Prediction of house calls in primary care: a time series approach using the AutoRegressive Integrated Moving Average model

Predição de visitas domiciliares na atenção primária: uma abordagem de séries temporais com o modelo Autoregressive Integrated Moving Average

Predicción de visitas domiciliarias en atención primaria: un enfoque de series temporales utilizando el modelo AutoRegressive Integrated Moving Average

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Abstract

Introduction: A new profile of demand for Brazil's public healthcare – Sistema Único de Saúde (SUS), is expected in the coming years, due to population-aging and increased prevalence of chronic diseases. Thus, it is necessary to use tools for planning the responsiveness of health services. Models for time series analysis such as the AutoRegressive Integrated Moving Average (ARIMA), can be useful. **Objective:** The aim of the study is to estimate the demand for home visits in Primary Health Care (PHC) of SUS, in Florianópolis (SC). **Methods:** Ecological study of time series using ARIMA for projections. Home visits carried out by the PHC, recorded in the electronic medical record of the Municipal Health Department, from January 2015 to February 2019 were used. **Results:** The forecast points to a maximum of 702 visits in August 2019, followed by a drop to 573 visits in December 2019, and subsequent recovery, with an estimate of 632 for October 2020. The forecast for each Health Center indicated variations in demand between units with the same number of Family Health Teams, between 11.3 to 1.3 visits/FHT, in the 20th month. **Conclusions:** ARIMA made it possible to carry out projections of home visits in the municipality, indicating a drop in the demand for home visits. The method can be of great value for the projection of other demands in the same municipality or in other municipalities that have historical series data. Future studies can expand the analysis in this regard, as well as compare ARIMA with models such as exponential smoothing.

Keywords: Needs assessment; Primary health care; House calls; Forecasting.

Resumo

Introdução: Espera-se, nos próximos anos, um novo perfil de demanda para o Sistema Único de Saúde em consequência do envelhecimento populacional e do aumento da prevalência de doenças crônicas. Diante disso, faz-se necessário o uso de ferramentas para estimar a demanda futura por serviços. Modelos para a análise de séries temporais como o *Autoregressive Integrated Moving Average* (ARIMA) podem auxiliar. **Objetivo:** Estimar a demanda por visitas domiciliares na Atenção Primária à Saúde (APS) do Sistema Único de Saúde, em Florianópolis (SC). **Métodos:** Estudo ecológico de séries temporais que utilizou o ARIMA para projeções. Adotaram-se as visitas domiciliares realizadas pela APS, registradas do prontuário eletrônico da Secretaria de Saúde do município, de janeiro de 2015 a fevereiro de 2019. As projeções dos 20 meses seguintes foram realizadas para o município e para cada um de seus 49 Centros de Saúde. **Resultados:** A previsão aponta, em agosto de 2019, a máxima de 702 visitas, seguida de queda para 573 visitas em dezembro de 2019 e posterior recuperação, com estimativa de 632 para outubro de 2020. A previsão para cada Centro de Saúde indicou variações na demanda entre unidades com o mesmo número de equipes de Saúde da Família (ESF), entre 11,3 e 1,3 visitas/ESF, no 20o mês. **Conclusões:** O ARIMA possibilitou a realização das projeções de visitas domiciliares no município, indicando queda na demanda de visitas domiciliares. O método pode ser de grande valia para a projeção de outras demandas no mesmo município ou em outros que possuam dados de série histórica. Estudos futuros podem expandir a análise nesse sentido, bem como comparar o ARIMA com modelos como a suavização exponencial.

Palavras-chave: Determinação de necessidades de cuidados de saúde; Atenção primária à saúde; Visita domiciliar; Projeções e predições.

Resumen

Introducción: En los próximos años se espera un nuevo perfil de demanda para el Sistema Único de Salud (SUS) – sistema de salud pública brasileño, debido al envejecimiento de la población y al aumento de la prevalencia de enfermedades crónicas. Por lo tanto, es necesario utilizar herramientas para estimar la demanda futura de servicios. Modelos para el análisis de series de tiempo, como el AutoRegressive Integrated Moving Average (ARIMA), pueden ayudar. **Objetivo:** Estimar la demanda de visitas domiciliarias en la Atención Primaria de Salud (APS), del Sistema Único de Salud, en Florianópolis, Santa Catarina. **Métodos:** Estudio ecológico de series temporales utilizando ARIMA para proyecciones. Se utilizaron los registros de visitas domiciliarias realizadas por la APS, a partir de la historia clínica electrónica de la Secretaría Municipal de Salud, de enero de 2015 a febrero de 2019. **Resultados:** El pronóstico apunta a un máximo de 702 visitas en agosto de 2019, seguido de una caída a 573 visitas en diciembre de 2019, y posterior recuperación, con una estimación de 632 para octubre de 2020. La previsión para cada Centro de Salud indicó variaciones en la demanda entre unidades con igual número de Equipos de Salud de la Familia, entre 11,3 a 1,3 visitas/ESF, en el mes 20º mes. **Conclusiones:** El ARIMA permitió realizar proyecciones de visitas domiciliarias en el municipio, indicando una caída en la demanda de visitas domiciliarias. El método puede ser de gran valor para la proyección de otras demandas en el mismo municipio o en otros municipios que cuenten con datos de series históricas. Futuros estudios pueden ampliar el análisis en este sentido, así como comparar ARIMA con modelos como el suavizado exponencial.

Palabras clave: Evaluación de necesidades; Atención primaria de salud; Visita domiciliaria; Predicción.

INTRODUCTION

The Brazilian population over 65 years of age is increasing. This growth has been accompanied by changes in morbidity, disability and death patterns, shaping a new demand profile. This requires rearrangements in the forms of organization and delivery of health services.[1] In this context, planning presents itself as an essential tool in the organization of the service to meet the demand in Primary Health Care (PHC).

It is estimated that 75 to 80% of the Brazilian population over 60 years of age has at least one noncommunicable chronic disease (NCD). It is estimated that 27 million people will have NCDs in 2025. Considering functional disability, the same projection would result in 6.7 million aged people in need of medical care.[2] In addition, sociodemographic changes, such as urbanization and structural family changes, increase the need for care beyond what the family can provide, leading to greater accountability of the health system.[3] The longitudinal monitoring of the population, inserted in health planning, is strategic in the care and management of Unified Health System (*Sistema Único de Saúde* – SUS).[4,5] The preparation of professional staff aiming at longitudinality and comprehensiveness of care should consider this fraction of the population. This involves adapting demands that depend on human resources, physical structure, and inputs in terms of quality and quantity.[2]

Home care can be seen as a sustainable approach to avoid unnecessary hospitalizations and keep individuals in their home and community for as long as possible.[6] It also builds a logic of care focused on health surveillance and the humanization of care and guarantees access to people in situations of fragility and immobilization. Evidence shows that home centered PHC approaches have been shown to be effective in reducing hospitalization rates and length of stay,[6] reducing costs[7] and improving symptom burden and quality of life.[8]

In the past, households were the main site of care, and home care was an important part of medicine and health in the community. Until 1930, about 40% of physicians provided home care. This number dropped to 1% in the 1980s.[9] Currently, Home Care is an inseparable part of the PHC work process.[10]

Traditional approaches for analyzing the demand for home care, such as those by Savassi et al.[11] and Coelho and Savassi,[12] propose the assessment of personal and family risk, based on a multifactorial analysis of the patient. Using these methods, it is possible to draw up a schedule, stipulating the frequency of visits according to the complexity of each patient and family risk. However, they are difficult to apply on a mass scale as they require evaluation of all patients through scales and questionnaires.

The construction and implementation of statistical models and the analysis of their results allow the generation of useful data for planning, diagnosing, and evaluating the size, distribution, composition, and organization of a population[13] of special interest to health. Health projections predict disease situations and episodes, helping to plan health systems.[14] Some approaches to developing projections are based on time series,[15] such as the Autoregressive Integrated Moving Average (ARIMA). In time series predictions, the observations available at time "t" are used to make the prediction of some future moment "t+1".[16]

Given the need to plan the structuring of the health system, knowledge of the demand for home care in the health care network is essential. Thus, this study sought to estimate the number of home visits within the scope of PHC, in Florianópolis, Santa Catarina.

METHODS

This is an ecological time series study. The data used were the number of home visits and consultations performed by doctors and nurses within the PHC in each of the 49 Health Centers (HC) in Florianópolis, per day. These data are input into the information system by recording the home visit/consultation in the electronic health record system. Such information was aggregated and made available anonymously by the Municipal Health Department. The research brings data extracted from the period from January 2015 to February 2019.

In the months of May 2015, March 2016, January and February 2017, and April to May 2018, there was a strike by the servers of Florianópolis, according to local press records.[17-20] The input of data from those months was carried out, substituting the observations for the simple average between the months before and after the shutdowns. This was done for the municipality and for each HC.

The ARIMA model was used for the estimation. With it, the model structure is adjusted to the data itself, following an interactive cycle in which a model is considered for analysis, identified based on the analysis of correlations and autocorrelations, among other criteria. Then, the parameters are estimated, and the adequacy is verified based on the residual analysis.[21] Once the model is identified and adequate, the future values are predicted according to the past and present values of the time series. The prediction intervals assume that the residuals are uncorrelated and that they have Gaussian distribution. The

prediction was made for the 20 months following February 2019, that is, from March 2019 to October 2020. The projections were finally evaluated in light of the number of teams in each HC.

The entire analysis was performed using the R® software, version 3.6.3 (GUI 1.70 El Capitan build [7735]) in the RStudio integrated development environment, version 1.3.1073. The script used for data processing and preparation and calculations are available at: https://github.com/luizabolsoni/visitadomiciliarforecast.git

The present study was not submitted to the Research Ethics Committee, as it is a research on databases whose information is clustered, without the possibility of individual identification.

RESULTS

In 2015, 6,683 home visits were carried out; on average, 608 visits per month. In 2016, 7,522 home visits were carried out, with an average of 627 visits per month. In 2017, there were 6,749 home visits and an average of 614 monthly visits. In 2018, there were 5,291, with a monthly average of 482. Finally, in 2019, only two observations were recorded, totaling 964 visits (Table 1).

The results of the projection of home visits in PHC in Florianópolis, from March 2019 to October 2020, are presented in Figure 1. Data were used with the imputation of strike periods, so some months have divergent data from the ones presented in Table 1. There is a downward trend in supply in the observed period (January 2015 to February 2019). The highest number of visits in each year of the period observed was recorded in the months of May or June. In the projection period, 535 visits were estimated

Table 1. Data from the historical series of home visits carried out per month, between 2015 and 2019, in the Primary Health Care of the Municipal Network of Florianópolis (SC), Brazil.

	2015	2016	2017	2018	2019
January	543	714	282*	527	484
February	456	581	41*	485	480
March	603	406*	602	553	
April	573	648	689	340*	
May	488*	1,019	877	478*	
June	941	831	563	688	
July	868	854	742	502	
August	777	631	811	608	
September	756	800	658	520	
October	603	519	553	540	
November	639	532	719	405	
December	467	393	535	463	
Monthly mean	608.64	627.83	614.64	482.09	482.00
Annual total	6,683.00	7,522.00	6,749.00	5,291.00	964.00
Total attendances[†]	416,225	456,827	440,270	496,707	102,650
Percentage of HV/attendances	1.61%	1.65%	1.53%	1.07%	0.94%

HV: home visits. * servers' strike periods. For the purposes of the projection, the data in months of strike of the Health Centers were replaced by the simple average between the month before and after the strike, and the grouping of data from the 49 centers provided the total value for the municipality of Florianópolis; [†] all care provided by doctors and nurses at the Florianópolis PHC Health Centers.

for March 2019, a peak in August 2019 with 702 estimated visits, and later, 632 visits in October 2020, the last month of the estimate.

The results for each month of the projection and the respective prediction intervals have their values for each month presented in detail in Table 2. The first prediction month (point 51) corresponds to March 2019, with a projection of 535 home visits, and the last month of the prediction (point 70) to October 2020, with 632 home visits. The 95% confidence interval, represented in Figure 1 as an area in light gray, has its values shown in the last column of Table 2.

Projection of home visits in Primary Health Care of the Municipal Network of Florianópolis (SC), Brazil, by projection month and accuracy intervals of 80 and 95%.

Next, Table 3 presents the results of the projection of visits, by HC, for the last month of the projection. Different numbers of observations were found in the records available in the database of each HC.

Among the HCs with six Family Health Teams (FHT), between 17 and 29 home visits are estimated for the last month of the projection. With five FHTs, the variation was from 8.6 to 37 home visits. Large variations were also found in HC with four teams, between nine and 30 visits; and, with three teams, between 5.6 and 24.7 home visits. The forecast for HC with two teams ranged between 2.7 and 27 visits. The highest prediction was for *Armação* HC, which corresponded to the highest number of visits provided by the FHT (11.5 home visits), and the lowest prediction found was for the *Ponta das Canas* HC, with about 1.3 visits per FHT in a month. In the HC with an FHT, between 9.5 and 1.5 visits were estimated for the last month of prediction. The data from *Alto Ribeirão* HC present only 24 months of historical series, not providing a good estimate for the following 20 months and, for this reason, we disregarded the estimate of 14.5 visits.
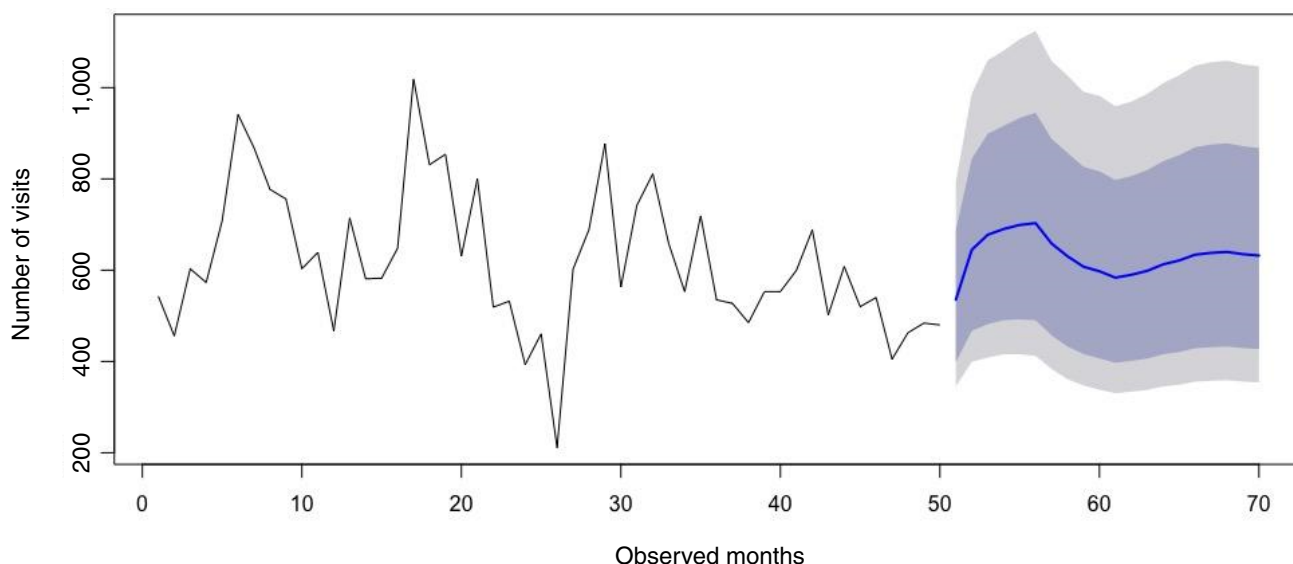
Caption: The horizontal axis represents the months of observation of the historical series (50 months), followed by the 20 months of the Autoregressive Integrated Moving Average — ARIMA projection (months 51 to 70). The graphic representation shows the number of visits per month of the historical series (black line), followed by the mean monthly prediction (dark blue line) and the variation of results in prediction intervals of 80% (blue) and 95% (light gray).

Figure 1. Projection of home visits in Primary Health Care of the Municipal Network of Florianópolis (SC), Brazil, from March 2019 to October 2020.

Table 2. Projection of home visits in Primary Health Care of the Municipal Network of Florianópolis (SC), Brazil, per month and accuracy intervals of 80 and 95%.

Projection point	Month/year of projection	Mean prediction of home visits	95% confidence Interval
51	March/2019	535.49	345.44–793.93
52	April/2019	644.60	399.35–987.33
53	May/2019	677.60	408.57–1,060.15
54	June/2019	690.20	415.65–1,080.92
55	July/2019	699.15	415.63–1,106.03
56	August/2019	702.97	412.19–1,124.06
57	September/2019	658.43	383.57–1,058.15
58	October/2019	630.45	361.03–1,026.63
59	November/2019	607.66	325.99–928.86
60	December/2019	573.35	347.36–990.90
61	January/2020	583.64	330.25–959.18
62	February/2020	589.85	333.75–969.40
63	March/2020	598.55	337.53–986.25
64	April/2020	612.75	345.40–1,009.95
65	May/2020	621.27	348.85–1,027.03
66	June/2020	633.94	348.85–1,027.03
67	July/2020	637.87	357.66–1,055.62
68	August/2020	639.95	358.77–1,059.18
69	September/2020	635.08	356.03–1,051.13
70	October/2020	632.06	354.06–1,046.75

DISCUSSION

The projection of demand for home visits in the PHC of the municipal network of Florianópolis resulted in an estimate of 535 visits for March 2019, with the highest estimates for the months of August 2019 (702 visits) and the last month of the estimate, October 2020 (632 visits).

In the present study, home visits carried out by doctors and nurses from the PHC in Florianópolis represent between 1.65% (2016) and 0.94% (2019) of the total number of visits in the municipal network, a percentage that is decreasing in the analyzed period.

Despite the trends of population aging and the increase in the prevalence of chronic diseases, the analysis of the historical series showed a reduction in home visits in the municipality of Florianópolis of about 20% in the period between January 2015 and February 2019.

A wide variation was observed in the projection of estimated home visits for HC with the same number of FHT. Variations in the demographic and epidemiological profile of families, population density between neighborhoods, distance and terrain characteristics to the HC are factors that may be involved in the variations presented among the HC in the Florianópolis network, in addition to the preferences of the team professionals, the organization of their schedules and the availability of transportation, which is provided by the Municipal Health Department.

Demand prediction studies are scarce in the scope of Home Care, especially in PHC. Thus, the development of new research in other health systems or municipalities in Brazil is important so that we

Table 3. Projection of home visits in Primary Health Care of the Municipal Network of Florianópolis (SC), Brazil, by Health Center and 95% confidence intervals.

Health centers	Number of FHT	Mean prediction of home visits	95% prediction range
Ingleses	6	17.69	5.76–42.50
Saco Grande	6	29.16	11.77–61.00
Canasvieiras	5	8.68	0.38–58.60
Monte Cristo	5	36.18	5.89–129.31
Trindade	5	37.04	15.91–74.29
Agronômica	4	12.95	1.06–65.58
Estreito	4	30.70	8.99–78.77
Itacorubi	4	9.10	1.65–30.68
Rio Vermelho	4	14.94	3.75–41.97
Tapera	4	13.02	4.05–32.21
Abraão	3	12.98	2.42–43.16
Capoeiras	3	22.42	5.37–64.82
Centro	3	17.60	4.23–50.76
Coloninha	3	9.75	3.03–24.14
Coqueiros	3	9.84	1.52–36.20
Costeira do Pirajubaé	3	5.66	0.62–24.78
Lagoa da Conceição	3	24.77	7.76–61.01
Monte Serrat	3	22.35	2.77–91.92
Novo Continente	3	6.46	0.84–25.88
Prainha	3	16.56	3.46–51.67
Saco dos Limões	3	21.24	9.18–42.43
Armação	2	23.19	6.69–60.03
Balneário	2	14.18	3.29–41.72
Barra da Lagoa	2	10.68	2.02–35.23
Cachoeira do Bom Jesus	2	5.88	1.10–19.44
Campeche	2	14.71	2.53–51.00
Carianos	2	5.99	1.53–16.66
Córrego Grande	2	6.89	1.41–21.70
Fazenda Rio Tavares	2	10.46	1.46–40.45
Jardim Atlântico	2	7.54	1.37–25.35
João Paulo	2	15.23	4.41–39.36
Morro das Pedras	2	15.57	4.44–40.59
Pantanal	2	13.83	5.89–27.90
Ponta das Canas	2	2.77	0.69–7.83
Rio Tavares	2	4.45	1.02–13.19
Santinho	2	6.33	1.04–22.43
Santo Antônio de Lisboa	2	5.01	0.78–18.36
Sapé	2	15.78	4.22–42.76
Alto Ribeirão	1	14.49	0.06–291.91
Caieira Barra do Sul	1	7.53	1.02–29.65
Canto da Lagoa	1	2.29	0.61–6.18
Costa da Lagoa	1	2.54	0.68–6.88
Jurerê	1	9.58	1.48–35.10
Pântano do Sul	1	6.86	1.25–23.08
Ratones	1	6.22	1.28–19.57
Ribeirão da Ilha	1	3.79	0.55–14.44
Vargem Grande	1	8.75	0.84–40.89
Vargem Pequena	1	1.58	0.47–4.04
Vila Aparecida	1	2.71	0.46–9.51

FHT: Family health teams.

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7

can have a larger universe of comparison and analysis of the use of the tool and methodology adopted in this study.

The methodology adopted for the prediction takes into account the offer of visits in the past as the greatest predictor for future projections; thus, it provides for the maintenance of the current supply pattern, which is one of the limitations of the method used in the present study. For this reason, there is a risk of underestimating the future demand, since currently the professional staff of PHC in the municipality already has a reduced number of professionals, which leads to a compromise in the provision of care, including home visits. Another limitation is due to the limited number of observations; thus, the projection assumes a wide range of possible outcomes, which can be verified in the 95% confidence intervals.

Future studies and the use of other prediction methods are needed to carry out demand projections considering demographic estimates for the coming years, making it possible to predict the need to adjust services based on aging and population growth. In addition, it would be interesting to identify, at the local level, which other factors limit the offer of home visits, as well as to estimate the need presented by patients for home visits in the locality.

In England and Canada, according to Savassi,[10] home visits account for 10.1 to 11.5% of all contacts between family doctors and their patients. According to data from Brazil, doctors dedicate up to seven days and nurses, up to eight days a month for visits.[22] In a study carried out in Florianópolis, home care represents a small part of the total consultations due to the difficulty of operationalization, corresponding to 1.7% of the total number of consultations performed by physicians in 2007.[23]

The reason for this drop in the number of home visits observed may be the significant reduction in human resources in the period, as presented in the institution's annual Management Reports.[24] The downward trend in home visits has been documented in international studies,[25,26] and some of the associated causes described were lack of time due to professional overload, time spent on care, limitation of diagnostic means, support and equipment, inadequate patient control, concerns about the professional's safety, feeling of unpreparedness, remuneration, among others,[27] resulting in a supply deficit in Home Care, both nationally and internationally.[28]

In addition to the difficulties in carrying out home visits, the drop in records coincides with a period of rise in telemedicine approaches. Teleconsultations have proved to be effective and have gained acceptance in recent years, especially in monitoring patients with chronic conditions, demonstrating a reduction in mortality, hospital admissions, and improved quality of life.[27] The context of the SARS-CoV-2 pandemic reinforces its incorporation into current medicine, with the potential to revolutionize the practice of home visits.[29]

CONCLUSION

The study sought to estimate the demand for home visits within the scope of the PHC of the SUS in Florianópolis, Santa Catarina, through the ARIMA forecast model, based on the records of visits of this type carried out in the municipal network between 2015 and 2019, presenting the estimate for the following 20 months. The forecast found was 535 home visits for March 2019, with the highest estimate for August 2019, with 702 visits, followed by October 2020, the last month of the estimate, with 632 visits. In the analysis of data from the historical series, a downward trend in the offer of home visits in the municipality was observed. For each of the 49 HC, an estimate was made of the supply of home visits, and the result for the 20th month of prediction was presented, with predictions of 1.3 to 11.3 visits per FHT. The findings

can serve as a subsidy to management for the organization of professional staff and teams to organize their agendas, as well as the methodology can be reproduced in other locations and systems for research and PHC management purposes.

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CONFLICT OF INTERESTS

Nothing to declare.

AUTHORS' CONTRIBUTIONS

LB: Project administration, Formal analysis, Conceptualization, Data curation, Writing – original draft, Writing – review & editing, Investigation, Methodology, Resources, Software, Supervision, Validation, Visualization. LPG: Project administration, Formal analysis, Conceptualization, Writing – original draft, Writing – review & editing, Investigation, Methodology, Resources, Software, Supervision, Validation, Visualization. DBLC: Project administration, Formal analysis, Conceptualization, Writing – original draft, Writing – review & editing, Investigation, Methodology, Resources, Supervision, Validation, Visualization.

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