

Geoinformation Technologies in Biomedicine and Health Care: Review of Scientific Journals

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Abstract. Geoinformation technologies (GT) play an increasing role in everyday life and are used in many fields. GT capabilities can also be used by health care providers, in the daily practice of medical doctors and for research on where to locate new facilities and also to monitor the health condition of the society at large. The possibilities of using GT in and around health care, including in biomedicine seem to be obvious. The objective of this paper is to quantify the prevalence of and to identify research directions on the use of GT in biomedicine and health care on the basis of the Polish and international scientific journals. Two groups of journals were studied: the field of geoinformation and the field of biomedicine and health care. Chronological scope of the research covered the period of 2007 through 2010. Critical analysis method and bibliometric method study have been carried out.

Keywords: geoinformation technologies, GIS, biomedicine, health care, literature review, bibliometric.

1 Introduction

Broadly speaking, information technologies is a conglomerate of resources (or devices such as computers with their peripherals and networks) and tools (i.e. software) as well as other technologies (such as telecommunications), which are there to handle information in a versatile manner [32]. Geographical Information Systems (GIS) are one of the components of specialized information systems as are other information technologies in the field of geodesy, cartography, photogrammetry, remote sensing and Global Positioning System (GPS). These technologies, termed geoinformation technologies, in short GT or GIS technologies [28], play an increasing role in everyday life and are used in many fields. GIS is a system for obtaining, collecting, reviewing, analyzing, transferring and sharing of spatial data [46]. GIS capabilities can also be used by health care providers. The spatial data and analyses have been used in health care for many years now. The most famous example is the work by John Snow, who applied, in the mid-nineteenth century, a hand-made map to examine spatial distribution of deaths caused by cholera outbreak. This gave rise to what is known as disease diffusion mapping [20].

Public health protection is a classic example of GIS application that allows one to combine data describing the population and environmental conditions, and to analyze spatial relationships that occur between them. According to ESRI Poland [27], GIS is used both in the daily practice of medical doctors and for research on where to locate new facilities and also to monitor the health condition of the society at large.

Human health depends predominantly on three factors: genetics, lifestyle and environment. The patient medical cases usually take into account the first two factors while tend to ignore the third one. Patients are being asked about their well-being, any illnesses in the family, habits, and addictions rather than about their former or current places of residence. At the TEDMED 2009 conference (Technology, Entertainment, and Design in Medicine), Bill Davenhall presentation "Can Geography Information Keep You Healthy? related locale to health. Davenhall noticed that a lot had been invested into research into relationship between the environment and human health, but the results had never been used directly in medical diagnostics. Meanwhile, geospatial analyses may help diagnose, treat, and in some cases, prevent diseases. Recently, a new discipline geomedicine [20], which is about conducting medical interviews while relying upon the national spatial data infrastructure. A new key to medical interview is to gain information about where the patient lives and stays, along with the history of such place. Universal access to spatial data facilitates the acquisition and collection of such information and the Internet provides an insight into it from anywhere on Earth.

It is estimated that 80% of administrative decisions are taken on the basis of spatial information, known also as geographical information or geoinformation, or information that is directly or indirectly linked to the location, size, shape and spatial relations happening between objects, phenomena and processes.

The possibilities of using GIS in and around health care, including in biomedicine, namely the science of biological effects on human health and life [76] seem to be obvious.

The objective of this paper is to quantify the prevalence of and to identify research directions on the use of geoinformation technologies in biomedicine and health care on the basis of the Polish and international scientific journals.

2 Investigation Methods

This paper, using the methods of literature review and critique and bibliometric analysis (which is a statistical method applied to quantitative study of the facts, phenomena and processes associated with body of writing), examined articles in the Polish and international journals in terms of prevalence of problems relating to the use of GT in biomedicine and health care. Two groups of journals were studied: the field of geoinformation and the field of biomedicine and health care. Chronological scope of the research covered the period of 2007 through 2010. Then, based on the themes of articles meeting the selection criteria, thematic areas were established and selected articles were classified to relevant subject

Table 1. List of Polish geoinformation journals for research

Title of journal	MoSHE scores	Source of journal
Acta Scientiarum Polonorum. Geodesia et Descriptio Terrarum - GDT	6	http://www.aqua.ar.wroc.pl/acta/pl/main.php?p=8&sub=10&act=31&s=4 [accessed 20 November 2011]
Archiwum Fotogrametrii, Kartografii i Teledetekcji (Archives of Photogrammetry, Cartography and Remote Sensing) - AFKT	6	http://www.sgp.geodezja.org.pl/ptfit/wydawnictwa/wydawnictwa.html [accessed 20 November 2011]
Geodesy and Cartography - GC	9	http://www.igik.edu.pl/~geoikar/index.html [accessed 20 November 2011]
Geodeta: Magazyn Geoinformacyjny (Geodeta: Geoinformation Magazine) - MG	2	http://www.geoforum.pl/?menu=47064&page=edition&link=archiwum-geodety [accessed 20 November 2011]
Geomatics and Environmental Engineering - GEE	6	http://journals.bg.agh.edu.pl/GEOMATICS/ [accessed 20 November 2011]
Przegląd Geodezyjny (Geodesic Review) - PG	6	http://www.sigma-not.pl/czasopisma-50-budownictwo-przeglad-geodezyjny.html [accessed 20 November 2011]
Roczniki Geomatyki (Annals of Geomatics) - RG	6	http://www.ptip.org.pl/phpnuke/page.php?lg=pl&id=repozytorium [accessed 20 November 2011]
Teledetekcja Srodowiska (Remote Sensing of Environment) - TS	2	http://www.telegeo.wgsr.uw.edu.pl/Teledetekcja_Srodowiska_pl.html [accessed 20 November 2011]

Source: Own elaboration based on: 1) A Unified List of Scoring Journals, MoSHE, <http://www.nauka.gov.pl/finansowanie/finansowanie-nauki/dzialalnosc-statutowa/ocena-jednostek-naukowych/lista-czasopism-punktowanych/ujednolicony-wykaz-czasopism-naukowych/ujednolicony-wykaz-czasopism-naukowych/artykul/ujednolicony-wykaz-czasopism-punktowanych-1/>; 2) www sites of selected journals.

areas, thereby indicating directions of research presented in the literature in the scope under review.

In order to select journals to be researched a review was done of the list of journals from a score list of the Ministry of Science and Higher Education (MoSHE), published June 25, 2010 *A Unified List of Scoring Journals* - for Polish Journal, and Journal Citation Reports (JCR) - for international journals. For the preliminary analysis journals were selected, whose range of subjects

Table 2. List of international geoinformation journals for research

Title of journal	IF 2010	Source of journal
Computational Geosciences - CG	1.056	http://www.springerlink.com/content/101744/ [accessed 1 March 2012]
Computers & Geosciences - C&G	1.416	http://www.elsevier.com/wps/find/journaldescription.cws_home/398/description#description [accessed 1 March 2012]
GeoInformatica - GI	1.357	http://www.springerlink.com/content/100268/ [accessed 1 March 2012]
GIScience & Remote Sensing - GIS&RS	1.000	http://www.bellpub.com/msrs/ [accessed 1 March 2012]
International Journal of Applied Earth Observation and Geoinformation - IJAEOG	1.557	http://www.elsevier.com/wps/find/journaldescription.cws_home/622741/description#description [accessed 1 March 2012]
International Journal of Geographical Information Science - IJGIS	1.489	http://www.tandfonline.com/loi/tgis20 [accessed 1 March 2012]
Journal of Earth System Science - JESS	0.941	http://www.springerlink.com/content/120420/ [accessed 1 March 2012]
Journal of Geographical Systems - JGS	1.289	http://www.springer.com/economics/regional+science/journal/10109 [accessed 1 March 2012]

Source: Own elaboration based on: 1) A Unified List of Scoring Journals, MoSHE, <http://www.nauka.gov.pl/finansowanie/finansowanie-nauki/dzialalnosc-statutowa/ocena-jednostek-naukowych/lista-czasopism-punktowanych/ujednolicony-wykaz-czasopism-naukowych/ujednolicony-wykaz-czasopism-naukowych/artikul/ujednolicony-wykaz-czasopism-punktowanych-1/>; 2) www sites of selected journals.

indicated the possibility of using GT in biomedicine and health care. The listing of such journals is summarized in Tables 1, 2, 3, 4. The final analysis chose 15 journals, taking into account detailed characteristics of the subjects ranges, the scientific prestige rating MoSHE scores and Impact factor (IF), and preliminary analysis of tables of contents of such journals. For detailed studies 4 Polish

and 4 international journals were selected in the field of geoinformation and 4 Polish and 3 international journals in the field of biomedicine and health care. Shortlisted journals are bolded in Tables 1, 2, 3, 4.

Table 3. List of Polish biomedical and health care journals for research

Title of journal	MoSHE scores	Source of journal
Acta of Bioengineering and Biomechanics - ABB	9	http://www.actabio.pwr.wroc.pl/acta.php [accessed 30 November 2011]
Advances in Medical Sciences - AMS	9	http://www.advms.pl/ [accessed 30 November 2011]
Biocybernetics and Biomedical Engineering - BBE	9	http://www.ibib.waw.pl/?act=show&lang=en&kat=97 [accessed 30 November 2011]
Family Medicine & Primary Care Review - FMPCR	6	http://www.familymedreview.org/ [accessed 30 November 2011]
International Journal of Occupational Medicine and Environmental Health - IJOMEH	9	http://www.highbeam.com/publications/international-journal-of-occupational-medicine-and-environmental-health-p62392 [accessed 30 November 2011]
Inżynieria Biomedyczna (Biomedical Engineering) - IB	6	http://www.inzynieria-biomedyczna.com/ [accessed 30 November 2011]
Problemy Higieny i Epidemiologii (Problems of Hygiene and Epidemiology) - PHE	6	http://www.phie.pl/ [accessed 30 November 2011]
Zdrowie Publiczne (Public Health) - ZP	6	http://www.zdrowiepubliczne.pl/ [accessed 30 November 2011]

Source: Own elaboration based on: 1) A Unified List of Scoring Journals, MoSHE, <http://www.nauka.gov.pl/finansowanie/finansowanie-nauki/dzialalnosc-statutowa/ocena-jednostek-naukowych/lista-czasopism-punktowanych/ujednolicony-wykaz-czasopism-naukowych/ujednolicony-wykaz-czasopism-naukowych/artykul/ujednolicony-wykaz-czasopism-punktowanych-1/>; 2) www sites of selected journals.

3 Results

A study of 3908 articles in selected journals was carried out, including 899 articles in the field of geoinformation in Polish journals, 1177 articles in the field of

geoinformation in international journals, 1023 articles of biomedicine and health care in Polish journals and 809 articles of biomedicine and health care in international journals. Using the method of literature review, abstracts and often the full texts of articles selected for the research journals were analyzed.

Table 4. List of international biomedical and health care journals for research

Title of journal	IF 2010	Source of journal
Biogeosciences - BG	3.587	http://www.biogeosciences.net/ [accessed 2 March 2012]
Biomedical and Environmental Sciences - BES	1.063	http://www.besjournal.com/ [accessed 2 March 2012]
Geobiology - GB	3.207	http://www.wiley.com/bw/journal.asp?ref=1472-4677&site=1 [accessed 2 March 2012]
Global Ecology and Biogeography - GEB	5.273	http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1466-8238 [accessed 2 March 2012]
IEEE Transactions on Information Technology in Biomedicine - TITB	1.707	http://ieeexplore.ieee.org/xpl/RecentIssue.jsp?punumber=4233 [accessed 2 March 2012]
Geospatial Health - GH	1.705	http://www.geospatialhealth.unina.it/ [accessed 2 March 2012]
Health & Place - HP	2.694	http://www.journals.elsevier.com/healthand-place/ [accessed 2 March 2012]
Journal of Epidemiology and Community Health - JECH	2.983	http://jech.bmj.com/ [accessed 2 March 2012]

Source: Own elaboration based on: 1) 2010 JCR Science Edition; 2) www sites of selected journals.

3.1 Result in the Group of Journals from the Field of Geoinformation

In the group of journals from the field of geoinformation 20 articles met the selection criterion for the application of GT for biomedicine and health care, 10 in Polish journals and 10 in international journals. The list of articles is presented in Table 5.

Table 5. List of articles from selected Polish and international journals in the field of geoinformation about the application of GT for biomedicine and health care

Journal	Source of article (no. in references)	No. of articles
Polish journals		
AFKT	[18]	4
MG	[2], [11], [19], [67]	4
PG	[68]	1
RG	[72]	1
International journals		
C&G	[26]	1
IJAEOG	[45], [58]	2
IJGIS	[3], [56], [74]	3
JGS	[5], [14], [15], [40]	4
Total		20

Source: Own elaboration

3.2 Result in the Group of Journals from the Field of Biomedicine and Health Care

In the group of biomedicine and health care journals, the selection criterion for the application of GT in biomedicine and health care, in Polish journals, has not been met adequately by any of the articles. Only the article of Usefulness of Address Data from Hospital Information Systems for Epidemiological Purposes [34] provides an assessment of geographic information systems data confidence (PESEL - social security cards, TERYT - National Territorial Units Register) in view of their usefulness for epidemiological research. Such studies outcomes could, however, be expected due to the need for a different perspective on issues in the field of biomedicine and health care by relevant experts in the domain. Undoubtedly, however, analysis of the articles confirmed that the application of GT to solving certain problems would allow their visualization, and a more complete analysis. For example, in the articles: - Air Pollution and Daily Emergency Department Visits for Depression [66], - Analysis of medical emergency squad responses mounted in the District of Czestochowa in 2004 [38], - Environmental health risks of population living in urban and outside areas of the District of Poznan [1]. 9 In the group of international journals from the field of biomedicine and health care 48 articles met the selection criterion for the application of GT for biomedicine and health care. The list of articles is presented in Table 6.

Table 6. List of articles from selected international journals in the field of biomedicine and health care about the application of GT for biomedicine and health care

Journal	Source of article (no. in references)	No. of articles
GH	[7], [9], [13], [23],[24], [29], [30], [33],[35], [37], [39], [41], [43], [44], [51], [57], [63], [64], [65], [71], [73]	21
HP	[4], [6], [12],[16], [21], [22], [25], [36], [48], [49], [53], [77]	12
JECH	[8], [10], [17], [31],[42], [47], [50], [52], [54], [55], [59], [60], [61], [62], [75]	15
Total		48

Source: Own elaboration

Table 7. List of articles from selected international journals in the field of biomedicine and health care about the application of GT for biomedicine and health care

Thematic field	Journal	Source of article	Number of articles	Total in field
geoinformation technology for human body search	AFKT	[18], [69], [70], [78]	4	4
geoinformation technology in health care	MG	[11]	1	54
	RG	[72]	1	
	C&G	[26]	1	
	IJAEOG	[45], [58]	2	
	IJGIS	[3], [56], [74]	3	
	JGS	[5], [14], [15]	3	
	GH	[7], [9], [13], [23],[24], [29], [30], [33], [35], [37], [39], [44], [51], [57], [63], [64], [65], [71], [73]	19	
	HP	[4], [6], [12], [16], [22], [25], [48], [49], [53], [77]	10	
JECH	[8], [10], [31],[42], [47], [50], [52], [54], [55], [59], [60], [61], [62], [75]	14		
geoinformation technology for aiding health service	MG	[2], [19], [67]	3	10
	PG	[68]	1	
	JGS	[40]	1	
	GH	[41],[43]	2	
	HP	[21], [36]	2	
	JECH	[17]	1	
Total				68

Source: Own elaboration

4 Thematic Fields of Application of Geoinformation Technologies for Biomedicine and Health Care

Analysis of the issues from selected articles helped identify areas of thematic GT applications in biomedicine and health. Then, bibliographic descriptions of selected articles were assigned to adopted thematic areas and a quantitative breakdown was made for particular areas using the bibliometric technique. The results of such quantitative research by different thematic areas are presented in Table 7.

5 Conclusions

The studies have demonstrated that Polish and international body of selected journals of recent years recognizes issues concerning the application of geoinformation technology for biomedicine and health care, centering around such themes as: GT for human body search, GT in health care, GT for aiding health service. The research shows that these issues are considered in the literature in both fields - geoinformation and in biomedicine and health care, but mostly in the area of health care. Also demonstrated the possible application of GT in the papers in Polish articles published in the biomedicine and health care literature. Reference material and statements by representatives of geoinformation firms confirm that the GT are increasingly being used in biomedicine and health care. They indicate that the implementation of GT brings tangible benefits. This technology allows for a quick and accurate representation of a specific phenomenon and allows to analyze the problem along with its spatial aspect. With this it became possible:

- to increase the effectiveness of first aid - by optimizing routes and times to reach the victims and bring them to the hospital;
- to track causes and areas of spreading diseases (viral or environmental), which enables effective control measures;
- to check the location of new health facilities, thus enabling distributing new health care centers according to the needs of local communities;
- to conduct pharmacological market research;
- analyze environmental impacts on health;
- to monitor public health;
- monitor drinking water quality, etc.;
- to monitor any spills or leakages of toxins and other hazardous substances in order to protect the health of persons in the immediate vicinity of the accident site.

Geoinformation company offers are addressed to all involved in protecting and improving health - doctors, health center and hospital managers, insurance companies, medical emergency squad personnel, epidemiologists, and scientists studying the spread of social diseases and their dependence on environmental factors [27].

References

1. Adamek, R., Adamek, A.M., Orłowski, J.: Srodowiskowe zagrozenia zdrowia populacji zamieszkujacej rejonu miejskie i pozamiejskie powiatu poznanskiego (Environmental health risks of population living in urban and outside areas of the District of Poznan). *Prob. Hig. Epidemiol. (Probl. Hyg. Epidemiol.)* 88(2), 200–205 (2007)
2. Antosiewicz, M.: GPS w Malopolsce (GPS in Malopolska). *Geod. Mag. Geoinf. (Geod. Geoinf. Mag.)* 5 (2007), http://geoforum.pl/?menu=47064&page=edition&id=34&option=artykuly#page_top (cited December 15, 2011)
3. Bastin, L., Rollason, J., Hilton, A., Pillay, D., Corcoran, C., Elgy, J., Lambert, P.A., De, P., Worthington, T., Burrows, K.: Spatial aspects of MRSA epidemiology: a case study 12 using stochastic simulation, kernel estimation and SaTScan. *Int. J. Geogr. Inf. Sci.* 7, 811–836 (2007)
4. Bautista, C., Saterén, W., Sanchez, J., Singer, D., Scott, P.: Geographic mapping of HIV infection among civilian applicants for United States military service. *Health Place* 14(3), 608–615 (2008)
5. Bhat, C.R., Sener, I.N.: A copula-based closed-form binary logit choice model for accommodating spatial correlation across observational units. *J. Geogr. Syst.* 3, 243–272 (2009)
6. Bhowmick, T., Griffin, A., MacEachren, A., Kluhsman, B., Lengerich, E.: Informing geospatial toolset design: Understanding the process of cancer data exploration and analysis. *Health Place* 14(3), 576–607 (2008)
7. Bhunia, G., Kesari, S., Jeyaram, A., Kumar, V., Das, P.: Influence of topography on the endemicity of Kala-azar: a study based on remote sensing and geographical information system. *Geospatial Health* 4(2), 155–165 (2010)
8. Bjork, J., Albin, M., Grahn, P., Jacobsson, H., Ardo, J., Wadbro, J., Ostergren, P.-O., Skarback, E.: Recreational values of the natural environment in relation to neighbourhood satisfaction, physical activity, obesity and wellbeing. *J. Epidemiol. Community Health* 62, e2 (2008), doi:10.1136/jech.2007.062414
9. Brooker, S., Utzinger, J.: Integrated disease mapping in a polyparasitic world. *Geospatial Health* 2, 141–146 (2007)
10. Bruneau, J., Daniel, M., Kestens, Y., Zang, G., Genereux, M.: Associations between HIV related injection behaviour and distance to and patterns of utilisation of syringe-supply programmes. *J. Epidemiol. Community Health* 62, 804–810 (2008)
11. Brzostowski, K., Foks-Ryznar, A., Sitek, P., Zdunek, R.: Odbiornik dla ratownika (Receiver for the Rescuer). *Geod. Mag. Geoinf. (Geod. Geoinf. Mag.)* 12 (2010), http://geoforum.pl/?menu=47064&page=edition2&id=1014&id_article=147#edition (cited December 13, 2011)
12. Buzzelli, M., Veenstra, G.: New approaches to researching environmental justice: Combining critical theory, population health and geographical information science (GIS). *Health Place* 13(1), 1–2 (2007)
13. Cinnamon, J., Rinner, C., Cusimano, M., Marshall, S., Bekele, T., Hernandez, T., Glazier, R., Chipman, M.: Evaluating web-based static, animated and interactive maps for injury prevention. *Geospatial Health* 4(1), 3–16 (2009)
14. Congdon, P.: A multiple indicator, multiple cause method for representing social capital with an application to psychological distress. *J. Geogr. Syst.* 1, 1–23 (2010)
15. Congdon, P.: The need for psychiatric care in England: a spatial factor methodology. *J. Geogr. Syst.* 3, 217–239 (2008)
16. Continelli, T., McGinnis, S., Holmes, T.: The effect of local primary care physician supply on the utilization of preventive health services in the United States. *Health Place* 16(5), 942–951 (2010)

17. Corcoran, P., Arensman, E., Perry, I.J.: The area-level association between hospital-treated deliberate self-harm, deprivation and social fragmentation in Ireland. *J. Epidemiol. Community Health* 61, 1050–1055 (2007)
18. Czechowicz, A., Tokarczyk, R.: Lokalizacja punktów pomiarowych w systemie do trójwymiarowego pozycjonowania ciała wybranymi metodami sztucznej inteligencji (Detection of measurement points in a 3D body positioning system by means of artificial intelligence). *Arch. Fotogram., Kartogr. Teledetekcji (Arch. Photogram., Cartogr. Remote Sens.)* 20, 67–79 (2009)
19. Czuchaj, J., Grabowski, J., Kozakiewicz, A., Kucharski, R.: Mapy akustyczne aglomeracji (Acoustic Agglomeration Maps). *Geod. mag. geoinf (Geod. geoinf. mag.)*, vol. 12 (2007), http://geoforum.pl/?menu=47064&page=edition&id=41&option=temat_z_okladki#page_top (cited December 16, 2011)
20. Davenhall B.: Geomedicine. Can Geographic Information Make Me Healthy. ESRI, USA (2010), <http://www.esri.com/library/ebooks/geomedicine.pdf> (cited December 15, 2011)
21. Dib, H., Sun, P., Minmin, Z., Wei, S., Li, L.: Evaluating community health centers in the City of Dalian, China: How satisfied are patients with the medical services provided and their health professionals? *Health Place* 16(3), 477–488 (2010)
22. Dunn, C., Bhopal, R., Cockings, S., Walker, D., Rowlingson, B., Diggle, P.: Advancing insights into methods for studying environment - health relationships: A multi-disciplinary approach to understanding Legionnairesof disease. *Health Place* 13(3), 677–690 (2006)
23. East, I., Hamilton, S., Sharp, L., Garner, M.: Identifying areas of Australia at risk for H5N1 avian influenza infection from exposure to nomadic waterfowl moving throughout the Australo-Papuan region. *Geospatial Health* 3(1), 17–27 (2008)
24. Estrada-Pena, A., Venzal, M.: A GIS framework for the assessment of tick impact on human health in a changing climate. *Geospatial Health* 2, 157–168 (2007)
25. Feldacker, C., Emch, M., Ennett, S.: The who and where of HIV in rural Malawi: Exploring the effects of person and place on individual HIV status. *Health Place* 16(5), 996–1006 (2010)
26. Gething, P.W., Atkinson, P.M., Noor, A.M., Gikandi, P.W., Hay, S.I., Nixon, M.S.: A local space-time kriging approach applied to a national outpatient malaria data set. *Comput. Geosci.* 10, 1337–1350 (2007)
27. GIS w ochronie zdrowia (GIS in Health Care) (2011), http://www.esripolska.com.pl/d.253.0chrona_Zdrowia.html (cited December 21, 2011)
28. Gotlib, D., Iwaniak, A., Olszewski, R.: GIS. Obszary zastosowan (GIS. Areas of Application). PWN, Warsaw (2007)
29. Guo-Jing, Y., Qi, G., Shui-Sen, Z., Malone, J., McCarroll, J., Tanner, M., Vounatsou, P., Bergquist, R., Utzinger, J., Xiao-Nong, Z.: Mapping and predicting malaria transmission in the People’s Republic of China, using integrated biology-driven and statistical models. *Geospatial Health* 5(1), 11–22 (2010)
30. Hendryx, M., Fedorko, E., Anesetti-Rothermel, A.: A geographical information systembased analysis of cancer mortality and population exposure to coal mining activities in West Virginia, United States of America. *Geospatial Health* 4(2), 243–256 (2010)
31. Hirte, L., Nolte, E., Mossialos, E., McKee, M.: The changing regional pattern of ischaemic heart disease mortality in southern Europe: still healthy but uneven progress. *J. Epidemiol. Community Health* 62, e4 (2008), doi:10.1136/jech.2007.067637

32. Information Technology - Definition and History (2011), <http://jobsearchtech.about.com/od/careersintechnology/p/ITDefinition.htm> (cited December 15, 2011)
33. Jacob, B., Krapp, F., Ponce, M., Gotuzzo, E., Griffith, D., Novak, R.: Accounting for autocorrelation in multi-drug resistant tuberculosis predictors using a set of parsimonious orthogonal eigenvectors aggregated in geographic space. *Geospatial Health* 4(2), 201–217 (2010)
34. Jarosz, M.J., Pasternak, M., Boguszewski, A., Horoch, A.: Przydatnosc danych adresowych ze szpitalnych systemow informatycznych do celow epidemiologicznych (Usefulness of Address Data from Hospital Information Systems for Epidemiological Purposes). *Zdr. Publiczne (Public Health)* 117(4), 425–430 (2007)
35. Jayakumar, D., Kavitha, S., Rathinam, S., Vasanthi, G.: Geomapping of trematode-induced granulomatous anterior uveitis - a newly identified cause of blindness among children in the Pudukkottai district of the Tamil Nadu State, India. *Geospatial Health* 4(1), 55–63 (2009)
36. Joyce, K.: To me it's just another tool to help understand the evidence: Public health decision-makers' perceptions of the value of geographical information systems (GIS). *Health Place* 15(3), 831–840 (2009)
37. Kakani, S., Desiree LaBeaud, A., King, C.: Planning for Rift Valley fever virus: use of geographical information systems to estimate the human health threat of white-tailed deer (*Odocoileus virginianus*)-related transmission. *Geospatial Health* 5(1), 33–43 (2010)
38. Kalinowski, P., Kapkowska, B.: Analiza interwencji zespolow ratownictwa medycznego w powiecie czestochowskim w 2004 roku (Analysis of medical emergency squad responses mounted in the District of Czestochowa in 2004). *Prob. Hig. Epidemiol (Probl. Hyg. Epidemiol.)* 88(1), 112–117 (2007)
39. LaBeaud, A.D., Gorman, A.M., Koonce, J., Kippes, C., McLeod, J., Lynch, J., Gallagher, T., King, C., Mandalakas, A.: Rapid GIS-based profiling of West Nile virus transmission: defining environmental factors associated with an urban-suburban outbreak in Northeast Ohio, USA. *Geospatial Health* 2(2), 215–225 (2008)
40. Lauridsen, J., Sanchez, M.M., Bech, M.: Public pharmaceutical expenditure: identification of spatial effects. *J. Geogr. Syst.* 2, 175–188 (2010)
41. Lee, J.E., Sung, J.H., Ward, W.B., Fos, P.J., Lee, W.J., Kim, J.C.: Utilization of the emergency room: impact of geographic distance. *Geospatial Health* 2, 243–253 (2007)
42. Lee, R.L., Cubbin, C., Winkleby, M.: Contribution of neighbourhood socioeconomic status and physical activity resources to physical activity among women. *J. Epidemiol. Community Health* 61, 882–890 (2007)
43. Leonardo, R., Crisostomo, A., Solon, A., Rivera, T., Marcelo, B., Villasper, M.: Geographical information systems in health research and services delivery in the Philippines. *Geospatial Health* 2, 147–155 (2007)
44. Li, S., Yi-Xiu, W., Kun, Y., Qin, L., Qiang, W., Yi, Z., Xiao-Hua, W., Jia-Gang, G., Bergquist, R., Zhou, X.: Landscape genetics: the correlation of spatial and genetic distances of *Oncomelania hupensis*, the intermediate host snail of *Schistosoma japonicum* in mainland China. *Geospatial Health* 3(2), 221–231 (2009)
45. Liu, Y., Chen, H., Wu, G., Wu, X.: Feasibility of estimating heavy metal concentrations in *Phragmites australis* using laboratory-based hyperspectral data - A case study along Le'an River. *China. Int. J. Appl. Earth Obs. Geoinf.* 12(supplement. 2), S166–S170 (2010)
46. Longley, P., Goodchild, M.F., Maguire, D.J., Rhind, D.W.: *Geographic Information Systems and Science*. John Wiley & Sons, Ltd. (2011)

47. Lovasi, G.S., Quinn, J.W., Neckerman, K.M., Perzanowski, M.S., Rundle, A.: Children living in areas with more street trees have lower prevalence of asthma. *J. Epidemiol. Community Health* 62, 647–649 (2008)
48. Maantay, J.: Asthma and air pollution in the Bronx: Methodological and data considerations in using GIS for environmental justice and health research. *Health Place* 13(1), 32–56 (2007)
49. Maclachlan, J., Jerrett, M., Abernathy, T., Sears, M., Bunch, M.: Mapping health on the Internet: A new tool for environmental justice and public health research. *Health Place* 13(1), 72–86 (2007)
50. Mair, C., Diez Roux, A.V., Galea, S.: Are neighbourhood characteristics associated with depressive symptoms? A review of evidence. *J. Epidemiol. Community Health* 62, 940–946 (2008)
51. Marechal, F., Ribero, N., Lafaye, M., Guell, A.: Satellite imaging and vector-borne diseases: the approach of the French National Space Agency (CNES). *Geospatial Health* 3(1), 1–5 (2008)
52. Matheson, F.I., White, H.L., Moineddin, R., Dunn, J.R., Glazier, R.H.: Neighbourhood chronic stress and gender inequalities in hypertension among Canadian adults: a multilevel analysis. *J. Epidemiol. Community Health* 64, 705–713 (2010)
53. McEntee, J., Ogneva-Himmelberger, Y.: Diesel particulate matter, lung cancer, and asthma incidences along major traffic corridors in MA, USA: A GIS analysis. *Health Place* 14(4), 817–828 (2008)
54. Meng, Y.-Y., Rull, R.P., Wilhelm, M., Lombardi, C., Balmes, J., Ritz, B.: Outdoor air pollution and uncontrolled asthma in the San Joaquin Valley, California. *J. Epidemiol. Community Health* 64, 142–147 (2010)
55. Merlo, J., Ohlsson, H., Lynch, K.F., Chaix, B., Subramanian, S.V.: Individual and collective bodies: using measures of variance and association in contextual epidemiology. *J. Epidemiol. Community Health* 63, 1043–1048 (2009)
56. Moreno-Sanchez, R., Anderson, G., Cruz, J., Hayden, M.: The potential for the use of Open Source Software and Open Specifications in creating Web-based cross-border health spatial information systems. *Int. J. Geogr. Inf. Sci.* 10, 1135–1163 (2007)
57. Murad, A.: Defining health catchment areas in Jeddah city, Saudi Arabia: an example demonstrating the utility of geographical information systems. *Geospatial Health* 2(2), 151–160 (2008)
58. Osei, F.B., Duker, A.A., Augustijn, E.-W., Stein, A.: Spatial dependency of cholera prevalence on potential cholera reservoirs in an urban area, Kumasi, Ghana. *Int. J. Appl. Earth Obs. Geoinf.* 5, 331–339 (2010)
59. Pearce, J., Hiscock, R., Blakely, T., Witten, K.: The contextual effects of neighbourhood access to supermarkets and convenience stores on individual fruit and vegetable consumption. *J. Epidemiol. Community Health* 62, 198–201 (2008)
60. Pearce, J., Hiscock, R., Moon, G., Barnett, R.: The neighbourhood effects of geographical access to tobacco retailers on individual smoking behaviour. *J. Epidemiol. Community Health* 63, 69–77 (2009)
61. Pearce, J., Mason, K., Hiscock, R., Day, P.: A national study of neighbourhood access to gambling opportunities and individual gambling behaviour. *J. Epidemiol. Community Health* 62, 862–868 (2008)
62. Rezaeian, M., Dunn, G., St Leger, S., Appleby, L.: Geographical epidemiology, spatial analysis and geographical information systems: a multidisciplinary glossary. *J. Epidemiol. Community Health* 61, 98–102 (2007)

63. Rizzoli, A., Neteler, M., Rosa, R., Versini, W., Cristofolini, A., Bregoli, M., Bucklez, A., Gould, A.: Early detection of tick-borne encephalitis virus spatial distribution and activity in the province of Trento, northern Italy. *Geospatial Health* 2, 169–176 (2007)
64. Rossi, E., Rinaldi, L., Musella, V., Veneziano, V., Carbone, S., Gradoni, L., Cringoli, G., Maroli, M.: Mapping the main *Leishmania* phlebotomine vector in the endemic focus of the Mt. Vesuvius in southern Italy. *Geospatial Health* 2, 191–198 (2007)
65. Stensgaard, A., Saarnak, C., Utzinger, J., Vounatsou, P., Simoonga, C., Mushingi, G., Rahbek, C., Mohlenberg, F., Kristensen, T.K.: Virtual globes and geospatial health: the potential of new tools in the management and control of vector-borne diseases. *Geospatial Health* 3(2), 127–141 (2009)
66. Szyszkowicz, M., Rowe, B.H., Colman, I.: Air Pollution and Daily Emergency Department Visits for Depression. *Int. J. Occup. Med. Environ. Health* 22(4), 355–362 (2009)
67. Tabecki, P., Zbysinski, R.: Szybciej do chorego (Faster for the Patient). *Geod. mag. geoinf* (*Geod. geoinf. mag.*), vol. 4 (2008), http://geoforum.pl/?menu=47064&page=edition&id=45&option=artykuly#page_top (cited December 14, 2011)
68. Tabecki, P.: Budowa infrastruktury uzytkowej systemu pozycjonowania satelitarnego w wojewodztwie mazowieckim (Construction of Utility Infrastructure for the Satellite Positioning System in the Masovian Province). *Prz. Geod. (Geod. Rev.)* 5 (2008), <http://www.sigma-not.pl/publikacja-35163-budowa-infrastruktury-uzytkowej-systemupozycjonowania-satelitarnego-w-wojewodztwie-mazowieckim-przeglad-geodezyjny-2008-5.html> (cited December 12, 2011)
69. Tokarczyk, R., Szczygie, M.: Analiza topografii cia.a ludzkiego w zastosowaniu do badania wad postawy (Human body topography analysis in posture investigation). *Arch. Fotogram., Kartogr. Teledetekcji (Arch. Photogram., Cartogr. Remote Sens.)* 18b, 601–612 (2008)
70. Tokarczyk, R., Tokarczyk, P.: Wykorzystanie analiz typu GIS do detekcji wybranych czesci anatomicznych cia.a ludzkiego dla potrzeb badania wad postawy (The application of GIS analysis for the detection of selected anatomical parts of human body for the posture defects examination). *Arch. Fotogram., Kartogr. Teledetekcji (Arch. Photogram., Cartogr. Remote Sens.)* 19, 423–435 (2009)
71. Tzai-Hung, W., Duan-Rung, C., Meng-Ju, T.: Identifying geographical variations in poverty-obesity relationships: empirical evidence from Taiwan. *Geospatial Health* 4(2), 257–265 (2010)
72. Ustrnul, Z., Stefanoff, P., Czekierda, D.: Weather conditions as a factor favouring the increase of tick. borne diseases prevalence in Poland. *Rocz. Geomat. (Ann. Geomat.)* 6(2), 113–120 (2008)
73. Wang, Y.-X., Hu, W., Tong, S.: Long-term exposure to gaseous air pollutants and cardiorespiratory mortality in Brisbane, Australia. *Geospatial Health* 3(2), 257–263 (2009)
74. Wang, J.-F., Li, X.-H., Christakos, G., Liao, Y.-L., Zhang, T., Gu, X., Zheng, X.-Y.: Geographical Detectors-Based Health Risk Assessment and its Application in the Neural Tube Defects Study of the Heshun Region, China. *Int. J. Geogr. Inf. Sci.* 1, 107–127 (2010)
75. Whitsel, E.A., Avery, C.L.: The environmental epidemiology of atrial arrhythmogenesis. *J. Epidemiol. Community Health* 64, 587–590 (2010)

76. Wikipedia. The Free Encyclopedia. Article: Biomedicine (2011), <http://en.wikipedia.org/wiki/Biomedicine> (cited December 10, 2011)
77. Yogeve-Baggio, T., Bibi, H., Dubnov, J., Or-Hen, K., Carel, R., Portnov, B.: Who is affected more by air pollution - Sick or healthy? Some evidence from a health survey of 19 schoolchildren living in the vicinity of a coal-fired power plant in Northern Israel. *Health Place* 16(2), 399–408 (2010)
78. Zarnowski, A., Levin, E., Skubiev, S.: Human centric approach to inhomogeneous geospatial data fusion and actualization. *Arch. Fotogram., Kartogr. Teledetekcji* (*Arch. Photogram., Cartogr. Remote Sens.*) 21, 523–533 (2010)