Postprint Version	1.0
Journal website	
Pubmed link	http://www.ncbi.nlm.nih.gov/pubmed/25463916
DOI	10.1016/j.healthplace.2014.10.008

Social safety, self-rated general health and physical activity: Changes in area crime, area safety feelings and the role of social cohesion

ANNEMARIE RUIJSBROEKA, , , MARIËL DROOMERSB, PETER P. GROENEWEGENC, D, WIM HARDYNSE, KARIEN STRONKSB

a Centre for Nutrition, Prevention and Health Services, National Institute for Public Health and the Environment (RIVM), PO Box 1, Bilthoven 3720 BA, The Netherlands
b Department of Public Health, Academic Medical Center (AMC), University of Amsterdam, PO Box 22660, 1100 DD Amsterdam, The Netherlands
c NIVEL (Netherlands Institute for Health Services Research), PO Box 1568, 3500 BN Utrecht, The Netherlands
d Department of Human Geography and Department of Sociology, Utrecht University, PO Box 80115, 3508 TC Utrecht, The Netherlands
e Department of Penal Law and Criminology, Ghent University, Universiteitstraat 4, 9000 Ghent, Belgium

ABSTRACT

The aim of this study was to examine whether changes over time in reported area crime and perceived area safety were related to self-rated general health and physical activity (PA), in order to provide support for a causal relationship between social safety and health. Additionally, we investigated whether social cohesion protects the residents against the negative impact of unsafe areas on health and PA. Multilevel logistic regression analyses were performed on Dutch survey data, including 47,926 respondents living in 2974 areas. An increase in area level unsafety feelings between 2009 and 2011 was associated with more people reporting poor general health in 2012 in that area, but was not related to PA. Changes in reported area crime were not related to either poor general health or PA. The social cohesion in the area did not modify the effect of changes in social safety on health and PA. The results suggest that tackling feelings of unsafety in an area might contribute to the better general health of the residents. Because changes in area social safety were not associated with PA, we found no leads that such health benefits were achieved through an increase in physical activity.

1. INTRODUCTION

Over the past 20 years, the neighbourhood has gained importance in public health research. Neighbourhoods emerged as potentially relevant contexts for health, since

their physical and social characteristics could plausibly affect health over and above individual risk factors, such as lifestyle factors (Diez Roux and Mair, 2010, p. 125). Compared to the physical environment, research on the social characteristics of the neighbourhood and their effect on health and behaviour is less common (Diez Roux and Mair, 2010 and Sampson, 2003). One social characteristic that has received some attention in relation to health is the social safety of the neighbourhood. In some studies, social safety has been associated with depression and depressive symptoms and worse physical health, but the findings are inconclusive (Diez Roux and Mair, 2010,Lovasi et al., 2014, Polling et al., 2014 and Lorenc et al., 2012).

Social safety can be divided into objective and subjective safety. Objective safety refers to the occurrence of criminal offences, such as theft or burglary. Subjective safety reflects the perception of social safety and encompasses fear or anxieties caused by real or assumed threats. In criminology, subjective safety is commonly divided into a cognitive component, an emotional-affective component, and a behavioural component (Hardyns and Pauwels, 2010a). The cognitive component refers to the risk perception of personally becoming a victim. The emotional affective-component refers to feelings of unsafety and fear of crime. Fear of crime can be considered a specific type of unsafety feeling that solely focuses on the fear of becoming a victim of crime while unsafety feelings in general may include other fears or anxieties concerning neighbourhood problems, such as vandalism, street harassment or youth hanging around (Skogan and Maxfield, 1981 and Hardyns and Pauwels, 2010a). The behavioural component refers to avoidance behaviour due to crime (Hardyns and Pauwels, 2010a and Oppelaar and Wittebrood, 2006). We will focus in this study on the occurrence of crime as a proxy for objective neighbourhood safety, and on the emotional component of subjective safety, because unsafety feelings and fear of crime are considered important factors influencing health (Lorenc et al., 2012).

Two pathways are commonly distinguished between neighbourhood crime, unsafety feelings, and health. The psychosocial mechanism is the most frequently mentioned pathway (Chandola, 2001). Crime and feeling unsafe induce stress, which negatively impacts mental and physical health (Chandola, 2001). It is further hypothesized that neighbourhood crime and unsafety feelings affect physical activity (PA) negatively. People may limit their outdoor activities because they feel unsafe there (McGinn et al. 2008). The empirical evidence for this latter mechanism is, however, inconsistent (Lorenc et al., 2012, Foster and Giles-Corti, 2008 and Mason et al., 2013).

A third proposed pathway between social safety and health is that crime and unsafety feelings may result in mistrust of others, forming a barrier for social interactions among neighbours (Stafford et al., 2007) and the creation of social cohesion, which could be detrimental to health as well (Kawachi and Berkman, 2000 and Diez Roux and Mair, 2010). On the other hand, it has been theorized that the level of social cohesion in a neighbourhood may reduce the development of feelings of unsafety in the presence of crime because people feel protected and less vulnerable (Ross and Jang, 2000 and Lorenc et al., 2012). In other words, the social cohesion of the neighbourhood might affect the impact of crime on the development of unsafety feelings. Based on this argument, we hypothesize that neighbourhood social cohesion might protect against the presumed, negative health impact of neighbourhood crime and unsafety feelings on health and PA. In socially cohesive neighbourhoods residents might feel supported by their neighbours, which lowers the stress-inducing

effect of neighbourhood crime and feelings of unsafety, resulting in better self-rated health and more PA.

So far, the evidence on the negative impact of neighbourhood social safety on health is based largely on cross-sectional studies. If neighbourhood crime and neighbourhood unsafety feelings determine the health of residents, we would expect changes over time in the neighbourhood social safety to affect health (Bambra et al., 2010). To our knowledge, no study has yet examined whether changes over time in the neighbourhood social safety affect the general health of residents. In case of PA, a few studies have considered the effect of changes over time in neighbourhood fear of crime. A recent Dutch study found favourable changes in fear of crime to be borderline statistically significantly associated with more residents being physically active (Jongeneel-Grimen et al., 2014). An Australian study reported an increase in fear of crime negatively influenced people's walking behaviour (Foster et al., 2014). A more comprehensive measure of social safety than just fear of crime could provide a clearer understanding of the relation between neighbourhood safety and physical activity. Furthermore, objective crime and subjective safety feelings are not strongly interrelated and, therefore, seem to represent two different aspects of social safety that may have a different impact on people's health and lifestyle (Lorenc et al., 2012). We will therefore study the impact of neighbourhood crime and unsafety feelings separately, and we will employ several measures of neighbourhood unsafety feelings.

In summary, the aim of this paper is to examine the causal relation between neighbourhood social safety and self-reported health and PA, and the protective effect of social cohesion herein. We will examine the effect of social safety on both self-rated health and PA, in order to respectively examine the psychosocial and the health-related behavioural mechanisms. The following research questions are addressed: Are neighbourhood crime and unsafety feelings associated with self-rated health and PA? Are changes over time in neighbourhood crime and unsafety feelings related to general health and PA? Do the presumed adverse effects of increasing neighbourhood unsafety on general health and PA vary by the level of social cohesion in the neighbourhood?

2. METHODS

2.1. Study population

Health and PA data and individual characteristics were obtained from the cross-sectional Dutch Housing Survey 2009 and 2012 (WoON), conducted by Statistics Netherlands (CBS). WoON is a nationwide, triennial survey of non-institutionalized adults (18 years and older). A stratified sample was drawn, covering municipalities nationwide. Data were collected through telephone, Internet, and face-to-face interviews. In total, 78,000 respondents completed the survey in 2009 (response rate 58%) and 69,330 in 2012 (response rate 63%). We selected respondents from the WoON 2012 survey who had lived at their current address since at least 2009 in order to examine the health effect of exposure to safety issues measured in 2009 and 2011.

The safety and cohesion measures were derived from repeated cross-sectional data from the Dutch Integral Safety Monitor 2009 and 2011 (Integrale Veiligheidsmonitor), conducted by Statistics the Netherlands (CBS). The Safety Monitor is a nationwide survey of non-institutionalized persons aged 15 years and

older that monitors the safety, liveability, and victimization in the Netherlands. A stratified sample covering municipalities nationwide was drawn. Residents participated in the survey via either the Internet or a written questionnaire. Non-responders were approached again by telephone or face-to-face. A total of 198,122 and 223,944 respondents completed the survey in 2009 and 2011 respectively (response rate 40% in 2009 and 43% in 2011). We selected respondents of 18 years and older (N=192,015 in 2009 and N=216,840 in 2011; mean of 57.1 to 73.6 observations per area) to match the data with the WoON dataset containing the health data. The safety scores constructed from the Safety Monitor were combined with the health data by using the 4-digit postal code of the address of the respondents.
In total, 47,926 respondents living in 2974 areas (74% of the Dutch postal-code areas) were included in the analyses.

2.2. Measures

2.2.1. Self-rated general health and PA

Self-rated general health was measured by the single-question item: 'In general, how do you rate your health?' Using a 5-point Likert-scale, answers ranged from 'very good' to 'very bad'. Because the answers were highly skewed, and in order to make the outcome measure comparable to other international studies as well, we dichotomized the answers into (very) good versus less than good. Self-rated general health has consistently proven to be an independent predictor of mortality (Idler and Benyamini, 1997) and morbidity (Simon et al., 2005).
The physical activity of the respondents was determined by the single question: 'How many hours per week do you spend on physical activity or sports?' Recent Dutch studies that used the same data showed that the neighbourhood environment affected whether or not people were physically active, but not the amount of time people exercised (Jongeneel-Grimen et al., 2013 and Jongeneel-Grimen et al., 2014). Therefore, we dichotomized PA and studied physical inactivity, defined as 0 hours of physical activity or sports per week.

2.2.2. Area-level social safety

In this study, we calculated aggregated social safety scores at the neighbourhood level, defined by the 4-digit postal code area. Criminological studies have shown variations in area crime and safety-related outcomes to be most pronounced at the neighbourhood level, as compared to larger geographic scales, such as the municipality level (Hardyns and Pauwels, 2010b and Oberwittler and Wikström, 2009). The Dutch four-digit postal code comprises, on average, around 4,000 residents. The area surfaces of the four-digit postal code areas range between 1 and 8 km2, depending on population density.
We measured two components of area social safety: area crime and area unsafety feelings. A crime frequency score was composed by summing the answers of respondents to five questions concerning the frequency of specific crime events in their neighbourhood: bicycle theft, theft from cars, threats, burglary and muggings. Possible answers were 'often', 'sometimes' and '(almost) never'.
Unsafety feelings were measured by three questions: 'Do you ever feel unsafe in your neighbourhood?' (answers: 'yes', 'no'), 'How often do you feel unsafe when you walk in your own neighbourhood at night?', and 'Do you ever feel unsafe in your own home?' (answers: 'often', 'sometimes' and '(almost) never'). The three

indicators were dichotomized in order for the score at the area-level to reflect the number of people that felt unsafe (no matter how often) rather than the degree of unsafety feelings (sometimes or often). If more people in the area felt unsafe, then the chance that residents are exposed to neighbours who felt unsafe was larger than when just a few people felt very unsafe. We therefore argue that the number of people that feel unsafe in a certain area is more important for the general health of all residents than the extent of their feelings of unsafety. We analyzed the three questions separately in order to investigate in which situations unsafety feelings were most relevant for health and PA. The questions about feeling unsafe included references to specific spatial and temporal contexts, which were important in assessing perceived safety issues accurately (Evans and Fletcher, 2000). To aggregate our social safety measures to the area level we conducted 'ecometrics' analyses (see the paragraph below on ecometrics-based measures of the area-level characteristics).

Changes in area crime frequency and unsafety feelings between 2009 and 2011 were computed by subtracting each area score in 2009 from that of 2011. Additionally, we divided the change scores into four equally sized groups (quartiles) to accommodate the analyses of a nonlinear relationship with the health outcomes. A higher quartile reflected increased levels of area crime frequency or unsafety feelings. Because the change rate between 2009 and 2011 is not similar for each safety indicator, the quartiles can represent different change groups (see Table 1). This is also reflected in the labels of the quartiles in Table 3.

[TABLE 1]

[TABLE 2]

[TABLE 3]

2.2.3. Area-level social cohesion

Social cohesion data were obtained from the 2009 IVM dataset and were measured by summing the answers to the following four statements concerning the social connectedness between neighbours: 'The people in this neighbourhood hardly know one another.', 'The people in this neighbourhood are friendly to one another.', 'I live in a cosy neighbourhood with much solidarity.', 'I feel at home with the people living in this neighbourhood.' (Statistics Netherlands, 2010). Using a 5-point Likert scale, answers ranged on from 'totally disagree' to 'totally agree'. We recoded the negatively stated items so that a higher score meant more social cohesion. Again, aggregated scores for social cohesion were created using ecometrics.

2.2.4. Ecometric-based measures of the area-level characteristics

Following the work of Raudenbusch and Sampson (1999), we conducted ecometrics analyses to calculate the social safety scores for each postal code area. Ecometrics takes into account differences in the number of respondents per area and the individual characteristics of these respondents between areas, as well as the interdependence of the answers to the questions per respondent. We adjusted the aggregated measures for five individual characteristics that can influence the

perception of area crime and the feelings of unsafety, i.e. sex, age, educational level, ethnicity, and number of household members. To aggregate the crime frequency measure and social cohesion measure, three-level (items, respondents, and area-level) ordinal regression models were used. The measurements of unsafety feelings were aggregated using two-level (respondent and area-level) logistic regression models. The scores were calculated on the link scale. We estimated Generalized Linear Mixed Models (GLMM), in which the linear mixed model is related to the outcome variable via a link function. The link function depends on the distributional assumptions of the outcome variable. For the ordinal regression models this is the cumulative logit function and the for the logistic regression models this is the logit function. The area level social safety scores are characterized by the best linear unbiased predictors (BLUPS), which are based on parameter estimates in the linear mixed model (Hartzel et al., 2001 and McCulloch and Searle, 2004). Correlations of the different social safety measures are provided in Table 1.

2.2.5. Confounders

The following individual characteristics were used as control variables: sex (male/female), age (continuous variable), highest achieved educational level (no education/only primary school, lower secondary, upper secondary, tertiary), household composition (partner/married, no child(ren); partner/married with child(ren); single, no child(ren); single with child(ren); other), ethnicity (ethnic Dutch, non-Dutch Western origin, non-Western origin), and disposable household income (continuous variable). Ethnicity and disposable household income were derived from the national population registry and the national tax registration from Statistics Netherlands, respectively. At the area-level, we controlled for urbanicity. Urban areas are usually regarded as less safe than rural areas (Oppelaar and Wittebrood, 2006), and people living in urban areas exhibit poorer health in general (Verheij, 1995). By controlling for urbanicity, we made sure that the relation between area safety and health was not assigned to the level of urbanicity. The measurement of urbanicity, provided by Statistics Netherlands, was based on the number of addresses per km2 of the municipality and translated into a 5-point scale. Higher values indicate higher urbanicity.

2.3. Data analyses

Multilevel models were used to take into account that respondents (level 1) cluster in areas (level 2). All regression models included sex, age, ethnicity, educational level, and household composition as individual-level control variables and urban density as an area-level control variable. First, we separately examined the relation between area crime/area feelings of unsafety in 2009 and less than ‘good’ self-rated health and physical inactivity in 2012, using multilevel random intercept logistic regression analyses. Next, we analyzed whether changes in area crime frequency and area feelings of unsafety between 2009 and 2011 were related to self-rated health and physical activity in 2012. In this way, we tested the experiment criterion for causation from Bradford Hill (1965) in which ‘a change in exposure should affect the frequency of the associated event’. To see if changes in crime and safety feelings influenced health and physical activity in 2012, independent of the crime level and level of safety feelings at baseline, we adjusted for area crime and safety feelings in 2009. For the same reason, we adjusted for area-level health status and physical activity in 2009. Finally, we investigated whether the association between changes in

social safety and health/PA varied with the level of social cohesion in an area by including an interaction between changes in social safety and social cohesion in the final model. Analyses were carried out using R, version 2.15.1 and SPSS version 20.

2.4. Results

2.4.1. Social safety in 2009 in relation to poor general health and physical inactivity in 2012

The general health and PA of residents differed between areas. The intraclass coefficients (ICC) for general health and PA were, respectively 4.18 and 3.23. This means that 4.2% of the variation in health and 3.2 % of the variation of PA was associated with the area level.

Living in an area characterized by higher area crime in 2009 was statistically significantly associated with a higher prevalence of poor general health and borderline significantly associated with more residents being physically inactive in 2012 (Table 2). The larger the proportion of the population who reported feeling unsafe in the neighbourhood in general or at night in 2009, the more the residents reported poor general health or physical inactivity in that area in 2012. Furthermore, areas where a larger proportion of residents reported feeling unsafe in the home were statistically significantly more likely to have more residents with poor general health, but not more physically inactive residents (Table 2). In all cases, area crime and unsafety feelings were more strongly related to poor self-rated general health than to physical inactivity (Table 2).

2.4.2. Change in social safety in relation to poor general health and physical inactivity

On the average, area-level unsafety feelings at home and in the neighbourhood in general increased between 2009 and 2011, while area-level unsafety feelings in the neighbourhood at night and area crime slightly decreased during this period (Table 1).

There was no linear relation between changes in social safety and health and physical inactivity, so we have only presented the results on changes in social safety divided into quartiles in Table 3. Areas with the highest increase in unsafety feelings in the neighbourhood in general had a higher prevalence of poor general health in 2012 compared with areas that experienced the highest decrease in unsafety feelings (Table 3). Areas with a moderate or high increase in unsafety feelings at home also showed a higher prevalence of poor general health compared to areas with the highest decrease in unsafety feelings at home. There was no statistically significant relation between changes in unsafety feelings at night and poor general health. In case of physical inactivity, areas with the highest increase in unsafety feelings at home showed a significantly higher prevalence of physical inactivity compared to areas with the highest decrease in unsafety feelings at home (Table 3). Changes in the other area-level unsafety feelings indicators were not associated with physical inactivity. Changes in reported area crime frequency between 2009 and 2011 were not statistically significantly related to either poor general health or physical inactivity in 2012 (Table 3).

2.4.3. Change in social safety, social cohesion, and the relation with poor general health and physical inactivity

The relation between changes in area crime and general health and PA did not differ by the level of social cohesion in the neighbourhood (Table 3). The relation between changes in area-level feelings of unsafety in the neighbourhood in general, at night, or at home and general health and PA did not differ by the level of social cohesion of the neighbourhood either (Table 3)1.

3. Discussion

Whereas people living in areas with lower social safety in 2009 showed poorer general health and physical inactivity in 2012, changes over time in social safety were only partially related to poor general health and not to physical inactivity. Inhabitants of areas that experienced an increase in feelings of unsafety reported more poor health, but physical inactivity levels were not affected. Additionally, an increase in the area crime frequency was unrelated to either poor health or physical inactivity. The strength of the association between changes in area social safety and poor health or physical inactivity did not differ by the level of social cohesion. Further elaboration of the results requires consideration of the strengths and limitations of this study. Strength of our study is the use of different data sources for exposure (area crime frequency and perceived area unsafety) and outcome measures (self-rated general health and physical activity), thereby limiting same-source bias (MacLeod et al., 2002). In addition, our data is nationwide and includes almost 90% of the postal code areas in the Netherlands, making it unlikely that our results are influenced by selective sample bias. In addition, we used ecometrics to compute area social safety, which is a more reliable way to calculate area-level indicators than the 'traditional', more simple calculation of an average for each neighbourhood based on individual information. One of this study's limitations is that the period we used for studying changes in social safety was relatively short. However, although the period was short, we measured changes in area social safety and were therefore able to study its impact on health. The observation time to detect the health impact of changes in social safety was short as well. Nevertheless, we selected health and lifestyle outcomes that can react relatively quickly, thereby limiting the chance that the lag-time in our study was too short to demonstrate an effect. Furthermore, we did observe an impact of changes in unsafety feelings on general health, and therefore believe that the limited period was not a major obstacle in our analyses and that our results indeed reflect a lack of impact of changes in social safety on PA. Second, we assumed that the 4-digit postal code area reflected the respondent's neighbourhood, while the 4-digit postal code is in fact an administrative unit and may not reflect the resident's perception of their neighbourhood. Most likely, the postal code units, with on average 4,000 residents, are larger than the areas residents consider their neighbourhood. This is specifically the case outside the cities, where one postal-code unit can sometimes include a complete (small) village. We attempted to adjust for the urban-rural differences in postal-code areas, by adding urbanicity to the statistical analyses. However, if the geographical level on which the mechanisms between social safety and health or PA took place is smaller than the postal code level, we might have miscalculated the association between social safety and health or PA. This could particularly be an issue for the exposure to area level feelings of unsafety. People have to talk with each other about their feelings of unsafety in order to expose one another. Because it is likely that people interact more with residents who live nearby (direct neighbours, residents who live in close proximity), smaller

geographical units could arguably be more appropriate to study the health impact of area-level unsafety feelings. Unfortunately, smaller geographical units were not available for this study. Third, we would have preferred to include police crime registrations in addition to the reported crime we obtained from the survey data, but this information was not available at the postal code level. Official recorded crime rates and perceived crime are not strongly correlated (McGinn et al., 2008 and Taylor and Shumaker, 1990) and may have a different impact on health (Lovasi et al., 2014 and McGinn et al., 2008). Even though we controlled for individual differences in reported crime frequency by using ecometrics, including crime registries would have provided us with a more comprehensive measure of objective neighbourhood social safety. We, therefore, cannot draw firm conclusions on the impact of changes in objective crime rates on health and PA. Furthermore, future studies might want to include cognitive and behavioural components of subjective social safety as well, in addition to the emotional component used in this study. Fourth, our measure of physical activity did not include reference to the place of activity. It is therefore likely that this measurement includes activities outside the neighbourhood as well, and this might have contributed to a weaker relation between PA and neighbourhood safety. Finally, the indicator 'unsafety feelings at home', which we used as an environmental characteristic, may partly reflect unsafety feelings related to other problems than those in the neighbourhood, such as domestic violence. If that is the case, we unjustly interpret the health impact of changes in feeling unsafe at home as an effect of neighbourhood safety. Because we cannot exclude this possibility, the findings concerning this safety indicator should be interpreted with some caution. Unfortunately, no information on the household level was available in our dataset to further investigate the importance of this level for health.

Overall, we found evidence that changes in area social safety may be more relevant to general health than to PA. This is in contrast to cross-sectional studies that, on several occasions, reported associations between social safety and PA as well (Diez Roux and Mair, 2010 and Lorenc et al., 2012). Although we found a relation between area-level unsafety feelings in 2009 and physical inactivity in 2012, there was no longer a relation between physical inactivity and area-level unsafety feelings when we looked at changes over time in area-level unsafety feelings. We did not find a relation between changes in area crime frequency and PA either. In other words, our results do not support a causal relationship between area social safety and PA. This questions the relevance of the behavioural mechanism. Another Dutch study by Jongeneel-Grimen et al. (2014) reported a weak, borderline significant association between a decrease over time in neighbourhood fear of crime and increased prevalence of PA. An Australian study, reported that an increase in fear of crime influenced people's walking behaviour negatively (Foster et al., 2014). Both studies used a different indicator of social safety than we did, namely fear of crime, which makes the results less comparable. Future research might want to incorporate various measures of area-level safety feelings to further study the effect of perceived area social safety on physical activity.

We only reported a significant relation between general health and changes in area-level safety feelings and not between general health and changes in area crime frequency. This fits the findings of Blackman et al. (2001), who found that increases in the residents' feelings of safety in the neighbourhood were beneficial for community mental health. It, however, does not fit in with the study by Browning et

al. (2012). They reported that increases in neighbourhood crime were associated with elevated C-reactive protein (CRP), which is considered a bio measure of risk for poor health. If replicated in future studies then our findings suggest that area-level safety feelings are causally related to health and area crime is not, suggesting that reducing feelings of unsafety is an important strategy to improve population health and that it is not enough to address only area crime.

Changes in area-level feelings of unsafety in the neighbourhood in general was related to self-rated health, but not changes in area-level feelings of unsafety in the neighbourhood at night. Possibly, area level unsafety feelings in the neighbourhood in general – thus also during the day – might be more threatening to residents than unsafety feelings at night, which can be experienced as a less safe time-period anyhow. This could clarify why feelings of unsafety in general among the residents in an area are related to health, but not area-level unsafety feelings specifically at night.

We found that social cohesion does not protect against the negative health consequences of increasing unsafety in the area. A Canadian study suggested that this might be the result of the fact that areas having high levels of social cohesion, as well as, concurrently, high crime levels or unsafety feelings do not exist in real life (Dupéré and Perkins, 2007) and can therefore not be studied. We found, however, that the areas with the highest levels of social cohesion were actually those with the highest increase in crime (not shown), therewith refuting the assumption made by Dupéré and Perkins.

The lack of a protective effect of strong social cohesion against the negative health consequences of increasing unsafety in the area does not mean that social cohesion is irrelevant in the context of social safety and health. As mentioned in the introduction, it has been suggested that area unsafety may limit the creation of social cohesion in a neighbourhood, and several criminological theories mention social cohesion as a determinant of neighbourhood crime and perceived unsafety (Skogan, 1990; Sampson et al., 1997). Perceived unsafety could then be a pathway between social cohesion and health (De Jesus et al., 2010 and Baum et al., 2009).

4. Conclusion

This study provides support for a causal relationship between area-level unsafety feelings and self-rated health. The absence of an effect of changes in area crime frequency on health and PA questions the causality of the relationship between crime and health that has been observed in cross-sectional studies. We found no support for a relation between social safety and health through the mechanism of limiting PA. Furthermore, social cohesion did not protect against the detrimental health effect of area unsafety. The results reported here suggest that tackling unfavourable changes in the resident's feelings of area unsafety might contribute to better general health.

Acknowledgements

The present study is funded by the National Institute of Public Health and the Environment of the Netherlands.

REFERENCES

Bambra,C.,Gibson,M.,Sowden,A.,Wright,K.,Whitehead,M.,Petticrew,M.,2010. Tacklingthewidersocialdeterminantsofhealthandhealthinequalities:evidence from systematicreviews.J.Epidemiol.CommunityHealth64,284–291.

Baum, F.E.,Ziersch,A.M.,Zhang,G.,Osborne,K.,2009.Doperceivedneighbourhood cohesion andsafetycontributetoneighbourhooddifferencesinhealth?Health Place 15,925–934.

Blackman, T.,Harvey,J.,Lawrence,M.,Simon,A.,2001.Neighbourhoodrenewaland health: evidencefromalocalcasestudy.HealthPlace7,93–103.

BradfordHill,A.,1965.Theenvironmentanddisease:associationorcausation? Proc. R.Soc.Med58,295–300.

Browning,C.R.,Cagney,K.A.,Iveniuk,J.,2012.Neighborhoodstressorsandcardi- ovascularhealth:crimeandC-reactiveproteininDallas,USA.SocSciMed75, 1271–1279.

Chandola, T.,2001.Thefearofcrimeandareadifferencesinhealth.HealthPlace7, 105–116.

De Jesus,M.,Puleo,E.,Shelton,R.C.,Emmons,K.M.,2010.Associationsbetween perceivedsocialenvironmentandneighborhoodsafety:healthimplications. Health Place16,1007–1013.

Diez Roux,A.V.,Mair,C.,2010.Neighborhoodsandhealth(AnnalsoftheNewYork AcademyofSciences.Issue:TheBiologyofDisadvantage).Ann.N.Y.Acad.Sci. (ISSN 0077-8923).

Dupéré, V.,Perkins,D.D.,2007.Communitytypesandmentalhealth:amultilevel study oflocalenvironmentalstressandcoping.Am.J.CommunityPsychol.39, 107–119.

Evans,D.J.,Fletcher,M.,2000.Fearofcrime:testingalternativehypotheses.Appl. Geogr.20,395–411.

Foster,S.,Knuiman,M.,Hooper,P.,Christian,H.,Giles-Corti,B.,2014.Dochangesin residents' fear ofcrimeimpacttheirwalking?LongitudinalresultsfromRESIDE. Prev.Med.62,161–166.

Foster,S.,Giles-Corti,B.,2008.Thebuiltenvironment,neighborhoodcrimeand constrainedphysicalactivity:anexplorationofinconsistent findings.Prev.Med. 47,241–251.

Hardyns W.,L.Pauwels.Differentmeasuresoffearofcrimeandsurveymeasure- ment errors.In:Coolsetal.(Ed.), GovernanceofSecurityResearchPapersSeries III, NewEmpiricalData,TheoriesandAnalysesonSafety,SocietalProblemsand Citizens' Perceptions, 2010a,Maklu;Antwerpen,19–39.

Hardyns W.,L.Pauwels.Theoreticalperspectivesoncommunitysocialcohesion and crime.In:PauwelsL.,HardynsW.,andVanderVeldeM.(Eds.), Social Disorganization, Offending,FearandVictimization, 2010b,BoomJuridische Uitgevers;DenHaag,59–76.

Hartzel, J.,Agresti,A.,Caffo,B.,2001.Multinomiallogitrandomeffectsmodels.Stat. Modell. 1,81–102. Idler, E.L.,Benyamini,Y.,1997.Self-ratedhealthandmortality:areviewoftwenty- seven communitystudies.J.HealthSoc.Behav.38,21–37.

Jongeneel-Grimen, B.,Droomers,M.,Busschers,W.,vanOers,H.A.M.,Stronks,K., Kunst.,A.,2013.Changeinneighborhoodtraffic safety:doesitmatterinterms of physicalactivity?PLoSOne8(5),e62525. http://dx.doi.org/10.1371/journal. pone.0062525.

Jongeneel-Grimen, B.,Droomers,M.,vanOers,H.A.M.,Stronks,K.,Kunst.,A.,2014. The relationshipbetweenphysicalactivityandthelivingenvironment:amulti- level analysesfocusingonchangesovertimeinenvironmentalfactors.Health Place 26,149–160. Kawachi,I.,Berkman,L.F.,2000.Socialcohesion,socialcapital,andhealth.In:Berkman, L.,Kawachi,I.(Eds.),SocialEpidemiology.OxfordUniversityPress,Oxford, pp.174–190. Lorenc,T.,Clayton,S.,Neary,D.,Whitehead,M.,Petticrew,M.,Thomson,H.,Cummins,S., Sowden,A.,Renton.,A.,2012.Crime,fearofcrime,environment,andmentalhealth and wellbeing:mappingreviewoftheoriesandcausalpathways.HealthPlace18, 757–765. Lovasi,G.S.,Goh,C.E.,Pearson,A.L.,Breetzke.,G.,2014.Theindependentassocia- tions ofrecordedcrimeandperceivedsafetywithphysicalhealthina nationally representativecross-sectionalsurveyofmenandwomeninNew Zealand. BMJOpen10(4),3(e004058). Mason, P.,Kearns,A.,Livingston.,M.,2013. "Safe going": theinfluence ofcrimerates and perceivedcrimeandsafetyonwalkingindeprivedneighbourhoods.Soc. Sci. Med.91,15–24. MacLeod, J.,DaveySmith,G.,Heslop,P.,Metcalfe,C.,Carroll,D.,Hart,C.,2002. Psychologicalstressandcardiovasculardisease:empiricaldemonstrationof bias inaprospectiveobservationalstudyofScottishmen.BMJ25(324), 1247–1251(7348). McCulloch, C.E.,Searle,S.R.,2004. Generalized,Linear,andMixedModels.Wiley,New York. McGinn, A.P.,Evenson,K.R.,Herring,A.H.,Huston,S.L.,Rodriquez.,S.L.,2008.The

association ofperceivedandobjectivelymeasuredcrimewithphysicalactivity: a cross-sectionalanalysis.J.Phys.Act.Health5(1),117–131. Oberwittler, D.,Wikström,P.H.,2009.Whysmallisbetter:advancingthestudyof the roleofbehavioralcontextsincrimecausation.In:Weisburd,D.,Bernasco, W.,Bruinsma,G.J.N.(Eds.),PuttingCrimeinitsPlace.UnitsofAnalysisin GeographicCriminology.Springer,NewYork,NY. Oppelaar, J.,Wittebrood,K.,2006.Angstigeburgers?Dedeterminantenvan gevoelensvanonveiligheidonderzocht(AnxiousCitizens?TheDeterminants of UnsafetyFeelingsExplored).TheNetherlandsInstituteforSocialResearch, Den Haag. Polling, C.,Khondoker,M.,Hatch,S.L.,Hotopf,M.,2014.SELCoHstudyteam. Influence ofperceivedandactualneighbourhooddisorderoncommonmental illness. Soc.PsychiatryPsychiatr.Epidemiol.49(6),889–901. Raudenbusch, S.W.,Sampson,R.J.,1999.Ecometrics:towardascienceofassessing ecological settings,withapplicationtothesystematicsocialobservationof neighbourhoods. Sociol.Methodol.29,1–41.
Ross,C.,Jang,S.J.,2000.Neighbourhooddisorder,fearandmistrust:thebuffering effect roleofsocialtieswithneighbours.Am.J.CommunityPsychol.28, 401–420. Sampson, R.J.,2003.Theneighborhoodcontextofwell-being.Perspect.Biol.Med. 46 (3)(supplement(summer2003)). Sampson,
R.J.,Raudenbusch,S.W.,Earls,F.,1997.Neighborhoodsandviolentcrime: a multilevelstudyofcollectiveefficacy. Science277(5328),918–924. Simon, J.G.,DeBoer,J.B.,Joung,I.M.A.,Bosma,H.,Mackenbach,J.P.,2005.Howis your healthingeneral?Aqualitativestudyonself-assessedhealth.Eur.J.Public Health 15(2),200–208. Skogan, W.G.,Maxfield, M.G.,1981.Copingwithcrime.IndividualandNeighbour- hood Reactions.Vol.124.SagePublications,London(SageLibraryofSocial Research). Skogan, W.G.,1990.DisorderandDecline.UniversityofCaliforniaPress,Berkeley.
Stafford,M.,Chandola,T.,Marmot,M.,2007.Associationsbetweenfearofcrimeand mentalhealthandphysicalfunctioning.Am.J.PublicHealth97(11),2076–2081.
StatisticsNetherlands.IntegraleVeiligheidsmonitor2010.Landelijkerapportage (IntegralSafetyMonitor2009,nationalreport), 2012,CBS;DenHaag/Heerlen.
Taylor,R.B.,Shumaker,S.A.,1990.Localcrimeasanaturalhazard:implicationsfor understandingtherelationshipbetweendisorderandfearofcrime.Am.J.Com-munityPsychol.18,619–641. Verheij,R.A.,1995.Explainingurban-ruralvariationsinhealth:areviewof interactionsbetweenindividualandenvironment.Soc.Sci.Med.42,923–935.

TABLES AND FIGURES

Table 1
Number, mean, standard deviation (SD), range for area crime and area unsafety feelings in 2009, change in area crime frequency and area unsafety feelings between 2009 and 2011, and Pearson's correlation between the area social safety indicators.

Indicator[b]	Area social safety[a]			
	Crime frequency	Feeling unsafe in the neighbourhood	Feeling unsafe in the neighbourhood at night	Feeling unsafe at home
In 2009				
N (areas)	2964	2965	2934	2910
Mean	−0.33	−1.67	−1.25	−2.66
SD	0.79	0.39	0.44	0.13
Range	−2.53–3.47	−2.67–0.21	−2.59–0.70	−3.23 to −1.71
In 2011				
N (areas)	2963	2964	2931	2911
Mean	−0.66	−1.64	−1.29	−2.55
SD	0.76	0.38	0.44	0.13
Range	−2.67–2.79	−3.05–0.09	−2.69–0.71	−3.11 to −1.81
Change between 2009 and 2011				
N (areas)	2953	2955	2895	2870
Mean	−0.33	0.03	−0.05	0.10
SD	0.52	0.33	0.36	0.15
Range	−3.05–1.58	−1.38–1.31	−1.56–1.37	−0.67–0.75
Change in quartiles				
25	−0.94	−0.40	−0.51	−0.10
50	−0.45	−0.07	−0.15	0.07
75	−0.17	0.14	0.08	0.14
100	0.32	0.47	0.43	0.32
Pearson's correlation[c]				
Crime frequency	1			
Feeling unsafe in the neighbourhood	0.71	1		
Feeling unsafe at night in the neighbourhood	0.69	0.81	1	
Feeling unsafe at home	0.30	0.47	0.43	1

[a] The scores for unsafety feelings and crime are based on ecometric outcomes and presented on a link-scale.
[b] Higher score means more criminality/unsafety feelings.
[c] Pearson's correlation between social safety indicators in 2009.

Table 2
Association of self-rated general health and physical inactivity in 2012 with area crime frequency and area unsafety feelings in 2009.

Determinants[a]	Poor general health OR (95% CI)	Physical inactivity OR (95%CI)
Crime frequency in 2009	1.13 (1.07–1.19)*	1.05 (1.00–1.10)
Feelings of unsafety 2009		
Feeling unsafe in the neighbourhood	1.25 (1.15–1.35)*	1.16 (1.07–1.25)*
Feeling unsafe in the neighbourhood at night	1.23 (1.14–1.33)*	1.18 (1.09–1.26)*
Feeling unsafe at home	1.54 (1.25–1.90)*	1.17 (0.96–1.43)

* $p < 0.05$.
[a] Adjusted for age, sex, ethnicity, household composition, educational level, household income and urbanicity.

Table 3
Association of self-rated poor general health and physical inactivity in 2012 with change in area crime frequency and area unsafety feelings between 2009 and 2011 in quartiles, the *p*-values of the interactions of changes in area crime frequency and area unsafety feelings with social cohesion (SC)[a].

Determinants	Poor general health		Physical inactivity	
	OR (95% CI)	*p*-Value interaction	OR (95% CI)	*p*-Values interaction
Change in crime frequency in 2009–2011				
High decrease (reference group)	1.00		1.00	
Moderate decrease	1.00 (0.91–1.11)		0.98 (0.89–1.08)	
Small decrease	1.02 (0.92–1.13)		0.98 (0.89–1.08)	
Increase	1.10 (0.98–1.23)		0.97 (0.87–1.07)	
Change in crime frequency × SC	–	0.96	–	0.22
Changes in feeling unsafe in 2009–2011				
Feeling unsafe in the neighbourhood				
High decrease (reference group)	1.00		1.00	
Moderate decrease	0.95 (0.86–1.06)		1.01 (0.91–1.11)	
Moderate increase	0.95 (0.86–1.06)		0.96 (0.86–1.06)	
High increase	1.16 (1.03–1.29)*		0.99 (0.89–1.11)	
Change in feeling unsafe in the neighbourhood × SC	–	0.94	–	0.35
Feeling unsafe in the neighbourhood at night				
High decrease (reference group)	1.00		1.00	
Moderate decrease	0.94 (0.85–1.04)		1.00 (0.90–1.10)	
Moderate increase	0.99 (0.89–1.09)		0.98 (0.89–1.08)	
High increase	1.05 (0.94–1.16)		0.96 (0.86–1.06)	
Change in feeling unsafe in the neighbourhood at night × SC	–	0.77	–	0.97
Feeling unsafe at home				
Decrease (reference group)	1.00		1.00	
Small increase	1.08 (0.96–1.20)		1.06 (0.96–1.18)	
Moderate increase	1.13 (1.01–1.26)*		1.03 (0.93–1.15)	
High increase	1.14 (1.01–1.28)*		1.12 (1.00–1.26)*	
Change in feeling unsafe at home × SC	–	0.70	–	0.78

[a] Adjusted for age, sex, ethnicity, household composition, educational level, household income, urbanicity, crime frequency/ unsafety feelings in 2009, and neighbourhood poor self-rated health in 2009

* $p < 0.05$.