Experiences, benefits and challenges of the use of geoprocessing for the development of primary health care*

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ABSTRACT

Objective.   To review the empirical results of the use of geoprocessing in the management of primary health care (PHC) services, and to disseminate the benefits of this technology and analyze the challenges that must be overcome in order for geoprocressing to contribute to the development of PHC.

Methods.   A systematic review of primary studies published in Spanish, English or Portuguese between 2000 and 2017 was carried out. First, a review of the academic production was conducted, by continent and type of objective. In a second stage, the studies that experimented with and evaluated the use of geoprocessing in empirical form were selected. Specific and generic benefits, as well as limitations, were reviewed.

Results.   134 articles were identified in the first stage of selection, half of them from the Region of the Americas. Only nine studies met the criteria and were reviewed in the second stage. These studies showed that the use of geoprocessing generates benefits that go beyond the technical benefits, with limitations that can be overcome.

Conclusions.   Although the benefits of using geoprocessing have been widely discussed, few studies have empirically evaluated its implementation in PHC. Practical experiences, which could easily be reproduced in different communities, show that its continued use could increase the capacity to respond to the goals of PHC, as well as to the goals of sustainable development.

Keywords   Primary health care; geographic information systems; spatial analysis; sustainable development goals.

Geoprocessing is a discipline that uses mathematical and computational techniques for geographic data processing (1).

The computational tools for geoprocessing, known as geographic information systems (GIS), are powerful software programs that can be used in public health for integrated georeferenced data processing (2). The Pan American Health Organization (PAHO) considers GIS one of the most effective technologies available for information processing and decision-making, since it facilitates the spatial-temporal pinpointing of health events,

the identification and monitoring of the characteristics of these events and their risk factors, recognition of the areas and population groups with the greatest access needs, integration of different variables, and assessment of the impact of health interventions (3, 4).

Since its conception in the Declaration of Alma-Ata, primary health care (PHC) has been considered an essential element in the social and economic development

of all nations (5). Today, health systems research, surveillance, continuous surveillance and evaluation, the sharing of best practices, and technological development are basic components of strategies to renew and strengthen PHC (6). PHC services should be tailored to local needs, with an emphasis on disease prevention and health promotion and a family and community focus. To this end, accurate data for planning and decision-making are needed. This is a prerequisite for meeting current international development goals (7), since addressing health as a social phenomenon today depends on intersectoral action to tackle the social and environmental determinants of health (8). Thus, the 2030 Agenda for Sustainable Development recognizes the need for integrated action among the different sectors to promote physical and mental health and social well-being, grounded in the principles of PHC and intersectoral, multidisciplinary action, given the range of connections among health determinants (9).

Geoprocessing can be a valuable tool in the self-evaluation of PHC activities (10). Its specific contribution lies in its ability to help target actions to smaller areas than traditional approaches do, prioritizing local communities where the potential for public policy intervention is greatest (2, 11). Nevertheless, despite the growing acceptance and use of GIS in public health, knowledge of these techniques in some health centers—and health workers' familiarity with them—remains limited (12). Also, there has not been enough experience with them and insufficient evaluation of their usefulness in managing services in a primary care setting (13). Territorialization is often limited to the concept of physical space and tends to be used in a merely administrative fashion, which is a waste of its potential as a local management tool (14, 15).

Therefore, given the intersectoral nature of PHC, its importance for achieving the Sustainable Development Goals of the United Nations Development Program (UNDP), the need to share best practices, and the virtues of using geoprocessing in public health, the objective of this article is to review the empirical consequences of using this technology in the management of PHC services, as observed by those who have experienced their use and evaluated their benefits and limitations. The purpose is to disseminate information about the advantages of using these tools and describe the challenges that must be met for their implementation and contribution to the development of PHC.

MATERIALS AND METHODS

The methodology employed was a systematic review of geoprocessing use in PHC, based on primary studies.

To identify the articles, digital databases (LILACS, SciE-LO, MEDLINE, and the Integrated Search System [Sibi] of the University of Sao Paulo Library) were searched for articles published between 2000 and 2017.

Articles were sought with titles or abstracts simultaneously containing both a term related to primary health care (*atención primaria, atención básica, servicios básicos de salud*) and a term related to the use of geoprocessing, (*sistema[s] de información[nes] geográfica[s], análisis espacial, geoprocesamiento, georreferenciación*) with their translation in English (primary health, basic health, primary care, general practice[s]) and (geographic information system[s], spatial analysis, geoprocessing, georeferencing) and Portuguese (*atenção primária, atenção básica, Serviços básicos de saúde*) and (*sistema[s] de informação[ões] geográfica[s], georreferenciamento, análise espacial, geoprocessamento*).

The inclusion criteria consisted of original articles relevant to PHC–that is, articles that used information related to the location of health centers, the number of professional staff, care or production records, service areas, or some indicator of the coverage or quality of care, such as hospitalization rates and deaths from conditions treatable in PHC–and included geoprocessing in their methodology. The exclusion criteria consisted of articles with no direct linkage to the work in PHC, duplicates, conference proceedings, letters to the editor, systematic reviews, and reviews in general.

To obtain an overview of academic production in this area, the articles were classified according to three types of objectives: 1) studies for the rational design and planning of PHC services; 2) studies to measure health service access and coverage; and 3) studies to understand health service utilization patterns.

Finally, from the articles that met the inclusion criteria, studies were selected for analysis that experimented with and empirically evaluated the use of geoprocessing in the ongoing management of PHC services; that is, where a geographic information system was continuously used by the services, where the use of the geoprocessing techniques was evaluated by individuals other than the authors of the articles, or where the use of geoprocessing techniques had an effect on the delivery of services. In this stage, the tangible benefits of the use of geoprocessing, the generic benefits reported by the authors, and the stated limitations of the use of this technology were reviewed.

RESULTS

A total of 224 articles were identified, 134 of which met the inclusion criteria in the first stage and nine in the second stage. The identification, inclusion, and exclusion process is illustrated in Figure 1.

Article production

During the study period, the Americas led in the publication of this type of study, with 56% of the published articles (37 in North America, 6 in Central America, and 32 in South America). Europe had 17 articles, Africa 15, Oceania 16, and Asia 11.

From 2000 to 2003, article production was still nascent; however, in 2004 more studies with the objective of measuring health service access and coverage areas began to emerge, along with others that sought to understand service utilization patterns (distribution of diseases or health risk factors, program coverage indicators, population use indicators), the latter predominating since 2010.

Only nine articles that used rational design techniques in planning PHC services were found, some of them by means of optimal location models (16–22) (Figure 2).

Empirical evaluation of the use of geoprocessing in the ongoing management of PHC services

In only nine studies (6.7% of the articles included in the review) were the benefits and limitations of the use of geoprocessing directly experimented with and evaluated when continuously used in the management of PHC services (Table 1). Two of the articles referred to the ongoing use of geographic

information systems in surveillance and decision-making (23, 24); three included an evaluation of the conclusions drawn by staff or the community through the use of geoprocessing (13, 15, 25); three tested and evaluated the experience of implementing geographic information systems in the management of the services (26–28); and two found that the use of geoprocessing had some effect on service delivery (13, 29). These studies were conducted in cities in Brazil (15, 27-28), Canada (25), Chile (26), the United States (13, 29), and Mexico (23); an international public health initiative in Africa was also included (24).

The empirically verified benefits of continuous geoprocessing on the management of PHC services were:

- It permits the entry, updating, and analysis of epidemiological and program data for presentation in map form (24, 26, 29).
- It consistently aids in decision-making for planning health services, analyzing inequities, and adjusting the allocation of resources (13, 23, 25, 26, 28).
- Its use is aimed at the rationalization of health care and its potential accreditation (15).
- It provides a real-time interactive dashboard for monitoring activities (23).
- It makes it possible to evaluate the comprehensiveness of local surveillance programs (24, 28).
- It permits a better understanding of problems at the group level, which facilitates the adoption of better interventions (23).
- It offers another view of the population's health situation, since it reveals details that were once of little relevance with greater clarity and speed (13, 15).
- Professionals optimize their work time, since the information provided is useful processed data with a natural logic that is highly valuable (15, 26).
- It permits geographical consultations (27).
- It makes it possible to link health problems to the environment, thus complementing the partial vision of

FIGURE 1. Diagram of the article identification, inclusion, and exclusion process
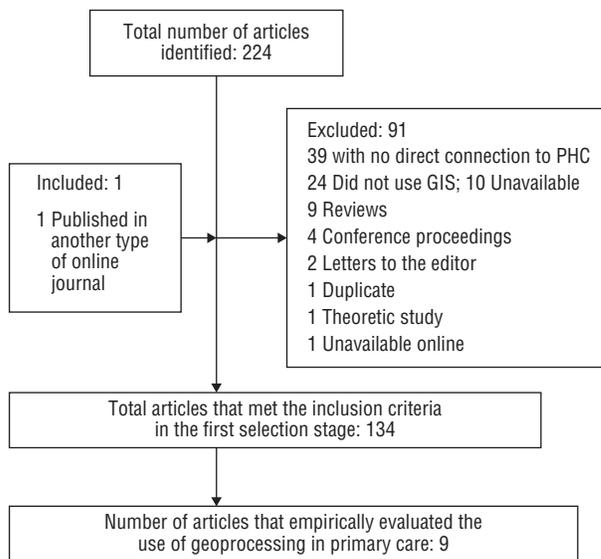
PHC, primary health care; GIS, geographic information systems.

FIGURE 2. Evolution over time of the types of studies on the use of geoprocessing in primary health care.
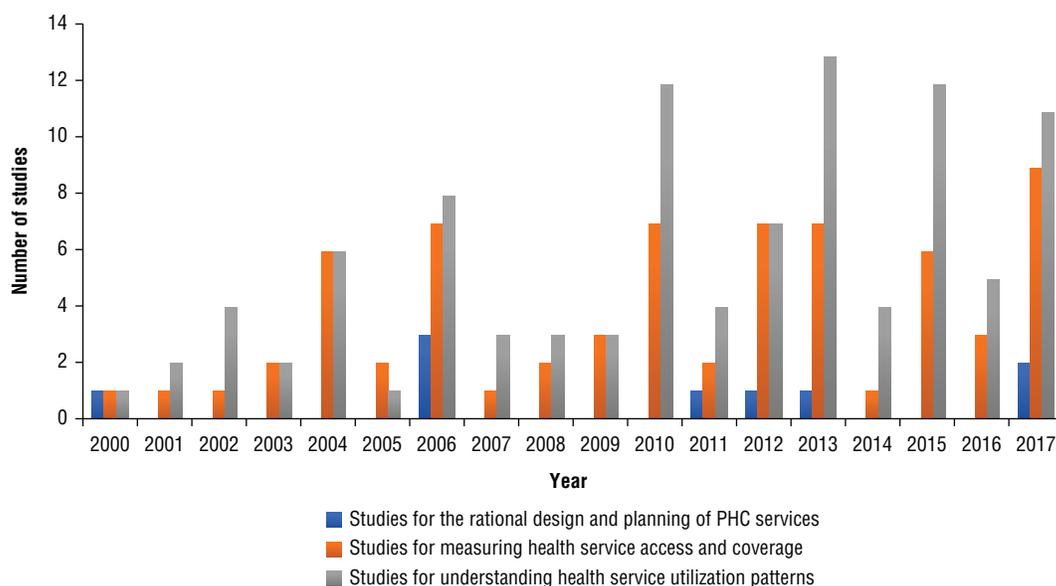
PHC, primary health care.
Source: Authors.

TABLE 1. Characteristics of the studies that empirically evaluated the benefits and limitations of the continuous use of geoprocessing in the management of primary health services.

Author and year (Reference)	Region/Country	Subject	Objective	Geoprocessing techniques and software used	Results	Tangible benefits of the use of geoprocessing	Generic benefits of geoprocessing reported	Limitations of geoprocessing
SILBERMAN et al., 2013 (23)	Álvaro Obregón/ D.F./Mexico.	Monitoring of the social determinants of health.	Learn about the socioeconomic conditions of households and the health status of their members.	Georeferencing of residences. Distribution of indicators. (Not included in GIS software).	Households in the district were classified by health risks. A program to reorganize the services was launched that made it possible to discretely but effectively reduce the risk of the households studied and their members.	The interventions implemented with the help of geoprocessing led to a 22% reduction in the number of households classified as "very high risk." The reorganization program has been widely accepted among staff, which, with a few exceptions, have implemented it very enthusiastically.	Geoprocessing makes it possible to locate the people with greater vulnerability in order to redirect resources toward them. It permits greater understanding of problems at the group level, which facilitates the adoption of better interventions. It provides an interactive dashboard for monitoring activities in real time.	The program requires new competencies among professional and non-professional health personnel, as well as an understanding of concepts and tools on among senior management.
RITTER; ROSA; FLORES, 2013 (15)	Porto Alegre/ HMN/Brazil.	Identification of the health situation.	Determine whether the introduction of georeferenced indicators improves the identification of people's health situation.	Distribution of indicators. (Not included in GIS software).	The results showed a significant difference in the classification of the health situation when georeferencing was used (p <0.05).	The use of geoprocessing led to a different interpretation of the results in nine out of the 24 indicators studied (37.5%).	Geoprocessing provides a different view of the population's health situation, since reveals heretofore unimportant details with greater clarity and speed. Professionals optimize their work time, since the information produced is in the form of useful processed data with a natural logic that is highly valuable. Its use is aimed at the rationalization of health care activities and the potential accreditation of health care.	Continuing education for professionals is needed to operationalize this technology and for professionals to interpret the data collected. Municipalities must create or expand the team that will manage the computer resources.
SCHARAGER; CONTRERAS 2002 (26)	La Florida/RM/ Chile	Epidemiological surveillance in mental health.	Design and test a surveillance system for detecting and ranking the most important mental health problems.	Demarcation of geographical areas Georeferencing of cases and health centers. Distribution of indicators. (Not included in GIS software).	The use of GIS made it possible to display different aspects of the health problems investigated on a single geographical map. Participating physicians received periodic reports that included hard copies of tables and maps. In developing the strategy, consideration was given to the experiences and contributions of health professionals, within the limits of human and financial resources and the time frame and in keeping with mental health policy guidelines.	All the interviewees reported advantages and no disadvantage to using the surveillance system with geoprocessing and even noted that it was important to include other diseases so that they could be monitored.	Geoprocessing offers speedy, periodic graphic information on the distribution of diseases by geographical area. It helps determine which sectors are at high-risk in an easy-to-read self-evident format. It makes it possible to relate health problems with the environment and thus complements the merely partial view of monitoring systems that do not include context variables. It aids in planning health services, analyzing inequities, and adjusting resource allocation, since it includes a permanent system to support decision-making with timely feedback in a readable and understandable format.	(There were no evaluations)

(Continued)

TABLE 1. Continued

Author and year (Reference)	Region/Country	Subject	Objective	Geoprocessing techniques and software used	Results	Tangible benefits of the use of geoprocessing	Generic benefits of geoprocessing reported	Limitations of geoprocessing
SÁ et al., 2012 (27)	São Paulo/SP/ Brazil.	Surveillance of monitored households	Propose a new mechanism for household data collection for use by PHC teams.	Georreferencing of residences. Distribution of indicators. GeoHealth –web software (Google Maps interface).	The form used made it possible to collect more accurate data, thanks to the use of standardized structured fields. As a result, the households and their information could be georeferenced.	Low total cost of ownership (TCO), estimated at US$0.01 per capita per month.	The data for localization and completing the forms can be collected with mobile devices and securely transferred to a web server. The financial investment is low compared to the benefits of a database with quality georeferenced records. Georeferencing of households facilitates more detailed geographical consultations on their health status, improving the design of initiatives for specific regions. The need to employ standardized data instead of open questions may lead to changes in existing forms, such as the inclusion of relevant data that is currently lacking.	(No limitations were mentioned).
CAIRNCROSS; MULLER; ZAGARIA, 2002 (24)	Africa.	Eradication of dracunculiasis (Guinea worm disease).	Develop a program tailored to dracunculiasis eradication needs that can easily be used by technical personnel in endemic countries.	Georreferencing of population groups, health centers, and urban infrastructure. Distribution of indicators. HealthMapper software.	HealthMapper software contains country borders, regions, districts, and subdistricts, with rivers, roads, villages, and waterways, in addition to social and health infrastructure. It includes an easy-to-use interface for the mapping and management of reported cases.	At the time of the report, 151 countries and territories had been certified by WHO as free of dracunculiasis transmission. This serves as an incentive and permits the surveillance of health events beyond those initially considered. Of the 11 countries that used the software, 5 recorded birth data, 7 recorded some categories of death, and 5 recorded measles cases. Since this is an international initiative, database maintenance and software costs are financed by international agencies.	Geoprocessing permits the entry, updating, and analysis of epidemiological data and programs, presenting the results in map form. It can easily be used by national and subnational technical personnel, thanks to an easy-to-use interface and ongoing training. It reveals ambiguities and aids consistent decision-making. It facilitates collaboration in the analysis of ill-defined situations. It makes it possible to evaluate the comprehensiveness of local surveillance programs.	Several types of surveillance activities are needed to obtain greater geographic coverage. Surveillance should be maintained and not limited to known endemic areas.

(Continued)

TABLE 1. Continued

Author and year (Reference)	Region/Country	Subject	Objective	Geoprocessing techniques and software used	Results	Tangible benefits of the use of geoprocessing	Generic benefits of geoprocessing reported	Limitations of geoprocessing
HARDT et al., 2013 (29)	Alachua/USA	Reduction of social vulnerability.	Illustrate health disparities to foster a community response and guide the reallocation of resources.	Georreferencing of urban infrastructure. Distribution of indicators. Kernel mapping. ArcGIS software.	Maps of hot spots were created to pinpoint the location of neighborhood disparities in important social and health indicators. The maps were widely shared with the community.	A family center was built in the neighborhood with the greatest needs, and a mobile clinic was provided. The maps moved community members themselves to call for the reallocation of resources to the neediest neighborhoods. In the two years after sharing the results with the community, new partnerships were established with public and private organizations and institutions for joint health care efforts in the neighborhoods with greater needs. The residents of the neediest neighborhoods have been satisfied with the interventions carried out.	Maps can illustrate changes in demographic, socioeconomic, and health indicators over time to identify, for example the neighborhoods with the greatest needs and examine the results of the action taken. Maps of hot spots enable multiple audiences to quickly interpret prevalence rates and trends, with virtually no explanation required, in a way that tables do not. Maps can help the community maintain government officials' attention and commitment to reallocating resources to specific neighborhoods.	(No limitations were mentioned).
ARGENTO et al., 2013 (28)	North and Northeast Regions/Brazil.	Territorialization.	Demonstrate the contribution of the participatory mapping process to the territorialization of basic health care activities.	Demarcation of geographical areas. Georreferencing of health centers. Distribution of indicators. Participatory mapping. (Not included in GIS software).	Examination of geoprocessing use showed limited utilization of this technology by primary health care teams. Workshops were held to prepare maps of the areas of operation, and different databases were used to calculate coverage indicators and evaluate the quality of the information.	The sources of information used to generate the maps were the staff members themselves, who designed the routes taken by the community agents and the areas covered by the health teams. Geoprocessing made it possible to verify problems of overlapping (residences covered by two health teams), as well as gaps (residences located in areas not covered by a team). It permitted comparisons between different databases of the estimates of the covered population, by sector, yielding differences that could be the result of errors in the assignment of the population. It showed that the health teams' areas of action were generally concentrated in low-income locations.	The design of the territorial mapping process can aid in the planning, structuring, and distribution of health teams. Maps make it possible to evaluate the operations of different health teams in a single territory. The use of geoprocessing tools and participatory mapping enables secondary data to be integrated into the information produced in the field and can serve as the basis for intra- and intersectoral action without detriment to the expression of the subjectivity of each team. Geoprocessing makes it possible to monitor changes made with respect to the creation or alteration of the areas of action.	Participatory approaches are still considered of little scientific relevance. Thus, the maps produced by self-taught individuals at the local level are not considered relevant for decision-makers at the municipal and state levels. Members of the health team must be trained in evaluation and the collection of objective and subjective data.

TABLE 1. Continued

Author and year (Reference)	Region/Country	Subject	Objective	Geoprocessing techniques and software used	Results	Tangible benefits of the use of geoprocessing	Generic benefits of geoprocessing reported	Limitations of geoprocessing
BAZEMORE, PHILLIPS, MIYOSHI, 2010 (13)	Baltimore/ Maryland/USA	Design of community-oriented information systems.	Conduct an in-depth study of the views and responses to the mapping of clinical and population data in a real community health setting, exploring the opportunities for and barriers to implementing these techniques with senior health center managers.	Georreferencing of patients and health centers. Distribution of indicators. Buffer. ArcView software.	Data on practice management were extracted, geocoded, and mapped to reveal variations between areas currently with clinical services and medically neglected areas. Mapping was also done to analyze the population's health center utilization patterns.	The service area maps revealed a range and overlapping of previously undetected areas. Health centers in the most neglected areas received financing, which center managers found surprising. Qualitative evaluations revealed enthusiastic participation in the process, which had led to better community understanding, new ideas concerning the use of data, and a variety of applications for clinical improvements. The interaction between technical personnel, administrators, clinicians, and members of the community permitted the capture of their knowledge and experience with respect to the neighborhood geographical data, the community history, or other areas, increasing the real power of the mapped data.	Geoprocessing boosts the potential to guide the strategic planning of PHC services and resource allocation. It permits the integration of local knowledge in map form to improve the interpretation and increase real power of the data in a way that tables, figures, and other forms of processed data cannot. It improves community understanding. It generates new ideas for data use.	Barriers to the use of geoprocessing include costs in terms of time, money and technical expertise, which could limit their use. A participatory interpretation is required for greatest understanding of the maps. Expanded use of GIS will require users to consider problems such as the quality of the data, the rate of geographical coincidence, the appropriate scale and area units, causality and correlation, and probably, additional training in spatial methodologies.
LOFTERS, GOZDYRA, LOBB, 2013 (25)	Peel/Ontario/ Canada.	Cancer detection.	Identify the most appropriate small geographical areas for cancer screening interventions in the community.	Georreferencing of patients and health centers. Distribution of indicators. Identification of clusters (LISA). GeoDa software.	Maps of the following were created: i) Rates of appropriate detection of breast, cervical, and colorectal cancer. Percentage of residents of South Asian origin. Location of primary care practices and community health centers. The maps were shared with the health services and community service organizations to examine the validity of the results.	Geoprocessing made it possible to detect marked variations in cancer detection rates, with the lowest rates of detection systematically associated with areas with larger South Asian populations. The LISA analysis identified a high-risk area consisting of multiple neighboring census sectors with relatively low detection rates for the three types of cancer and a relatively large population from South Asia, even with a community health center very nearby. The partner organizations recognized and validated the geographical location revealed by the LISA analysis.	GIS, in particular the LISA analysis, which shows statistically significant clusters and not only by chance, can be invaluable when working with health services and community organizations to identify the areas with the greatest need for interventions to reduce health inequities. Visual representation of the results through the use of maps is easily understandable, even when advanced spatial analysis methodologies are used.	Outdated databases affect the interpretation of the results. The use of data at the area level instead of the individual level can alter the distribution of the results (ecological fallacy). The use of very small areas can lead to instability in calculating rates.

monitoring systems that do not include context variables (26).

- The localization data and data for completing the forms can be collected with mobile devices and securely transferred to a web server (27).
- The financial investment is low compared with the benefits of having a database with quality georeferenced records (27).
- The need to use standardized data, instead of open questions, can lead to changes in existing data collection forms, such as the inclusion of relevant data not currently collected (27).
- It permits intra- and intersectoral work, which includes the views and experiences of different actors for the analysis of ill-defined situations (13, 24).
- It enables multiple audiences to quickly interpret prevalence rates and trends, virtually without explanation and in a way that tables cannot (13, 25, 29).
- Maps can help the community maintain the attention and commitment of government officials to reallocating resources to specific neighborhoods (25, 29).
- It enables secondary data to be integrated into information produced in the field (13, 28).
- It makes it possible to monitor changes with respect to the creation or alteration of areas of action (28).
- It sparks enthusiasm and motivation among professionals to include new monitoring events (13, 23, 26).

The limitations were:

- The need to train health service personnel to handle the concepts and tools and collect objective and subjective data (13, 15, 23, 28).
- Surveillance systems require different types of activities to achieve greater geographical coverage (24).
- Surveillance should be ongoing and not limited to known endemic areas (24).
- Participatory approaches are still considered of little scientific relevance. Thus, the maps produced by self-taught individuals at the local level are not considered relevant for decision-makers at the municipal and state levels (28).
- Barriers involving time, financing, and technical experience (13, 15).

- A participatory interpretation is required to ensure the greatest understanding of the maps (13).
- Outdated databases affect the interpretation of the results (25).
- Use of data at the area level rather than the individual level can alter the distribution of results (ecological fallacy) (25).
- The use of very small areas can lead to instability in calculating rates (25).

DISCUSSION

The results of this review demonstrate that in recent years and especially in the Americas, there has been increased use of studies that employ geoprocessing techniques for research on PHC; however, as Bazemore A, RL Phillips, and Miyoshi T (13) suggest, articles that show the results of implementing such initiatives are rare.

The benefits of using geoprocessing in PHC found in this review coincide with those noted by PAHO in the sphere of public health: it is one of the most effective technologies available for facilitating information and decision-making processes (3, 4).

Specifically in the PHC setting, this technology had already been considered useful for estimating travel times to health centers, spatially understanding and quantifying the accessibility and performance of services and programs, identifying inequities, modeling service areas, and optimally locating new health centers, thus facilitating more efficient and targeted resource allocation (20, 30). It had also been mentioned that information on the built environment could be applied to specific health promotion and disease prevention needs to increase the overall effectiveness of health interventions (30), and that the use of geoprocessing contributes to smart management of health services, thanks to a growing range of data sources, analytical techniques, and software routinely available for research and development in PHC (31).

Until now, no study had noted that in various experiences, the use of geoprocessing in PHC also helps to motivate health workers and even the community, because it facilitates intrasectoral and intersectoral work by incorporating the knowledge and experiences of different agents. Moreover, it enables multiple audiences to quickly interpret the results

and discover details that were once of little relevance, with virtually no explanation and in a way that tables cannot– all this, with the use of rather simple spatial analysis techniques.

The studies that used geoprocessing in PHC were largely aimed at measuring access and understanding the distribution of diseases, risk factors, use, and program coverage. The importance of these techniques for meeting the Sustainable Development Goals is clear, since increasing access to PHC services is one of the prerequisites for achieving these goals, which include reducing infant mortality, improving maternal health, combatting chronic and communicable diseases, and achieving universal health coverage (9). Geoprocessing's contribution to achieving the SDGs also lies in its intersectoral and integrative nature, which is a prerequisite for achieving the goals (9).

The challenges that must be met are related to the problems encountered. It was clear that training was needed for proficient handling of concepts and tools, as was financial investment for the procurement of software and equipment and the hiring of skilled technical personnel. In this regard, Bazemore, Phillips, and Miyoshi (13) suggest that one way of overcoming these limitations is to prepare cost-effectiveness studies, take advantage of economies of scale via web platforms, and use interactive software for consultations of interest to professionals. In fact, in this review, only one of the studies had estimated the cost of introducing this technology, which was considered relatively low in comparison with the benefits obtained (27).

Software costs are becoming less and less of a problem, as inexpensive and even free high-quality software programs are now available, especially for public institutions. Examples of these programs are Brazil's SPRING® and TerraView® software (2) and software with a public health focus, such as EpiInfo/ EpiMap®, HealthMapper®, SIGEpi®, and Geoda® (32). Indeed, one of the studies found in this review used one of these programs (25). Other free programs that can contribute to the use of geoprocessing in PHC are QGIS®, GvSIG®, OpenJUMP®, SI-GEpi®, and tabwin-GEO®, for which universities and public and private agencies offer constant training, in addition to online tutorials and videos.

Careful consideration of resource constraints and strategic objectives is essential for successful introduction of this technology in an organization (31). One recommendation is not to ignore the inclusion of participatory approaches, which improve the understanding of maps and the contribution they can make (13).

Geoprocessing is a powerful tool capable of transforming the way information is managed (33). Thus, another recommendation is to conduct spatial analyses, even when the quality of the databases is questionable, since the results will help reveal where the errors lie and can aid in the preparation of better data collection forms (27).

Finally, for successful monitoring of a health program, evaluations should take place during day-to-day activities (34); thus, continuous use of GIS is recommended to guarantee equitable access to quality care (30). Closer partnerships between universities and health institutions are also recommended to increase the production of case studies, with evaluations of community interventions.

The main limitation of this study was its search method, which necessarily included terms related to primary health care; however, it is likely that articles in which PHC was part of a broader concept, such as "public health care," were left out. Although aware of this limitation, the authors did not alter the search method, since part of the motivation for this article was to increase knowledge for sharing specific best practices in this sector. In fact, the high number of articles found at the beginning of the selection process confirms the importance of its results about the state of the art and the benefits obtained in PHC. A second limitation is that only scientific articles were considered; although we are aware of other community-level experiences with the use of geoprocessing in PHC, no articles have not been published to date (for example, studies on use of geoprocessing in the municipality of Sao Paulo) (35). In this regard, we wished to show that these methodologies not only have a technical component, but a scientific one as well; nevertheless, we hope that this will serve as an incentive for agencies that have not published their experiences to share their results.

CONCLUSIONS

Now, more than ever, good tools are needed to guide the development of primary care. However, while the benefits of geoprocessing have been widely discussed in this setting, few studies have empirically evaluated the advantages and disadvantages of its use as a tool for continuous management of the development of health services. Practical experiences, which could be replicated in other communities, show that its use yields benefits beyond the technical sphere. The challenge, therefore, is to overcome the problems encountered and introduce its continuous use, which could increase the capacity to meet PHC targets and, indeed, the Sustainable Development Goals themselves.

Conflicts of interest. None declared.

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RESUMO

Experiências, benefícios e desafios do uso de geoprocessamento para o desenvolvimento da atenção primária à saúde

Objetivo. Revisar as consequências empíricas do uso de geoprocessamento na gestão dos serviços de atenção primária à saúde (APS), com o propósito de difundir os benefícios do uso desta tecnologia, bem como precisar os desafios que devem ser superados para sua contribuição no desenvolvimento da APS.

Métodos. Foi realizada uma revisão sistemática de estudos primários publicados em espanhol, inglês ou português, entre os anos 2000 e 2017. Em primeiro lugar, uma revisão geral da produção acadêmica é efetuada por continente é tipo de objetivo. Em uma segunda etapa, são selecionados os estudos que experimentaram e avaliaram o uso de geoprocessamento em forma empírica, onde são revisados benefícios concretos é genéricos, bem como as limitações.

Resultados. Foram identificados 134 artigos na primeira etapa de seleção, a metade deles proveniente do continente americano. Nove estudos cumpriram os requisitos da segunda etapa; no entanto, demonstraram que o uso de geoprocessing, gera benefícios que vão além dos benefícios técnicos, com limitações factíveis de serem superadas.

Conclusões. Embora os benefícios do uso de geoprocessamento tenham sido amplamente discutidos, são escassos os estudos que avaliaram sua implementação em APS em forma empírica. Experiências práticas, que poderiam ser facilmente reproduzidas em outras comunidades, demonstram que seu uso contínuo poderia aumentar a capacidade de resposta às metas de APS, bem como às próprias metas do desenvolvimento sustentável.

Palavras-chave

Atenção primária à saúde; sistemas de informação geográfica; análise espacial; objetivos de desenvolvimento sustentável.

RESUMEN

Experiencias, beneficios y desafíos del uso de geoprocesamiento para el desarrollo de la atención primaria de salud

Objetivo. Revisar las consecuencias empíricas del uso de geoprocessing, en la gestión de los servicios de atención primaria de salud (APS), con el propósito de difundir los beneficios del uso de esta tecnología, así como precisar los desafíos que deben ser superados para su contribución en el desarrollo de la APS.

Métodos. Se realizó una revisión sistemática de estudios primarios publicados en español, inglés o portugués, entre los años 2000 y 2017. En primer lugar, se efectúa una revisión general de la producción académica por continente y tipo de objetivo. En una segunda etapa, se seleccionan los estudios que experimentaron y evaluaron el uso de geoprocessing, en forma empírica, donde se revisan beneficios concretos y genéricos, así como las limitaciones.

Resultados. Se identificaron 134 artículos en la primera etapa de selección, la mitad de ellos provenientes del continente americano. Tan solo nueve estudios cumplieron con los requisitos de la segunda etapa; sin embargo, demostraron que el uso de geoprocessing, genera beneficios que van más allá de los beneficios técnicos, con limitaciones factibles de ser superadas.

Conclusiones. Aun cuando los beneficios del uso de geoprocessing, han sido ampliamente discutidos, son escasos los estudios que han evaluado su implementación en APS en forma empírica. Experiencias prácticas, que podrían ser fácilmente reproducidas en otras comunidades, demuestran que su uso continuo podría aumentar la capacidad de respuesta a las metas de APS, así como a las propias metas del desarrollo sostenible.

Palabras clave

Atención primaria de salud; sistemas de información geográfica; análisis espacial; objetivos de desarrollo sostenible.