden as compared with shootings in the U.S., but this question is warranted. This is the first European study on near-repeat shootings, and it has largely replicated the findings from the U.S. setting, but because of the different effect sizes noted, more studies from Europe are needed to further advance our knowledge of the near-repeat phenomena. The results of this study have policy and law enforcement implications, both for Sweden and for other countries that exhibit similar patterns of near-repeat shootings.

Firearm violence in Sweden has increased and changed during the last 10–15 years (National Council for Crime Prevention 2015a, b), and this problem needs to be taken seriously. In Sweden in the 1990s, many firearm-perpetrated crimes were committed with firearms stolen from military depots. After the break-up of the Yugoslavian republic and the ensuing war in the Balkans, the Swedish police found that a rather high proportion of illicit firearms is illegally imported from abroad, mainly from former Yugoslavian countries (Swedish National Police 2013). It is an open question what will happen with the firearms in Syria, Ukraine and other areas of conflict when the wars there end. However, stronger border control is not a panacea, as those who intend on violence can find other tools such as knives or improvised firearms. Instead, there is a need for comprehensive response strategies that address policy, as well as operational policing strategies. The findings from the present paper should be considered in the light of what is overall known about gun violence in Sweden: most firearms used in illegal activities are unlicensed (Swedish National Police 2013), there has been an increase in shootings (National Council for Crime Prevention 2015b) and a decrease in homicide clearances (Sturup and Granath in review). The findings of considerable frequency of shootings from a European perspective and the evidence of near-repeat patterns of shootings means that this study bolsters the understanding that there has been a shift in firearm-perpetrated violence, and that there is a need for a comprehensive response strategy to curb this transformation.

Patrolling and tactics

Close-proximity interventions in both time and place to a shooting to attempt to prevent further shootings make sense, but as previous research has noted it may be difficult to identify effective preventive measures against near-repeat shootings (Ratcliffe and Rengert 2008). The next step is to develop and evaluate intervention strategies to prevent escalation and retaliatory violence. However, the scientific literature regarding prevention of shootings is not conclusive; near-repeat shootings in particular seem to be strongly resistant to police interventions (Ratcliffe and Rengert 2008; Wells et al. 2011), and a newly published study reports that when offenders can predict police operations, such interventions even

be counterproductive (Ariel and Partridge forthcoming). With shootings there is an elevated risk of a new shooting in close geographical proximity within the first few weeks, but considering the relative rarity of shootings in Sweden, the absolute risk is still fairly small. In the case of Malmö, for instance, 23% ($n = 69$) of shootings were followed by another shooting within 4 weeks and 300 m. Although this may sound like a low number, it is vastly higher than what would be predicted by chance alone. More research is needed to establish why some places have more shootings, and in particular near-repeat shootings. In the case of Sweden, most places that experience multiple shootings are located in disadvantaged neighbourhoods built during the late 1960s and early 1970s. These neighbourhoods exhibit several common characteristics, but it is unclear which of these characteristics that matter the most. While sociodemographical (e.g. share of youth, share of immigrants) and socioeconomic (e.g. disadvantage, poverty) explanations are reasonable, many of these neighbourhoods also share some common patterns of physical structure. They are typically almost exclusively residential, except for a centre with shops and businesses, and they are in addition often built to be car free internally, something that the police suggest make them difficult to work in (Swedish National Police 2015). It cannot be ruled out that some of these physical characteristics matter too.

Although no solid evidence on the prevention of near-repeat shootings exists, potential efforts that could be tested by law enforcement agencies include intensifying enforcement activities, e.g. such as patrolling, stop and search, in the specific spatial parameter and targeting high-risk offenders, e.g. deploying gang investigations squads and enforcing zero tolerance approach against members of the same organized crime groups or other rival groups through stop and search, arrests and other investigation and administrative measures with a period of 3–4 weeks. A meta-study on the effect of directed patrols focusing on illegal weapons showed that it was associated with significantly reduced gun violence (Koper and Mayo-Wilson 2012). Such activities may result in a decrease in offenders' mobility and a reduction in the availability of weapons used to carry out firearm-related crimes, for example, by intensifying the suppression activities and intelligence gathering the police can be able to increase its ability to intensify searches for illegal guns in high risk and relevant places such as safe houses, both before shootings occur and particularly after a shooting. This may, for example, be achieved by high operational capacity in high-risk places and groups, for example saturation patrolling and intelligence-led stop and search (Dedel 2007) or gun detection patrols (Koper and Majo-Wilson 2012). Increased operations may have at least two implications: first, increased presence may either prevent the following shooting or in the worst case just push the retaliatory violence elsewhere and second, in retaliatory shootings it may also increase the possibility of clearing that case, thereby preventing new repeat shootings. This may not address the proximate causes underlying motivations of the offenders, but it can frustrate offenders' intentions and restrain their impulsive acts, resulting in a reduction in problematic acts (Weisel and Stedman 1998; Lasley 1998).

Social and criminal policy

Although many shootings occur spontaneously, a large percentage is catalysed by past altercations and ongoing gang conflicts (National Council for Crime Prevention 2015a; Liem and Pridemore 2012). A comprehensive response strategy, therefore, must include a strategy for dealing with gang crime and proliferation, since gangs and shootings are strongly related. It is important to understand gang dynamics so that targeted efforts by the law enforcement do not increase group cohesiveness (Klein 1995; Rostami 2016b). In long-lasting and recurrent gang conflicts, such the ones in Gothenburg and Malmö, the police need to explore alternative methods such as gang dialogue and mediations (see Leinfelt and Rostami 2012; Holgersson 2008). Since crime witnesses seem to be somewhat reluctant to provide information to police, and gang-related shootings are often highly precise rather than impulsive, law enforcement needs to develop special response teams. Responding rapidly and methodically to this kind of shooting not only increases the chances of apprehending the offenders but also offers an opportunity to intercept plans for retaliation (Dedel 2007). Key lessons may also be learned from research in the United States on the prevention of (gun) violence and crime. "Pulling levers", the focused deterrence strategy of clearly communicated sanctions and risks for potential offenders combined with social support, have been effective in crime reduction (Braga and Weisburd 2012; Abt and Winship 2016). There is also some evidence, although more mixed, that the use of trained mediators to stop the spread of violence combined with attempts at changing the norms of high-risk individuals may have some impact on reducing gun violence (Butts et al. 2015).

Gun policy

At the policy level, Sweden has recently implemented a series of measures such as targeting firearms trafficking through stepping up cooperation with western Balkan countries (The Government Offices of Sweden 2016). The Swedish legislative body has also implemented stricter arms legislation (Prop. 2013/14:226). However, illicit weapons are not merely a national problem but an international one, and the European Union needs to take common action to harmonize arms legislation and control, such as a common minimum rules on criminal sanctions for illicit firearms trafficking.

Methodological considerations

The main objection to the study is that it does not establish whether a shooting and the following near-repeat shooting were actually related. This methodological shortcoming is shared with all other existing studies of near-repeat shootings, and future research needs to closely target this aspect of the near-repeat phenomena. Another methodological objection is that the exact location of 10% of the incidents was not known, and that the coordinates were set to the middle of the street, which may result in an upward bias of near repeats, in particular in relation to repeat shootings at the same location. Numbers of same location patterns should not be

considered valid because of the risk that coding may have a large impact on such events. Lastly, the potential bias between registries of shootings may have an impact on findings. For the between-city rate comparison, the analysis focused on shootings with injuries and deaths to reduce such a bias, but the near-repeat analysis may be influenced by such differences.

Conclusions

This trilateral population-based study conducted in the three largest cities in Sweden is the first study to replicate the evidence from the U.S. of near-repeat shootings in a European setting. The findings are not revolutionary for experienced police officers and crime analysts but may be of useful support when developing operations at the everyday level, adapting strategies to interfere with shootings and when requesting more resources to prevent future firearm-perpetrated violence. The study adds knowledge to what is arguably the changing nature of violent crime in Sweden, involving more firearms. The police, politicians and social policy makers need to take this change into account and allocate adequate resources, changing the legal setting of prevention and investigation into such violence.

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Appendix

See Tables 6, 7, 8 and 9

Table 6 Observed-to-expected mean frequencies for shootings, with spatial band width of 500 metres and temporal bandwidth of 3 days based on 403 shootings in Stockholm county between 2011 and 2015

	0–3 days	4–6 days	7–9 days	10–12 days	More than 12 days
Same location	8.92	0.00	0.00	9.00	0.96
1–500 m	3.04*	2.17	0.46	2.90*	0.98
501–1000 m	2.35	1.92	0.00	0.59	1.00*
1001–1500 m	2.15	0.40	2.00	1.81	0.99
1501–2000 m	1.34	0.91	1.84	1.41	0.99
2001–2500 m	0.95	0.28	1.44	1.56	1.00
2501–3000 m	0.34	1.25	0.63	0.70	1.00
3001–3500 m	0.38	0.66	0.68	1.15	1.00
3501–4000 m	0.91	1.56	0.54	2.68*	0.99
4001–4500 m	1.27	0.69	0.70	1.04	1.00
4501–5000 m	1.86	0.56	0.95	1.09	1.00*
More than 5000 m	0.95	1.01	1.01	0.94	1.00

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 7 Observed-to-expected mean frequencies for shootings, with spatial band width of 500 m and temporal bandwidth of 3 days based on 231 shootings in Gothenburg between 2011 and 2015

	0–3 days	4–6 days	7–9 days	10–12 days	More than 12 days
Same location	0.00	0.00	20.39	0.00	0.91
1–500 m	3.07*	1.61	1.11	0.92	0.99
501–1000 m	0.49	1.73	1.54	1.48	0.99
1001–1500 m	2.95*	2.54*	2.33*	0.50	0.98
1501–2000 m	1.05	1.61	0.91	1.14	1.00
2001–2500 m	0.00	0.61	0.56	1.40	1.01
2501–3000 m	2.05	0.96	1.69	0.71	0.99
3001–3500 m	0.29	0.28	2.15*	0.61	1.00
3501–4000 m	1.50	0.55	0.49	1.56	1.00
4001–4500 m	1.06	1.53	0.68	0.88	1.00
4501–5000 m	0.81	0.50	0.90	0.57	1.00
More than 5000 m	0.90	0.96	0.91	1.01	1.00

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 8 Observed-to-expected mean frequencies for shootings, with spatial band width of 500 m and temporal bandwidth of 3 days based on 304 shootings in Malmö between 2011 and 2015

	0–3 days	4–6 days	7–9 days	10–12 days	More than 12 days
Same location	76.31*	6.94	6.57	7.80	0.65
1–500 m	3.59*	2.32*	0.74	1.51	0.99
501–1000 m	1.07	0.43	0.74	0.54	1.00
1001–1500 m	0.72	1.14	0.91	0.57	1.00
1501–2000 m	0.73	0.59	1.34	1.74*	1.00
2001–2500 m	1.00	1.24	1.28	1.22	1.00
2501–3000 m	1.02	0.75	0.84	1.00	1.00
3001–3500 m	1.03	1.24	0.95	1.20	1.00
3501–4000 m	0.52	1.05	1.19	0.81	1.00
4001–4500 m	0.39	0.74	0.74	1.06	1.00
4501–5000 m	1.19	0.83	0.24	0.72	1.00
More than 5000 m	0.83	1.06	1.13	0.74	1.00

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 9 Observed-to-expected mean frequencies for shootings, with spatial band width of 500 m and temporal bandwidth of 3 days based on 197 shootings in Stockholm municipality between 2011 and 2015

	0–3 days	4–6 days	7–9 days	10–12 days	More than 12 days
Same location	11.89	0.00	0.00	12.81	0.92
1–500 m	2.95*	1.36	0.00	3.91*	0.98
501–1000 m	2.71	0.77	0.00	0.00	1.00
1001–1500 m	1.92	0.65	1.70	1.37	0.99

Table 9 continued

	0–3 days	4–6 days	7–9 days	10–12 days	More than 12 days
1501–2000 m	0.82	1.35	1.19	0.92	1.00
2001–2500 m	0.96	0.54	1.35	1.61	1.00
2501–3000 m	0.58	0.71	0.84	1.37	1.00
3001–3500 m	0.00	1.40	0.00	0.69	1.01
3501–4000 m	0.56	1.81	0.79	1.27	1.00
4001–4500 m	0.97	0.58	0.00	0.56	1.01
4501–5000 m	2.05	0.00	1.61	0.76	1.00
More than 5000 m	0.88	1.04	1.05	0.91	1.00

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

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