



**HAL**  
open science

## Evolution of research in health geographics through the International Journal of Health Geographics (2002–2015)

Sandra Perez, Vincent Laperrière, Marion Borderon, Cindy Padilla, Gilles Maignant, Sébastien Oliveau

### ► To cite this version:

Sandra Perez, Vincent Laperrière, Marion Borderon, Cindy Padilla, Gilles Maignant, et al.. Evolution of research in health geographics through the International Journal of Health Geographics (2002–2015). International Journal of Health Geographics, 2016, 15 (3), pp.1-9. 10.1186/s12942-016-0032-1 . hal-01260193

**HAL Id: hal-01260193**

**<https://hal.science/hal-01260193>**

Submitted on 26 Jan 2016

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.




Distributed under a Creative Commons Attribution - NonCommercial - ShareAlike 4.0 International License

REVIEW

Open Access



# Evolution of research in health geographics through the International Journal of Health Geographics (2002–2015)

Sandra Pérez<sup>1\*</sup> , Vincent Laperrière<sup>2</sup>, Marion Borderon<sup>2</sup>, Cindy Padilla<sup>3</sup>, Gilles Maignant<sup>1</sup> and Sébastien Oliveau<sup>2</sup>

## Abstract

Health geographics is a fast-developing research area. Subjects broached in scientific literature are most varied, ranging from vectorial diseases to access to healthcare, with a recent revival of themes such as the implication of health in the Smart City, or a predominantly individual-centered approach. Far beyond standard meta-analyses, the present study deliberately adopts the standpoint of questioning space in its foundations, through various authors of the *International Journal of Health Geographics*, a highly influential journal in that field. The idea is to find space as the common denominator in this specialized literature, as well as its relation to spatial analysis, without for all that trying to tend towards exhaustive approaches. 660 articles have been published in the journal since launch, but 359 articles were selected based on the presence of the word “Space” in either the title, or the abstract or the text over 13 years of the journal’s existence. From that database, a lexical analysis (tag cloud) reveals the perception of space in literature, and shows how approaches are evolving, thus underlining that the scope of health geographics is far from narrowing.

**Keywords:** Health geographics, Geographic space, Spatial analysis, Lexical analysis

## Background

Health Geographics is a relatively recent field of research. Indeed, although the link between man’s health and his environment has been underlined in medical sciences since Hippocrates, it took a long time for geography to consider that studying health facts was interesting and justified. A proper current of health geographics only emerged in the years 1970–1980. Research is flourishing and concerns themes as varied as the spread of vectorial diseases, access to healthcare, a space’s potential to be or not favorable to health, or looking for environmental determinants in the occurrence of a pathology. Spatial analysis, through the study of closeness, spread, spatial interaction, self-correlation, interpolation, progress and accessibility, is naturally at the center of this research. We wanted to find out how research work carried out on this theme has evolved with the passing time. To do so,

we have opted for analyzing the way space is broached in the articles of the *International Journal of Health Geographics*, a benchmark journal on health geographics and geo-informatics fields. The material for this study was the corpus of articles published between the date when the journal was created and the present day.

## Data collection methods

The idea was to select articles including the word “space” either in the title, or the abstract or the text. 359 articles fit that request in the period spreading from the time the journal was created by Boulos [4] to the present day (September 2015). Subsequently, the title and abstract were integrated into a utility software enabling one to carry out a lexical analysis of the corpus, essentially from the most frequent words (TagCrowd) [1–3]. We only integrated the articles’ titles and abstracts into the utility, because we considered that they were good indicators of the main words used in the text, bearing in mind that they synthesize the article’s object. Representation is by means of a tag cloud. Words with the same root as *space*—like

\*Correspondence: Sandra.PEREZ@unice.fr

<sup>1</sup> UMR ESPACE 7300, University of Nice Sophia, Nice, France

Full list of author information is available at the end of the article

*spatial*—are merged in our request. We requested that the hundred most used words appear, as well as their frequency. We broke up the analysis period (13 years) into three temporally homogeneous sub-periods (2002–2005, 2006–2010 and 2011–2015).

## Results (2002–2005)

The tag cloud for the first sub-period (2002–2005) shows that the terms most used in the 43 articles which had been selected are *spatial* (122), *health* (89), *cancer* (82), *clusters* (81) and *maps* (75) (Fig. 1).

Indeed, during the first 3 years of the journal's existence (2002–2005), the researchers' attention focused mainly on issues concerning cartography, visualization of data and the use of GIS. Actually, the first article written by the journal's founder is about retrieving metadata contained in web files in order to produce interactive maps [4], just like another in 2003 by the same author [5]. This goes hand in hand with the georeferencing of data, in particular data on cancer, and the development of spatial analysis tools [6]. In that period, spatial analysis is essentially used with a view to detecting clusters: "We were able to pinpoint geographic areas with higher risk through exploratory spatial analyses, and to assess temporal variability of the risk surfaces, thus providing a working hypothesis on breast cancer and environmental exposures" [7], see also [8]. Then the authors wonder about the best statistical methods for detecting clusters. For example, in the article headed *A flexibly shaped scan statistic for detecting clusters*, Tango and Takahashi question Kulldorff's statistic which uses a circular window, and put forward another method to approach non-circular clusters (along a road or a river, for example) [9]. Researchers also look into comparing methods and statistical models—*Comparison of spatial scan statistic and spatial filtering in estimating low birth weight* [10], or rather in their combination so as to produce

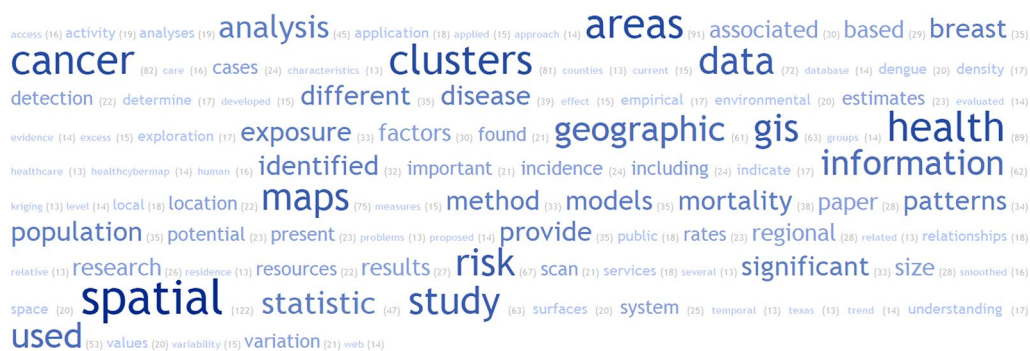
reliable results [11]. GISs are considered as likely to play an important part in following up and understanding the spread of an epidemic of the SARS type in 2003. They allow one to go very far, up to identifying infected buildings that could then be avoided [12].

Spatial clusters are looked for, and so is their temporal inertia. Thus, in *Detecting spatio temporal clusters of accidental poisoning among Texas counties, US, 1980–2001*, Nikhoma et al. examine whether clusters vary spatiotemporally when gender and ethnic group are introduced [13]. Results show the persistence through time of the fact that the black population is the most at risk of accidental poisoning, compared to other ethnic groups, and all the more so when the male population is analyzed.

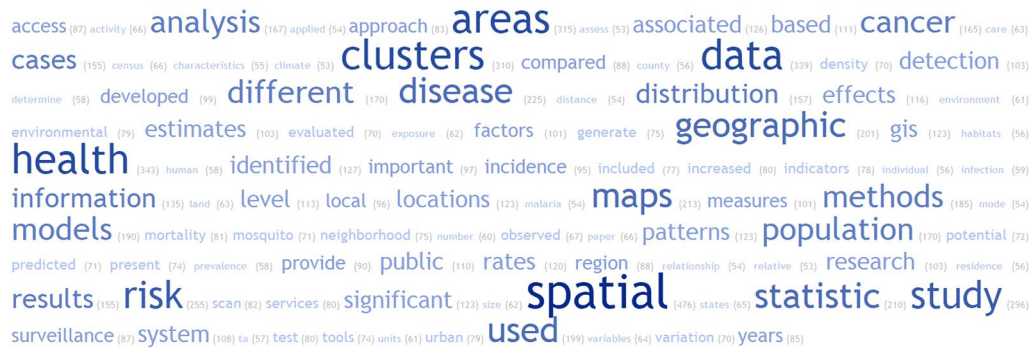
In parallel, warnings against the systematic use of spatial analysis, or at least its limits, appear as early as 2004 [14], with the multi-scale problem (MAUP), the subjectivity of spatial models, looking for associations of variables that do not necessarily imply a causality among them, the fact that there is not such a thing as an absolute model, and that each has its own interests and limits, the ecological inference problem etc.... The very term of "cluster" is challenged, or at least its lack of precision.

## (2006–2010)

During the second period (2006–2010), the most frequent words are *spatial* (476), *health* (343) *data* (339), *areas* (315) and *clusters* (310) (Fig. 2). Cluster issues mobilize even more the researchers' energy (339 against 81), but the link between health geographics and technological progress is increasingly obvious, in particular through geolocation [15, 16]. In parallel, ethics issues and those of right to privacy accompanying these data appear in some articles [17]. Nowadays, the disaggregation of geographic data makes it possible to conduct a reflection on the individual scale, even in the case of GISs [18], since in that article GISs appear in the analysis of



**Fig. 1** Most used words in the IJHG journal's articles between 2002 and 2005, the larger the words, the more frequent they are



**Fig. 2** Most used words in the IJHG journal's articles between 2011 and 2015, the larger the words, the more frequent they are

the relation between the location of certain lesions and clinical results...

**(2011–2015)**

More recently, between 2011 and September 2015 (147 articles), *spatial* is the most frequent word (367), followed by *data* (322) and *model* (300) (Fig. 3). The question appears of the potentiality of space to influence health, for example through its capacity to favor walking [19], or conversely, environments that are not conducive to that activity and even favorable to falls [20]. Thus, in the article referred to, places conducive to falling down have been identified in a particularly dense Hong Kong neighborhood (MongKok), such as the proximity of underground stations, the junctions of congested streets, traffic lights with too short a time reserved for pedestrians to cross, street edges badly adapted to easy walking, or a sudden and abrupt change of curb. In *Geospatial examination of lithium in drinking water and suicide mortality* [21], it even seems that in some spaces, the suicide rate is lower than national average owing to the natural presence of a certain concentration of lithium in public water, which is a regulator of emotions.

In this lexical study, we have seen the evolution in time of the articles published in the journal. However, although trends can be detected, the articles are highly diversified, which reveals the richness of this field of research. Moreover, space can be approached in very different ways. To make sure of the foregoing, we then selected articles concerning the same research subject, but in which space is not approached in the same way.

The relation to space by different authors can range from space seen as a mere medium for the variables occurring there, to space acknowledged as a proper actor with specific attributes that will influence the phenomenon or the pathology under study either positively (amplification, facilitation...) or on the contrary, negatively (barrier, constraint, attenuation...).

We decided to study the way space is considered via two areas which focus the energy of numerous researchers in Health Geographics, namely vectorial diseases and access to healthcare.

**Vectorial diseases**

In the case of articles on vectorial diseases, space is at the same time actor through the numerous determinants



**Fig. 3** Most used words in the IJHG journal's articles between 2011 and 2015, the larger the words, the more frequent they are

(environmental, socio-economic, climatic) that influence the spread of viruses, and medium for the populations or agents (depending on the level considered) implied in the transmission cycles and their interactions. Thus, in *Environmental predictors of West Nile fever risk in Europe* [22], emphasis is put on the role of environmental determinants in the spatial spread of the West Nile virus, a vectorial disease which is transmitted to man via an infected mosquito. Here, environmental determinants designate the physical and climatic characteristics of the spaces being studied. In order to understand the place of these environmental factors, a logistic regression model is used, the dependent variable being the virus infection status (infected/non-infected), and the explanatory variables being environmental determinants provided by tele-detection, such as for example the presence of wetlands. The model helps to underline the part of the environment which explains the risk of being infected by the virus. Subsequently, this model can be used as a predictive model so as to assess the probability of future cases. So, here space is perceived as an actor having variable physical and climatic characteristics both in time and space, which plays a determining role in the transmission of the vectorial disease and explains its uneven (spatial and temporal) distribution. Thus, studying the environmental characteristics of the space being studied makes it possible to better understand and predict the spatial variability of the risk of transmission.

In *Agricultural landscape and spatial distribution of *Toxoplasma gondii* in rural environment: an agent-based model* [23], the authors consider space essentially as a medium of interactions aiming, via multi-agent model, to predict the spatial distribution of a pathogenic factor (difficult to assess in real life), via a number of variables that seem to influence its distribution. Here the parasite is *Toxoplasma gondii*, which is responsible for toxoplasmosis and is excreted in the environment by infected cats (the definitive host) and rodents (intermediate host). The spatial distribution of farms (where cats find shelter) and the distance to the nearest farm could, among others, serve as a medium for the spread of the parasite, and explain high levels of contamination. The risk of contamination is higher if farms are inside a village than if they are scattered. Model entities are cats, rodents, farm buildings and environment cells, each agent and cell being characterized by a state of contamination and specific rules (for example, population dynamic, activity or mobility for the hosts).

In the article by Kienberger et al., *Spatial-explicit modeling of social vulnerability to malaria in East Africa* [24], space is perceived both as a medium of the phenomenon being studied and an actor in its representation. This paper is interesting in so far as it proposes an original

method to analyze the risk of malaria that can be used as a support for intervention measures. The method is based on a regionalization process. In the paper, results (an index of vulnerability to malaria in the eastern part of sub-Saharan Africa) are visualized by a constructed geographical unit named “geon”. The idea is to offer an alternative to MAUP with a data aggregation method that does not take into account administrative limits or cell grids when data are gridded. The very choice of aggregated data and their regionalization is a process which has a direct influence on the modeling and representation of the variability of the phenomenon being studied.

Unlike vectorial diseases that are not directly transmitted from human to human, interactions such as more or less close contact between healthy and infectious individuals are determining in infectious and contagious diseases [25]. A detailed follow-up of individual behaviors (their mobility in space–time, their exposure to the resulting risk factor) is made possible thanks to geolocation tools. Then the individuals themselves spread the diseases by means of their interactions in their space of activity, and thus create spaces with a more or less high risk of infection.

#### **Accessibility to health care**

The objective is now to synthesize current evidence regarding how space is taken into account in health-related accessibility studies.

Three ecological articles were selected and screened in full text journal. Two articles are from Canada [26, 27], and one article is from France [28]. The aim of the three articles is to assess the spatial accessibility to facilities and more precisely propose the measurement of accessibility on a regional scale using aggregated data in Strasbourg for the methodological article of Salze et al. [28], assess spatial accessibility to healthcare facilities for senior residents in Montreal, in the article of Paez et al. [27], and assess the spatial accessibility to healthy and affordable food in food deserts in a Canadian city for Larsen et al. [26]. For the same objective space was used and analyzed by different means.

Spatial factors have been used to examine how people's habitual movements interact with their environment. Access is influenced by the shape and area of an individual's activity space, the spatial distribution of opportunities, and by the spatial structures that constrain and direct movement through space; the shape and area of the activity space is partly a product of how it is conceptualized and measured. Despite being of obvious interest, until recently relatively little was known about the geographical accessibility to healthcare. Whereas Salze and Larsen only take into account spatial factors [28], Paez et al. [27], take into account both individual and spatial factors together.

Two methods were used to assess the spatial accessibility to healthcare: geographic information system (GIS) and spatial analysis with complex models. GIS were used to measure distance between the patient's location and the facilities. For these measures, they used distance on foot, by car, public transport, and streets. Tools used are mean distance, straight line distance, network based approach [26] or indicators like accessibility or relative accessibility indicators [27]. GISs were used to measure indicators of availability of healthcare facilities using buffers, like the number of facilities taking into account the area around the patient [26]. GISs were used to map the spatial distribution of healthcare facilities and areas of low and high risk of geographical accessibility to healthcare [28]. The second approach is the spatial modeling approach. Salze et al. propose a spatial modeling approach which statistically determines areas of low and high accessibility to a facility in food deserts [28].

#### Recent trends

Finally, we wanted to find out what was the latest trend in the last articles. Gong et al.'s article [29] refers to smart space meaning for example "smart city" (see also [30]); there, space is apprehended through a network of economic, smart and communicating sensors able to produce real-time data (coupling GIS and web platform), and warn us when some "event" occurs. Here the term "event" must be understood as a geographic phenomenon occurring at a specific point from a trigger threshold, for example when a certain air pollution threshold is reached. Smart cities were even the subject of a thematic collection of four articles [30–33] published in the journal on January 31, 2015, headed "Smart healthy cities and regions". What emerges from these is that smart cities, because they are able to act simultaneously on numerous health determinants—for example via a better knowledge of the environment (urban monitoring) and their social action in favor of the elderly (to break their isolation and maintain their autonomy) -, would contribute to reducing health inequalities, even social inequalities among people. Thus, the Internet of Things [31] would be much more than just objects internet-connected through technology, and would make individuals fully in control of their health via, for example, crowdsourcing [32] and feedbacks on noisy environments, love-clean streets, and also more responsible for their health (connected watches, exergames that require physical exercises and make them more attractive for people tending to be sedentary [33]). Cities which are at the same time social, innovative and smart have the capacity to improve their inhabitants' quality of life and become healthier places where life is pleasant.

Whereas green space, or at least green spaces are seen as contributing too, under certain conditions, not only to our health but also to our overall wellbeing, nevertheless Wheeler et al. [34] underline the importance of carrying out in-depth studies because this relation, which is a priori positive, could not be as linear as one would like to assume...

Finally, the perception of the surrounding space, if it is positive, can both maintain people in good health and avoid to adopt risk behaviors, notably among the youth [35].

This journal specializing in geo-informatics applied to health sometimes deals with non-geographic spaces such as virtual spaces, in order to better figure out, for example, impacts on the health of people living in conflict zones and for whom it is very difficult to have access to data [36], or else space inside our body [18].

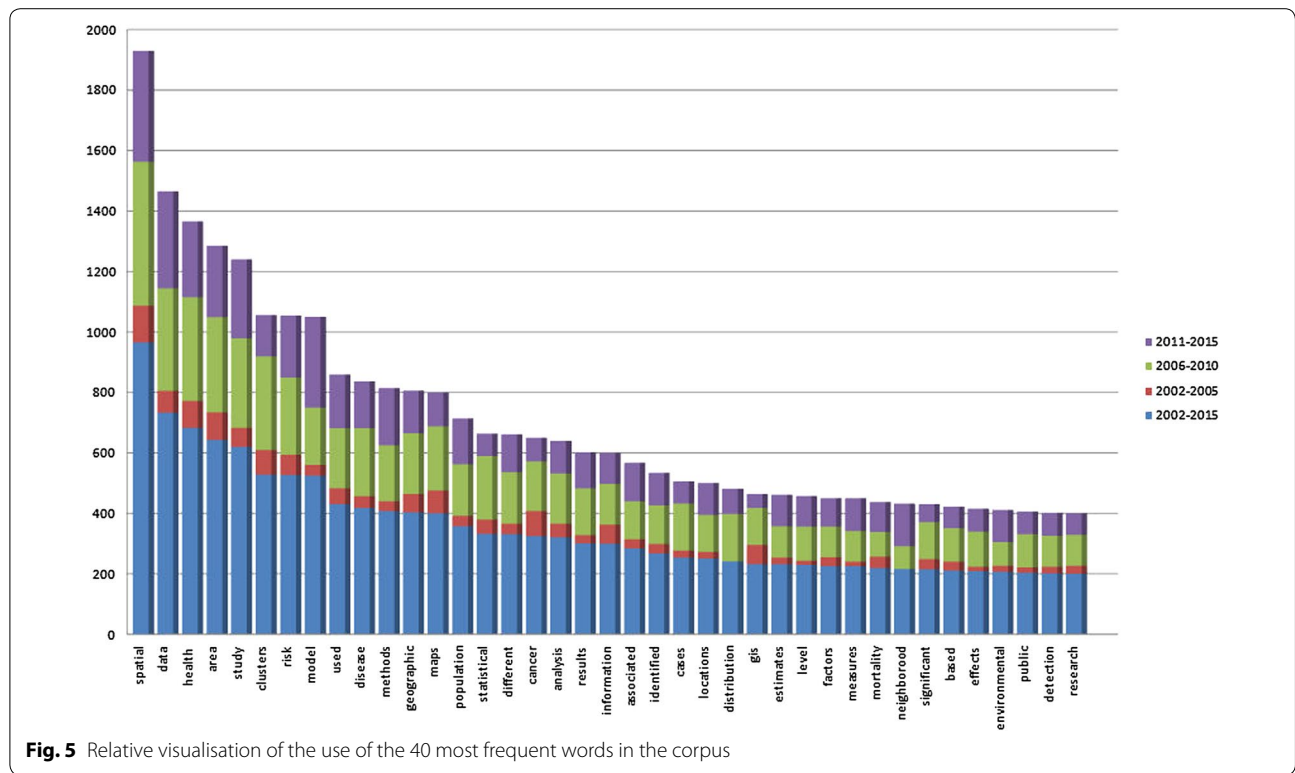
#### Discussion

Our aim was to focus on the term *space*, and to find out in what way this term and those related were broached in the various articles of the journal in which they appear either in the title or in the abstract. We were particularly interested in the question of what potential has the geographic space to have a direct influence on health matters.

However, we are well aware that other articles in which these terms appear neither in the title nor in the abstract can nonetheless broach these issues using other words. That is why a lexical analysis has also been done on the articles that had been excluded in order to see whether they were different from those selected. The process was carried out only on articles concerning the most recent period (2011–2015), namely on 108 articles (Fig. 4). What emerges from this analysis is that, most of the time, the words most frequently used are the same as those where the word *space* came out in the forefront, however less frequently, apart from the word *system* which is the most frequently used (77 against 59). But new words appear: *available* (35), *care* (50), *countries* (29), *facilities* (48), *food* (33), *individual* (28), *patient* (39), *physical* (50), *school* (29), *services* (55), *social* (48) and *transport* (38).

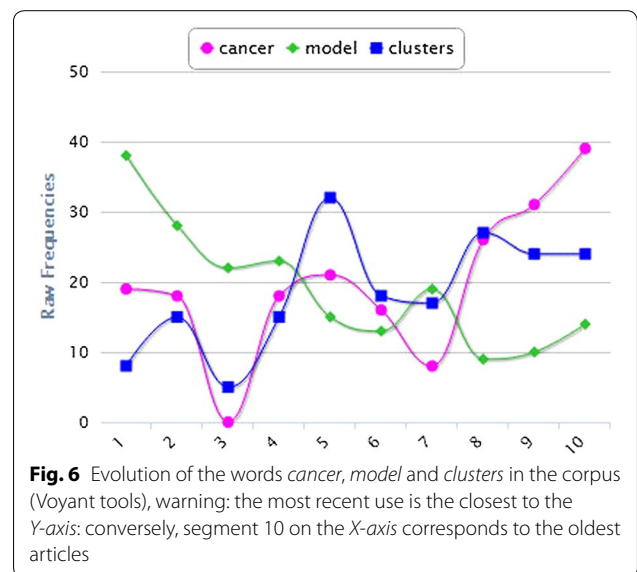
What are these articles, and in what way do they differ from those previously selected? Some are centered on data-related methodological difficulties, whether these are linked to geo-referencing or cartographic representation, for example they are about how difficult it is to have access to Gis data on a fine scale in some rural regions, and how useful it is then to rely on previously trained community health workers in order to obtain data on the repartition of safe water for people in northern Rwanda [37]. These articles also deal with the development of





That’s the reason why if we want to go deeper into these analyses, it is preferable to carry out a Keyword in Context analysis (KWIC analysis) using for example a free online tool called Voyant Tools suite (<http://voyant-tools.org/>). An example of this kind of analysis with free text from the health domain can be found in Maramba et al. [3].

We used this tool notably to observe more closely the evolution in time of the three terms which evolved most over time (*cancer*, *cluster* and *model*) (Fig. 6). We can see on this chart that although the terms *cluster* and *cancer* have evolved in parallel with the passing time (apart from a slight decoupling between the two curves, where the term *cluster* seems to be used independently from studies on cancer, for example in data relating to congenital malformations [55]), these two terms are less and less used these days, contrary to the term *model* which seems to be used more and more frequently. Indeed, although the detection of clusters is effective for infectious diseases, it seems to be less successful in the case of cancer. This can be explained by the fact that cancer is indubitably a multifactorial disease. Therefore, it is difficult to draw one or several causes that are easily identifiable and explanatory. Thus, researchers may detect cancer clusters in different environmental expositions. Few significant results have come out of such studies [56], and for this reason



research on clusters associated to cancer tends to slow down. At present, research extends both to other types of modeling and to numerous themes other than cancer, as shown in Fig. 7 which represents an extract of a KIWC analysis carried out on the word *model*, which contributes to diversifying approaches in health geographics.



Left	Keyword	Right
...human Q fever incidence to	model	Atmospheric dispersion mo...
...data in the Netherlands to m	model	with a uniform concentration...
...spatial exposure models: 1)	model	with concentrations proporti...
...concentrations modelled by	model	to correlate the observed in...
...using cross-validation. Res	model	always performed significan...
...best to the incidence data.	model	. ADM concentrations base...
...of the relationships between	model	. According to the social ec...
...and active commuting: towa	model	of health-related behaviors, ...
...residing in and around Paris	model	. Objective environmental v...
...the 457 urban villages of Ka	model	development and evaluation...
...There were in total 2,997 co	model	was fitted to the daily incide...
...to the daily incidents occurri	model	was then used to predict th...
...prepare the data into a form	model	and sensor web service pla...
...data management under the	model	and a Sensor Web service ...
...under the Geospatial Servic	model	manages real-time data. Th...
...Sensor Web service platfor	model	based on the Sensor Web t...
...based on the Sensor Web t	model	, a Sensor Web service plat...
...real-time air quality monitori	model	in the Sensor Web service ...
...s and 9.2 s. The experiment	model	and Sensor Web Service Pl...
...California (DISTANCE) coh	model	, we assessed the amount ...
...epidemiological research.Ag	model	. Predicting the spatial distri...
...the spatial distribution of oo	model	to study how landscape str...
...results of the two settings w	Model	predictions showed a steep...
...village. Maps of the risk of s	model	. The agent-based model pr...
...the risk of soil contaminated	model	provides a useful tool to ass...
...environment that would othe	model	: a visual analytic perspecti...
...healthcare centers with a m	model	, demanding points are likel...
...but this method exhibits evi	model	in which exact and approxi...

**Fig. 7** KIWC analysis carried out on the term *model* in the corpus

## Conclusion

The interest of this contribution was to list a number of general trends that are at the core of health geographics. Health geographics is a recent discipline that relies on new technologies in order to better grasp the links between health facts and their context; it is characterized by a wide methodological diversity and the variety of subtopics broached. Our aim was to emphasize that this field of research is vast, and that beyond the subjects studied, it contributes to a revival of geography via the extension of problems such as MAUP, the visualization of data, issues of ethics and protection of individuals, in particular in regard to the explosion of detailed and geolocated data. In view of the richness of this fast-expanding field, we wished to encourage young geographers to work on these health issues, because there is still so much to do.

## Authors' contributions

This paper is the brainchild of SP, SO and VL. SP carried out the articles' lexical analysis and interpreted results. VL, MB and SO wrote the section on vectorial

diseases, CP that on accessibility to healthcare, and GM that on recent trends and the abstract. All authors read and approved the final manuscript.

## Authors' information

The authors belong to a UMR ESPACE group of research named "Espaces de Santé, Santé des Espaces" (Health Spaces, Health of Spaces, ESSE in French). The purpose of this group is to study the relations between geographic space and people's health. It is composed of ten researchers or lecturers-researchers whose names follow: Daniel Bley, Marion Borderon, Vincent Laperrière, Gilles Maignant, Sébastien Oliveau, Cindy Padilla, Sandra Pérez, Alain Sandoz, Dorian Souliès, Nicole Vernazza-Licht.

## Author details

<sup>1</sup> UMR ESPACE 7300, University of Nice Sophia, Nice, France. <sup>2</sup> UMR ESPACE 7300, University of Aix-Marseille, Aix-en-Provence, France. <sup>3</sup> DSET-GS, School of Public Health, Rennes, France.

## Acknowledgements

The authors thank UMR ESPACE for its support to the ESSE research group.

## Competing interests

The authors declare that they have no competing interests.

Received: 2 November 2015 Accepted: 7 January 2016

Published online: 20 January 2016

## References

- Gill D, Griffin A. Good Medical Practice: what are we trying to say? Textual analysis using tag clouds. *Med Educ*. 2010;44:316–22.
- Armfield NR, Edirippulige S, Caffery LJ, Bradford NK, Grey JW, Smith AC. Telemedicine—a bibliometric and content analysis of 17,932 publication records. *Int J Med Inform*. 2014;83:715–25.
- Maramba ID, Davey A, Elliott MN, Roberts M, Roland M, Brown F, Burt J, Boiko O, Campbell J. Web-based textual analysis of free-text patient experience comments from a survey in primary care. *JMIR Med Inform*. 2015;3:e20.
- Boulos MNK, Roudsari AV, Carson ER. A simple method for serving Web hypermaps with dynamic database drill-down. *Int J Health Geogr*. 2002;1:1.
- Boulos MNK. The use of interactive graphical maps for browsing medical/health Internet information resources. *Int J Health Geogr*. 2003;2:1.
- Boscoe FP, Ward MH, Reynolds P. Current practices in spatial analysis of cancer data: data characteristics and data sources for geographic studies of cancer. *Int J Health Geogr*. 2004;3:28.
- Han D, Rogerson PA, Bonner MR, Nie J, Vena JE, Muti P, Trevisan M, Freudenheim JL. Assessing spatio-temporal variability of risk surfaces using residential history data in a case control study of breast cancer. *Int J Health Geogr*. 2005;4:9.
- Pickle L, Waller LA, Lawson AB. Current practices in cancer spatial data analysis: a call for guidance. *Int J Health Geogr*. 2005;4:3.
- Tango T, Takahashi K. A flexibly shaped spatial scan statistic for detecting clusters. *Int J Health Geogr*. 2005;4:11.
- Ozdenerol E, Williams BL, Kang SY, Magsumbol MS. Comparison of spatial scan statistic and spatial filtering in estimating low birth weight clusters. *Int J Health Geogr*. 2005;4:19.
- Griffith DA. A comparison of six analytical disease mapping techniques as applied to West Nile Virus in the coterminous United States. *Int J Health Geogr*. 2005;4:18.
- Boulos MNK. Descriptive review of geographic mapping of severe acute respiratory syndrome (SARS) on the Internet. *Int J Health Geogr*. 2004;3:2.
- Nkhoma ET, Hsu CE, Hunt VI, Harris A. Detecting spatiotemporal clusters of accidental poisoning mortality among Texas counties, US, 1980–2001. *Int J Health Geogr*. 2004;3:25.
- Jacquez GM. Current practices in the spatial analysis of cancer: flies in the ointment. *Int J Health Geogr*. 2004;3:22.

15. Rainham D, Krewski D, McDowell I, Sawada M, Liekens B. Development of a wearable global positioning system for place and health research. *Int J Health Geogr*. 2008;7:59.
16. Wiehe SE, Carroll AE, Liu GC, Haberkorn KL, Hoch SC, Wilson JS, Fortenberry JD. Using GPS-enabled cell phones to track the travel patterns of adolescents. *Int J Health Geogr*. 2008;7:22.
17. Boulos MNK, Curtis AJ, Malik PA. Musings on privacy issues in health research involving disaggregate geographic data about individuals. *Int J Health Geogr*. 2009;8:46.
18. Garb JL, Ganai S, Skinner R, Boyd CS, Wait RB. Using GIS for spatial analysis of rectal lesions in the human body. *Int J Health Geogr*. 2007;6:11.
19. Mayne DJ, Morgan GG, Willmore A, Rose N, Jalaludin B, Bambrick H, Bauman A. An objective index of walkability for research and planning in the Sydney Metropolitan Region of New South Wales, Australia: an ecological study. *Int J Health Geogr*. 2013;12:61.
20. Lai PC, Low CT, Wong M, Wong WC, Chan MH. Spatial analysis of falls in an urban community of Hong Kong. *Int J Health Geogr*. 2009;8:14.
21. Helbich M, Leitner M, Kapusta ND. Geospatial examination of lithium in drinking water and suicide mortality. *Int J Health Geogr*. 2012;11:19.
22. Tran A, Sudre B, Paz S, Rossi M, Desbrosse A, Chevalier V, Semenza JC. Environmental predictors of West Nile fever risk in Europe. *Int J Health Geogr*. 2014;13:26.
23. Gotteland C, McFerrin BM, Zhao X, Gilot-Fromont E, Lélou M. Agricultural landscape and spatial distribution of *Toxoplasma gondii* in rural environment: an agent-based model. *Int J Health Geogr*. 2014;13:45.
24. Kienberger S, Hagenlocher M. Spatial-explicit modeling of social vulnerability to malaria in East Africa. *Int J Health Geogr*. 2014;13:29.
25. Qi F, Du F. Tracking and visualization of space-time activities for a micro-scale flu transmission study. *Int J Health Geogr*. 2013;12:6.
26. Larsen K, Gilliland J. Mapping the evolution of "food deserts" in a Canadian city: supermarket accessibility in London, Ontario, 1961–2005. *Int J Health Geogr*. 2008;7:16.
27. Paez A, Mercado RG, Farber S, Morency C, Roorda M. Accessibility to health care facilities in Montreal Island: an application of relative accessibility indicators from the perspective of senior and non-senior residents. *Int J Health Geogr*. 2010;9:52.
28. Salze P, Banos A, Oppert J-M, Charreire H, Casey R, Simon C, Chaix B, Badariotti D, Weber C. Estimating spatial accessibility to facilities on the regional scale: an extended commuting-based interaction potential model. *Int J Health Geogr*. 2011;10:2.
29. Gong J, Geng J, Chen Z. Real-time GIS data model and sensor web service platform for environmental data management. *Int J Health Geogr*. 2015;14:2.
30. Boulos MNK, Tsouros AD, Holopainen A. Social, innovative and smart cities are happy and resilient: insights from the WHO EURO 2014 International Healthy Cities Conference. *Int J Health Geogr*. 2014;14:3.
31. Boulos MNK, Al-Shorbaji NM. On the Internet of Things, smart cities and the WHO Healthy Cities. *Int J Health Geogr*. 2014;13:10.
32. Boulos MNK, Resch B, Crowley DN, Breslin JG, Sohn G, Burtner R, Pike WA, Jezierski E, Chuang K-Y. Crowdsourcing, citizen sensing and sensor web technologies for public and environmental health surveillance and crisis management: trends, OGC standards and application examples. *Int J Health Geogr*. 2011;10:67.
33. Boulos MN, Yang SP. Exergames for health and fitness: the roles of GPS and geosocial apps. *Int J Health Geogr*. 2013;12:18.
34. Gong J, Geng J, Chen Z. Beyond greenspace: an ecological study of population general health and indicators of natural environment type and quality. *Int J Health Geogr*. 2015;14:17.
35. Spilkova J, Dzúrova D, Pitonak M. Perception of neighborhood environment and health risk behaviors in Prague's teenagers: a pilot study in a post-communist city. *Int J Health Geogr*. 2014;13:41.
36. Curtis A, Ye X, Hachey K, Bourdeaux M, Norris A. A space–time analysis of the WikiLeaks Afghan War Diary: a resource for analyzing the conflict–health nexus. *Int J Health Geogr*. 2015;14:29.
37. Munyaneza F, Hirschhorn LR, Amoroso CL, Nyirazinyoye L, Birru E, Mugunga JC, Murekatete RM, Ntaganira J. Leveraging community health worker system to map a mountainous rural district in low resource setting: a low-cost approach to expand use of geographic information systems for public health. *Int J Health Geogr*. 2014;13:49.
38. Malkhazova SM, Mironova VA, Kotova TV, Shartova NV, Orlov DS. Natural-focal diseases: mapping experience in Russia. *Int J Health Geogr*. 2014;13:21.
39. Tatem AJ, Campbell J, Guerra-Arias M, de Bernis L, Moran A, Matthews Z. Mapping for maternal and newborn health: the distributions of women of childbearing age, pregnancies and births. *Int J Health Geogr*. 2014;13:2.
40. Hanvoravongchai P, Chavez I, Rudge JW, Touch S, Putthasri W, Chau PN, Phommasack B, Singhasivanon P, Coker R. An analysis of health system resources in relation to pandemic response capacity in the Greater Mekong Subregion. *Int J Geogr*. 2012;11:53.
41. Cavalieri M. Geographical variation of unmet medical needs in Italy: a multivariate logistic regression analysis. *Int J Health Geogr*. 2013;12:27.
42. Patel AB, Waters NM, Blanchard IE, Doig CJ, Ghali WA. A validation of ground ambulance pre-hospital times modeled using geographic information systems. *Int J Geogr*. 2012;11:42.
43. Blanford JI, Kumar S, Luo W, Eachren AMM. It's a long, long walk: accessibility to hospitals, maternity and integrated health centers in Niger. *Int J Health Geogr*. 2012;11:24.
44. Richardson EA, Pearce J, Tunstall H, Mitchell R, Shortt NK. Particulate air pollution and health inequalities: a Europe-wide ecological analysis. *Int J Health Geogr*. 2013;12:34.
45. Hurley S, Nelson DO, Garcia E, Gunier R, Hertz A, Reynolds P. A cross-sectional analysis of light at night, neighborhood sociodemographics and urinary 6-sulfatoxymelatonin concentrations: implications for the conduct of health studies. *Int J Health Geogr*. 2013;12:39.
46. Bauer SE, Wagner SE, Burch J, Bayakly R, Vena JE. A case-referent study: light at night and breast cancer risk in Georgia. *Int J Health Geogr*. 2012;12:23.
47. Burgoine T, Harrison F. Comparing the accuracy of two secondary food environment data sources in the UK across socio-economic and urban/rural divides. *Int J Health Geogr*. 2013;12:2.
48. Oyeyemi AL, Sallis JF, Deforche B, Oyeyemi AY, De Bourdeaudhuij I, Van Dyck D. Evaluation of the neighborhood environment walkability scale in Nigeria. *Int J Health Geogr*. 2012;12:16.
49. Pearson AL, Apparicio P, Riva M. Cumulative disadvantage? Exploring relationships between neighbourhood deprivation trends (1991 to 2006) and mortality in New Zealand. *Int J Health Geogr*. 2013;12:38.
50. Calzolari M, Albieri A. Could drought conditions trigger Schmallenberg virus and other arboviruses circulation? *Int J Health Geogr*. 2013;12:7.
51. Zhang X, Cook PA, Lisboa PJ, Jarman IH, Bellis MA. The effects of deprivation and relative deprivation on self-reported morbidity in England: an area-level ecological study. *Int J Health Geogr*. 2013;12:5.
52. Puigpinós-Riera R, Mari-Dell'Olmo M, Gotsens M, Borrell C, Serral G, Ascaso C, Calvo M, Daponte A, Domínguez-Berjón FM, Esnaola S, Gandarillas A, López-Abente G, Martos CM, Martínez-Beneito MA, Montes-Martínez A, Montoya I. Cancer mortality inequalities in urban areas: a Bayesian small area analysis in Spanish cities. *Int J Health Geogr*. 2011;10:27.
53. Yang Q, Mwenda KM, Ge M. Incorporating geographical factors with artificial neural networks to predict reference values of erythrocyte sedimentation rate. *Int J Health Geogr*. 2013;12:11.
54. Plantinga L, Howard VJ, Judd S, Muntner P, Tanner R, Rizk D, Lackland DT, Warnock DG, Howard G, McClellan WM. Association of duration of residence in the southeastern United States with chronic kidney disease may differ by race: the REasons for Geographic and Racial Differences in Stroke (REGARDS) cohort study. *Int J Health Geogr*. 2012;12:17.
55. Guttman A, Li X, Gaudart J, Gérard Y, Demongeot J, Boire J-Y, Ouchchane L. Spatial heterogeneity of type I error for local cluster detection tests. *Int J Health Geogr*. 2014;13:15.
56. Goodman M, Naiman JS, Goodman D, Lakind JS. Cancer clusters in the USA: what do the last twenty years of state and federal investigations tell us? *Crit Rev Toxicol*. 2012;42(6):474–90.