Evaluation of the structure of primary maternal and infant healthcare in the state of Roraima, the North region of Brazil, and Brazil, 2012-2017

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Abstract *Primary healthcare is the main gateway and priority for healthcare management in Brazil. However, there are significant challenges in the quality of care, particularly for those most vulnerable, especially maternal and infant healthcare. This fact is exacerbated by regional inequalities, which have historically left the North and Northeast regions at a relative disadvantage. The study involves an analysis of the resources available for maternal and infant healthcare in the state of Roraima, the North region, and Brazil as a whole in 2012, 2014, and 2017, using data from Module I of the National Program for the Improvement of Access and Quality of Primary Care (PMAQ-AB). There was a significant improvement in physical infrastructure indicators (e.g., ventilation and air conditioning) as well as improvement in the distribution of supplies and equipment needed for maternal and infant care between 2014 and 2017. However, the availability of medicines and the number of human resources and hours worked diminished. The study offers a crucial longitudinal analysis, comparing the situation in Roraima and Brazil, whose findings could contribute to the development of programs and public policymaking for reproductive rights and maternal and infant health.*

Key words *Maternal and infant health, Primary healthcare, PMAQ-AB*

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Introduction

Primary healthcare (PHC) is a strategy for the organization of healthcare that is designed to enable a continuous, systematic, regionalized response to most of a population's health needs, combining preventive and curative actions[1].

The assurance of access to healthcare is part of the principle of universality enshrined in the Brazilian public health system, Sistema Único de Saúde (SUS). However, it is a principle that has yet to be realized for a significant portion of the country's population, particularly those in vulnerable situations – a reality that is compounded for women during the prenatal and postpartum periods and their newborns, despite their being strategic priorities for the Brazilian state[1].

The Brazilian Ministry of Health has developed different strategies and taken different measures to improve the SUS healthcare model. These include consolidating the family health strategy as a priority for the reorganization of PHC[2]. The idea is for PHC to operate as a gateway to health services, making it a priority for the management of care in the country. It should be able to receive and treat or refer patients, whatever their health status, in addition to coordinating the continuity of care[3].

Studies on access to PHC in Brazil should take account of interregional differences in accessibility, inequities of access, the availability of health workers, and the physical infrastructure of health facilities, all of which are more precarious in the North and Northeast[4,5]. In particular, these are all factors that impair the quality of PHC in the Amazonian state of Roraima[6].

This study focuses on the importance of PHC for maternal and infant health in the state of Roraima, as well as in the rest of the North region and across Brazil. The choice of this geographic region is due to the lower Human Development Indices in the North of the country compared to the rest of Brazil[4]. In particular, it is important to determine whether the infrastructure of the region's PHC facilities is capable of providing adequate maternal and infant healthcare. In Roraima, the supply of quality care to children, households, and the community is hampered for several reasons, which are exacerbated by the unequal distribution of federal funds[7].

It was in this context that the Program for Improving Primary Health Care Access and Quality (Programa de Melhoria do Acesso e da Qualidade da Atenção Básica, PMAQ-AB) was designed and implemented. Run in 2012, 2014, and 2017, its goal was to help expand access to PHC services and set a national quality standard, encouraging the action of local SUS managers by regularly gathering data on different parameters, to be monitored and evaluated on an ongoing basis[8,9]. Furthermore, PMAQ-AB aimed to encourage SUS teams and their managers to improve the quality of care offered to users of PHC facilities through a process of self-evaluation, the development of improvements, and external certification.

PMAQ-AB was therefore a valuable instrument in assessing the quality of maternal and infant healthcare, mainly because it was an important source of information on the healthcare infrastructure, since studies on maternal and infant health tend to analyze indicators of the healthcare process (e.g., the number of consultations)[10] and outcomes (e.g., maternal and infant mortality)[11-13]. In general, studies investigating such outcomes show that somewhere in the world, a woman dies every minute due to pregnancy- and delivery-related complications. In Brazil, the absolute number of maternal deaths rose 11.9% between 2000 and 2009, and the maternal mortality coefficient grew from 52.29 to 65.13 per 100,000 live births, constituting a major public health challenge[11-13], and reflecting the challenges in the quality of maternal and infant healthcare in the country[14,15].

Assessing the distribution and scope of the infrastructure in the region is essential for improving the indicators of maternal and infant health cited above, enabling healthcare strategies to be rethought so that they meet the needs of the population, and making it possible to keep track of the available operational capacity and its ability to meet these needs.

Therefore, the objective of this research was to appraise the PMC resources available for maternal and infant healthcare in the state of Roraima, the North region, and Brazil in 2012, 2014, and 2017.

Methodology

This study involved: (1) analyzing the spatial distribution of healthcare facilities in the Brazilian state of Roraima (using QGIS software), based on the IBGE digital cartographic grid; (2) compiling the historical series of PHC coverage per municipality, using the e-gestor website (https://egestorab.saude.gov.br/); (3) checking/adjusting the items from PMAQ-AB module I for Roraima,

the North region, and Brazil to ensure their compatibility across the three data-gathering cycles studied (2012, 2014, and 2017); and (4) analyzing indicators of infrastructure needed for maternal and infant healthcare.

This cross-sectional, retrospective, analytical study used secondary data from three cycles of the external evaluation of the PMAQ-AB program: cycle 1 (in 2012), cycle 2 (in 2014), and cycle 3 (in 2017).

To analyze the indicators of physical infrastructure, equipment, inputs, and medicines used for maternal and infant healthcare, based on the three cycles of the PMAQ-AB program (in 2012, 2014, and 2017), the variables were selected according to the equivalence between the questions in module I of the PMAQ-AB in the three years, given that the form and/or content of the questions and/or answer options could undergo changes across the cycles. Some questions were adapted to ensure compatibility across the cycles, as detailed in Muzy *et al.* research on patients with diabetes[16].

The data used to characterize the municipalities in terms of their PHC management (PHC coverage, number of community health workers, participation in PMAQ, oral health teams, and family health support units) were obtained from the PHC management website of the Department of Family Health, Ministry of Health (https://egestorab.saude.gov.br).

A spatial analysis of health facilities in the state of Roraima was also carried out (using QGIS 3.18) based on the IBGE digital cartographic grid to map the geographic distribution of the PHC units that took part in PMAQ-AB, in each one of its respective cycles, making it possible to measure the trends in adhesion, based on their respective institutional registry codes (CNES).

Ensuring compatibility of the questions

The PMAQ-AB modules underwent changes during the period analyzed: some questions were added and others were deleted or modified. This meant some adaptations had to be made to make them compatible, the criteria of which had to be described in detail. In order to ensure the greatest possible comparability with the least possible loss of information, the following strategies were used: (a) use of questions with synonyms or similar questions, with minimal or no change of meaning; (b) use of questions with different types of answers (changing from single to multiple responses, or from categorical to continuous

responses); (c) use of complementary response categories (when in one year the question is asked in a positive sense and in the others, in a negative sense); and (d) use of proxy questions for the construct measured (when the questions refer to the same or a similar concept, even if the target population is different).

In the analysis of the questions after compatibilization, their degree of comparability was classified as follows: (1) total, when the formulation of a question was exactly the same in the three cycles; (2) high, when there were small changes in the way a question was asked, but its meaning did not change (e.g., when synonyms were used or similar/complementary response categories were made compatible); and (3) medium, when there were significant changes in the form of a question, but it was still comparable (e.g., the terms used were not synonymous, but referred to the same concept/object of analysis, or else to a different population group). Questions whose comparability was low, requiring greater effort to make the concepts or object investigated comparable, were excluded from the analysis. Questions that were of particular relevance to the topic were maintained, even if they were available for only one or two cycles. Chart 1 contains a summary of the standardization of the questions related to maternal and infant healthcare across the three cycles, as well as their inter-cycle comparability.

For the statistical analysis of item 4 (analysis of indicators of resources used for material and infant healthcare), the difference between the annual proportions and means for the PMAQ-AB cycles were ascertained according to the type of variable. Pearson's chi-squared test was used for the categorical variables when there were sufficient cases, and Fisher's non-parametric test was used when the number of cases was small. For the continuous variables, the ANOVA test was used for the differences between the means for Brazil and the North region; and the Kruskal-Wallis test was used for Roraima. Statistical significance was set at p-value < 5%, and the calculations were made using IBM SPSS 21. As the study was based on secondary data in the public domain, there was no need for approval by a research ethics committee[17].

Results

Roraima is the northernmost state in Brazil and has 15 municipalities. It shares 1,922 km of border with Guyana and Venezuela, which form a

Chart 1. Compatiblization of questions of relevance for maternal and infant health from module 1 (primary health infrastructure) of the National Program for the Improvement of Access and Quality of Primary Care, in 2012, 2014, and 2017.

Id.	2012		2014		2017		Degree of comparability across years
	Variable	**Category**	**Variable**	**Category**	**Variable**	**Category**	
Q1	I.3.6.1	Specialist Physician	I.3.5.1	Specialist Physician	I.3.2.1	Médico especialista	Total
Q2	I.3.6.2	Psychologist	I.3.5.2	Psychologist	I.3.2.2	Psicólogo	Total
Q3	I.3.6.3	Physiotherapist	I.3.5.3	Physiotherapist	I.3.2.3	Fisioterapeuta	Total
Q4	I.3.6.4	Nutritionist	I.3.5.4	Nutritionist	I.3.2.4	Nutricionista	Total
Q5	I.3.6.5	Social Worker	I.3.5.5	Social Worker	I.3.2.5	Assistente social	Total
Q6	I.7.2.1	Yes/No	I.8.1.1	Yes/No	Not available		High
Q7	I.7.2.2	Yes/No	I.8.1.2	Yes/No	Not available		High
Q8	I.7.2.3	Yes/No	I.8.1.3	Yes/No	Not available		High
Q9	I.8.1.1	Yes/No	I.10.1.35.1	Yes/No	I.6.4.1	Yes/No	Total
Q10	I.8.1.2	Yes/No	I.10.1.35.2	Yes/No	I.6.4.2	Yes/No	Total
Q11	I.8.1.3	Yes/No	I.10.1.35.3	Yes/No	I.6.4.3	Yes/No	Total
Q12	I.8.1.4	Yes/No	I.10.1.35.4	Yes/No	I.6.4.4	Yes/No	Total
Q13	I.8.1.5	Yes/No	I.10.1.35.5	Yes/No	I.6.4.5	Yes/No	Total
Q14	I.9.13	Yes/No	I.10.1.19	Yes/No	I.6.3.8	Sim/Não	Medium
Q15	I.9.14	Yes/No	I.10.1.18	Yes/No	I.6.3.5	Sim/Não	High
Q16	I.9.17	Yes/No	I.10.1.27	Sim/Não	I.6.3.14	Sim/Não	Medium
Q17	I.18.1	Yes/No	I.6.1	Sim/Não	Not available		High
Q18	I.18.2	Yes/No	I.6.2	Sim/Não	Not available		High
Q19	I.17.1.1	Quantity	I.11.1	Quantity	I.7.1	Quantity	Total
QE20	I.17.10	Yes/No	Not available		I.6.3.3	Sim/Não	Medium
QE21	I.11.2/1	Quantity	I.12.2/1	Quantity	I.8.2/1	Quantity	Total
QE22	I.11.3/1	Quantity	I.12.2.1/1	Quantity	I.8.4/1	Quantity	Total
QE23	I.11.4/1	Quantity	I.12.3/1	Quantity	I.8.7/1	Quantity	Total
QE24	I.11.8/1	Quantity	I.12.5/1	Quantity	I.8.9/1	Quantity	Total
QE25	I.11.14/1	Quantity	I.12.10/1	Quantity	I.8.14	Quantity	Total
QE26	I.11.20/1	Quantity	I.12.14/1	Quantity	I.8.15/1	Quantity	Total
QE27	I.11.21/1	Quantity	I.12.15/1	Quantity	I.8.16/1	Quantity	Total
QE28	I.11.25/1	Quantity	I.12.17/1 e I.12.22/1	Quantity	I.8.17 e I.8.18	Quantity	High
QE29	I.12.5	Yes/No	I.16.7	Yes/No	I.12.14	Yes/No	High
QE30	I.12.7	Yes/No	I.16.8	Yes/No	I.12.15	Yes/No	High
QE31	I.12.9	Yes/No	I.16.10	Yes/No	I.12.21	Yes/No	High
QE32	I.12.10	Yes/No	I.16.11	Yes/No	I.12.16	Yes/No	High
QE33	I.12.12	Yes/No	I.16.13	Yes/No	I.12.19	Yes/No	High

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triple border point with Brazil. It has two towns that have twin towns across their respective borders: Bonfim, which twins with Lethem, in Guyana, and Pacaraima, which twins with Santa Elena do Uairén, in Venezuela.

PHC is the gateway to SUS health services and is the level of care with the largest volume of health facilities in the state. The spatial distribution of these health facilities, based on the geographic coordinates that locate the health facilities that took part in PMAQ-AB, shows a concentration of services in the seats of the municipalities in the state (Figure 1).

Figure 1 illustrates the evolution of participation in PMAQ-AB, showing the geographical spread of these PHC facilities in Roraima (n =

Chart 1. Compatiblization of questions of relevance for maternal and infant health from module 1 (primary health infrastructure) of the National Program for the Improvement of Access and Quality of Primary Care, in 2012, 2014, and 2017.

Id.	2012		2014		2017		Degree of comparability across years
	Variable	**Category**	**Variable**	**Category**	**Variable**	**Category**	
QE34	I.12.15	Yes/No	I.16.15	Yes/No	I.12.17	Yes/No	High
QE35	I.12.16	Yes/No	I.16.16	Yes/No	I.12.18	Yes/No	High
QE36	I.13.1	Yes/No	I.13.2	Yes/No	I.9.2	Yes/No	High
QE37	I.13.2	Yes/No	I.13.3	Yes/No	I.9.1	Yes/No	High
Q38	I.14.5	Yes/No	I.18.14	Yes/No	I.15.4.2	Yes/No	Total
Q39	I.14.11	Yes/No	I.18.13	Yes/No	I.15.4.1	Yes/No	Total
Q40	I.14.48	Yes/No	Not available		I.15.9.5	Yes/No	Medium
Q41	I.14.56	Yes/No	I.20.13	Yes/No	I.15.9.13	Yes/No	Total
Q42	I.16.1	Yes/No	I.15.1	Yes/No	I.11.1	Yes/No	High
Q43	I.16.2	Yes/No	I.15.2	Yes/No	I.11.2	Yes/No	High
Q44	I.16.3	Yes/No	I.15.3	Yes/No	I.11.3	Yes/No	High
Q45	I.16.4	Yes/No	I.15.5	Yes/No	I.11.7	Yes/No	High

Note: Q1, Q2, Q3, Q4, and Q5 (How many professionals are there working in each profession?). Q6; I.7.2., 1.I.8.1.1 (What shifts do they cover? [Morning]). Q7: I.7.2.2, I.8.1.2 (What shifts do they cover? [Afternoon]). Q8: I.7.2.3, I.8.1.3 (What shifts do they cover? [Night]). Q9: I.8.1.1, .10.1.35.1, I.6.4.1 (Are the rooms well-ventilated or air-conditioned?). Q10: I.8.1.2, I.10.1.35.2, I.6.4.2 (Are the rooms well-lit?). Q11. I.8.1.3I, 10.1.35.3, I.6.4.3 (Are the walls and floors of the facility washable?) Q12: I.8.1.4, I.10.1.35.4, I.6.4.4 (Do the facility's acoustics prevent internal and external noise?). Q13: I.8.1.5 /I.10.1.35.5/I.6.4.5 (Do the consultation rooms ensure privacy for service users?). Q14: I.8.1.5/ I.10.1.35.5/I.6.4.5 (Is there a room exclusively for procedures?); in 2012, >1 is transformed into "yes"; in 2017, included the word "exclusively". Q15: I.9.14/I.10.1.18/I.6.3.5 (Nebulization room); in 2012, > 1 is transformed into "yes". Q16: I.9.17/I.10.1.27/I.6.3.14 (Room for group activities); >1 is transformed into "yes"; in 2014 and 2017, change of wording. Q17: I.18.1/I.6.1 (Is there a vehicle available for external activities by the team(s)?, like home visits, campaigns, follow-up and oversight of work in the field, etc.?) Q18: I.18.2/I.6.2 (Does the vehicle available meet the teams' needs?). Q19: I.17.1.1/I.11.1/I.7.1 (How many working computers are there?). Q20: I.17.10/I.6.3.3 (Do the consulting rooms have a computer with internet connection?). Q21: I.11.2/1; I.12.2/; 1/I.8.2/1 (Adult blood pressure devices: how many in working condition?). Q22: I.11.3/1; I.12.2.1/1; I.8.4/1 (Infant blood pressure devices: how many in working condition?). Q23:I.11.4/1; I.12.3/1; I.8.7/1 (Nebulizers: how many in working condition?). Q24: I.11.8/1; I.12.5/;1I.8.9/1 (Adult scale [up to 150 kg]: how many in working condition?). Q25: I.11.14/1; I.12.10/1; I.8.14 (Light for gynecological examinations: how many in working condition?). Q26: I.11.20/1; I.12.14/1; I.8.15/1 (Examination couch with stirrups: how many in working condition?). Q27: I.11.21/1; I.12.15/1; I.8.16/1 (Examination couch: how many in working condition?). Q28; I.11.25/1; I.12.17/1 and I.12.22/1; I.8.17 and I.8.18 (Pinard horn or stethoscope: how many in working condition?). Add quantities of both equipment. Q29: I.12.5; I.16.7; I.12.14 (Measuring tape always available?); in 2012 and 2014, always/sometimes = yes. Q30: I.12.7; I.16.8; I.12.15 (Disposable speculum always available?); in 2012 and 2014, always/sometimes = yes. Q31: I.12.9; I.16.10; I.12.21 (Endocervical brush always available?); in 2012 and 2014, always/sometimes = yes. Q32: I.12.10; I.16.11; I.12.16 (Ayre spatula always available?); in 2012 and 2014, always/sometimes = yes. Q33: I.12.12; I.16.13; I.12.19 (Slide fixer always available?); in 2012 and 2014, always/sometimes = yes. Q34: I.12.15; I.16.15; I.12.17 (Glass slide with frosted side always available?); in 2012 and 2014, always/sometimes = yes. Q35: I.12.16; I.16.16; I.12.18 (Slide holder always available?); in 2012 and 2014, always/sometimes = yes. Q36; I.13.1; I.13.2; I.9.2 (Pregnancy health booklet always available?); in 2012 and 2014, always/sometimes = yes. Q38; I.14.5; I.18.14; I.15.4.2 (Folic acid). Q39; I.14.11; I.18.13; I.15.4.1 (Ferrous sulphate). Q40; I.14.48; I.15.9.5 (Cephalexin [sodium or hydrochloride]); not available in 2014 (checked by random draw). Q41; I.14.56; I.20.13; I.15.9.13 (Nitrofurantoin). Q42: I.16.1; I.15.1; I.11.1 (Rapid syphilis test); in 2012 and 2014, always/sometimes = yes. Q43: I.16.2; I.15.2; I.11.2 (Rapid pregnancy test – always available?); in 2012 and 2014, always/sometimes = yes. Q44: I.16.3; I.15.3; I.11.3 (Rapid HIV test – always available?); in 2012 and 2014, always/sometimes = yes. Q45: I.16.4; I.15.5; I.11.7 (Malaria screening [thick blood smear] – always available?).

Source: PMAQ-AB 2012, 2014 e 2017.

26 in 2012, n = 55 in 2014, and n = 86 in 2017), providing an improved estimated number of family healthcare and PHC teams, with a view to strengthening SUS planning.

It can also be seen from Table 1 that six municipalities had 100% coverage of PHC facilities in the three periods studied. In three municipalities (Cantá, Caroebe, and Uiramutá) the percentage of coverage increased over the years, but four (Amajari, Boa Vista, São João da Baliza, and São Luiz) had a decline in coverage between 2012 and 2014 and three (Boa Vista, Normandia Rorainópolis, and São Luiz) had a decline in coverage between 2014 and 2017. Regarding the creation of Family Health Support Groups, while there were just nine in 2014 (one in each of nine
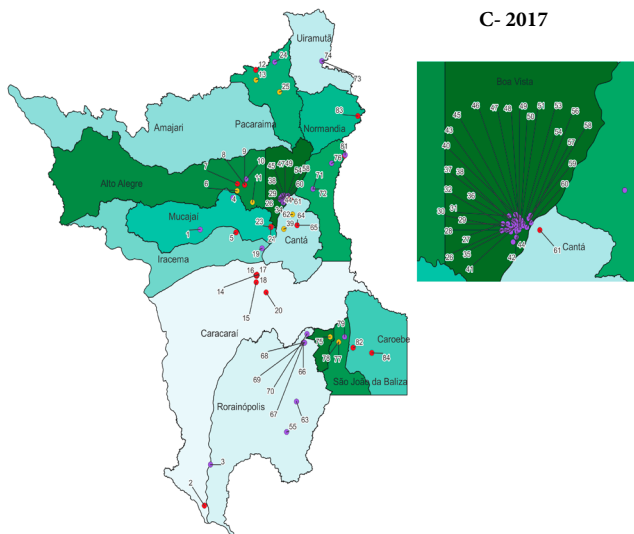
A- 2012
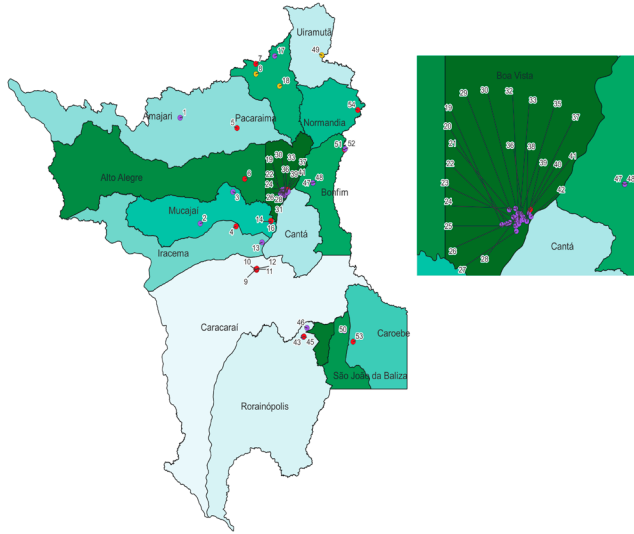
B- 2014
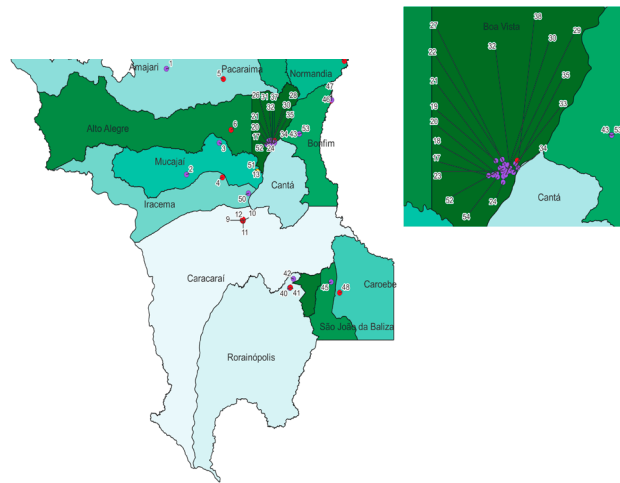
C- 2017

Unit type

- Posto de Saúde (PS)
- Unidade Básica de Saúde (UBS)
- Centro de Saúde (CS)

0.04 hab/km²   52.2 hab/km²

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Figure 1. Georeferencing of the health facilities from Roraima that joined PMAQ-AB: 2012, 2014, and 2017.

1. UBS Venâncio Rodrigues Chaves
2. UBS José Rodrigues Bezerra
3. UBS Sabino Paulo da Silva
4. CS Ana Hipolito dos Santos
5. CS Jair da Silva Mota
6. CS Ana Pereira
7. URF Maria dos Anjos Pimentel Guerreiro
8. PS Andre Fernandes
9. CS Novo Paraiso
10. CS Anfremon Ferreira de Figueiredo
11. CS Manoel Luiz Rodrigues
12. CS Renato Costa Santiago
13. UBS Francisco da Silva
14. UBS Dr Vicenzo di Manso
15. PS J Flores
16. CS Edite Cardoso
17. UBS Telmario Gouveia Coelho
18. PS Surumu
19. UBS Jorge André Gurjão Vieira
20. UBS Sayonara Maria Dantas Licariao Matos
21. UBS Aygara Motta Pereira
22. UBS Lupercio Lima Ferreira
23. UBS Dr Silvio Leite
24. UBS Dr Helio Macedo
25. UBS Senador Helio Campos
26. UBS Asa Branca
27. UBS Raiar do Sol
28. UBS Olenka Macellaro Thome Vieira
29. UBS Pastor Luciano Galdino Rabelo
30. UBS Prof Mariano de Andrade
31. UBS Carana
32. UBS Buritis
33. UBS Cinturão Verde
34. UBS Pricuma
35. UBS Jardim Floresta
36. UBS Mecejana
37. UBS Vilena
38. UBS São Vicente
39. UBS Vanderly Nascimento de Souza
40. UBS 31 de Março
41. UBS Dr Silvio Lofego Botelho
42. UBS Ione Santiago N/A*
43. UBS Anisio Silva
44. UBS Maria Raimunda Batista
45. CS Dra Maria Yandara
46. UBS Antonio Carlos Pereira
47. UBS Maria Jandira Vieira Peixoto São Francisco
48. UBS Alessandra Rosas Sarmento Nova Esperança
49. USF Uiramuta Jose Julio
50. UBS Regina Ribeiro Paiva
51. CS Cristino José da Silva
52. UBS Diminiz Diniz da Silva
53. CS Claiton O da Silva
54. CS Iracema Galvão
55. UBS Antonio Lucas de Souza
56. UBS São Vicente
57. UBS Vanderly Nascimento de Souza
58. UBS 31 de Março
59. UBS Dr Silvio Lofego Botelho
60. UBS Ione Santiago
61. CS Jose Eucio Rodrigues
62. PS Martinho Paulo Israel
63. UBS Vila do Equador
64. PS Cicero Rodrigues de Morais
65. CS Sebastião Rodrigues Silva
66. UBS Anisio Silva
67. UBS Maria Raimunda Batista
68. CS Dra Maria Yandara
69. UBS Gentil Carneiro Brito
70. UBS Antonio Carlos Pereira
71. UBS Maria Jandira Vieira Peixoto São Francisco
72. UBS Alessandra Rosas Sarmento Nova Esperança
73. USF Uiramuta Jose Julio
74. UBS David Cavalcante de Lima
75. PS Raimunda de Araujo Silva
76. UBS Estevam Pereira da Costa Tucano
77. CS Noeme Tereza de Jesus
78. PS Nelson Dias Fernandes
79. UBS Regina Ribeiro Paiva
80. CS Cristino José da Silva
81. UBS Diminiz Diniz da Silva
82. CS Claiton O da Silva
83. CS Iracema Galvão
84. CS Walter Gomes Portela
85. CS Antonio Pereira da Silva

* No coordinates found.

Figure 1. Georeferencing of the health facilities from Roraima that joined PMAQ-AB: 2012, 2014, and 2017.

Source: Authors.

municipalities), by 2017 there were three in Boa Vista and one in all but two of the other municipalities (Cantá and Normandia).

Regarding the participation in healthcare facilities in Roraima to PMAQ-AB, this rose from 18% in 2012 to 48% in 2014, and around 100% in 2017. A progressive increase was also observed over the years in 14 of the 15 municipalities, the exception being Amajari, which saw increased participation between 2012 and 2014, but then a drop to zero in 2017. In 2014, the only municipality to with 100% participation was Bonfim,

Gondim DAD et al.

Table 1. Characteristics of primary health care and its management in the municipalities of Roraima in 2012, 2014, and 2017.

	2012					
	PMCcov (%)	**CHW (n)**	**FHS (n)**	**OHS (n)**	**FHSU (n)[1]**	**PMAQ Participation (%)**
Alto Alegre	100.00	52	6	2	0	9.09
Amajari	97.63	17	2	0	0	7.69
Boa Vista	71.14	193	40	0	0	33.33
Bonfim	100.00	35	5	0	0	33.33
Cantá	97.32	39	4	1	0	0.00
Caracaraí	100.00	50	6	0	0	18.75
Caroebe	83.13	22	2	0	0	0.00
Iracema	100.00	26	4	0	0	0.00
Mucajaí	100.00	38	5	0	0	44.44
Normandia	100.00	25	3	0	0	0.00
Pacaraima	100.00	29	4	1	0	14.29
Rorainópolis	74.53	59	0	0	0	42.86
São João Da Baliza	100.00	16	2	0	0	0.00
São Luiz	100.00	20	3	1	0	0.00
Uiramutã	68.70	11	2	0	0	0.00
	2014					
Alto Alegre	100.00	52	6	2	0	9.09
Amajari	97.63	17	2	0	0	7.69
Boa Vista	71.14	193	40	0	0	33.33
Bonfim	100.00	35	5	0	0	33.33
Cantá	97.32	39	4	1	0	0.00
Caracaraí	100.00	50	6	0	0	18.75
Caroebe	83.13	22	2	0	0	0.00
Iracema	100.00	26	4	0	0	0.00
Mucajaí	100.00	38	5	0	0	44.44
Normandia	100.00	25	3	0	0	0.00
Pacaraima	100.00	29	4	1	0	14.29
Rorainópolis	74.53	59	0	0	0	42.86
São João Da Baliza	100.00	16	2	0	0	0.00
São Luiz	100.00	20	3	1	0	0.00
Uiramutã	68.70	11	2	0	0	0.00
	2017					
Alto Alegre	100.00	52	7	7	1	100.00
Amajari	95.16	19	3	1	1	0.00
Boa Vista	65.75	297	49	0	3	98.08
Bonfim	100.00	35	6	6	1	100.00
Cantá	100.00	39	5	2	0	100.00
Caracaraí	100.00	47	8	8	1	100.00
Caroebe	97.83	25	4	2	1	100.00
Iracema	100.00	26	5	5	1	100.00
Mucajaí	100.00	43	6	6	1	100.00
Normandia	77.78	0	0	0	0	100.00
Pacaraima	100.00	28	5	4	1	100.00
Rorainópolis	93.23	45	8	5	1	100.00
São João Da Baliza	98.41	14	3	2	1	100.00
São Luiz	95.50	20	3	3	1	100.00
Uiramutã	100.00	29	4	2	1	100.00

[1] Sum of FHU types I, II, and III; [2]. Sum of OHS types I and II; N.B.: mean participation in PMAQ in Roraima was: 18% in 2012, 48% in 2014, and approximately 100% in 2017.

Legend: PMCCov = primary health care coverage; CHW = community health workers; FHS = family health strategy; OHS = oral health strategy; FHU = family health support unit.

Source: e-Gestor Atenção Básica, Department of Family Health, Primary Health Care Secretariat, Ministry of Health.

while in 2017 all the municipalities but two (Amaraji and Boa Vista) achieved 100% participation (Table 1).

As for the standardization of the questions pertaining to maternal and infant care (based on module 1 of the PMAQ-AB, which refers to the structure of the PHC facility), the formulation of the questions was exactly the same (total comparability) in 21 of the 45 items investigated, while small changes in form, but not content, occurred in another 20 items (high comparability). The remaining four items displayed significant changes, but still referred to the same concepts over time (medium comparability).

Regarding the distribution of the physical infrastructure needed for primary maternal and infant healthcare in Roraima, the North, and across Brazil, the number of PHC facilities increased progressively between 2012 and 2017 in Roraima – an increase that was reflected throughout the North region and in Brazil (Table 2). The number of professionals in all categories was higher in Roraima in 2012 and 2014 than in the other territories included in the study. In 2017, the indicators relating to human resources dropped substantially in Roraima, and also decreased in the North and across Brazil.

There were statistically significant differences in the state of the physical infrastructure between 2012 and 2017. Roraima improved vis-à-vis the North and Brazil: its percentages were lower in 2012, but exceeded those of the North and Brazil in 2017 with regard, among other aspects, to the quality of the environment (ventilation/air conditioning, lighting, acoustics, etc.) (Table 2). In all three geographical areas studied, the mean availability of computers increased (Table 2).

As for the distribution of equipment, supplies, and medicines needed for maternal and infant healthcare in the PHC facilities, there was a greater availability of adult blood pressure devices, examination couches, and Pinard horns or stethoscopes in Roraima than there was in the North region as a whole or Brazil in all three years investigated. As for other equipment, such as nebulizers, adult scales, and couches with stirrups (for gynecological examinations), there was a greater availability of these in Roraima vis-à-vis the North region, but not in comparison to Brazil as a whole (Table 3).

However, the availability of inputs decreased in Roraima between 2012 and 2017, and a similar trend was identified in the North and in Brazil, albeit to a less marked degree. The year 2014 proved to be one in which the availability of inputs was greater in Roraima, the North Region and Brazil (Table 3).

Finally, as for medications, the availability of folic acid, ferrous sulfate, and cephalexin in Roraima was highest in 2012, reaching its lowest point in 2014, and rising again in 2017, but not to 2012 levels. In the North and in Brazil, the availability of these medicines dropped consistently from one period to the next. The distribution of tests for syphilis increased substantially in Roraima from 2012 to 2014, and to a lesser extent in the North and in Brazil. As for HIV tests, their availability fell between 2014 and 2017 in Roraima, but increased in the North and in Brazil in the same period (Table 3).

Discussion

This study investigated the availability of resources needed for the quality of maternal and infant care in Roraima, the North of Brazil, and Brazil, using data from three years: the geographical distribution of PHC facilities, the physical infrastructure of the facilities, the human resources available, and the availability of medicines and medical supplies and equipment.

Roraima was found to have full PHC coverage in six of its 15 municipalities in all three years studied. Of the remaining nine, Cantá, Carobé, and Uiramutá achieved improved PHC indicators. In contrast, this coverage declined in Amajari, Boa Vista, São João da Baliza, and São Luiz between 2012 and 2014, and in Boa Vista, Normandia, Rorainópolis, and São Luiz between 2014 and 2017.

In 2014, there was at least one family health support unit in each of nine of the 15 municipalities in Roraima. In 2017, the state capital Boa Vista had three centers, and all the other municipalities except Cantá and Normandia had one apiece. The purpose of these centers is to provide a comprehensive, multidisciplinary health strategy to enhance the effectiveness of PHC, increasing its territorial coverage and scope of services[18].

In Roraima, as in Brazil, multidisciplinary health teams form the backbone of family health support system. In addition to family doctors, there are social workers, speech therapists, physiotherapists, veterinarians, public health nurses, and psychologists, who provide services for households through combined consultations between the doctor and other specialists, when necessary, to put the strategies into practice. Furthermore, it offers group prenatal guidance and

Table 2. Distribution of infrastructure and human resources needed for material and infant health care at primary health care facilities in Roraima, the North region, and Brazil. PMAQ-AB 2012, 2014, and 2017.

Items Investigated	Roraima [1][a]			North Region [1][b]			Brazil [1][c]		
	2012	2014	2017	2012	2014	2017	2012	2014	2017
Total PHC facilities (N)	28	55	86	804	1690	2384	13843	24055	30346
Q6. Opening hours, morning shift (% yes) – [b]	100.0	100.0	-	99.5	99.3	-	99.8	99.8	-
Q7. Opening hours, afternoon shift (% yes) – [bc]	100.0	98.2	-	93.3	94.1	-	94.9	97.9	-
Q8. Opening hours, night shift (% yes) – [b]	7.1	5.5	-	6.6	5.0	-	4.9	5.0	-
Q9. Rooms well ventilated or air-conditioned (% yes) – [abc]	53.6	67.3	84.9	60.8	64.3	74.2	71.4	68.7	83.1
Q10. Rooms well lit (% yes) – [abc]	60.7	70.9	87.2	67.7	73.4	79.2	73.5	79.5	85.6
Q11. Floors, walls, and ceilings with flat/washable surfaces (% yes) – [abc]	39.3	49.1	74.4	48.0	53.4	62.8	54.6	58.8	67.4
Q12. Acoustics designed to prevent external noise pollution (% yes) – [abc]	35.7	50.9	91.9	42.2	51.7	57.8	40.6	57.2	67.9
Q13. Privacy for users during consultations (% yes) – [bc]	100.0	92.7	93.0	86.4	89.7	82.4	89.0	89.8	86.0
Q14. Procedure room (% yes) – [bc]	53.6	69.1	55.8	46.6	69.6	37.2	51.8	78.8	42.2
Q15. Nebulization room (% yes) – [abc]	25.0	54.5	23.3	20.1	49.6	22.3	30.2	63.4	32.0
Q16. Group activity room. (% yes) – [abc]	28.6	23.6	50.0	29.0	27.2	35.2	45.5	42.3	48.9
Q17. Vehicle for off-site activities (% yes) – [abc]	42.9	21.8	-	45.3	34.9	-	73.7	67.5	-
Q18. Vehicle to meet health team's needs (% yes) – [bc]	10.7	14.5	-	28.6	28.8	-	50.6	58.2	-
Q20. Computer with internet connection in consultation room (% yes) – [bc]	39.3	-	38.4	58.8	-	37.6	58.5	-	54.1
Q1. No. of health workers: specialized physician - (mean quantity) – [bc]	0.67	0.67	0.26	0.23	0.60	1.04	0.55	1.10	1.36
Q2. No. of health workers: psychologist - (mean quantity) – [bc]	0.33	0.28	0.09	0.12	0.44	0.14	0.28	0.62	0.34
Q3. No. of health workers: physiotherapist - (mean quantity) – [abc]	0.41	0.11	0.04	0.17	0.56	0.22	0.29	0.65	0.32
Q4. No. of health workers: nutritionist - (mean quantity) – [bc]	0.12	0.28	0.04	0.13	0.48	0.20	0.24	0.54	0.24
Q5. No. of health workers: social worker - (mean quantity) – [abc]	0.08	0.33	0.17	0.10	0.41	0.16	0.20	0.41	0.18
Q19. No. of working computers - (mean quantity) – [abc]	2.00	1.33	5.47	2.66	1.44	4.39	4.02	2.81	5.52

(1) Tests used for categorical variables: Fisher/chi-squared for continuous variables; ANOVA (Brazil and North) and Kruskal-Wallis (Roraima). (a) p-value < 5% between years for Roraima; (b) p-value < 5% between years for North; (c) p-value < 5% between years for Brazil.

Source: PMAQ-AB 2012, 2014 e 2017.

lectures, and liaises with the broader PHC network, improving the territorialization and regionalization of care, all with the aim of strengthening PHC[19].

Alongside the expansion of family health support units, our results show that participation in PMAQ-AB grew significantly, rising from 18% in 2012 to approximately 100% in 2017. The performance of some municipalities was atypical: for example, participation in Amajari grew from 2012 to 2014, but then dropped to zero in 2017. Bonfim was the first town to achieve full participation (in 2014), with the other municipalities (except Amaraji and Boa Vista) following suit in 2017. A similar increase in participation was observed nationwide[20], which had a positive impact

Table 3. Distribution of medicines, medical supplies, and equipment needed for material and infant health care at primary health care facilities in Roraima, the North region, and Brazil. PMAQ-AB 2012, 2014, and 2017.

Items investigated	Roraima [1][a]			North Region [1][b]			Brazil [1][c]		
	2012	2014	2017	2012	2014	2017	2012	2014	2017
Total PHC facilities (N)	**28**	**55**	**86**	**804**	**1690**	**2384**	**13843**	**24055**	**30346**
Q21. Adult blood pressure device - (mean quantity) – [abc]	2.36	2.60	4.02	2.26	2.36	2.72	3.17	3.15	3.27
Q22. Pediatric or neonatal blood pressure device - (mean quantity) – [abc]	0.29	1.22	1.17	0.56	1.32	0.96	0.73	1.45	1.18
Q23. Nebulizer - (mean quantity) – [bc]	1.43	1.66	1.25	1.01	1.19	1.10	1.47	1.74	1.31
Q24. 150 kg scale - (mean quantity) – [abc]	0.82	2.11	1.49	1.07	1.28	1.16	1.29	1.58	1.21
Q25. Light for gynecological examination - (mean quantity) – [abc]	1.32	1.18	2.33	1.10	1.26	1.38	1.35	1.45	1.50
Q26. Examination couch with stirrups - (mean quantity)– [bc]	1.18	1.25	1.10	1.07	1.17	1.24	1.25	1.33	1.32
Q27. Examination couch – (mean quantity) – [abc]	2.50	3.07	3.90	2.20	2.50	3.13	2.86	3.13	3.74
Q28. Pinard horn or stethoscope – (mean quantity)– [abc]	1.68	2.22	3.33	1.25	2.04	2.09	1.59	2.32	2.38
Q29. Measuring tape (% yes) – [c]	92.9	96.4	90.7	96.8	97.3	91.1	97.5	98.3	92.8
Q30. Disposable speculum (% yes) – [bc]	100.0	96.4	90.7	95.9	93.7	88.6	92.3	95.5	92.7
Q31. Endocervical brush (% yes) – [bc]	100.0	96.4	93.0	94.2	91.9	88.8	96.7	97.2	93.1
Q32. Ayre spatula (% yes) – [c]	100.0	96.4	91.9	93.7	91.7	88.0	96.5	97.2	92.8
Q33. Slide fixer (% yes) – [abc]	71.4	90.9	93.0	84.7	86.3	86.8	83.6	94.0	91.7
Q34. Glass slide with frosted side (% yes) – [bc]	100.0	94.5	93.0	91.2	89.6	87.7	95.9	96.9	93.1
Q35. Slide holder (% yes) – [bc]	96.4	92.7	94.2	77.1	78.3	82.4	83.6	89.2	89.0
Q36. Printed matter: pregnancy health booklet (% yes) – [bc]	96.4	96.4	88.4	96.0	96.6	84.4	87.8	94.1	88.9
Q37. Printed matter: infant health booklet (% yes) – [bc]	92.9	78.2	74.4	84.2	81.8	74.9	76.8	79.8	75.4
Q38. Folic acid. (% yes) – [abc]	85.7	38.2	59.3	68.5	61.4	60.4	71.3	66.6	58.5
Q39. Ferrous sulphate. (% yes) – [abc]	92.9	43.6	77.9	75.7	65.3	58.0	72.4	68.2	57.8
Q40. Cephalexin (sodium or hydrochloride). (% yes) – [bc]	89.3	-	73.3	61.9	-	49.9	59.7	-	51.9
Q41. Nitrofurantoin (% yes) – [c]	3.6	3.6	4.7	8.1	7.0	5.0	17.1	15.9	13.3
Q42. Rapid syphilis test (% yes) – [abc]	28.6	81.8	74.4	10.4	39.8	73.5	3.5	28.7	68.8
Q43. Rapid pregnancy test (% yes) – [abc]	75.0	34.5	51.2	19.4	17.0	25.9	6.8	28.5	39.9
Q44. Rapid HIV test (% yes) – [abc]	14.3	85.5	80.2	11.6	40.3	73.8	15.9	30.2	69.8
Q45. Malaria screening (thick blood smear) (% yes) – [bc]	50.0	50.9	38.4	18.4	18.5	13.6	2.3	2.1	1.2

(1) Tests used for categorical variables: Fisher/chi-squared for continuous variables; ANOVA (Brazil and North) and Kruskal-Wallis (Roraima). (a) p-value < 5% between years for Roraima; (b) p-value < 5% between years for North; (c) p-value < 5% between years for Brazil.

Source: PMAQ-AB 2012, 2014 e 2017.

on PHC management, access, and quality of care. This final factor was instrumental in achieving a comparable quality of care across the country[8,18].

These data are consistent with the importance of the PMAQ-AB in changes occurring in the Ministry of Health, mainly regarding the rules for participation in the program, which in turn points to the centrality of PHC and the redesign of the regionalization and financing of the public health system, SUS, as evaluation strategies[2].

Studies of the distribution of PHC facilities that participated in PMAQ-AB show they tend to be in urban areas[20]. This also applied to Roraima in 2012, but by 2017 the pattern had changed,

as there was 100% participation in the majority of the municipalities. Nonetheless, a direct relationship can be observed between population density and the supply of health services, which in a way impacts the distribution of participation in PMAQ-AB.

According to Garnelo *et al.* (2018)[6], health facilities are generally introduced according to the demographic density of the territory. Consequently, accessing PHC is harder in areas of the Legal Amazon, where there is lower demographic density, leaving these patients no option but to make their own way to the places where there are floating and riverside PHC units[7].

For Louzada and Ramos[21], the main obstacles in the healthcare offered by the PHC facilities that participated in PMAQ-AB are their location and their distance from patients' homes, prompting the need to provide transportation options and therefore raising costs. Similarly, the geographical relief and peculiarities of the forest and the state of Roraima as a whole hamper the logistics and distribution of medical supplies[21].

As mentioned above, in order to conduct a longitudinal analysis of our study data, a process had to be employed to make the different versions of the PMAQ-AB instruments investigated compatible. Nonetheless, the level of comparability of most of the questions relating to maternal and infant healthcare was high across the years studied, even though some important questions did not appear in all the cycles.

The absence of some data in all three cycles limited the longitudinal comparability of some topics of importance for maternal and infant health. Specifically, information on the following subjects was only available for 2012: personal protective equipment (gloves, goggles, masks, aprons, caps, etc.); pregnancy records in the PHC Information System; requisition records and cytopathology test results in the SISCOLO system; and prenatal care records. The inability to monitor these aspects hampers planning and the appraisal of subjects that are important for healthcare of any kind. The availability of accurate information of this kind would help managers revise and formulate policies for women's health[22].

Therefore, it could be said that indicators such as these can yield the knowledge needed to support and substantiate public planning and policymaking in different spheres of government, enabling the monitoring of the population's living conditions and wellbeing and thus allowing for more in-depth research into societal changes and the determinants of different social phenomena[5].

Overall, the data analyzed in this study revealed some significant improvements in the indicators related to physical infrastructure, such as ventilation, air conditioning, etc., and also in the distribution of instruments and equipment needed for maternal and infant healthcare in Roraima, which saw progressive growth between 2014 and 2017. However, the availability of essential supplies – not only medicines, but also other materials and equipment, such as vehicles to enable home visits – and the average amount of human resources diminished. It should be noted that the ability to monitor the availability of vehicles for home visits is particularly important in areas such as Roraima, where, as explained above, the distance between patients and health units is a significant challenge[6].

It is worth noting that the time period studied coincided with a period of significant migration of Venezuelans and Guyanese into Roraima, which began in 2015, and therefore had a major impact on the data from 2017[23,24]. This influx of migrants could have overloaded the state's health system, as it may have led to an increased utilization of medical supplies, medicines, and other healthcare resources, affecting the overall quality of care. Similar results were found in an in-depth study into the impact of Venezuelan immigration on local health services in Roraima, based on different data from those used here[25,26].

Even so, our analysis indicates that the PHC infrastructure in Roraima improved significantly between 2012 and 2017 in terms of the physical infrastructure needed to receive and care for patients. Furthermore, there was an increase nationwide in the number of computers in PHC facilities. However, the data available in the PMAQ-AB and e-Gestor databases were insufficient to enable a more detailed picture of the IT infrastructure and thus a fuller discussion of the topic, such as the quality or quantity of internet connections.

Another cause for concern is the availability of medicines such as cephalexin, folic acid, and ferrous sulfate, which declined overall in the three periods, reaching the lowest level in 2014 and recovering slightly in 2017. Furthermore, data on the availability of cephalexin were not complete in 2014. At the same time, despite the increase in testing for syphilis between 2012 and 2014, the same did not apply for HIV testing, which declined not only in Roraima, but across the country from 2014 to 2017.

Finally, it is worth noting the low level of malaria testing, particularly for a region where the

disease is endemic: the vast majority (99.7%) of all cases of malaria in Brazil occur in the Amazon region[27]. This is therefore a deficit in the state's health strategy, especially for prenatal care[28]. It is estimated that around the world, some 50 million pregnant women are exposed to the risk of malaria infection every year. Malaria can affect the course of a pregnancy and lead to a range of negative outcomes, including anemia, premature delivery, low birth weight, fetal loss, and maternal death[29,30] cross-border importation of malaria has become a challenge to malaria elimination. The border areas between Brazil and Venezuela have experienced high numbers of imported cases due to increased population movement and migration out of Venezuela. This study aimed to identify risk factors for imported malaria and delineate imported malaria hotspots in Roraima, Brazil and Bolivar, Venezuela between 2016 and 2018. Data on malaria surveillance cases from Roraima, Brazil and Bolivar, Venezuela from 2016 to 2018 were obtained from national surveillance systems: the Brazilian Malaria Epidemiology Surveillance Information System (SIVEP-Malaria.

The limitations of this study include the fact that the analysis of issues related to maternal and infant health was restricted by the way PMAQ-AB is structured – a limitation that is standard when using secondary databases, as few details regarding the availability of medical supplies, medicines, and equipment needed for patient care are made available to the public.

Any generalization of the results presented depends on the health facilities' participation in PMAQ-AB; however, as explained above, this is something that evolved significantly and positively throughout the cycles. It is therefore to be hoped that more detailed comparisons will be possible in the future based on new data.

Most studies on maternal and infant health tend to analyze indicators of the healthcare process (e.g., number of services provided) and outcomes (e.g., maternal and infant mortality). However, being able to adequately assess the availability and quality of physical healthcare infrastructure is essential to overcome deficits in indicators of maternal and infant health and revise strategies to meet the needs of the population, as well as to understand the health system's operational capacity and its ability to meet demands[11,12,14].

This research was based on information extracted from public, freely available secondary databases, whose data are detailed on a national and subnational level (macro-regions and states). These databases can therefore help the scientific community by serving as a basis for other research. Since the vast majority of the issues investigated were largely compatible across the cycles, this study could be replicated for other states and to address other health topics, such as hypertension, mental health, preventive care, multidisciplinary care, and many others.

The improvements to the health infrastructure in Roraima are undeniable; however, they contrast dramatically with the decline in human resources, particularly in view of the sharp population growth in mid-2015. Future studies could investigate the quality of maternal and infant care in view of this fact.

Finally, it is essential to highlight that this same methodology for ensuring compatibility across the PMAQ cycles could be applied to Module II (PHC teams) and Module III (PHC users) of PMAQ-AB, enabling assessments of healthcare processes and outcomes from these perspectives.

While recognizing this methodology could be replicated for future studies addressing issues of concern both to maternal and infant health and to other areas covered by PMAQ-AB, this is currently hampered by the fact that the federal government discontinued this important program in 2019. Muzy et al. (2021)[31] note that this decision has significantly impacted SUS, especially with regard to the treatment and prevention of chronic diseases, as it was the only way some services could be monitored, reinforcing regional inequalities in PHC. It also leaves a hiatus in the data needed for future analyses of performance indicators of importance to so many aspects of healthcare management, such as PHC[20].

It is worth noting that although the federal government replaced the family health support strategy with the Previne Brasil ("Prevent Brazil") Program in 2019 (Ministry of Health Ordinance #2,979), which also resulted in changes to the PHC funding mechanism, the indicators of maternal and infant healthcare used in this study were not affected. In other words, this methodology is replicable for future monitoring and evaluation of maternal and infant healthcare, provided PMAQ-AC is reinstated by the Ministry of Health.

This study constitutes an important contribution to actions within the sphere of reproductive rights, whose findings could be used in developing public policies aimed at improving the quality of women's healthcare in Roraima.

Furthermore, it could be used to review PHC in-frastructure planning, given the understanding it fosters of the impact of the demographics on access, coverage, infrastructure, medicines, and medical supplies and equipment in the organization and provision of primary care services needed for maternal and infant healthcare.

Collaborations

DAD Gondim was responsible for developing the study concept, reviewing existing literature, analyzing the collected data and writing the manuscript. MR Campos contributed to the development of the study concept, methodological design, data collection, data analysis and critical review of the manuscript. D Castanheira participated in the development of the concept, literature review, data analysis, writing of the manuscript and critical review. Each author played an essential role in carrying out this study and their contributions were fundamental to the quality and integrity of the work presented.

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