RESEARCH ARTICLE

Area-to-Area Poisson Kriging Analysis of Mapping of County-Level Esophageal Cancer Incidence Rates in Iran

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Abstract

Background: Esophagus cancer, the third most common gastrointestinal cancer overall, demonstrates high incidence in parts of Iran. The counties of Iran vary in size, shape and population size. The aim of this study was to account for spatial support with Area-to-Area (ATA) Poisson Kriging to increase precision of parameter estimates and yield correct variance and create maps of disease rates. Materials and Methods: This study involved application/ecology methodology, illustrated using esophagus cancer data recorded by the Ministry of Health and Medical Education (in the Non-infectious Diseases Management Center) of Iran. The analysis focused on the 336 counties over the years 2003-2007. ATA was used for estimating the parameters of the map with SpaceStat and ArcGIS9.3 software for analysing the data and drawing maps. Results: Northern counties of Iran have high risk estimation. The ATA Poisson Kriging approach yielded variance increase in large sparsely populated counties. So, central counties had the most prediction variance. Conclusions: The ATAPoisson kriging approach is recommended for estimating parameters of disease mapping since this method accounts for spatial support and patterns in irregular spatial areas. The results demonstrate that the counties in provinces Ardebil, Mazandaran and Kordestan have higher risk than other counties.

Keywords: Disease mapping - area-to-area Poisson Kriging - esophagus cancer - Iran

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Introduction

Cancer is the third cause of mortality after car accident and cardiovascular disease in Iran, so cancer is an important problem in public health in Iran. Esophagus cancer has high incidence in north counties of Iran. The main aim of this study is the Esophagus Cancer mapping for describe geographic of disease risk and identifying unusual high risk areas. The counties of Iran vary in size, shape and population size.

The area data used in this study is count data based on the Poisson distribution, so Area-to-Area Poisson kriging approach has been used for estimating the parameters of the map. Area-to-Area Poisson kriging approach is available to account for spatially varying population sizes and spatial patterns in the mapping of disease rates. This approach estimates disease risk more accurately and precisely. Area-to-Area Poisson kriging is a geostatistical techniques for the discrete distribution. Kaiser et al. (1997) introduced a spatial Poisson distribution. Oliver et al. (1998) employed binomial cokriging to produce a map of childhood cancer risk in the West Midlands of England. Monestiez et al. (2004; 2006) developed Poisson kriging to model spatially heterogeneous observation in the field of marine ecology. Goovaerts (2005) generalized Poisson kriging to analyse cancer data under the assumption that all geographic units are the same size, then Goovaert (2006) used Area-to-Area Poisson kriging technique for corporate the geometry of administrative units and the spatial repartition of the population at risk. This approach applied areal supports to predict area values by taking into account the spatial support of data as well as the varying population size, leading to more precise and accurate estimates of the risk.

The case of interest was esophagus cancer patients registered between the years 2003-2007 and adjusted

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using the 2006 population pyramid. Data recorded on incident cases of cancer were obtained from ministry of health and medical education (in the non-infectious diseases management center) of Iran. The major sources of data collection related to cancer were reports from pathology laboratories, hospitals and radiology clinics. The geographical units are 336 counties of display a wide range of size and shapes, which should favour Area-to-Area Poisson Kriging that implicitly accounts for the spatial support of the data in the analysis. The population-weighted average of cancer rate is 2.92 per 100,000 person- years.

Materials and Methods

The Area-to-Area Poisson kriging technique for the estimation of risk values is described in detailed in Goovaerts (2006). This section provides a brief recall of the approach.

Let v_α represent area supports and $z(v_\alpha)=d(v_\alpha)/n(v_\alpha)$ denote the observed incidence rates where $d(v_\alpha)$ is the number of recorded incidence case and $n(v_\alpha)$ is the size of population at risk. Area-to-Area Poisson kriging spatial interpolation is predict any area value $z(v)$ using K area data neighboring units v_i: 1) $z(v_\alpha)={}^K\Sigma_{i=1}\lambda_i(v_\alpha)z(v_\alpha)$

Where $\lambda_i(V_\alpha)$ are weights assigned to rates are computed by solving the following equations: 2) ${}^K\Sigma_{j=1}\lambda_j(v_\alpha)\{\bar{C}_R(v_i,v_j)+\delta_{ij}[m^*/n(v_i)]\}+\mu(v_a)=\bar{C}_R(v_i,v_\alpha)$ $\quad i=1,\ldots,K$ ${}^K\Sigma_{j=1}\lambda_j(v_\alpha)=1.$

Where $\mu(v_a)$ is the Lagrange parameter, $\delta_{ij}=1$ if $i=j$ and **0** otherwise. m^* is the population-weighted mean, $\bar{C}_R(v_i,v_j)$ is the among-areas covariance and, $n(v_i)$ is the size of the population at risk in area v_i. The term $m^*/n(v_i)$ accounts for the variability resulting from the population size. The variance is calculated as: 3) $\sigma(v_\alpha)=\bar{C}_R(v_\alpha,v_\alpha)-{}^K\Sigma_{i=1}\lambda_i\bar{C}_R(v_i,v_\alpha)-\mu(v_a)$.

Where $\bar{C}_R(v_\alpha,v_\alpha)$ is the with-area covariance. The Area-to-Area Poisson kriging technique accomplished using the public-domain executable poisson-kriging.exe described in Goovaerts (2005)

Results

According to Figure1, crude rate and population at risk mapped in top graph, risk estimated using Area-to-Area Poisson kriging approach and corresponding prediction variance mapped in bottom graph. Crude rate mean is 2.70 and estimated risk mean is 2.84 and prediction variance mean is 0.42. North, north west and north east counties have higher risk than other counties.

Discussion

Ignoring spatial support in parameter estimation may lead to more smoothing and less precise estimates. The objective of this paper was to illustrate esophagus cancer incidence rate mapping by a geostatistic technique for health data to the popular Area-to-Area Poisson kriging. This approach account spatial support so generate less smoothing and more precise than other approaches such as BYM model and point Poisson kriging that ignore spatial support.

The Area-to-Area Poisson kriging approach is recommended for estimation of disease mapping parameters, since this method accounts spatial support and pattern in irregular spatial area. The results demonstrate that the counties in provinces Ardebil, Mazandaran and Gilan have higher risk than other counties.

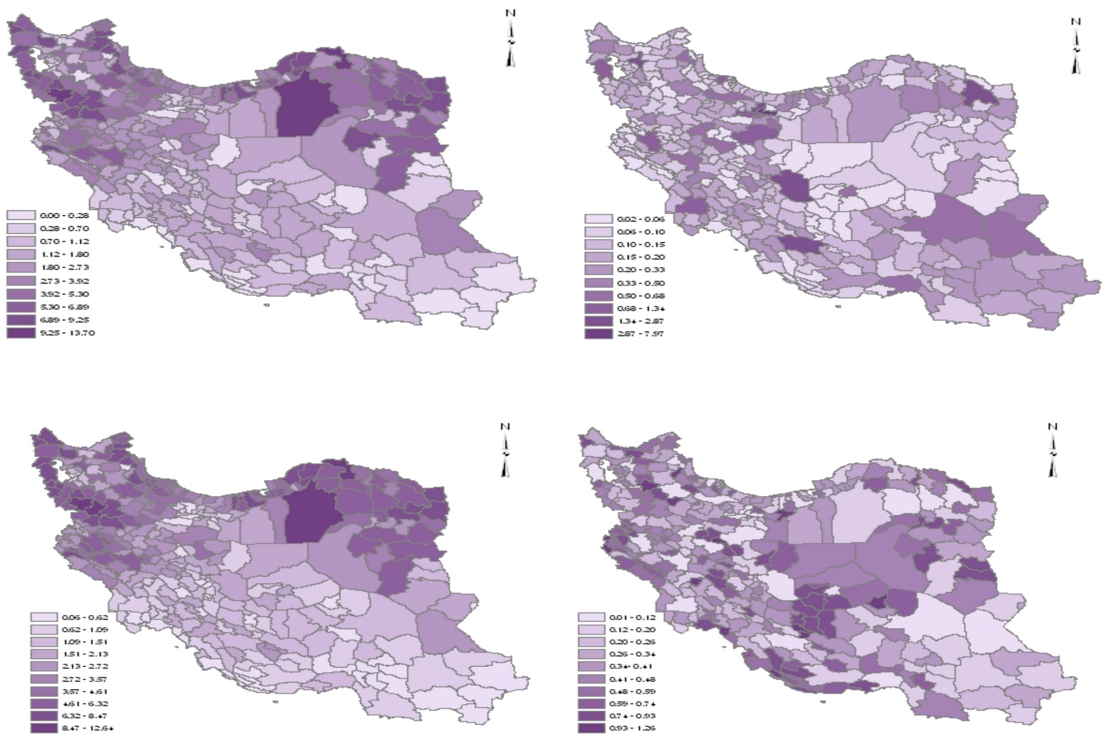

Figure 1. Esophagus Cancer Incidence Rate Per 100,000 Person Years During the Period 2003-2007 in Iran. Crude rates (top, left), Population at risk (top, right), risk estimated (by ATA Poisson kriging) (bottom, left), prediction variance (by ATA poisson kriging) (bottom, right)

In short, the risk of people developing esophagus cancer in Iran is heterogeneous during the period 2003-2007. People living north of Iran had a higher chance of cancer risk than people living in other areas.

Epidemiologists and investigators believe that the cause of high incidence in north is nitrate including soil and particular nourishing in those areas.

References

Goovaerts P (2005). Geostatistical analysis of disease data: estimation of cancer mortality risk from empirical frequencies using Poisson kriging. Int J Hlth Geogr, **4**, 31.

Goovaerts P (2006). 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 Hlth Geogr*, **5**, 52.

Kaiser MS, N Cressie (1997). Modeling Poisson variables with positive spatial dependence statistical and probability. *Letters*, **35**, 423-32.

Kyriakids P (2004). A geostatistical framework for area-to-point spatial interpolation. *Geographical Analysis*, 36.

Monestiez P, L Dubroca, E Bonin (2004). Comparison of model based geostatistical methods in ecology: application to fin whales spatial distribution in northwestern Mediterranean Sea. *Geostatistics Banff*, **2**, 777-86.

Monestiez P, L Dubroca, E Bonin (2006). Geostatistical modelling of spatial distribution of Balaenoptera physalus in the northwestern Mediterranean Sea from sparse count data and heterogeneous observation efforts. *Ecological Modelling*, **193**, 615-28.

Oliver MA, R Webster, C Lajaunie, KR Muir (1998). Binomial cokriging for estimating and mapping the risk of childhood cancer. *IMA J Mathematics Applied in Medicine and Biology*, **15**, 279-97.

Iran Cancer Registry Report (2009). Provincial report, Islamic Republic of Iran-2007. Ministry of Health and Medical Education, Deputy for Health. Center for Diseases Control and Management. Tehran.

Iran Non-communicable Diseases Risk Factors Surveillance (2010). Provincial report, Islamic Republic of Iran-2007. Ministry of Health and Medical Education, Deputy for Health. Center for Diseases Control and Management. Tehran.