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Research Article

Temporal trend of complications of the diabetic foot and Primary Health Care coverage in Brazilian capitals, 2008–2018

Tendência temporal das complicações do pé diabético e da cobertura da Atenção Primária à Saúde nas capitais brasileiras, 2008–2018

Evolución temporal de las complicaciones del pie diabético y cobertura de la Atención Primaria de Salud en las capitales brasileñas, 2008–2018

Adson Aragão de Araújo Santos[1], André Fellipe Lima Gomes[1], Fillipe Siqueira Santos da Silva[1], Hellen de Carvalho Lima[1], José Matheus Mendonça da Silva[1], Marcello Barbosa Otoni Gonçalves Guedes[2], Diego Neves Araújo[3], Carlos Alberto de Lima Botelho Filho[1], Matheus Rodrigues Lopes[1], Johnnatas Mikael Lopes[1]

[1]Universidade Federal do Vale do São Francisco, Departamento de Medicina – Paulo Afonso (BA), Brazil.
[2]Universidade Federal do Rio Grande do Norte, Departamento de Fisioterapia – Natal (RN), Brazil.
[3]Centro Universitário Unifacisa, Departamento de Medicina – Campina Grande (PA), Brazil.

Abstract

Introduction: Diabetic complications are mostly preventable conditions, the diabetic foot being one of the most common. Proper management of the diabetic foot mitigates disabling events and higher costs to the health system. Effective interventions in Primary Health Care (PHC) make it possible to prevent diabetic complications. The care scenario for preventing diabetic complications is Primary Health Care (PHC). **Objective:** To analyze the temporal trend of diabetic foot complications and their relationship with PHC coverage in Brazilian capitals, between 2008 and 2018, and the relationship between them. **Methods:** An ecological time-series study of the cumulative incidences of diabetic foot complications in the 27 capitals using data from the Information System on Hypertensive and Diabetic Patients. The independent variables were year, PHC coverage and the family health strategy (ESF). A Prais-Winsten regression model was used. **Results:** In Brazil, there were 45,095 cases of diabetic foot complications in the period, with an average of 0.57 cases/100,000 inhabitants ($p<0.001$), being stable in 14 capitals ($p>0.05$) and 13 increasing capitals ($p<0.05$). There is an interaction between the increase in the level of PHC coverage and stability in the evolution of diabetic complications ($p<0.05$). **Conclusions:** Despite the increase in the occurrence of diabetic foot complications, however, in the capitals with growth in PHC coverage, there was control of the progression of diabetic foot complications.

Keywords: Diabetic foot; Diabetes complications; Primary health care; Time series studies; Ecological studies.

Corresponding author:
Johnnatas Mikael Lopes
E-mail: johnnatas.lopes@univasf.edu.br
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Resumo

Introdução: Complicações diabéticas são condições preveníveis em sua maioria, sendo o pé diabético uma das mais comuns. O manejo adequado do pé diabético mitiga eventos incapacitantes e maiores gastos ao sistema de saúde. As intervenções efetivas na Atenção Primária à Saúde (APS) possibilitam prevenir as complicações diabéticas. **Objetivo:** Analisar a tendência das complicações do pé diabético e sua relação com a cobertura da APS nas capitais brasileiras, entre 2008 e 2018. **Métodos:** Estudo ecológico de séries temporais das incidências acumuladas de complicações do pé diabético nas 27 capitais utilizando dados do Sistema de Informação sobre Hipertensos e Diabéticos. As variáveis independentes foram ano, cobertura da APS e da Estratégia Saúde da Família. Empregou-se modelo de regressão de Prais-Winsten. **Resultados:** No Brasil, ocorreram 45.095 casos de complicações do pé diabético no período, com média de 0,57 casos/100.000 habitantes ($p<0,001$) — estável em 14 capitais ($p>0,05$) e crescente em 13 capitais ($p<0,05$). Há associação entre elevação do nível de cobertura da APS e estabilidade na evolução das complicações diabéticas ($p<0,05$). **Conclusões:** Evidencia-se aumento da ocorrência das complicações do pé diabético, contudo, nas capitais com crescimento da cobertura da APS, houve controle da progressão.

Palavras-chave: Pé diabético; Complicações do diabetes; Atenção primária à saúde; Estudos de séries temporais; Estudos ecológicos.

Resumen

Introducción: Las complicaciones diabéticas son en su mayoría condiciones prevenibles, siendo el pie diabético una de las más comunes. El manejo adecuado del pie diabético mitiga eventos incapacitantes y mayores costos al sistema de salud. Intervenciones efectivas en la Atención Primaria de Salud (APS) permiten prevenir las complicaciones diabéticas El escenario asistencial para la prevención de las complicaciones diabéticas es la Atención Primaria de Salud (APS). **Objetivo:** Analizar la tendencia temporal de las complicaciones del pie diabético y su relación con la cobertura de la APS en las capitales brasileñas, entre 2008 y 2018, y la relación entre ellas. **Métodos:** Estudio ecológico de serie temporal de las incidencias acumuladas de complicaciones del pie diabético en las 27 capitales utilizando datos del Sistema de Información de Pacientes Hipertensos y Diabéticos. Las variables independientes fueron el año, la cobertura de la APS y la estrategia de salud de la familia (ESF). Se utilizó un modelo de regresión de Prais-Winsten. **Resultados:** En Brasil, hubo 45.095 casos de complicaciones del pie diabético en el período, con una media de 0,57 casos/100.000 habitantes ($p<0,001$), manteniéndose estable en 14 capitales ($p>0,05$) y 13 capitales crecientes ($p<0.05$). Existe una interacción entre un aumento en el nivel de cobertura de la APS y la estabilidad en la evolución de las complicaciones diabéticas ($p<0,05$). **Conclusiones:** A pesar del aumento en la ocurrencia de complicaciones del pie diabético, sin embargo, en las capitales con crecimiento en la cobertura de la APS, hubo control de la progresión de las complicaciones del pie diabético.

Palabras clave: Pie diabético; Complicaciones de la diabetes; Atención Primaria de Salud; Estudios de series temporales; Estudios ecológicos.

INTRODUCTION

Diabetes mellitus (DM) is a chronic non-communicable disease resulting from autoimmune destruction of pancreatic tissue (type 1) or from insulin resistance and insufficiency (type 2) and which causes hyperglycemia.[1] It has multiple causes, such as obesity, overweight, sedentary lifestyle, and high-sugar diet.[1,2]

DM is an important morbidity in the world, with an overall prevalence of 8.8%.[3] It is present in developing countries, such as Brazil, which is the fourth country in the world with the highest prevalence of the disease.[4] In 2017, the country had 12.5 million carriers, and the estimate for 2045 is 20.3 million. This is due to the epidemiological and nutritional transition in the country, in addition to the increase in physical inactivity and the weight of the population.[4]

The low awareness and education of the population,[3] in addition to the chronicity and insidious progression of DM,[2] contribute to its late diagnosis. They also contribute to the high occurrence of complications such as diabetic foot, a clinical condition that requires continuous and long-term care for its management.[5]

In the management of the diabetic condition, the presence of tegumentary and musculoskeletal lesions in the body extremities are common, especially in the feet. Characterized by the association of infections and ulcerations with neurological and vascular changes in the lower limbs, the diabetic foot

results from prolonged exposure to hyperglycemia, leading to neuropathy and limited joint mobility. Diabetic foot injury is usually produced by improper clipping of toenails, poor hygiene, habit of walking barefoot, and wearing inappropriate shoes.[6]

As for social factors, people in condition of socioeconomic vulnerability are more susceptible to diabetic foot complications. This is because these patients are unable to maintain lifestyle habits such as adequate food, hygiene, and physical activity, as well as having more barriers to accessing medical care.[6,7] In addition, there is the lack of follow-up by a multidisciplinary team in care. Primary Health Care (PHC) of the Unified Health System (*Sistema Único de Saúde* – SUS), mainly in the Family Health Strategy (*Estratégia Saúde da Família* – ESF), which could reduce the risk of complications when the user is in an area covered by the services.[7,8]

PHC/ESF play a fundamental role in preventing DM complications, especially diabetic foot ulcers.[7] Risk screening strategies for these complications, associated with health education practices, especially instruction on self-care for patients, are effective ways to prevent diseases.[9-12] Considering that the prevention, diagnosis, and treatment of DM and its complications occur in PHC/ESF, the evaluation of indicators of complications is necessary to guide public health actions related to PHC in all spheres of management.[13,14]

The assessment of the impact of PHC on diabetic complications can be measured through several dimensions of care quality; however, we chose to investigate the dimension of access to this level of care, as it is a measurement metric with a shorter time interval and concomitant with the investigated outcome. Thus, the present study aimed to estimate the relationship between the temporal trend of diabetic foot complications and PHC coverage in Brazilian capitals, from 2008 to 2018.

METHODS

Study design

This is an ecological study, with a time series design, from 2008 to 2018. The study analysis units were the 27 Brazilian capitals, since the management of direct preventive actions for the management of DM and its complications occur at the municipal level.

Background and population

PHC has decentralization and regionalization as guidelines. This division aims to establish an orderly and organized health system, which allows for the proper execution of health services and their administrative activities. Thus, each municipality is responsible for offering services and supplies for the diagnosis and treatment of DM in preventive actions and has the autonomy to exercise them.

The target population of the study were the inhabitants of Brazilian capitals accompanied by PHC services. The capitals were selected due to their autonomy for the execution of PHC and for being the federative entities in each unit with the largest population and contribution of resources for this action. Today, more than 50 million Brazilians live in capitals and are users of SUS services, either directly or indirectly.[15] The period of the ten-year time series includes a sufficient follow-up to detect the trend and the effect of programmatic actions of the health system.

Variables

As an outcome, the occurrence of diabetic foot complications coded in the Hiperdia system was determined, measured using the indicator of cumulative incidence of diabetic foot complications.

Independent variables were:

- year of hospitalization (2008–2018);
- PHC population coverage;
- ESF population coverage;
- Brazilian capital.

Data sources and measurement

Data on the outcome of diabetic foot complications were collected from the System for Registration and Monitoring of Hypertensive and Diabetic Patients, in the diabetic foot section, which deals with the registration of complications of this condition.[16] The number of events of the outcome of diabetic foot complications was collected between April and May 2019 and used to prepare the indicator of accumulated incidence of diabetic foot complications.[16,17]

Demographic data of population estimates for the construction of the outcome indicator were collected in the area of demographic and socioeconomic information of the Department of Informatics of the SUS (*Departamento de Informática do SUS* – Datasus), in the database of the Federal Audit Court, between April and May 2019.[16] Thus, the outcome for cumulative annual incidence of diabetic foot complications was calculated by the ratio between the total number of complications in the year and the total population, multiplied by 100,000 inhabitants.

The percentage of the population referring to the history of PHC and ESF coverage was taken from the e-gestor website between April and May 2019,[18] in the public reports section, and the percentages of PHC and ESF coverage were obtained, by capital, for each year of the time series.

Statistical methods

For the analysis of the temporal trend of the outcome and the coverage of PHC and ESF, a Prais-Winsten polynomial regression model was used in order to obtain the best curve for linear trend adjustment. This curve relates the variable of interest, "accumulated incidence of diabetic foot complications", with the independent variable "year", producing a first-degree equation ($y=\beta_1 x+\beta_0$) in which y corresponds to the outcome, β_1 corresponds to the annual average evolution and β_0 corresponds to the average of the outcome in the period. To prevent the inflation of the model constant, the difference between the year and the midpoint of the historical series was used, rather than the specific year. The same procedure was carried out for PHC and ESF coverage to investigate their trend in the capitals.

The Prais-Winsten regression coefficients ($\beta 1$) inform the average annual evolution of the outcome. If its sign is (+), this determines an increasing trend, and if it is (-), it determines a decreasing trend of the outcome. The stationary trend is identified when the Prais-Winsten equation presents a p-value greater than the adopted significance level, $p>0.05$. The adjusted coefficient of determination (R2) corresponds to the proportion of explanation of the model in relation to the observed values of the cumulative incidence rates of diabetic foot complications.

After the isolated analysis of the outcome trend and the population coverage of the PHC and the ESF, the data on the accumulated incidence of diabetic foot complications in the capitals were grouped according to the evolutionary pattern of the coverage of the PHC and the ESF. That is, the evolutionary behavior of the outcome was analyzed in the groups with increasing, decreasing and stationary trends for PHC and ESF coverage. With this stratification device, it is possible to infer the type of relationship between the outcome trend and the population coverage trend of PHC and FHS. The Prais-Winsten method was applied again to identify the trend of the outcome in each evolutionary stratum of coverage. In all analyses, a significance level of 5% was considered in order to reduce type I errors in the modeling processes.

Ethical aspects

The data obtained in the present study came from a database in the public domain, a feature that makes it unnecessary the approval of this research by a Research Ethics Committee, in accordance with the Resolution of the National Health Council No. 510, of 2016, and the research did not have the participation of patients or the community in its planning or elaboration.

RESULTS

In the 27 capitals analyzed, there were 45,095 complications of diabetic foot in the period from 2008 to 2018. In 2008, an average of 5.68 (±5.77) complications of diabetic foot per 100 thousand inhabitants was identified in 2018, reaching an average of 17.68 (±24.41) in 2018. In Brazil, there was an increasing trend in diabetic foot complications, with an average annual increase of 0.57 cases per 100,000 inhabitants ($p<0.001$) (Table 1).

In the capitals with a steady trend for the cumulative incidence of diabetic foot complications, three are from the Northeast Region: Fortaleza ($p=0.060$), Maceió ($p=0.990$) and Salvador ($p=0.970$); four are from the North Region: Boa Vista ($p=0.710$), Macapá ($p=0.300$), Palmas ($p=0.070$) and Rio Branco ($p=0.470$); three are from the Midwest Region: Brasília ($p=0.060$), Campo Grande ($p=0.820$) and Goiânia ($p=0.760$); two from the South Region: Florianópolis ($p=0.21$) and Porto Alegre ($p=0.28$); and two from the Southeast: Rio de Janeiro ($p=0.270$) and Vitória ($p=0.450$). The other capitals showed an increasing trend (Table 1).

As for the coverage of PHC and ESF, there was a tendency for both to increase in Recife, Salvador, Rio de Janeiro, São Paulo, Brasília, Campo Grande, and Porto Alegre ($\beta>0$; $p<0.050$). Among these seven capitals, five (71.4%) showed stationarity in the trend of cumulative incidence of diabetic foot complications, as well as Maceió, where there was an increase only in PHC coverage ($\beta=0.007$; $p=0.040$), as shown in Table 2.

In Fortaleza ($\beta=0.01$; $p<0.001$), São Luís ($\beta=0.006$; $p=0.010$), Belo Horizonte ($\beta=0.008$; $p=0.005$) and Cuiabá ($\beta=0.01$; $p=0.040$), the increase in coverage occurred only in the ESF, and only the capital of Ceará managed to prevent the growth of diabetic foot complications. The only capital that declined PHC and ESF coverage was Aracaju ($\beta<0$; $p<0.010$), which showed a tendency to increase the incidence of the outcome. In the capitals with a decreasing or stationary trend of PHC and ESF, seven (50.0%) had an increase in diabetic foot complications (Table 2).

In summary, the capitals with a decreasing and stationary PHC trend showed an increase in the accumulated incidence of diabetic foot complications, while the capitals with an increase in PHC coverage

Table 1. Analysis of the trend of the cumulative incidence of diabetic foot complications in Brazilian capitals, between 2008 and 2018.

Capitals	Cumulative mean incidence of diabetic foot complications	Equation	R^2	p-value*	Trend
Brasil		0.57x +3.27	0.97	<0.001	Growing
Capitals					
Belém	11.92 (±6.33)	1.860x+11.92	0.95	<0.001	Growing
Boa Vista	24.00 (±12.79)	0.70x+24.61	-0.22	0.710	Stationary
Macapá	16.97 (±3.62)	0.42x+16.83	-0.25	0.300	Stationary
Manaus	24.02 (±9.12)	2.585x+24.23	0.62	0.002	Growing
Palmas	1.72 (±1.38)	-22.62x+52.29	-0.07	0.070	Stationary
Porto Velho	6.16 (±3.90)	0.70x+6.19	0.47	0.010	Growing
Rio Branco	2.44 (±0.90)	0.08x+2.44	-0.06	0.470	Stationary
Aracaju	7.45 (±4.90)	1.159x+7.43	0.51	0.008	Growing
Fortaleza	4.52 (±1.33)	0.297x+3.60	0.22	0.060	Stationary
João Pessoa	32.47 (±9.09)	2.312+32.44	-0.08	0.001	Growing
Maceió	9.49 (±9.21)	-0.01x+8.25	0.65	0.990	Stationary
Natal	50.13 (±37.82)	10.27x+50.86	0.18	0.003	Growing
Recife	2.44 (±0.90)	0.91x+22.44	-0.16	0.010	Growing
Salvador	5.82 (±2.00)	0.009x+5.81	0.46	0.970	Stationary
São Luís	29.89 (±15.93)	4.224x+28.83	0.71	0.010	Growing
Teresina	2.71 (±1.76)	0.42x+2.71	-0.16	0.005	Growing
Brasília	4.82 (±1.21)	0.229x+4.82	0.24	0.060	Stationary
Campo Grande	6.25 (±1.60)	-0.050x+6.13	-0.24	0.820	Stationary
Cuiabá	12.95 (±8.96)	2.00x+12.71	0.40	0.010	Growing
Goiânia	4.52 (±1.33)	-0.05+4.1	-0.23	0.790	Stationary
Belo Horizonte	8.32 (±4.27)	1.185x+8.46	0.69	0.001	Growing
Rio de Janeiro	3.98 (±1.02)	0.16x+3.93	-0.25	0.270	Stationary
São Paulo	3.26 (±0.42)	0.09x+3.29	0.55	0.001	Growing
Vitória	30.69 (±12.88)	1.23x+29.55	0.26	0.450	Stationary
Curitiba	1.09 (±0.51)	0.118x+1.07	0.34	0.020	Growing
Florianópolis	2.85 (±2.16)	-0.289+2.88	-0.02	0.210	Stationary
Porto Alegre	6.16 (±3.90)	-0.18x+5.76	0.42	0.280	Stationary

R^2: adjusted coefficient of determination; *Prais-Winsten regression.

indicated stationarity of complications (Figure 1). This stratification, when modeled (Table 3), demonstrates that in the seven capitals with PHC growth, regardless of the evolution of the ESF, there is stationarity of diabetic foot complications (p>0.050). On the other hand, in the 17 capitals where there was no expansion of PHC coverage, we observed an increase in complications (p<0.050), regardless of ESF coverage, with an increase ranging from 7.76 to 17.31 cases per 100,000 inhabitants, annually.

Paradoxically, there is also stationarity of diabetic foot complications in Goiânia and Vitória, where PHC coverage was decreasing. However, in the latter, even with a decline in PHC coverage, more than 90.0% of the population receives care (Table 3). Goiânia, on the other hand, shows a decline in PHC

Table 2. Modeling trends in coverage of Primary Health Care services in Brazilian capitals between 2008 and 2018.

Capitals	PHC coverage				ESF coverage			
	Equation	R^2	p-value*	Trend	Equation	R^2adjus†	p-value	Trend
Belém	0.002x+0.45	0.18	0.520	Stationary	0.002x+0.22	0.20	0.610	Stationary
Boa Vista	-0.01x+0.71	0.07	0.130	Stationary	-0.01x+0.57	0.08	0.300	Stationary
Macapá	0.001x+0.82	0.24	0.930	Stationary	0.003x+0.53	0.22	0.690	Stationary
Manaus	-0.02x+0.52	0.87	<0.001	Descending	-0.006x+0.31	0.12	0.100	Stationary
Palmas	0.01x+0.87	0.07	0.130	Stationary	0.02x+0.85	0.04	0.150	Stationary
Porto Velho	-0.01x+0.71	0.09	0.120	Stationary	0.01x+0.51	0.13	0.400	Stationary
Rio Branco	0.01x+0.71	0.13	0.380	Stationary	0.01x++0.47	0.02	0.220	Stationary
Aracaju	-0.02x+0.86	0.96	<0.001	Descending	-0.02x+0.76	0.79	<0.001	Descending
Fortaleza	0.005x+0.54	0.18	0.530	Stationary	0.01x+0.39	0.76	<0.001	Growing
João Pessoa	-0.006x+0.93	0.15	0.430	Stationary	-0.008x+0.83	0.01	0.200	Stationary
Maceió	0.007x+0.42	0.28	0.040	Growing	0.001x+0.28	0.19	0.570	Stationary
Natal	-0.01x+0.58	0.13	0.380	Stationary	-0.001x+0.38	0.24	0.940	Stationary
Recife	0.005x+0.60	0.46	0.010	Growing	0.004x+0.53	0.35	0.020	Growing
Salvador	0.01x+0.32	0.68	0.001	Growing	0.01x+0.20	0.88	<0.001	Growing
São Luís	0.004x+0.43	0.15	0.430	Stationary	0.006x+0.32	0.43	0.010	Growing
Teresina	4.9.10-5x+1.0	0.23	0.740	Stationary	0.002x+0.98	0.03	0.220	Stationary
Belo Horizonte	0.007x+0.97	0.22	0.060	Stationary	0.008x+0.75	0.56	0.005	Growing
Rio de Janeiro	0.05x+0.46	0.92	<0.001	Growing	0.05x++0.35	0.94	<0.001	Growing
São Paulo	0.006x+0.57	0.15	0.080	Growing	0.005x+0.32	0.81	<0.001	Growing
Vitória	-0.01x+0.97	0.32	0.030	Descending	-0.006x+0.75	0.06	0.270	Stationary
Brasília	0.02x+0.52	0.55	0.005	Growing	0.03x+0.22	0.93	<0.001	Growing
Campo Grande	0.01x+0.40	0.39	0.010	Growing	0.01x+0.34	0.71	0.001	Growing
Cuiabá	0.007x+0.48	0.04	0.240	Stationary	0.01x+0.35	0.28	0.040	Growing
Goiânia	-0.02x+0.70	0.35	0.020	Descending	0.01x+0.40	0.06	0.130	Stationary
Curitiba	-0.003x+0.55	0.19	0.560	Stationary	0.005x+0.35	0.13	0.390	Stationary
Florianópolis	-0.001x+0.99	0.14	0.400	Stationary	0.01x+0.87	0.02	0.220	Stationary
Porto Alegre	0.02x+0.60	0.80	<0.001	Growing	0.03x+0.34	0.91	<0.001	Growing

PHC: Primary Health Care; ESF: Family Health Strategy; R^2: coefficient of determination; R^2adjus: adjusted coefficient of determination;* probability of the null hypothesis.

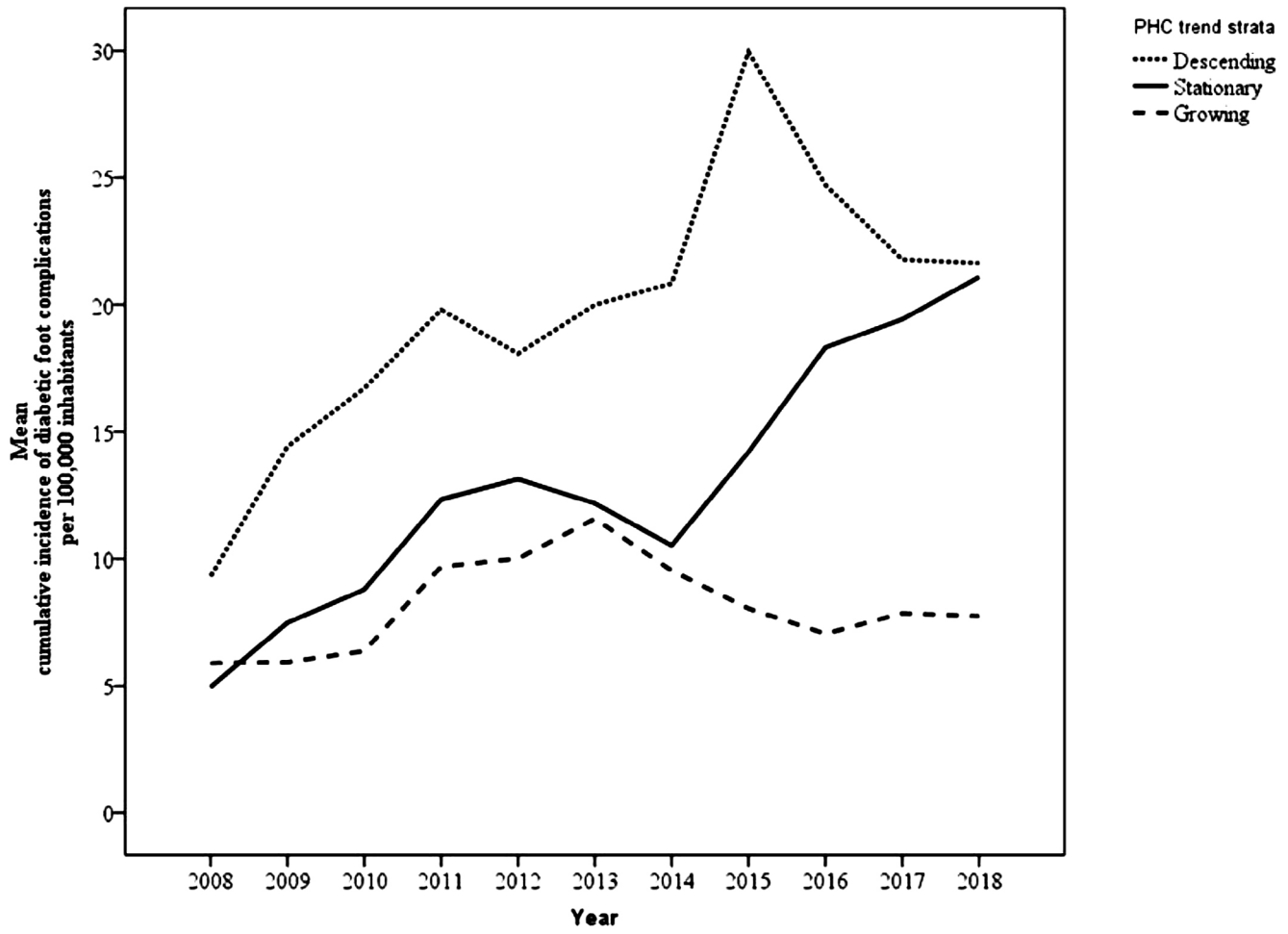
coverage, with a proportion below 75% as of 2012, in addition to the stationarity of the ESF, which has always had coverage below 50% of the population, unlike Vitória.

DISCUSSION

It was found that diabetic foot complications increased from 2008 to 2018 in Brazil. However, in 14 capitals of the federative units, these complications stabilized. In addition, it was possible to observe that, grouping the capitals by evolution of PHC coverage, regardless of FHS coverage, those with increased coverage had stabilization of diabetic foot complications in the period.

Diabetic foot complications are among the main difficulties faced in conducting preventive care in health systems. In a large study carried out in some Latin American countries, it was shown that diabetic foot complications accounted for 20% of complications in people with DM and 3.7% of patients in general.[19]

When compared to diabetic patients without ulcerations, those with diabetic foot ulcers present older age, lower muscle mass, longer disease duration, higher prevalence of diabetic retinopathy, smoking, and



PHC: Primary Health Care.

Figure 1. Trend in the cumulative incidence of diabetic foot complications, stratified by the evolution of Primary Health Care coverage in Brazilian capitals, between 2008 and 2018.

Table 3. Trend models of diabetic foot complications stratified by evolutionary trend in coverage of Primary Health Care and Family Health Strategy, in Brazilian capitals, between 2008 and 2018.

Coverage evolution	Equation	p-value*	R^2adjus	Trend
PHCdesc and ESFstt	2.25x+271.43	0.720	0.06	Stationary
PHCstt and ESFdesc	7.76x+46.25	0.007	0.53	Growing
PHCstt and ESFstt	16.63x+97.29	0.013	0.15	Growing
PHCstt and ESFgrow	17.31x+184.79	<0.001	0.34	Growing
PHCgrow and ESFstt	0.26x+81.66	0.980	0.25	Stationary
PHCgrow and ESFgrow	3.21x+216.80	0.240	0.10	Stationary

PHCdesc: descending coverage of Primary Health Care; ESFstt: stationary coverage of Family Health Strategy; PHCstt: stationary coverage of Primary Health Care; ESFdesc: descending coverage of Family Health Strategy; ESFgrow: growing coverage of Family Health Strategy; PHCgrow: growing coverage of Primary Health Care; R^2adjus: adjusted coefficient of determination; * probability of the null hypothesis.

hypertension.[20] Mitigating these preventable events is the role of PHC when acting in the management of this clinical condition.[21]

Based on these aspects of care, the question of the parameter of access to the care process in PHC arises as a possible influencer of results or impact on health conditions such as diabetes and its adjacent morbidities. Our findings indicate that increasing the population's access to PHC services reduces diabetic foot complications. This may be due to the characteristics of assistance programs, such as Hiperdia, leading to better identification of individuals at risk of complications and offering specific care. Therefore, it seems that expanding the population's access to systematic and linked monitoring improves the health outcomes of diabetic people, which perhaps would not occur in situations of free demand for services due to the socioeconomic vulnerability of most of the population.

The care to avoid complications with the diabetic foot in PHC through Hiperdia involves the need for collaboration between different professionals, considering that actions related to the patients' lifestyle are necessary, such as monitoring glycemic control, use of adequate shoes, education about foot checking; as well as specific care more directly related to wounds, such as treatment of infections, debridement of necrotic tissue and adequate hygiene associated with appropriate dressings.[22]

When a multidisciplinary health care team carries out frequent follow-up and focuses on patient education, there is less morbidity in people with diabetic ulcers, in addition to reducing the frequency of major lower limb amputations resulting from the disease.[23,24]

It is worth noting that the reduction in amputations and morbidities as a result of primary care programs has the potential to alleviate the financial burden of health systems, being particularly important in developing countries, given the greater limitation of resources. For example, the diabetic foot management project aimed at screening and educating health users, applied in 15 care centers in Tanzania, resulted in a significant drop in the need for care at the tertiary level in a period of three years.[25] Thus, public policies implemented in PHC can positively impact the management of individuals with diabetic foot injuries and possibly reduce the complications of this condition.

Despite the effectiveness of Brazilian PHC programmatic actions, the country is divided into five regions and PHC coverage has a heterogeneous distribution, growing more in the North and Northeast of Brazil, which are socioeconomically more vulnerable regions.[26,27] However, the executive management of PHC and the planning of its expansion are direct attributes of Brazilian municipalities. This makes the implementation of access and quality hostage to local policies, without regulation of minimum coverage parameters by the other federated entities that finance the primary subsystem. Establishing minimum limits of care coverage in cities with greater vulnerabilities and on clinical and social risk criteria can ensure effective and efficient care, as observed in a South Korean cohort with more than 976,000 participants between 2011 and 2015, in which the most vulnerable people socioeconomically and with diabetic ulcers had worse prognoses.[28]

In addition to access, other dimensions of care quality can be highlighted as intervening factors in the management of diabetic conditions, such as lack of clinical and laboratory follow-up, incorrect use of medicines by patients with DM, limited number of vacancies for medical care and insufficient frequency of consultations.[29] However, the dimensions of primary care quality, such as equity, efficiency and patient safety, were not examined in this investigation, which may add more determinants to diabetic foot care.

Another also important finding in this study is the lack of impact of the expansion of ESF coverage on diabetic foot complications in Brazilian capitals. This may be due to the fact that the characteristic of ESF is one of the components of PHC in Brazil and is limited to the expansion of PHC, leaving population

territories uncovered and vulnerable to longitudinal monitoring. Thus, health policies should aim to expand PHC coverage in order to identify patients with this condition and monitor them, providing more access to programs such as Hiperdia and a multidimensional approach.[30]

There are other factors that may contribute to the growth of diabetic foot complications in addition to the population coverage of PHC, which were not analyzed in the study: the increase in cases of chronic conditions resulting from the growth of the elderly population in Brazil, such as diabetes itself.[3] However, PHC services are designed to cover population contingents and not disease burdens, so it is plausible that: the covered people will be insured for their condition; a sedentary lifestyle[2] and poor eating habits,[3] despite being individual health conditions, are strongly determined by factors such as income and education;[3,6] late diagnosis for the proper management of one's health can put extra pressure on PHC services[9,11] and more critical cases of sequelae; the level of care quality of PHC services in the dimensions of effectiveness and efficiency are increased[11] and there is greater accessibility to hospital services in capitals, which focus only on curative treatment.[31]

Among the limitations of this study, it is noteworthy that the observed data are from the capitals of the federative units, which may present important disparities in relation to the smaller cities in the interior of each of these units. The second limitation comes from the ecological design, which, despite being concurrent with events and one of the few ways to evaluate policies on a large scale, does not allow identifying the magnitude of diabetic foot complications at an individual level. Thirdly, it is possible to have inaccuracy in the magnitude of the coefficients of the equations due to random error, but it is unlikely that it interferes with trend inference, as the census data are used. Fourth, the use of secondary data in ecological designs prevents us from assessing the agreement and consistency of the collected data. As a fifth limitation, the Hiperdia information system presents completeness of variable clinical data that depend on the qualification of the teams in filling out the system, which can imply inaccuracy.[32] Finally, the lack of analysis of aggregate data on the quality of care in PHC based on the Access and Quality Improvement Program and other social indicators of the cities analyzed prevented further inferences, but this limitation comes from the incongruity of temporality of events, indicators and interventions.

Overall, Brazil has an increasing trend of diabetic foot complications, which implies greater damage and avoidable expenses. However, this growth is heterogeneous, with state capitals with a steady evolution of these avoidable complications, especially those with an increasing trend in PHC coverage. This finding allows us to infer that the expansion of PHC coverage was related to the stabilization of diabetic foot complications due to the temporal concurrence of the analyzed events, which may interact with other dimensions of care quality.

CONFLICT OF INTERESTS

Nothing to declare.

AUTHORS' CONTRIBUTIONS

JML: Project administration, Formal analysis, Conceptualization, Writing – review & editing, Methodology, Supervision, Validation. AAAS: Conceptualization, Data curation, Writing – original draft, Writing – review & editing, Investigation, Methodology. AFLG: Conceptualization, Data curation, Writing – original draft, Investigation, Methodology. FSSS: Conceptualization, Data curation, Writing – original

draft, Investigation, Methodology. HCL: Conceptualization, Data curation, Writing – original draft, Writing – review & editing, Investigation, Methodology. JMMS: Conceptualization, Data curation, Writing – original draft, Investigation, Methodology. MBOGG: Formal analysis, Writing – review & editing, Methodology, Visualization. DNA: Formal analysis, Writing – review & editing, Methodology, Visualization. CALBF: Formal analysis, Writing – review & editing, Methodology, Visualization. MRL: Formal analysis, Writing – review & editing, Methodology, Supervision, Visualization.

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