Original Article

Empirical Bayesian Geographical Mapping of Occupational Accidents among Iranian Workers

Nasim Vahabi PhD[1], Anoshirvan Kazemnejad PhD•[1], Somnath Datta PhD[2]

Abstract

Background: Work-related accidents are believed to be a serious preventable cause of mortality and disability worldwide. This study aimed to provide Bayesian geographical maps of occupational injury rates among workers insured by the Iranian Social Security Organization.

Methods: The participants included all insured workers in the Iranian Social Security Organization database in 2012. One of the applications of the Bayesian approach called the Poisson-Gamma model was applied to estimate the relative risk of occupational accidents. Data analysis and mapping were performed using R 3.0.3, Open-Bugs 3.2.3 rev 1012 and ArcMap9.3.

Results: The majority of all 21,484 investigated occupational injury victims were male (98.3%) including 16,443 (76.5%) single workers aged 20 – 29 years. The accidents were more frequent in basic metal, electric, and non-electric machining jobs. About 0.4% (96) of work-related accidents led to death, 2.2% (457) led to disability (partial and total), 4.6% (980) led to fixed compensation, and 92.8% (19,951) of the injured victims recovered completely. The geographical maps of estimated relative risk of occupational accidents were also provided. The results showed that the highest estimations pertained to provinces which were mostly located along mountain chains, some of which are categorized as deprived provinces in Iran.

Conclusions: The study revealed the need for further investigation of the role of economic and climatic factors in high risk areas. The application of geographical mapping together with statistical approaches can provide more accurate tools for policy makers to make better decisions in order to prevent and reduce the risks and adverse outcomes of work-related accidents.

Keywords: Empirical Bayes, Iran, Poisson-gamma, work-related accidents

Cite this article as: Vahabi N, Kazemnejad A, Datta S. Empirical Bayesian geographical mapping of occupational accidents among Iranian workers. *Arch Iran Med.* 2017; **20(5):** 302 – 307.

Introduction

Work-related accidents are among the most serious preventable health problems around the world. These accidents contribute to considerable mental and physical consequences in most developed and developing countries. Additionally, they have serious economic and social impacts due to the fatality, disability, and other adverse effects that they cause during the individuals' productive periods.[1,2] Because of these catastrophic outcomes, scientific evidence based on relevant studies is needed in order to develop promotional and preventive activities.[3–5] Many previous studies have investigated the patterns of occupational fatal injuries in different societies, but the geography and the epidemiological distribution of work-related accidents have not received enough attention.[6–13]

To improve the available knowledge on fatal and disabling patterns of work-related accidents, epidemiological research can be helpful in evaluating the effectiveness of past preventive actions and showing the extent of such events in the society to policymakers.[12–14] Investigating disease incidence or mortality rates by epidemiological disease mapping is the best way to determine disease etiology. In these maps, areas with the highest and lowest rates of accidents are of particular importance and analytic epidemiologic studies can be conducted to identify etiologic factors in these regions.[15]

In disease mapping, standardized mortality ratios (SMRs) and standardized incidence ratios (SIRs) are two important measures which rank the relative risks by color codes in corresponding regions. Most of the time, researchers focus on moderate to high relative risk areas, but often the regions with higher risks receive more attention. In many cases, one faces heterogeneity of populations in small areas which leads to unreliable and imprecise estimations. Reliable estimation methods have been developed to solve this problem and adjust the effect of such inconsistency.[16–18]

Smoothing methods and hierarchical models such as generalized linear mixed models are commonly used to take the heterogeneity and spatial correlations into account and to calculate robust estimates. These estimations can be made using either a classical likelihood function or Bayesian methods; the former does not require additional assumptions on population heterogeneity.[19,20]

Smoothing methods such as kernel regression, Kriging, and partition methods are some useful nonparametric methods which are distribution free.[21,22] Comparing Bayesian and smoothing methods, it has been suggested that modeling using Bayesian inference yields more precise and reliable estimates.[23] Bayesian models include empirical and full Bayes methods, both of which use probability distributions called 'priors' based on plausible or expected values assigned to the parameters. In empirical

Authors' affiliations: [1]Department of Biostatistics, Faculty of Medical Sciences, Tarbiat Modares University, Tehran, Iran, [2]Department of Biostatistics, College of Public Health and Health Professions College of Medicine, University of Florida, Florida, Gainesville, FL 32610, USA.

•**Corresponding author and reprints:** Anoshirvan Kazemnejad PhD, Department of Biostatistics, Faculty of Medical Sciences, Tarbiat Modares University, Jalal-Ale-Ahmad Highway, P. O. Box: 14115-111, Tehran, Iran. Tel: +98-912-1088097, Fax: +98-21-88006544, E-mail: Kazem_an@modares.ac.ir.

Accepted for publication: 19 April 2017

Bayes methods, unlike standard Bayesian methods, the prior distributions are estimated from the distribution of the data for which the prior distribution is fixed. Empirical Bayes may be considered an approximation to a full Bayesian approach which allocates second stage priors to the hyper-parameters controlling the distribution.[20,24,25] The most important advantage of the Bayesian approach is taking the uncertainty of estimations into account and providing more reliable and robust estimates.[21,24,26]

Poisson regression is a well-known member of the generalized linear models family for considering and modelling count data, such as death number or death rate. There are, however, some limitations to the application of the Poisson model in the context of spatial modeling. First, the regions' heterogeneity reduces the precision of rate estimates. Moreover, in small areas with rare fatal work-related accidents, the observed number of events might strongly exceed the expected cases in the Poisson model. Due to this variation in the observed number of fatal events, over-dispersion might happen, which lowers the accuracy of rate estimates. Finally, spatial pattern is not taken into account in Poisson modeling. To overcome these limitations, a Bayesian inference was used to estimate the fatal work-related accident rates. We considered a Gamma prior distribution of the variance component of the fatality rate in the overall area of interest.

No previous analyses have been conducted on fatal work-related accident rates and geographical mapping in Iran. The objective of this study was to model Bayesian Poisson-Gamma for fatal work-related accidents and to prepare geographical maps for recording data in 2012.

Methods

Study population

The population of this cross-sectional study included all insured people who had experienced work-related accidents and claimed compensation from the Iranian Social Security Organization (ISSO) between March 21, 2012 (the beginning of the Iranian New Year) and March 21, 2013. The adverse complications of work-related accidents were recorded and documented in a database at the Office of Statistics and Socio-Economic Calculations of the ISSO as death, full recovery, minor disability or fixed compensation, partial disability, and total disability. Data published by the ISSO about the total number of insured people for the considered year were used as the denominator of incidence rates.

Definitions

Total disability

Any damage other than death, which permanently makes workers incapable of performing the material and substantial duties of their regular occupations, or leads to loss of function of a body organ, or its complete loss, such as loss of both eyes, or an eye, a hand or a foot. About 66% or higher disability is called total disability.[27]

Partial disability

Any damage other than death or total disability, which leads to loss of functional abilities or complete/partial body organ amputation. Between 33% and 66% disability is called partial disability.[27]

Fixed compensation

Workers with less than 33% disability are categorized as the fixed compensation category of occupational accident outcomes.[27]

Ethical issues

Ethical issues including data fabrication, double publication, and plagiarism were considered and the study proposal was approved by the Ethical Committee of Iran University of Medical Sciences, Tehran, Iran. Moreover, the ISSO has properly anonymized personal information; therefore, identifiers were not linked to our data and no identifying information of participants (e.g., name, email address, video-recording, etc) was used.

Poisson-Gamma modeling

We considered a prior distribution for the variance component of fatal rate in the overall area of interest. We assumed that all the SIRs, r_i, were distributed according to a Gamma distribution with a mean of $\mu = \frac{v}{\alpha}$ and a variance of $\tau^2 = \frac{v}{\alpha^2}$ where α and v are scale and shape parameters, respectively. So, the Gamma probability function of r_i is:

$$g(r_i|\alpha, v) = \frac{\alpha^v r_i^{v-1} e^{-\alpha r_i}}{\Gamma(v)}$$

To obtain empirical Bayes estimates of the SIR given by $\hat{r}_i = \frac{y_i+\hat{v}}{e_i+\hat{\alpha}}$, , we had to estimate the mean and variance of the Gamma distribution. Therefore, the marginal probability of observed fatal events which has negative binomial distribution with expected number of events $e_i r_i$, was used to estimate μ and τ^2 of the gamma distribution. The log-likelihood function of the negative binomial distribution for μ and τ^2 is:

$$L(\mu,\tau^2) = \sum_i \left[\ln\left\{ \frac{\Gamma\left(y_i + \frac{\mu^2}{t^2}\right)}{\Gamma\left(\frac{\mu^2}{t^2}\right)} \right\} + \frac{\mu^2}{t^2}\ln\left(\frac{\mu}{t^2}\right) - \left(y_i + \frac{\mu^2}{t^2}\right)\ln\left(e_i + \frac{\mu}{t^2}\right) \right]$$

We can compute the log-likelihood function L for a set of values of τ^2 which maximize L for a given μ.[16]

Statistical Analysis

Descriptive analysis of work-related accidents was performed using R 3.0.3 and Open-Bugs 3.2.3 rev 1012 to fit the Poisson-Gamma model. Also, the estimated fatal work-related accident rates in different regions were illustrated in color coded geographical maps using ArcMap 9.3.

Results

In this cross-sectional study from among all 8,263,077 insured workers, 21,484 work-related accidents leading to injury were registered in the ISSO. About 21,113 (98.3%) of occupational injury victims were men and 371 (1.7%) were women which include 16,443 (76.5%) single and 5,041 (23.5%) married injury victims. The mean age (SD) was 33.2 (9.9) years with the distribution presented in Table 1. The most frequent occupational injury victims were workers aged between 20 and 29 years.

In terms of occupational activity type, basic metal, electric and non-electric machinery jobs were the category with the highest rates of work-related accidents (Table 2).

The distribution of occupational accident outcomes is presented

Table1. Age distribution of the occupational injured victims

Age (year)	N (%)
10–19	542 (2.5)
20–29	9336 (43.5)
30–39	7331 (34.2)
40–49	3088 (14.4)
50–59	991 (4.5)
60–69	157 (0.7)
> 69	39 (0.2)
Total	**21484 (100.0)**

Table 2. Distribution of work-related injuries

Occupational activity	N (%)
Agriculture, forestry, hunting and fishing	596 (2.8)
Mining	835 (3.9)
Food and tobacco industries	992 (4.6)
Textile, clothing, and shoe making industries	685 (3.2)
Wood, furniture, paper, printing, wood cotton, leather	832 (3.9)
Chemical and Rubber products industries	2160 (10.1)
Basic metal, electronic and non-electric machinery	5253 (24.5)
Other industries	71 (0.3)
Building	4052 (18.8)
Electricity, water, gas, steam, machine service	236 (1.1)
Business, bank, insurance, real estate	371 (1.7)
Transportation, warehousing, communications	549 (2.6)
Service	1039 (4.8)
Other activities	367 (1.7)
Unknown	3446 (16.0)
Total	**21484 (100.0)**

Table 3. Distribution of occupational accident outcomes

Accident outcomes	Women	Men	Total
	N (%)	N (%)	N (%)
Death	- - -	96 (0.4)	96 (0.4)
Total disability	- - -	183 (0.9)	183 (0.9)
Partial disability	5 (1.7)	269 (1.3)	274 (1.3)
Fixed compensation	31 (9.7)	949 (4.5)	980 (4.6)
Complete recovery	281 (88.6)	19616 (92.9)	19951 (92.8)
Total	**317 (100.0)**	**21113 (100.0)**	**21484 (100.0)**

in Table 3. About 2.6% (553) of work-related accidents led to disability (partial and total) or death and 92.8% (19951) of injury victims recovered completely. Moreover, no fatal occupational accidents occurred for women.

Figure 1 shows the comparative maps of observed and estimated relative risk of occupational accidents using the Bayesian Poisson-Gamma model in different provinces for women and men separately. As the figure depicts, Tehran (17.00%) and Isfahan (8.99%) provinces had the highest and South Khorasan (0.32%) and North Khorasan (0.53%) provinces had the lowest rates of work-related accidents.

Similar maps were prepared to represent the estimated relative risk of fatal occupational accidents and disability in different provinces using the Bayesian Poisson-Gamma model compared to the observed data (Figure 2 and Figure 3).

Discussion

In 2012, the work-related accident rate for all workers insured by the Iranian Social Security Organization (ISSO) was 2.6 in 1000. However, there are different estimates of 3.3 and 3.8 work-related accidents in 1000 for a 5-year period in Iran.[28,29] Also, this rate was estimated to be 9 in 1000 for Middle Eastern countries in 2006.[30]

Based on the sex distribution of occupational accidents, injuries occur more frequently for men (98.3%) than women (1.7%). Additionally, during this study, no fatal events were observed for women. The low number of working women, more hazardous jobs for men, different assignment of tasks in the same job, and women's cautiousness at work could be the reasons for this pattern. Other studies have also reported more frequent occupational accidents for men.[28,31,32]

In the present study, single workers were more susceptible to

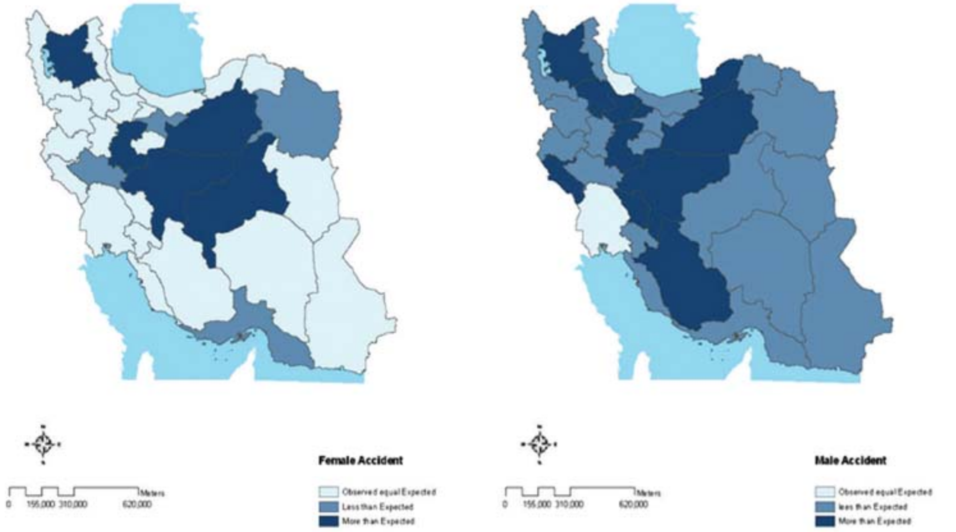

Figure 1. Comparative maps of the observed and estimated relative risks of occupational accidents using Bayesian Poisson-gamma model for women and men in 2012, Iran

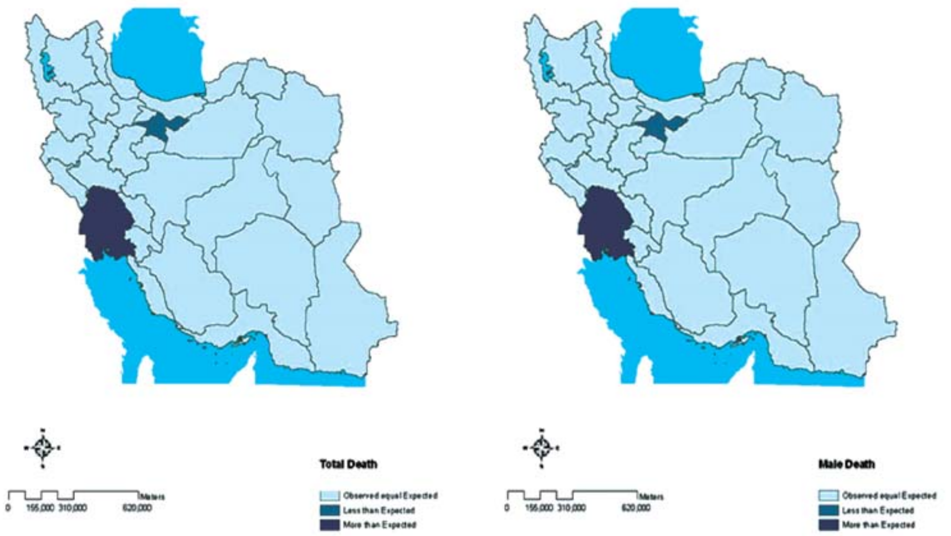

Figure 2. Comparative maps of the observed and estimated relative risks of fatal occupational accidents using Bayesian Poisson-gamma model for men and total population in 2012, Iran

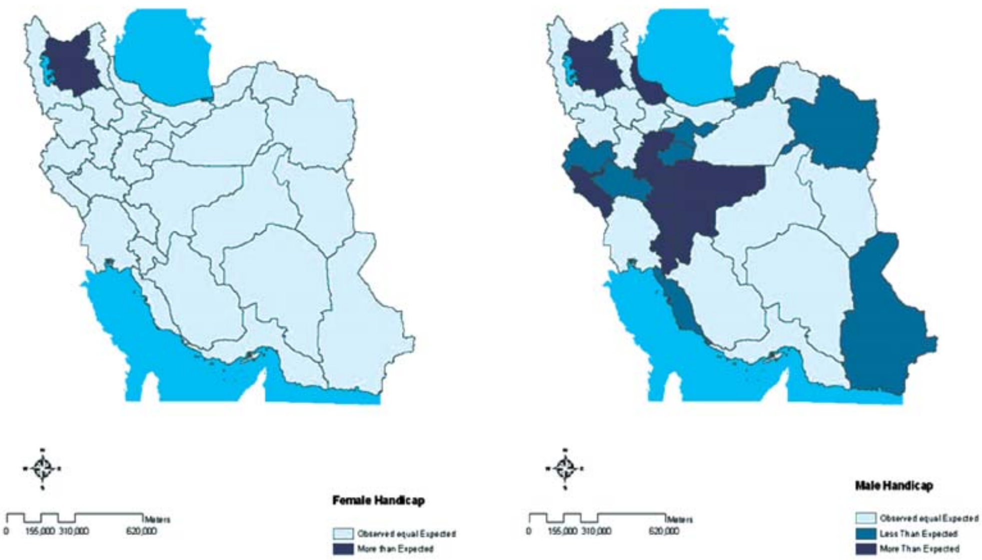

Figure 3. Comparative maps of the observed and estimated relative risks of disability due to occupational accidents using Bayesian Poisson-gamma model for women and men in 2012, Iran

work-related accidents. Disabling and fatal events could be due to insufficient experience and carelessness regarding safety issues. Additionally, occupational injuries were more frequent among those aged 20 – 29 years, which is similar to other studies in Iran.[28,33] Moreover, different studies around the world have also revealed that younger workers are more vulnerable to work-related accidents.[34–36]

Related studies have maintained that inexperience, incompetency, youth, courage, employment of younger workers for high-risk jobs, and less attention to safety issues are the most significant risk factors for work-related accidents.[28,37,38] Job classification has been conducted by the ISSO in Iran, which is conventional and is not based on international standards. As a result, it can be claimed that some of the occupational categories are lost or their data are not recorded appropriately. In this study, 16% of occupational accidents are placed in the unknown category leading to some limitations on the quality of the information. Therefore, determining priorities, conducting more typical studies and developing registration systems based on ILO recommendations can be helpful tools for providing more efficient preventive strategies by policy makers.[39–43]

Based on the results, more frequent occupational accidents occurred in basic metal, electric and non-electric machinery, and construction categories, which may be due to the high immigration of less experienced and inadequately trained workers from rural to urban areas.[44] However, other studies have shown that agriculture, fishery, and construction were the job categories with the highest rates of accidents.[45–47]

Occupational accidents lead to adverse outcomes such as disability, death, and work loss; in this study, partial and total disability, fixed compensation, and death were professional terms used by the ISSO to show these outcomes. Our findings observed complete recovery for the majority of injured workers (93%), while a small number of them died (0.4%). No women were victims of a fatal event which may be related to gender differences discussed earlier. This finding corroborates other studies showing higher fatality rates in work-related accidents for men.[28,48]

The main purpose of disease mapping is to describe the variation in disease incidence and provide stable local and trend estimations. Using statistical mapping approaches can help to provide more precise estimates.[49,50] The Bayesian Poisson-Gamma approach was proposed here for geographical mapping of work-related accident rates adjusted for the population heterogeneity which does not include spatial autocorrelation. With regard to the maps of estimated relative risk of occupational accidents using the Bayesian Poisson-Gamma model, the highest estimations pertained to provinces which were mostly located along the mountain chains, some of which are categorized as deprived provinces in Iran. Moreover, significantly higher fatality occurred in Khouzestan which is one of the deprived provinces. Similar studies have shown a correlation between economic and climatic conditions of different areas with occupational accident rates which corroborates the present findings.[51–53]

In conclusion, this study addresses high risk areas for occupational accidents which should be targeted for monitoring and prevention. The study also reveals the need for further investigation of the role of economic and climatic factors in high risk areas. The application of geographical mapping in addition to statistical approaches can provide more accurate tools for policy makers to make better preventive decisions in order to reduce the risk and adverse outcomes of work-related accidents.

Acknowledgment

This research is part of the PhD thesis in Tarbiat Modares University.

References

1. Santana VS, Loomis D. Informal Jobs and Non–fatal Occupational Injuries. *Ann Occup Hyg*. 2004; 48(2): 147 – 157.
2. Li CY, Du CL, Chen CJ, Sung FC. A registry–based case–control study of risk factors for the development of multiple non – fatal injuries on the job. *Occup Med (Lond)*. 1999; 49(5): 331 – 334.
3. Courtney TK, Burdorf A, Sorock GS, Herrick RF. Methodological challenges to the study of occupational injury–an international epidemiology workshop. *Am J Ind Med*. 1997; 32: 103 – 105.
4. Hagberg M, Christiani D, Courtney TK, Halperin W, Leamon TB, Smith TJ. Conceptual and definitional issues in occupational injury epidemiology. *Am J Ind Med*. 1997; 32: 106 – 115.
5. Rivara FP. The scientific basis for injury control. *Epidemiol Rev*. 2003; 25: 20 – 23.
6. Rossignol M, Pineauk M. Fatal occupational injury rates: Quebec, 1981 through 1988. *Am J Public Health*. 1993; 83: 1563 – 1566.
7. Jenkins EL. Occupational injury deaths among females. The US experience for the decade 1980 to 1989. *Ann of Epidemiol*. 1994; 4: 146 – 151.
8. Toscano G, Jack T. Occupational injury fatalities–1994. *Stat Bull Metro Insur Comp*. 1994; 77: 12 – 22.
9. Fullerton L, Olson L, Crandall C, Sklar D, Zumwalt R. Occupational injury mortality in Mexico. *Ann Emerg Med*. 1995; 26: 447 – 454.
10. Stout NA, Jenkins EL, Pizatella TJ. Occupational injury mortality rates in the United States: changes from 1980 to 1989. *Am J Public Health*.1996; 86: 73 – 77.
11. Schoemaker M, Barreto S, Swerdlow A, Higgins C, Carpenter R. A nested case–control study of fatal work related injuries among Brazilian steel workers. *Occup Environ Med*. 2000; 57(8): 555 – 562.
12. Nurminen M, Karjalainen A. Epidemiologic estimate of the proportion of fatalities related to occupational factors in Finland. *Scand J Work Environ Health*. 2001; 27(3): 161 – 213.
13. Villanueva V, Garcia AM. Individual and occupational factors related to fatal occupational injuries: A case–control study. *Accid Anal Prev*. 2011; 43(1): 123 – 127.
14. Thacker SB, MacKenzie EJ. The role of the epidemiologist in injury prevention and control–an unmet challenge. *Epidemiol Rev*. 2003; 25: 1 – 2.
15. Porta MA. Dictionary of Epidemiology. New York: Oxford University Press, Fifth Edition. 2008.
16. Devesa SS, Grauman DJ, Blot WJ, Pennello GA, Hoover RN, Fraumeni JF Jr (1999; Atlas of cancer mortality in the United States, 1950–94. Washington (DC): US Govt Print Off [NIH Publ No. NIH 99–4564].
17. Clayton D, Kaldor J. Empirical Bayes estimates of age–standardized relative risks for use in disease mapping. *Biometrics*. 1987; 43: 671 – 681.
18. Knorr–Held L, Rasser G. Bayesian detection of clusters and discontinuities in disease maps. *Biometrics*. 2000; 56: 13 – 21.
19. Waller LA, Gotway CA. Applied spatial statistics for public health data. New Jersey: Wiley. 2004.
20. Congdon P. Applied Bayesian Modeling. West Sussex: Wiley. 2003.
21. Lawson AB, Browne WJ, Vidal Rodeiro CL. Disease mapping with WinBUGS and MLWin. West Sussex: Wiley. 2003.
22. Goovaerts P. Geostatistical analysis of disease data: Accounting for spatial support and population density in the isopleth mapping of cancer mortality risk using area–to–point Poisson kriging. *Int J Health Geogr*. 2006; 5: 52.
23. Disease Mapping Collaborative Group, Lawson AB, Biggeri AB, Boehning D, Lesaffre E, Viel JF, Clark A, et al. Disease mapping models: An empirical evaluation. *Stat Med*. 2000; 19: 2217 – 2241.
24. Ghosh M, Natarajan K, Waller LA, Kim D. Hierarchical Bayes GLMs for the analysis of spatial data: An application to disease mapping. *J Stat Plan Inf*. 1999; 75: 305 – 318.
25. Bernardinelli L, Montomoli C. Empirical Bayes versus fully Bayesian analysis of geographical variation in disease risk. *Stat Med.* 1992; 11: 983 – 1007.
26. Banerjee S, Carlin BP, Gelfand AE. Hierarchical modeling and

analysis for spatial data. Boca Raton: Chapman & Hall/CRC. 2004.
27. Dunson DB. Commentary: Practical advantages of Bayesian analysis of epidemiologic data. *Am J Epidemiol*. 2001; 15; 153(12): 1222 – 1226.
28. Wakefield J. Disease mapping and spatial regression with count data. *Biostatistics*. 2007; 8: 158 – 183.
29. I.S.S. Orginaization. Book of Legislations, Wage Compensation during Disease, In: Orginaization, I.s.s.Ed.). Tehran: Arithmetic & Recalculation Unit Publication, Iran. 2000.
30. Bakhtiyari M, Delpisheh Al, Riahi M, Latifi A, Zayeri F, Salehi M, et al. Epidemiology of occupational accidents among Iranian insured workers. *Safety Science*. 2012; 50(8): 1480 − 1484.
31. Ghods A, Alhani F, Monireh A, Kahoie M. Epidemiology of occupational accidents in Semnan (2002 – 2006). *Journal of Semnan University of Medical Sciences*. 2009; 10(2): 95 – 101. [In Persian]
32. Shafieian SH, Tofighi H, Rezvani Ardestani F, Beheshti S, Khaji A. Epidemiologic survey of death related to occupational accidents referred to Tehran medical organization (2003 – 2004). *Medical Jurisprudence*. 2007; 12(1): 30 – 34. [In Persian]
33. Coutinho ESF, Fletcher A, Bloch KV, Rodrigues LC. Risk factors for falls with severe fracture in elderly people living in a middle–income country: A case control study. *BMC Geriatr*. 2008; 8: 21.
34. Villanuevaa V, Garcia AM. Individual and occupational factors related to fatal occupational injuries. *Accid Anal Prev*. 2011; 43(1): 123 – 127.
35. Mosavi ME. Epidemiology and etiology of orthopedic trauma related to work. *Tavanbakhshi*. 2002; 3(1): 29 – 34. [In Persian]
36. McCaig LF, Burt CW, Stussman BJ. A comparison of work–related injury visits and other injury visits to emergency departments in the United States, 1995–1996. *J Occup Environ Med*. 1998; 40(10): 870 – 875.
37. International Labour Office [ILO]. ILO Safety in numbers: Pointers for a global safety culture at work, Geneva. Available from: URL: http: //www.ilo.org/safework/info/publications/WCMS_142840/lang–en/index.htm (Accessed Date: April 2016).
38. Cloutier E. The effect of age on safety and work practice among domestic trash collectors in Québec safety science. *Safety Sci*. 1994; 17(4): 291 – 308.
39. Soori H, Rahimi M, Mohseni H. Survey relation between job stress and occupational accidents. A case control study. *Iran J Epidemiol*. 2006; 1: 53 – 58.
40. Mohamdfam I, Zamanparvar A. Survey of unsafe action in Hamedan' Godazan moulding factory, 2001. *J Hamedan Med Sci Univ*. 2003; 9: 51 – 56.
41. Smith G. Public health approaches to occupational injury prevention: Do they work? *Inj Prev*. 2001; 7(1): 3 – 10.
42. Lortie M, Rizzo P. The classification of accident data. *Saf Sci*. 1999; 31: 31 – 57.
43. Jacinto Celeste, Aspinwall Elaine. A survey on occupational accidents' reporting and egistration systems in the European Union. *Safety Sci*. 2004; 42(10): 933 – 960.
44. Mariko N, Eiji Y. Differences in the lethality of occupational accidents in ECD countries. *Safety Sci*. 2008; 46(7): 1078 – 1090.
45. International Labour Office [ILO]. An ILO Code of Practice: Recording and Notification of Occupational Accidents and Diseases, Geneva. Available from: URL: http: //www.ilo.org/wcmsp5/groups/public/@ed_protect/@protrav/@safework/documents/normativeinstrument/wcms_107800.pdf. (Accessed Date: April 2016).
46. Moradinazar M, Kurd N, Farhadi R, Amee V, Najafi F. Epidemiology of work–related injuries among construction workers of Ilam (Western Iran; during 2006 – 2009. *Iran Red Crescent Med J*. 2013; 15(10): e8011. Available from: URL: http: //www.ncbi.nlm.nih.gov/pubmed/24693372. (Accessed Date: 5 October 2013).
47. Ahn YS, Bena JF, Bailer AJ. Comparison of unintentional fatal occupational injuries in the Republic of Korea and the United States. *Inj Prev*. 2004; 10(4): 199 – 205.
48. Villanueva V, Garcia AM. Individual and occupational factors related to fatal occupational injuries: A case-control study. *Accid Anal Prev*. 2011; 43(1): 123 – 127
49. Horwitz IB, Mc Call BP. Disabling and fatal occupational claim rates, risks, and costs in the Oregon construc on industry 1990–1997. *J Occup Environ Hyg*. 2004; 1(10): 688 – 698.
50. Mehrdad R, Seifmanesh SH, Chavoshi F, Aminian O, Izadi N. Epidemiology of Occupational Accidents in Iran Based on Social Security Organization Database. Iran *Red Cres Med J*. 2014; 16(1): e10359. Available from: URL: http: //www.ncbi.nlm.nih.gov/pmc/articles/PMC3964417. (Accessed Date: 5 January 2014).
51. Berke O. Exploratory disease mapping: Kriging the spatial risk function from regional count data. *Int J Health Geogr*. 2004; 3: I8. Available from: URL: http: //www.ij – healthgeographics.com/content/3/1/18. (Accessed Date: 26 August 2004).
52. Lawson AB, Clark A. Spatial mixture relative risk models applied to disease mapping. *Stat Med*. 2002; 21: 359 – 370.
53. Amiri M, Ardeshir A, Fazel–Zarandi MH. Risk–based analysis of construction accidents in Iran during 2007–2011: Meta-analysis study. *Iranian J Publ Health*. 2014; 43(4): 507 – 522.