Rev Saúde Pública 2008;42(2)

Lia Thieme Oikawa Zangirolani[I]

Ricardo Cordeiro[II]

Maria Angélica Tavares de Medeiros[I]

Celso Stephan[I]

Spatial distribution of risks for work-related injuries in a city of Southeastern e Brazil

ABSTRACT

OBJECTIVE: To assess spatial distribution of risks for work-related injuries controlled for nutritional variables and other covariables.

METHODS: Hospital-based spatial case-control study with work-related injuries spatial distribution as the main variable of interest. A total of 794 workers were selected between May and October 2004. Inclusion criteria for cases (N=263) were: worker with work-related injury; living in Piracicaba (Southeastern Brazil); age between 15 and 60 years old; and cared at an orthopedics and trauma center. Controls (N=531) met the same criteria for age and residence, but had non-work-related injuries and workers accompanying cases were included as well. Spatial distribution was estimated by adjusting a generalized additive model with geographical coordinates of cases and controls as spatial non-linear component and the remaining covariables as linear components.

RESULTS: The variation of estimated spatial risks for work-related injuries controlled for gender (OR=1.87, p<0.001), schooling (OR=0.85, p<0.0001), self-employed (OR=0.36, p<0.01), and waist circumference (OR=0.98, p=0.05) showed that the mideastern area and north-to-south "strip" have higher risk for injuries.

CONCLUSIONS: The use of geoprocessing tools and nutritional variables can provide input for understanding the universe of risks for work-related injuries. Further investigation exploring these factors is needed.

DESCRIPTORS: Accidents, Occupational. Risk Factors. Geographic Information Systems, utilization. Case-Control Studies.

INTRODUCTION

Work-related injuries are the most common and widespread condition affecting workers' health and they have become a public health concern. Events that are socially determined, predictable and preventable should not be addressed as incidental or accidental conditions as its name may suggest.[8]

Knowing factors and causes associated to work-related injuries from different perspectives allows to exploring this issue comprehensively. There is a need for multiprofessional and interdisciplinary investigations to provide input for prevention and control policies.

Workers' nutritional status is a major factor to be taken into consideration given its impact on their overall health. Studies have sought to gain more knowledge on food and nutritional variables associated to work-related conditions.[1,4,13]

Although obesity is a long-known metabolic disorder, its prevalences have never been epidemic as it is seen nowadays.[16,23] In all regions of Brazil, a considerable

[I] Programa de pós-graduação em Saúde Coletiva. Faculdade de Ciências Médicas (FCM). Universidade Estadual de Campinas (Unicamp). Campinas, SP, Brasil

[II] Departamento de Medicina Preventiva e Social. FCM/Unicamp. Campinas, SP, Brasil

Correspondence:
Lia Thieme Oikawa Zangirolani
Departamento de Medicina Preventiva e Social
Faculdade de Ciências Médicas, Unicamp
C.P. 6111
13083-970 Campinas, SP, Brasil
E-mail: liatoz@fcm.unicamp.br

Received: 12/12/2006
Reviewed: 8/29/2007
Approved: 10/15/2007

proportion of adult population is overweight or obese. Substitution of processed products for fresh food in the diet, inactivity, changes in work organization and technology breakthroughs are all pointed out as main causes for weight disorders.[2,7,15,18,19]

The impact of obesity on workers' health has been investigated in studies assessing the relationship between worker's anthropometric profile and their functional capacity for work-related and daily activities and risks of injuries associated to high body mass index (BMI).[11,17,20]

To help elucidate the effect of nutritional status on work-related issues new instruments have been proposed to deepen the understanding of work-related injuries. The application of tools that enable to view the distribution of events in a geographic space is a major contribution for the detection of injuries and can provide input for planning actions in high-risk geographic points or areas.

One of the tools available is the Geographic Information System (GIS). It has been applied in health since the late 1980s when the first discussions and experimental studies based on GIS and spatial distribution of health conditions were carried out.[6] Spatial analysis added to health research helps restoring the ecological dimension of epidemiological studies as it allows to take into consideration the interaction between people and the environment, which is approached as a social being.

The application of GIS has been proposed in epidemiological surveillance to include a spatial dimension and render it more effective.[5,6,21,22] However, it has been little discussed GIS application in nutritional surveillance for the detection of conditions as well as planning of prevention and therapeutic actions in health settings following the Brazilian National Health System guidelines.

The objective of the present study was to describe the spatial distribution of risk for work-related injuries controlled for nutritional variables and other covariables.

METHODS

As part of the multi-center Diagnosis and Control of Work-Related Injuries (DIATEP) project, developed in the city of Piracicaba[9,10,14] (Southeastern Brazil) a spatial case-control study[3] where the main variable of interest was spatial distribution of work-related injuries was conducted. The source population consisted of injured workers living in Piracicaba, aged between 15 and 60 years, who were cared at an orthopedics and trauma center. This specialty center provided care to near 42%[14] of all work-related injuries in the city. Matched controls were also workers living in the city of Piracicaba, aged between 15 and 60 years, who were cared at the same setting but for non-work-related injuries. Workers accompanying cases were included as well. A total of 794 workers were studied: 263 cases and 531 controls.

Inclusion criteria for both cases and controls were as follows: 1) injury occurring in a site located within the geographical map of Piracicaba; 2) agreement to participate in the study and signing of a free informed consent form.

After inclusion criteria were met, information of cases and controls were collected by trained interviewers through a questionnaire comprising occupational, biological, social and economic and nutritional variables. Social and economic and nutritional variables were assessed through weight and height measurements for BMI estimation and classification of nutritional status following the World Health Organization (WHO) guidelines.[24] Waist circumference (WC) was also measured for estimating risks of cardiovascular diseases.[23] Weight was measured using a digital scale with 150-kg capacity and 0.05-kg precision. Subjects were weighed barefoot and in light clothing. Height measurements were taken using a 0.1-cm precision stadiometer with a measuring slide (mounted against a wall with no baseboard). Subjects were placed in upright position, body touching the wall at five different points (heels, calves, gluteal muscles, scapulas and head), weight placed even onto both legs and head up and straight ahead. WC measurements were taken using a non-elastic anthropometric band, placed in the midpoint between the iliac crest and the last rib, at exhalation. Three measurements were taken and then averaged. Information on changes in weight in the last year and how they affected work activities were collected.

Subjects had blood drawn for capillary blood glucose after check-in.

Data were collected on working days between May 16 and October 29, 2004.

The city's geographical map was adapted in DIATEP[a] project based on material provided by Piracicaba Department of Planning for the projection UTM Zone 23 (south), datum SAD-69. The urban area of Piracicaba was covered between coordinates NS 7.492.000 to 7.478.000 and EW 238.000 to 220.000, comprising a population estimated in 355,039 inhabitants in 2004 according to the Brazilian Institute of Geography and Statistics (IBGE).[b] Data were exported to GIS ArcView™ version 8.1 for analysis and management.

---

[a] Cordeiro, R. DIATEP: diagnóstico e controle dos acidentes do trabalho em Piracicaba – relatório de pesquisa. Campinas; 2005. [Mimeografado]. (FAPESP; 00/13719-3).

[b] Instituto Brasileiro de Geografia e Estatística. Estimativas Populacionais para os municípios brasileiros em 01/07/2004. (acesso em 15/1/2005). Disponível em: http://www.ibge.gov.br/home/estatistica/populacao/estimativa2004

An exploratory data analysis was conducted focused on the distribution of categorical variables and measures of central location and dispersion of continuous variables. Categorical variables with more than two levels were assessed as dummy variables. Univariate logistic regression models included work-related injury as the categorical, dichotomous response variable (case=1; control=0). The predictive variables were: gender, age, schooling, fixed workplace, participation in the labor market, employer-employee relationship, occupation category, shift, level of work demands, daily working hours (h), weekly overtime (h), weight (kg), height (m), WC (cm), capillary blood glucose (g/dL), BMI (kg/m²), changes in weight in the last year (kg), weight gain in the last year (kg).

Next, using the same response variable (work-related injury), a multiple logistic regression model was created including those variables that in univariate analyses had p<0.3. Data were analyzed using SAS software program version 8.0. Estimate of spatial distribution of risks for work-related injury was drawn from the adjustment of a generalized additive model controlled for the following variables: vector of spatial location of cases and controls (predictive) and variables with p<0.05 in the multiple logistic model. R software program version 2.1.1 was used in this analysis.

The study was approved by the Research Ethics Board, Botucatu Medical School, Universidade Estadual Paulista.

RESULTS

Cases and controls had similar gender and age distribution; most were males (84.0% cases; 77.0% controls). Subjects' distribution by age group showed that most were young aged between 20 and 39 years (72.0% cases; 69.0% controls). The overall description of the study sample is shown in Table 1.

The most common injury among cases was bruises seen in 45.2%, followed by sprains (17.5%), cuts (10.7%), and fractures (9.5%) among others.

The most injured body parts were hands (35.0%) and feet (19.4%) and the most immediate causes were machine or equipment injuries (22.1%), falls of objects (21.7%), and exertion/weight lifting (13.3%).

The nutritional assessment showed 46.4% of cases and 47.3% of controls were eutrophic. Overweight was found in 32.7% and 26.9% of cases and controls, respectively, and obesity in 16% and 21.8%, respectively. In regard to risk of cardiovascular diseases assessed based on WC, moderate risk was found in 16.4% and 19.2% of cases and controls, respectively; and high risk in 12.9% and 19.2%, respectively.

Table 1. Description of work-related injuries. Piracicaba, Southeastern Brazil, 2005.

Variable	Case %	Control %
Formal job	86.7	80.6
Traditional employer-employee relationship	87.8	78.7
Fixed workplace	57.4	62.1
Fixed day shift	92.0	91.3
Occupation category		
Factory worker	56.4	40.5
Services	22.2	28.9
High level of work demands	41.4	32.0
Schooling		
Low	18.2	11.7
Intermediate	47.6	38.8
High	34.2	49.5

A good number of cases and controls reported changes in weight in the last year, 54.4% and 52.4%, respectively. Of those who reported improved work performance due to changes in weight, 34.7% had weight loss while 80.9% who gained weight reported poorer work performance.

Variables with p<0.3 associated to injuries in the univariate analyses were: gender, schooling, fixed workplace, participation in the informal labor market, employer-employee relationship (self-employed, domestic and sideline work); occupation category (administrative personnel, maintenance services and factory worker); level of work demands (medium and high); weekly overtime, weight, height, WC, blood glucose, BMI and changes in weight in the last year (Table 2).

Variables that in the multiple regression analysis were associated to work-related injuries were: gender (OR=1.97; p=0.0014), schooling (OR=0.89; p<0.0001), being self-employed (OR=0.35; p=0.0002), WC (OR=0.98; p=0.0035), and BMI (OR=1.09; p=0.0230).

Table 3 shows the statistics obtained in the generalized additive model. Male workers were 1.87 times more likely (p<0.001) to have injuries. Being self-employed was a protective factor for injury (OR=0.36; p<0.01) as well as higher schooling (OR=0.85; p<0.0001). As for nutritional variables, WC was a protective factor (OR=0.98; p=0.05).

The Figure shows an estimate of spatial distribution of risk for work-related injuries in urban Piracicaba controlled for gender, schooling, being self-employed, and WC. The black dots represent locations where injuries occurred and the gray dots represent the distribution of

Table 2. Univariate analysis of work-related injuries and associated variables. Piracicaba, Southeastern Brazil, 2005.

Variable	OR	p
Gender	1,57	0,02
Age	0,99	0,67
Schooling (years)	0,90	<0,0001
Fixed workplace	0,82	0,20
Labor market: informal	0,64	0,03
Employer-employee relationship		
Self-employed	0,37	0,0004
Domestic	0,45	0,3
Brazilian Labor Law contract	1,21	0,65
Sideline work	3,62	0,29
Intern	0,60	0,66
Other	<,001	0,98
Occupation category		
Administrative personnel	1,63	0,27
Farming	0,60	0,64
Services	1,62	0,19
Management	<,001	0,98
Maintenance	2,91	0,01
Factory	2,94	0,002
Technical	1,02	0,97
Shift		
Alternate	0,89	0,85
Night	0,73	0,45
Short hours and multiple shifts	>999.999	0,98
Mixed	0,93	0,88
Level of work demands		
Medium	1,39	0,09
High	1,85	0,002
Daily working hours	1.04	0.40
Weekly overtime	1.01	0.3
Weight (kg)	0.99	0.08
Height (m)	0.28	0.15
Waist circumference (cm)	0.99	0.05
Blood glucose (g/dL)	0.99	0.15
Body mass index (kg/m²)	0.99	0.3
Changes in weight in the last year	0.99	0.3
Weight gain in the last year	1.08	0.59

controls' workplaces. The risk for work-related injury increases from lighter to darker colors; i.e., the mid-eastern area and north-to-south "strip" shows higher risk for work-related injuries.

Table 3. Generalized additive model analysis of work-related injuries and associated variables. Piracicaba, Southeastern Brazil, 2005.

Variable	OR	p-value
Gender	1.87	<0.001
Schooling	0.85	<0.0001
Self-employed	0.36	<0.01
Waist circumference (cm)	0.98	0.05

r^2 of spatial distribution: 0.30 p<0.0001

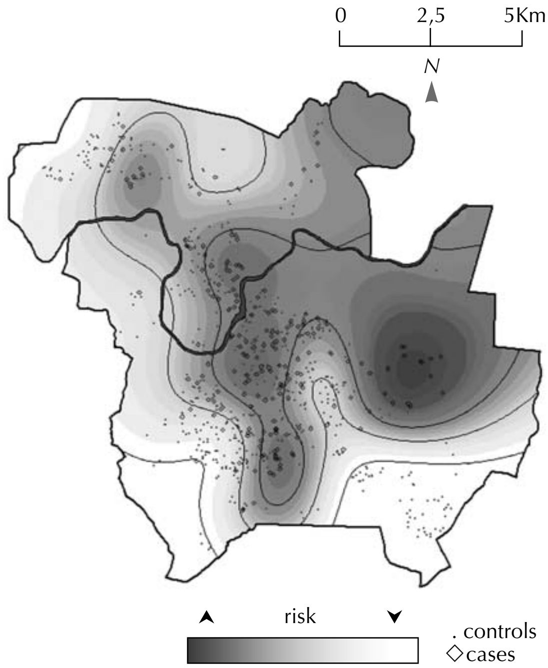

Figure. Spatial distribution of work-related risks. Piracicaba, Southeastern Brazil, 2005.

DISCUSSION

The spatial distribution of risk for work-related injuries controlled for nutritional variables showed male workers have a significantly higher risk. This finding corroborates other studies showing higher risks in occupations mostly taken by men.[9,12]

In regard to occupation, being self-employed proved to be a protective factor for injuries. Thus far there are no data in the literature questioning this finding, but it is suggested that greater flexibility in work daily routine and activities would contribute to lower risk exposure to injury in self-employed workers.

In the present study, the higher the schooling, the lower the injury risks. The same was verified in other case-control studies,[12] which showed low schooling as a major risk factor for work-related injuries.

With respect to nutritional variables, WC is a measure of central body fat and is believed to be an important predictor of chronic non-transmissible diseases such as hypertension and diabetes. In the present study, contrary to what was expected, WC proved to be a protective factor for work-related injuries. It can be thus assumed that a potential limitation in workers' agility and/or mobility as a result of increased WC can contribute to lower exposure to injuries. While studies[17] show central body fat as a limiting factor for daily activities reducing performance by 30%, it needs to be further investigation. On the other hand, to assume WC as a protective factor does not mean that the risk for work-related injuries is eliminated but rather that WC is associated with a reduced likelihood of injuries. The very status of being overweight or obese may make workers perform activities of lower risk exposure.

The incidence of work-related injuries in Piracicaba was estimated in 3.8%.[9] However, as shown in the Figure, this risk is not evenly distributed in the urban area and there can be seen areas of higher and lower risk compared to the mean risk rate in the city.

Despite the limitation of a hospital-based study, it can be assumed the heterogeneous distribution found is not resulting from uneven spatial distribution of variables such as gender, schooling, being self-employed and WC since the estimate of spatialization of risk for injuries was controlled for.

The study draws attention to city areas of higher risk for work-related injuries, such as the mid-eastern area and the north-to-south "strip". These areas should be targeted in surveillance actions for injury prevention in Piracicaba. The study also points out to the need of further investigating the role of social and environmental factors in high risk exposure in the areas identified.

The application of geoprocessing tools in addition to nutritional variables can provide input for better understanding the complex relationships involved in risks for work-related injuries. Further investigations on these factors are recommended.

REFERENCES

1. Assis MA, Nahas MV, Bellisle F, Kupek E. Meals, snacks and food choices in Brasilian shift workers with high energy expenditure. *J Hum Nutr Diet.* 2003;16(4):283-9.
2. Assis MAA, Rolland-Cachera MF, Vasconcelos FAG, Bellisle F, Calvo MCM, Luna MEP, *et al*. Sobrepeso e baixo peso em crianças de 7a 9 anos de idade de Florianópolis, Sul do Brasil: uma comparação com estudo francês usando protocolo similar. *Rev Nutr.* 2006;19(3):299-308.
3. Bailey TC, Cordeiro R, Lourenço RW. Semiparametric modeling of the spatial distribution of occupational accident risk in the casual labor market, Piracicaba, Southeast Brazil. *Risk Anal*. 2007;27(2):421-31.
4. Burlandy L, Anjos LA. Acesso a vale-refeição e estado nutricional de adultos beneficiários do Programa de Alimentação do Trabalhador no Nordeste e Sudeste do Brasil, 1997. *Cad Saude Publica.* 2001;17(6):1457-64.
5. Camargo-Neves VLF, Katz G, Rodas LAC, Poletto D, Lage LC, Spinola RMF, et al. Utilização de ferramentas de análise espacial na vigilância epidemiológica de leishmaniose visceral americana - Araçatuba, São Paulo, Brasil, 1998-1999. *Cad Saude Publica.* 2001;17(5):1263-7.
6. Carvalho MS, Souza-Santos R. Análise de dados espaciais em saúde pública: métodos, problemas, perspectivas. *Cad Saude Publica.* 2005;21(2):361-78.
7. Castanheira M, Olinto MTA, Gigante DP. Avaliação de variáveis sócio-demográficas e comportamentais com a gordura abdominal em adultos: estudo de base populacional no Sul do Brasil. *Cad Saude Publica.* 2003;19(Sup 1):S55-65.
8. Cordeiro R, Clemente APG, Diniz CS, Dias A. Exposição ao ruído ocupacional como fator de risco para acidentes de trabalho. *Rev Saude Publica.* 2005;39(3):461-6.
9. Cordeiro R, Vilela RAG, Medeiros MAT, Gonçalves CGO, Bragantini CA, Varolla AJ, et al. O sistema de vigilância de acidentes do trabalho de Piracicaba, São Paulo, Brasil. *Cad Saude Publica*. 2005;21(5):1574-83.
10. Cordeiro R, Vilela RAG, Medeiros MAT, Gonçalves CGO, Bragantini CA, Stephan C. A system for occupational accident surveillance in southeast Brazil. *New Solut*. 2007;17:365-77.
11. Hisao H, Long D, Snyder K. Antropometric differences among occupacional groups. *Ergonomics.* 2002;45(2):136-52.
12. Lima RC, Victora CG, Dall'Agnol M, Facchini LA, Fassa A. Associação entre as características individuais e sócio-econômicas e os acidentes do trabalho em Pelotas, Rio Grande do Sul, Brasil. *Cad Saude Publica.* 1999;15(3):569-80.
13. Matos CH, Proença RPC. Condições de trabalho e estado nutricional de operadores do setor de alimentação coletiva: um estudo de caso. *Rev Nutr.* 2003;16(4):493-502.
14. Medeiros MAT, Gonçalves CGO, Cordeiro R, Vilela RAG. Acidentes de Trabalho em Piracicaba em 2002. *Saude Rev.* 2005;7(15):7-13. Disponível em: http://www.unimep.br/phpg/editora/revistaspdf/saude15art01.pdf
15. Monteiro CA, Mondini L, Costa BL. Mudanças na composição e adequação nutricional da dieta familiar nas áreas metropolitanas do Brasil (1988-1996). *Rev Saude Publica.* 2000;34(3):251-8.
16. Pender JR, Pories WJ. Epidemiology of obesity in United States. *Gastroenterol Clin North Am.* 2005;34(1):1-7.
17. Raso V. A adiposidade corporal e a idade prejudicam a capacidade funcional para realizar as atividades da vida diária de mulheres acima de 47 anos. *Rev Bras Med Esporte.* 2002;8(6):225-34.
18. Sampaio LR, Figueiredo VC. Correlação entre o índice de massa corporal e os indicadores antropométricos de distribuição de gordura corporal em adultos e idosos. *Rev Nutr.* 2005;18(1):53-61.
19. Sartorelli DS, Franco LJ. Tendências do *diabetes mellitus* no Brasil: o papel da transição nutricional. *Cad Saude Publica.* 2003;19(Sup1):S29-36.
20. Schlosser JF, Debiasi H, Parcianello G, Rambo L. Antropometria aplicada aos operários de tratores agrícolas. *Cienc Rural.* 2002;32(6):983-8.
21. Souza WV, Albuquerque MFM, Barcellos CC, Ximenes RAA, Carvalho MS. Tuberculose no Brasil: construção de um sistema de vigilância de base territorial. *Rev Saude Publica.* 2005;39(1):82-9.
22. Tassinari WS, Pellegrini DCP, Sabroza PC, Carvalho MS. Distribuição espacial da leptospirose no município do Rio de Janeiro, Brasil, ao longo dos anos de 1996-1999. *Cad Saude Publica.* 2004;20(6):1721-9.
23. World Health Organization. Division of Noncommunicable Diseases. Programme of Nutrition Family and Reproductive Health. Obesity: preventing and managing the global epidemic: report of a WHO consultation on obesity. Geneva; 1998. (WHO/NUT/NCD/98.1).
24. World Health Organization. Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. WHO Technical Report Series. Geneva; 1995. (Technical Report Series; 854). Disponível em: http://whqlibdoc.who.int/trs/WHO_TRS_854.pdf

---

Article based on master's dissertation by LTO Zangirolani, presented to the Department of Preventive and Social Medicine, Faculdade de Ciências Médicas, Universidade Estadual de Campinas, in 2007.
Supported by Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP – Process No. 00/13719-3).