QUANTITATIVE RESEARCH

A Multilevel Analysis of the Socio-spatial Pattern of Assault Injuries in Greater Vancouver, British Columbia

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ABSTRACT

Objectives: The purposes of this study are to a) determine the extent to which individual and neighbourhood-level socio-economic indicators broadly reflect the social conditions associated with assault injuries within an urban Canadian city, b) examine the significance of this relationship and c) determine if this relationship is best explained at the individual or neighbourhood scale.

Methods: Assault-related hospitalization data (2001-2006) were obtained from the British Columbia Trauma Registry (BCTR). Data from the 2001 Census were used as proxy measures of individual and neighbourhood socio-economic status (SES). A generalized hierarchical nonlinear model was used to differentiate between individual and neighbourhood effects.

Results: A social gradient according to individual and neighbourhood SES and frequency of assault injuries was observed for adults of all ages. After controlling for age and individual SES, probability of greater risk of assault injury among individuals living in progressively less privileged neighbourhoods remained 1.5-3 times higher than individuals living in the least deprived neighbourhoods. For adults under the age of 35, neighbourhood SES was a more statistically significant indicator of increased odds of assault injury than individual income.

Discussion: Assessing compositional and contextual variations in health outcomes provides health researchers engaged in injury surveillance a way of showing how, and for which type of people, neighbourhood environments influence the likelihood that an individual will be hospitalized due to an intentional injury. This analysis suggests that prevention efforts exclusively focused on the individual may have a limited effect in reducing the occurrence of assault-related injuries, especially among young adults.

Key words: Injuries; socioeconomic factors; residential characteristics; public health

La traduction du résumé se trouve à la fin de l'article.

In Canada, injuries are the leading cause of death among people under the age of 45 and the leading cause of potential years of life lost, with indirect and direct costs estimated at over $12.7 billion.[1] Studies have routinely shown that unintentional and intentional injuries are preventable and – as in many health outcomes – have also been found to vary according to both individual and neighbourhood socio-economic determinants.[2-4] Evidence from international cohort investigations on multilevel modeling of hospitalization patterns from injury found that individuals living in disadvantaged neighbourhoods experience a disproportionately higher risk of trauma.[5,6] One such study in Canada found that self-perceived measures of neighbourhood quality were negatively associated with higher risk for fighting injury among adolescents.[7]

While we are aware of no study in Canada that has investigated the multilevel association between individual and residential socio-economic influences on adult hospitalizations from severe assault injury, evidence suggests that individuals living in disadvantaged neighbourhoods are more susceptible to committing violent crime.[8,9] Multilevel analysis of health outcomes has gained currency over the past decade due to its ability to examine the dual complexity of compositional and contextual influences on health.[10-12] This research area is underdeveloped within Canadian injury prevention, but may potentially provide health researchers engaged in injury surveillance with a more comprehensive understanding of intentional injury patterns and whether public health initiatives toward injury reduction are best directed at individuals, neighbourhoods, or both.

Using population data from greater Vancouver, British Columbia as a case study, the purposes of this study are to a) determine the extent to which individual and neighbourhood-level socio-economic variables taken from the Census can be used to broadly reflect the social conditions associated with assault injuries within an urban Canadian city, b) examine the significance of this relationship and c) determine if this relationship is best explained at the individual or neighbourhood scale.

METHODS

Assault-related hospitalization data (2001-2006) from the British Columbia Trauma Registry (BCTR), the most detailed source of information on severe injuries throughout BC, were used for this analysis. The BCTR contains data for patients injured from multisystem trauma requiring 2 or more days of hospitalization and with an Injury Severity Score (ISS) greater than 12. The database also contains information on the injury mechanism, treatment paths, and in most cases sufficient data on the geographical location of the injury (intersection or postal code) to spatially map the incident and link the patient record with additional attribute information. ICD-10 classification codes were used to determine if the injury mechanism could be attributed to an assault. Injuries sustained from an assault by bodily force or stemming from legal intervention were excluded.

Patient data were spatially linked to population data from the Vancouver Census Metropolitan Area (CMA) using the CanMap

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Postal Geography dataset. Each patient's residential postal code was assigned to the Census Dissemination Area (DA) and Census Tract (CT) administrative boundary that encapsulated its location. Due to data suppression in the National Census and to minimize the effect of ecological fallacy, micro-level socio-economic data on average individual income using Census DAs were used as proxy indicators for individual socio-economic position. Neighbourhood SES was assessed using the Vancouver Area Neighborhood Deprivation Index (VANDIX). The VANDIX was previously developed by the authors using feedback from provincial Medical Health Officers (MHOs) as to the Census indicators that best characterized health and socio-economic deprivation outcomes in the province.[13] The final index was constructed from the aggregation of the seven variables (shown in Table 1) that were most frequently selected by the MHOs. Each variable was given a weight proportional to frequency of expert responses. The outcome score is the product of the seven SES indicators z-score, which were standardized to span a negative (least deprived) to positive (most deprived) scale. To control for sampling error and representation, DA and CT boundaries with populations of at least 250 residents, on Aboriginal reserves or contained in regional district electoral areas (RDAs), were suppressed from this analysis. In a small number of cases (n=29), CTs with less than 3 DAs were aggregated into the neighbouring tract to increase the sampling parameters of the multilevel model.

A two-level fixed effects Bernoulli generalized hierarchical linear model (GHLM) was constructed for this analysis using Hierarchical Linear and Nonlinear Modeling (HLM©) software published by Scientific Software International. GHLM models are appropriate when it is unrealistic to assume the data follows a Gaussian (e.g., normal curve) distribution and it is not realistic – as is often the case with injury records – to perform a transformation to make them do so. Level-1 variables (n=3,181) represented individual SES records and were constructed from the DA data. Level-2 variables (n=345) represented neighbourhood SES and were constructed from the CT data. Dummy variables were constructed for both factors and recoded into high, medium-high, medium-low, and low SES categories. High SES was used as the reference category. Patient records were stratified into 10-year age groupings and weighted based on the 2001 Census population data. In order to decrease the risk of ecological fallacy, our analysis was not adjusted by gender as there is no unique identifier linking the BCTR to the National Census.

RESULTS

Descriptive statistics of individual and area assault injury distributions within the Vancouver CMA between 2001-2006 are listed in Table 2. Figure 1 shows the prevalence scores for assault injury by individual SES. A social gradient follows assault injury patterns for all ages. For all ages, there is over a threefold increase when classified according to individual income. Injury occurrences rose stepwise from 12% for individuals within the highest income quartile to 41% for those in the lowest income quartile. This gradient is most evident for adults between 18-54, with an average stepwise increase from 11% to 43%. Prevalence of assault injury according to individual SES was less pronounced for adults between the ages of 55-64 and highly variable for adults over 65. Figure 2 shows the frequency distribution of assault injuries by neighbourhood SES. For all ages, there is a sixfold increase in assault injury rates by neighbourhood SES. The gradient was evident for all adults under

Table 1. Census SES Variables Selected by Provincial MHOs for Building the VANDIX Deprivation Index

SES Constructs	Response Rank	Weight (%)
Average Income	5.5	0.089
Home Ownership	5.5	0.089
Single Parent Family	4	0.143
No High School Completion	1	0.250
With a University Degree	3	0.179
Employment Ratio	7	0.036
Unemployment Rate	2	0.214

See ref. 13 for listing of survey.

Table 2. Descriptive Statistics of Assault-related Intentional Trauma Injuries (2001-2006), Vancouver CMA

	Count	Mean Age	Mean LOS*	Mean ISS†
Individual Statistics				
Males	374	35	17	23
Females	29	42	19	21

	Low SES‡	Mid/Low SES	Mid/High SES	High SES
Area Statistics (Age)				
18-24	50	35	23	13
25-34	39	22	19	7
35-44	47	13	14	4
45-54	30	17	6	3
55-64	13	5	4	2
65 +	4	3	3	3
Total	183	95	69	32

Data from BCTR (2001-2006)
* LOS = hospital length of stay
† ISS = Injury Severity Score
‡ Socio-economic classification assigned using the VANDIX

the age of 65, with approximately an 11-fold increase in injury rates across neighbourhood SES for adults between the ages of 35-54. Figure 3 provides an illustration of assault injury locations within the Vancouver CMA mapped by postal code of the patient's residence and individual-income data from the Census.

In the unconditional HLM model (no SES indicator variables), the results suggest that partial explanation of the variation in assault injuries can be attributed to the between-neighbourhood variation in injury rates (χ_2=821.8, p=0.000, 344$_{df}$). Results from the conditional HLM model between individual SES and neighbourhood SES are shown in Table 3. After weighting for age variation and controlling for individual SES, adults between the ages of 18 and 65 and residing in the most deprived neighbourhoods throughout the Vancouver CMA were 3 to 5 times more likely to be hospitalized from an intentional injury than adults living in the least deprived neighbourhoods. While a stepwise social gradient in injury hospitalizations according to neighbourhood SES was similarly found for all ages, itemized age variations across neighbourhoods for adults over the age of 35 collapsed or mirrored the probabilities generated from the individual level model. For adults of all ages, after controlling for neighbourhood SES, using average individual income as a proxy measure for individual SES was not a significant predictor of assault-related injury.

DISCUSSION

This research provides evidence of a social gradient in hospitalizations from intentional injury throughout greater Vancouver according to both individual and neighbourhood SES patterns. Similar to other health outcomes research from the Vancouver CMA,[14] the results from the HLM show that substantial neighbourhood gradients in assault injuries across all social groups remain or are intensified even after controlling for age and individual income

Figure 1. Distribution of hospitalization cases from assault-related injuries by age and individual SES quartiles derived from average income statistics, BCTR (2001-2006)
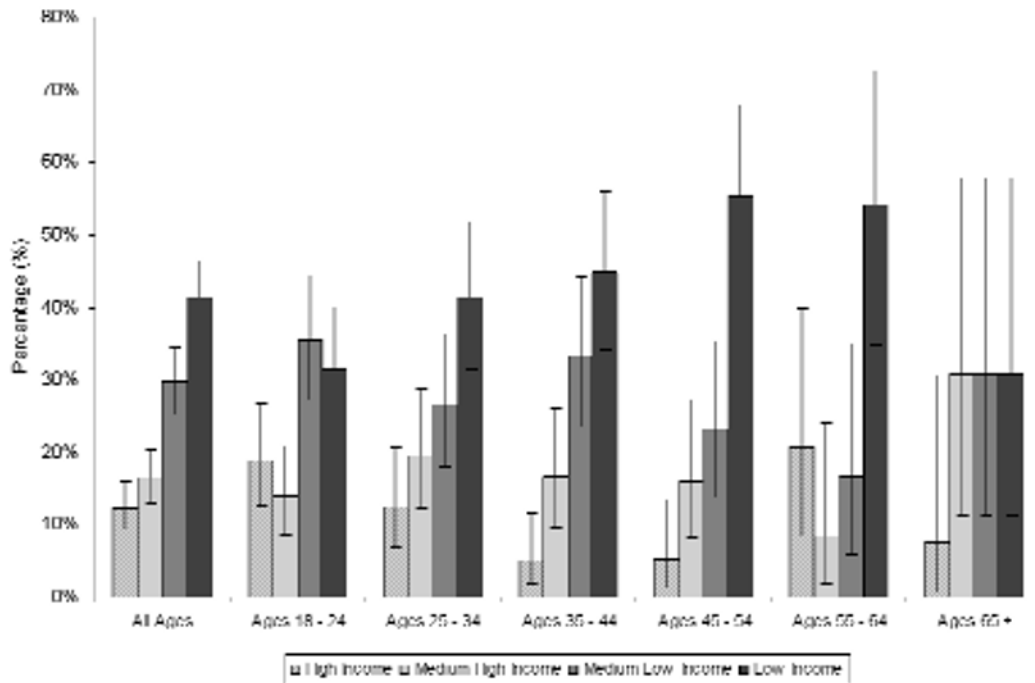
BCTR = British Columbia Trauma Registry.
*   Average income was derived from the 2001 Canadian Census Dissemination Area (DA) geographies.

Figure 2. Distribution of hospitalization cases from assault-related injuries by age and neighbourhood SES quartiles, BCTR (2001-2006)
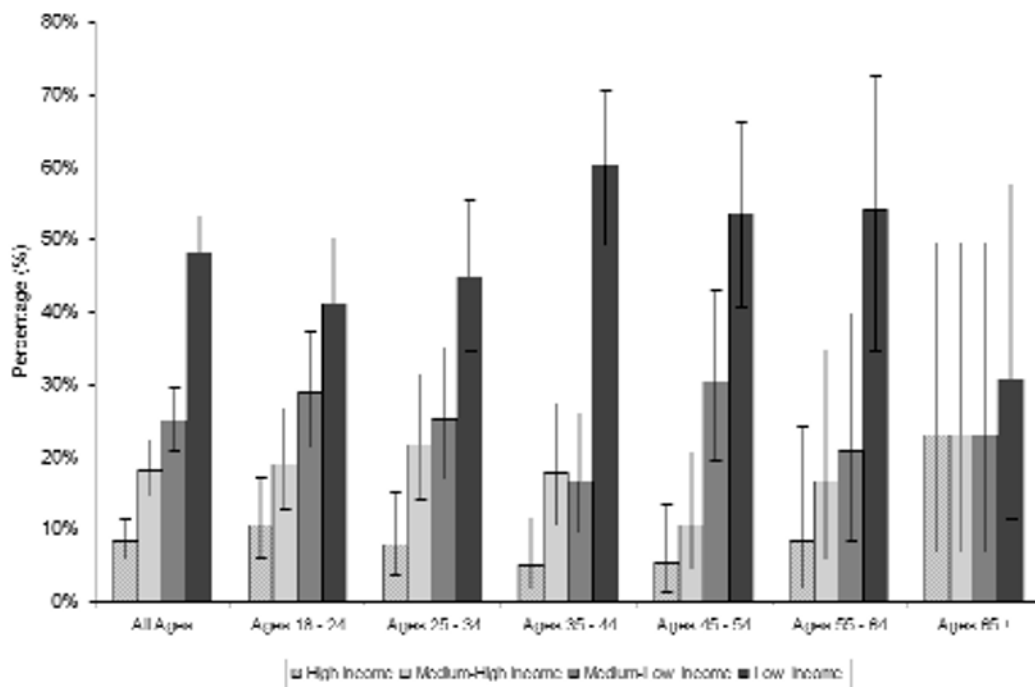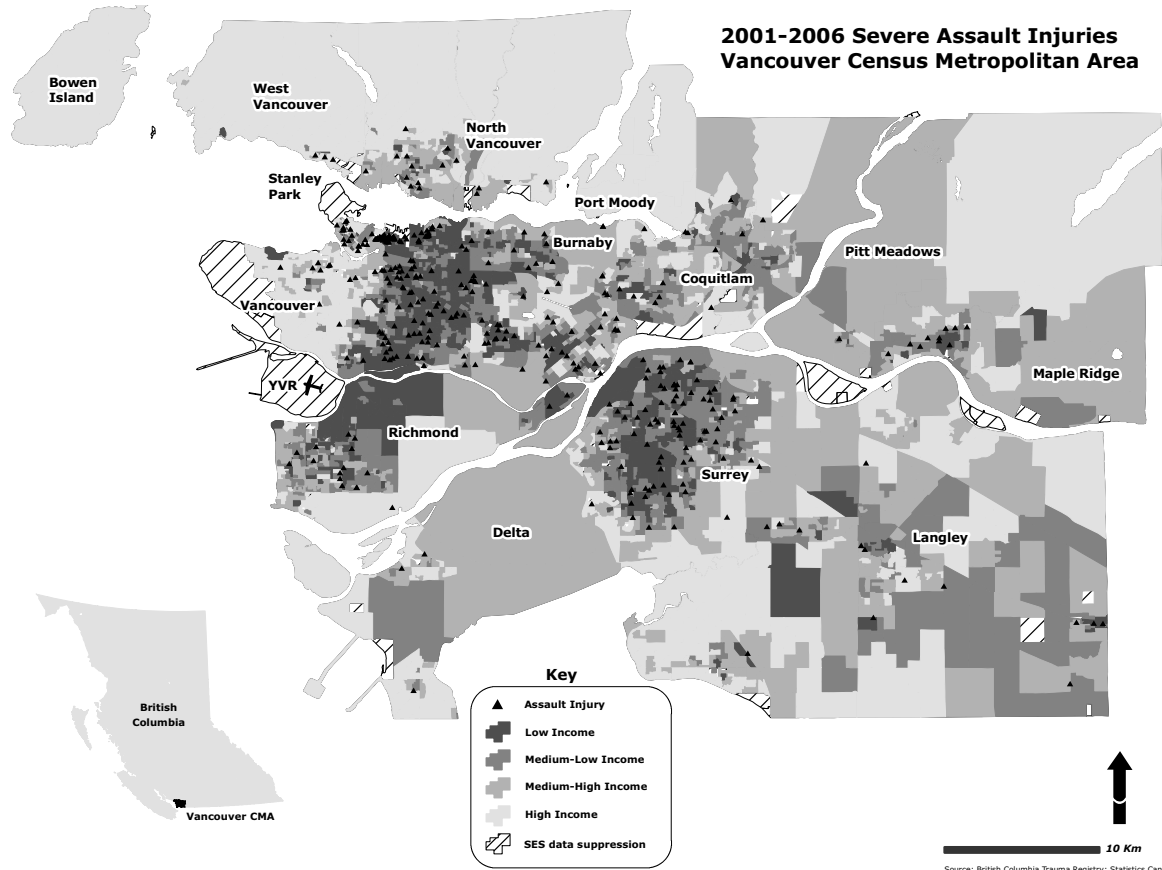

BCTR = British Columbia Trauma Registry
*   Neighbourhood SES was derived from the VANDIX and 2001 Census Tract (CT) geographies.

characteristics. As in other health outcomes research,[15-18] disentangling individual and area SES characteristics associated with increased risk of trauma injury enables researchers to assess the extent to which neighbourhoods influence health. The findings in this research are consistent with other studies that have isolated individual and neighbourhood influences of assault injuries and

points to the efficacy of targeting injury prevention at neighbourhoods – as it is more likely that the determinants of intentional injury have to do directly with the contextual environment of the neighbourhood rather than singularly on the individual.[19]

The results also show that, when itemized by age, after controlling for neighbourhood SES, greater probability of increased risk of

Figure 3. Map of severe assault trauma injury and residential income patterns, Vancouver CMA

2001-2006 Severe Assault Injuries
Vancouver Census Metropolitan Area

Key
▲ Assault Injury
Low Income
Medium-Low Income
Medium-High Income
High Income
SES data suppression

10 Km

Source: British Columbia Trauma Registry; Statistics Canada

injuries among adults under the age of 35 was statistically unrelated to individual income statistics. This relationship changed among older adults where the influence of neighbourhood SES collapsed or remained equally constant against individual socio-economic position. This variation may point to the likelihood that, among young adults, disadvantaged neighbourhoods increase feelings of social isolation and, in turn, violence. The results also suggest that neighbourhoods are powerful markers of residential stability and community cohesion that can help reduce or buffer the social and psychological factors that influence violent behaviour. Though neighbourhood SES was not a statistically significant indicator of increased injury risk among older adults, its relationship mirrored the stepwise gradient between individual income and increased probability of assault injury. This suggests that older adults injured from assault tend to cluster in areas that are more homogenous in terms of individual and neighbourhood characteristics. However, as the main focus of this study was to identify the 'general' association between individual and neighbourhood characteristics and prevalence of intentional trauma injury throughout greater Vancouver, we did not identify particular neighbourhoods more or less prone to varying injury rates or if the location of neighbourhoods with similar injury patterns were spatially clustered.

Although multilevel modeling techniques are increasingly the standard for disentangling the impact and relevance of individual and neighbourhood influences on health, their complexity makes these models highly conditional.[20] In particular, HLM models are extremely data hungry and there has been little discussion as to a minimum number of records to produce reliable estimates. Research from education-related studies suggests a minimum range

of 25 cases nested in each of 25 groups to 60 cases nested within 160 groups,[21,22] though others have suggested that these thresholds generally pertain to maintaining the reliability in estimates generated from small level-two sample sizes.[23] The use of multilevel modeling has also renewed discussion over the use of administrative data to quantify area influences on health over more meaningful neighbourhood or community geographies.[12,24] However, this caveat is often unavoidable in health research, as is the reliance on proxy measures of individual SES using small-area Census variables such as income. While this remains a limitation, administrative geographies and their data nevertheless capture broad notions of context, as factors such as income are one of the strongest indicators of health inequality and widely understood as one of the most important indicators of class status.[25]

In conclusion, one of the benefits of simultaneously assessing compositional and contextual variations in health outcomes is that they provide a way of showing how, and for which type of people, neighbourhood environments matter.[23] Within Vancouver, it is estimated that over 50% of all assaults take place in either the assailant's or victim's residence – with nearly two out of every three victims knowing their assailants.[26] This analysis suggests that an exclusive focus on individual determinants of intentional injuries will have limited effect on reducing their occurrence, especially among young adults. While the differences between individual and neighbourhood socio-economic characteristics are complex and difficult to completely reduce to individual indicators of material deprivation, such as average income or the VANDIX, these variables nevertheless capture many of the broader social conditions that characterize health outcomes. Thus, and as was emphasized in this

Table 3. Results of the Multilevel Model Contrasting Individual Income and Neighbourhood SES against the Occurrence of Severe Trauma Injury from Assault (2001-2006), Vancouver CMA

Conditional HLM Model	All Ages OR	95% CI Lower	Upper	18-24 OR	95% CI Lower	Upper	25-34 OR	95% CI Lower	Upper	35-44 OR	95% CI Lower	Upper	45-54 OR	95% CI Lower	Upper	55-64 OR	95% CI Lower	Upper	65 + OR	95% CI Lower	Upper
Individual Level																					
Low Income	1.13	0.70	1.85	0.34*	0.19	0.62	0.86	0.46	1.61	3.37*	1.53	7.44	3.36*	1.43	7.91	0.84	0.34	2.09	21.21*	11.36	39.61
Med. - Low Income	1.26	0.80	1.98	0.59	0.34	1.02	0.63	0.35	1.13	5.12*	2.55	10.29	2.38*	1.04	5.42	0.23*	0.12	0.44	22.40*	10.85	46.29
Med. - High Income	0.83	0.54	1.30	0.36*	0.21	0.63	0.67	0.37	1.19	2.83*	1.54	5.20	2.14	0.93	4.90	0.31*	0.18	0.53	9.16*	5.91	14.18
High Income	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Neighbourhood Level																					
Low SES	3.08*	1.81	5.23	5.29*	2.57	10.92	4.33*	2.18	8.62	3.27*	1.53	6.98	4.00*	1.91	8.38	4.27*	1.77	10.32	0.40	0.14	1.15
Med. - Low SES	1.79*	1.07	3.00	2.70*	1.35	5.40	2.58*	1.39	4.82	1.15	0.58	2.31	2.81*	1.43	5.56	2.89*	1.31	6.36	0.30*	0.13	0.66
Med. - High SES	1.45	0.84	2.49	1.51	0.70	3.28	3.38*	1.67	6.86	1.64	0.86	3.15	1.42	0.73	2.76	1.60	0.79	3.25	0.59	0.26	1.33
High SES	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

* Odds Ratios (OR) are statistically significant at $p < 0.05$

study, multilevel models can provide health researchers with a stronger understanding of the pathways and mechanisms through which the social environment influences injury patterns.

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RÉSUMÉ

Objectifs : Cette étude vise à : a) déterminer s'il existe une correspondance générale entre les indicateurs socioéconomiques individuels et par quartier et les conditions sociales associées aux blessures par suite d'agressions dans une grande ville canadienne, b) examiner l'importance de cette correspondance et c) déterminer si cette correspondance s'explique le mieux à l'échelle individuelle ou du quartier.

Méthode : Les données sur les hospitalisations des victimes d'agressions (2001-2006) ont été extraites du registre des traumatismes de la Colombie-Britannique (BCTR). Les données du Recensement de 2001 ont servi de variables substitutives au statut socioéconomique (SSE) individuel et par quartier. Un modèle hiérarchique non linéaire généralisé a servi à différencier les effets individuels des effets du quartier.

Résultats : Nous avons observé, pour les adultes de tout âge, un gradient social selon le SSE individuel et du quartier et la fréquence des blessures par suite d'agressions. Compte tenu de l'âge et du SSE individuel, la probabilité d'un risque plus élevé de blessure par suite d'agression chez les personnes vivant dans des quartiers progressivement moins privilégiés demeurait de 1,5 fois à 3 fois plus élevée que chez les personnes vivant dans les quartiers les moins démunis. Chez les adultes de moins de 35 ans, le SSE du quartier était un indicateur plus significatif d'une probabilité accrue de blessure par suite d'agression que le revenu personnel.

Discussion : L'évaluation des écarts compositionnels et contextuels dans les résultats cliniques offrent aux chercheurs médicaux qui s'intéressent à la surveillance des blessures un moyen de montrer comment, et pour quels types de personnes, l'environnement du quartier influence la probabilité qu'une personne soit hospitalisée à la suite d'une agression. Cela pourrait vouloir dire que les efforts de prévention qui s'adressent exclusivement aux individus n'ont qu'un effet limité pour réduire la fréquence des blessures par suite d'agressions, surtout chez les jeunes adultes.

Mots clés : blessures; facteurs socioéconomiques; caractéristiques résidentielles; santé publique