Correlation between drinking water quality and occurrence of diarrhea and hepatitis A in the Federal District/Brazil

Correlação entre qualidade da água e ocorrência de diarreia e hepatite A no Distrito Federal/Brasil

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ABSTRACT Safe and efficient public water supply is still a challenge in Brazil. This may lead to an increased incidence of diseases such as Acute Diarrheal Disease (ADD) and hepatitis A. The aim of this study was to associate the quality of water distributed and the occurrence of ADD and hepatitis A in the Federal District (FD) (Brazil) between 2012 and 2017. Data regarding the complaint rates related to water and the non-compliance of its quality were provided by the Supply Company of the FD. The occurrence rates of ADD and hepatitis A were obtained by the Department of Health. Complaint rates were directly related to the non-conformities in relation to free residual chlorine concentration and turbidity of water; however, that relation was inverse to the injuries. This shows that the monitoring carried out by the concessionaire's quality control was relevant in reducing these problems, even during the intermittent supply period (2017). Therefore, the communication channel between users and the service provider was fundamental for the company's corrective actions, which reflected in the reduction of ADD and hepatitis A cases.

KEYWORDS Basic sanitation. Water rationing. Diarrhea. Hepatitis A.

RESUMO *O abastecimento público de água de maneira segura e eficiente ainda é um desafio no Brasil. Isso pode levar a um aumento na incidência de agravos como Doença Diarreica Aguda (DDA) e hepatite A. O objetivo deste trabalho foi associar a qualidade da água distribuída e a ocorrência de DDA e hepatite A no Distrito Federal (DF) (Brasil) entre 2012 e 2017. Os dados referentes aos índices de reclamação relativos à água e da não conformidade da sua qualidade foram cedidos pela Companhia de Abastecimento do DF. As taxas de ocorrência de DDA e hepatite A foram obtidos pela Secretaria de Saúde. Os índices de reclamação tiveram relação direta com os de não conformidades na concentração de cloro residual livre e de turbidez da água; no entanto, essa relação foi inversa aos agravos. Isso mostra que o monitoramento realizado pelo controle de qualidade da concessionária teve relevância na redução desses agravos, inclusive durante o período de intermitência no abastecimento (2017). O canal de comunicação entre os usuários e o prestador de serviços, portanto, foi fundamental para as ações corretivas da empresa, o que refletiu na redução de casos de DDA e de hepatite A.*

PALAVRAS-CHAVE *Saneamento básico. Racionamento de água. Diarreia. Hepatite A.*

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Introduction

The concern about distributing water in a safe way to avoid the occurrence of waterborne diseases has been happening since the ancient civilizations[1]. However, the correlation between the occurrence of health problems and the public supply system was only performed in 1832 by John Snow, in Inglaterra[2]. From this milestone, regulations to ensure that all forms of water supply would occur in a sanitary way were created to prevent waterborne diseases from occurring.

The water may contain inappropriate constituents, and treatment prior to consumption is necessary. After this procedure, water is usually distributed through pipelines and reservoirs to users. Thus, the public water supply system consists of water treatment and distribution. Leaks in the pipes and intermittence of the system can compromise the quality of the water reaching the population and thus carry etiologic agents causing diseases, being one of the most common symptoms to acute diarrhea[3,4]. The so-called Acute Diarrheal Diseases (ADD) is of infectious origin and can be caused by different agents, being characterized by constant evacuation, and may lead to dehydration[5].

From 2010 to 2014 alone, 21 million ADD in children under the age of 5 years were reported in the Federal District (FD), probably due to inadequate water supply; however, a reduction in this epidemiological picture has been observed in recent years[6]. In addition to ADD, a very characteristic health indicator in relation to water supply is the occurrence of hepatitis A.

Ordinance MS nº 2.914[7] defines parameters and criteria for acceptance of water quality at its various levels: after treatment, reservoirs and distribution network. The quality of water distributed in a city should be verified by the concessionaire that administers these services both by its quality control and by the municipality or by the FD, through health surveillance. Among the priority parameters used to monitor water quality, turbidity, free residual chlorine and microbiological contamination (Total Coliforms and *Escherichia Coli*) stand out. These parameters may signal irregularities in the supply system. The standard states that the water of the distribution network must have between 0.5 and 5.0 $mg.L^{-1}$ free residual chlorine and a turbidity below 5 UNT (Nephelometric Turbidity Unit), besides being free of microbiological contamination.

The FD belongs to the Central Plateau, where are the main headwaters of the three great Brazilian hydrographic regions: Tocantins-Araguaia, São Francisco and Paraná. This way, the water availability of the region depends directly on the incidence of rainfall. However, the year 2016 was marked by a drop in the rainfall index, which caused a significant reduction in these main reservoirs of the city[8]. Containment measures such as supervision and reduction in the granting of agricultural activities and awareness of the rational use of water were not sufficient to avoid a rotation of public water supply in 2017. This alternation worked with a day of interruption, two for water return (regularization period) and four with standardized water supply[9].

Therefore, the objective of this study was to make a possible correlation between the nonconformities regarding the water quality that supplies the FD, the complaint rates of users regarding the water consumed and the occurrence of ADD and hepatitis A in the period from 2012 to 2017.

Material and methods

An ecological study was carried out having as unit of analysis the population of FD, Brazil. This approach aims to relate exposure indicators to the epidemiological indicators of certain population groups. Exposure indicators were the different parameters used to define the water quality that supplied the FD, while the epidemiological indicators were the

occurrence of diseases recognized as associated with water quality. This study occurred between 2012 and 2017, period that incorporated the year in which water scarcity and rotation were declared in the public supply.

Results on the quality of the water distributed were provided by the Regulatory Agency for Water, Energy, and Basic Sanitation (Adasa). These data are open to the population as determined by the law on access to information. The parameters obtained were: Free Residual Chlorine (FRC), Turbidity (T), Total Coliforms (TC) and *Escherichia Coli* (EC). Usually, the concessionaire collects a minimum number of samples from the distribution network depending on the parameter to be analyzed. Samples that, haply, may have been found to fall outside the standards recommended by the ordinance *(table 1)* are identified as Non-Conforming (NC). The monthly data of total samples collected in the network as well as the quantity of NC samples were made available by Adasa. The Non-Compliance Indexes (NCI) of the water distributed in the FD for each parameter was calculated from the ratio between the quantity of NC samples and the total amount of samples collected in the period. In order to be able to correlate with the indices of diseases (ADD and hepatitis A), the integration of these data per year was carried out.

Complaints data regarding water quality were accessed directly from the Performance Indicators Report of the Company, which are data also open to the population. This report contains all complaints made to the company regarding water or not. Accordingly, the Relative Complaints Index (RCI) was calculated by the ratio of water quality complaints to the total complaints that came to the company. Data regarding the occurrence of ADD and hepatitis A in FD were provided by the Health Department. It was possible to obtain all these data for each month of the period of this study. The ADD and hepatitis A rate per thousand inhabitants was determined from the ratio between the occurrence of each grievance and the estimated population in the corresponding year multiplied by one thousand.

All data obtained were plotted by month in order to know the trend of each indicator in the period, except for the complaint rates, as they are not available. The NCI for each water quality and RCI parameter per year (independent variables) were analyzed by their 'one-to-one' correlation with ADD rate and hepatitis A rate (dependent variables). In addition, a probable correlation analysis was performed between the NCI (independent variables) and the RCI (dependent variable).

Initially, simple linear regression analysis was performed between each group of variables (dependent and independent) to select the indicators that were used in the Stepwise analysis. The significance level adopted in these correlations was 20% ($p \leq 0,2$). All statistical tests were performed using the R-Studio program.

Results and discussion

Water quality distributed in the Federal District

Figure 1 shows that, from 2015, there was an increase in the number of water samples from FD with non-compliance with the acceptable quality standard for FRC, T, TC and EC. It is observed that the non-compliances of these samples were more significant in the year in which the rotation was implemented in the supply *(figure 1)*. However, during this period, the number of samples taken from the network was higher than in the previous ones *(table 1)*.

Figure 1. Number of Non-compliant (outside the potability standard) monthly samples in water distributed in FD between 2012 and 2017 according to the priority parameters of Free Residual Chlorine (A); Turbidity (B); Total Coliforms (C) and *Escherichia Coli* (D). Data provided by the Regulatory Agency for Water, Energy, and Basic Sanitation (Adasa)

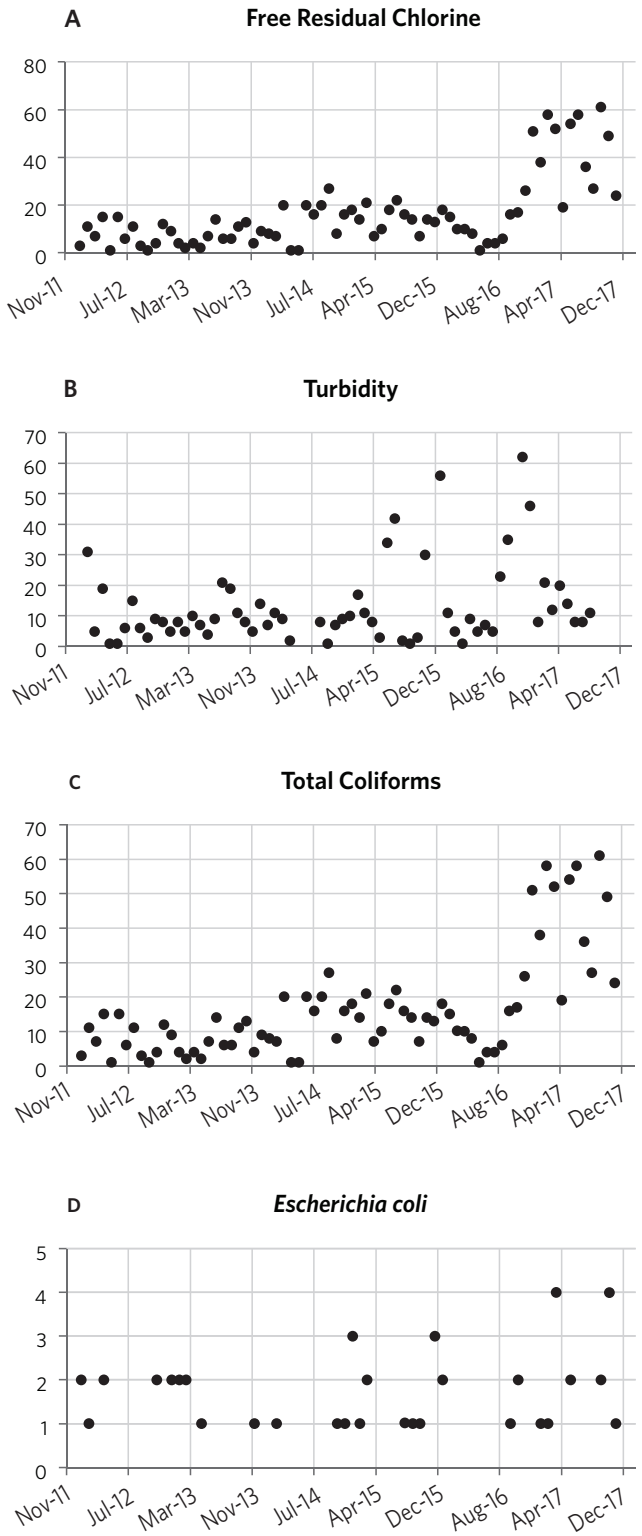


Table 1 shows the number of samples collected by the quality control of the concessionaire between 2012 and 2017, as well as the NCI of the water quality in relation to the parameters FRC, T, TC and EC, the annual injury rates for ADD and hepatitis A, the estimated population each year and the population growth rate.

The parameters that had the most expressive number of NC samples were FRC, TC and T *(table 1)*. Morais and collaborators[10] obtained FRC values below that recommended by the ordinance when monitoring the distributed water in Goiás. The low concentration of chlorine in the distribution network may occur due to operational errors during the water treatment process (inadequate chlorine dosage) and/ or its consumption in the network itself (organic matter present in the network)[11]. The intermittent water supply can cause internal dryness in the pipes and this can cause the detachment of fouling and silt, which, with the return of water, can be carried, causing an increase of T and the concentration of organic material in water; and this increase can consume the chlorine of the net[12]. The incrustation and the slime are formed with the time of use and are common in the distributions13. The NCI of TC and T in 2017, the year in which the water rotation was operated, was smaller than in 2016 *(table 1)*. A possible explanation for this may be the maneuver during the rationing period, in which water sampling was performed only after normalization of supply, that is, 48 hours after the return of water. With this, the frequency of NC samples for these two parameters tends to be lower, a fact that was not reflected in the FRC. Therefore, 48 hours may not have been sufficient for the normalization of the supply network.

Table 1. Variables collected by databases: amount of samples collected in the water distribution network by the utility, relative percentage of non-compliance samples (NCI), relative complaints index (RCI) to water quality, total estimated population of FD and population growth rate

Variables		Data Collection Period					
		2012	2013	2014	2015	2016	2017
Amount of Samples Collected	FRC(1)	9.174	9.243	8.474	10.546	8.552	19.517
	T(2)	9.117	9.237	8.408	10.544	8.540	19.512
	CT(3)	9.172	9.241	7.754	10.532	8.560	19.526
	EC(4)	9.171	9.241	7.754	10.532	8.560	19.526
NCI	FRC(1)	0,010	0,009	0,018	0,016	0,016	0,023
	T(2)	0,021	0,012	0,007	0,013	0,030	0,019
	TC(3)	0,018	0,011	0,017	0,028	0,031	0,022
	EC(4)	0,0007	0,0009	0,0004	0,0011	0,0006	0,0008
Diseases Index(5)	DDA(6)	27,12	21,56	28,79	12,03	11,01	7,18
	HEP A(7)	0,060	0,028	0,020	0,010	0,004	0,005
RCI(8)		0,22	0,14	0,15	0,15	0,23	0,32
Estimated population(9)		2.648.532	2.789.761	2.852.372	2.914.830	2.977.216	3.039.444
Rate of Population Growth(10)		1,015	1,053	1,022	1,022	1,021	1,021

Notes: (1) Free Residual Chlorine; (2) Turbidity; (3) Total coliforms; (4) *Escherichia Coli;* (5) Relative damage index for every 1.000 inhabitants; (6) Acute Diarrheal Disease; (7) Hepatitis A; (8) Relative Complaints Index; (9) Data collected from IBGE[14]; (10) Ratio between the population of the current year and that of the previous year. Water quality data were provided by the Regulatory Agency for Water, Energy and Basic Sanitation (Adasa) of the FD. Health data were provided by the Health Department of the FD.

The minimum amount of samples to be collected for monitoring depends on the population served by the supply system[7]. The FD has about 2.5 million inhabitants, therefore, the monitoring carried out by the concessionaire should take approximately 8.460 samples per year in the water distribution system[7]; however, in 2017, the Company performed more than 19 thousand samples *(table 1)*. This result may indicate a greater concern for the company in monitoring the supply system due to intermittency. This measure corroborates the recommendations cited by O'Connor[15] in the Toronto Walkerton survey that places monitoring as an effective barrier to the risk of contamination in the management of water supply systems.

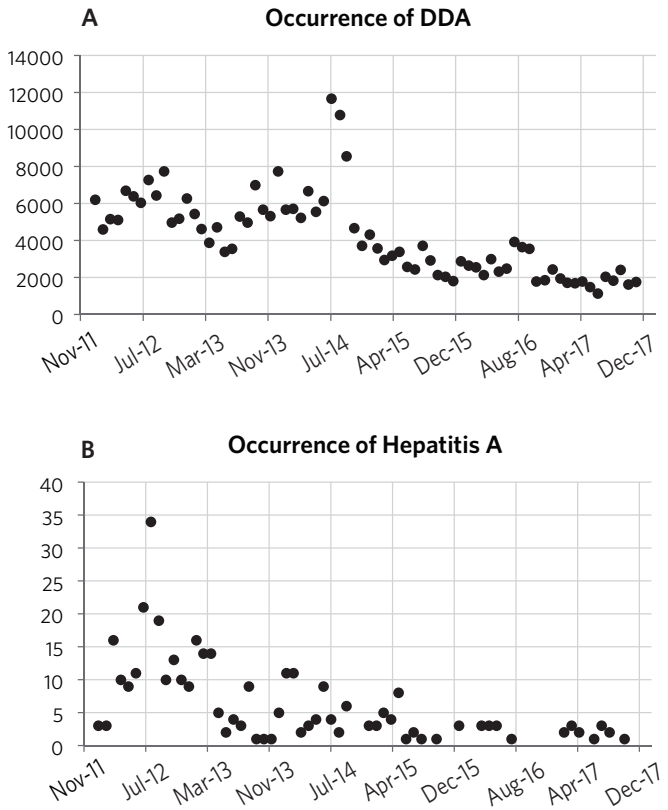
The monitoring of water quality for human consumption must be performed by two different actors: environmental health surveillance and the concessionaire responsible for the supply. While surveillance seeks to associate and/or prevent injuries that can be transmitted by water, the concessionaire aims at controlling the quality of its offered product. For the concessionaire, a non-conformity shows the occurrence of some error in the water distribution system, and the company must follow protocols for the correction of these faults. After corrective actions, a new sampling at the non-compliant points shall be performed to verify the effectiveness of the action and to confirm the improvement of the system[7]. Therefore, the result of non-conformity may not correspond to a poor water quality that reaches the end user. Surveillance typically collects a smaller amount of samples than that practiced by the concessionaire's quality control[16]. As stated in the National Guideline for the Environmental Health Surveillance Sampling Plan related to the Quality of Water for Human Consumption of the Ministry of Health[16], the number of water samples from the city of Ubatuba, São Paulo, collected by surveillance, was much lower than the control from the concessionaire in 2003. While surveillance collected 463, 463, and 448 samples for FRC, T, and TC analysis, respectively, the control sampled 1.232, 1.275, and 1.257 for these same parameters. This resulted in a higher percentage of non-quality (non-conformance) samples in surveillance sampling. This difference presents different NCI obtained by these two actors. The fact that the number of samples performed by the concessionaire of the Federal District was higher, mainly, during the intermittent period (2017) causes a drop in the NCI, which probably would not be observed by surveillance *(table 1)*. Therefore, the absolute non-compliance values of the samples reflect the impacts to the water distribution system suffered by the supply rotation in 2017.

The Indicators Report of the concessionaire show that the RCI of the water quality increased in 2016 and 2017 *(table 1)*. In absolute terms, in 2015, 721 complaints were registered regarding the quality of water distributed in FD against 894 in 2016 and 1.382 in 2017. These figures represent an increase of approximately 24% in 2016 and 91% in 2017, compared to 2015. Complaint by users usually occurs by the perception of the organoleptic characteristics of the water consumed. The presence of color, flavor and odor, as well as T, are factors that lead the user to question the water quality[13]. This result reinforces the idea of failures in the management of maneuvers in the rationing period, in which, probably, users may have been attended by water before the normalization period, that is, in the intermediate period between the cut-off and the normal supply and, with that, they have stored and even consumed this water which was not fit for their consumption.

Acute Diarrheal Disease (ADD) and Hepatitis A rates in the Federal District

Figure 2 shows the monthly cases of ADD and hepatitis A registered at the Health Department of the FD between 2012 and 2017. It can be observed that in the last three years (2015, 2016 and 2017) there was a decrease in the number of cases of these two diseases. In addition, *table 1* also shows a reduction in the incidence rates of these two diseases over this period.

Figure 2. Number of notifications of Acute Diarrheal Disease (ADD) (A) and Hepatitis A (B) in FD between 2012 and 2017. Data provided by the Health Department of the FD



This result shows that these two problems have been reduced over the years, which corroborates the studies conducted by Meneguessi and collaborators[17] between 2003 and 2012. These authors found around 70 thousand ADD records in 2012 – which was close to that found in this study –; and, in 2017, this amount reached less than 22 thousand cases. Despite a positive result regarding the occurrence of these diseases in this population, this trend cannot be celebrated. ADD is a problem that can be prevented by simple public health improvements. It is noteworthy that not only the water supply is responsible for its transmission, but also sanitary sewage and drainage are also ways of dissemination of pathogens responsible for this disease. Almeida[18] associated the occurrence of ADD caused by bacterial agents in Anápolis (GO) to the poor conditions of hygiene and conservation of its water reservoirs. She explained that the habit of consuming tap water from poorly conserved reservoirs was correlated with ADD of bacterial origin. Therefore, even with the guarantee of a satisfactory water distribution system, ADD indices can only be reduced to a satisfactory threshold when other intrinsic problems are resolved.

On the other hand, hepatitis A occurrence is intrinsically associated with the quality of the water consumed. Braga and collaborators[19] identified the risk of hepatitis A correlated with deficiencies or lack

of water supply in different territories in the municipality of Duque de Caxias (Rio de Janeiro). The occurrence of hepatitis A in FD was lower in the last years of this study, reaching 13 and 14 in 2016 and 2017, respectively, which corresponds to half of the cases reported compared to 2015. In addition, hepatitis A rates for each thousand inhabitants in recent years have been reduced from 0,060 in 2012 to 0,005 in 2017 *(table 1)*. These observations show that there may be a greater concern for the water quality that supplies the FD, confirming the importance of both the control carried out by the concessionaire and the active participation of users. However, the hepatitis rate in 2017 was slightly higher than 2016, probably due to intermittent supply. Therefore, it is important to carry out a critical analysis in the management of water for human consumption when intermittent supply is required.

Correlation between data

Table 2 shows the results of simple linear regression applied in the variables ADD rate, hepatitis A rate and RCI related to water quality as dependent variables with the NCI for each distribution network water quality parameter (FRC, T, TC and EC) and RCI related to water quality as independent variables. From this result, the variables that obtained values of $p \leq 0.2$ were submitted to Stepwise in order to obtain Pearson correlation indices *(figure 3)* between them.

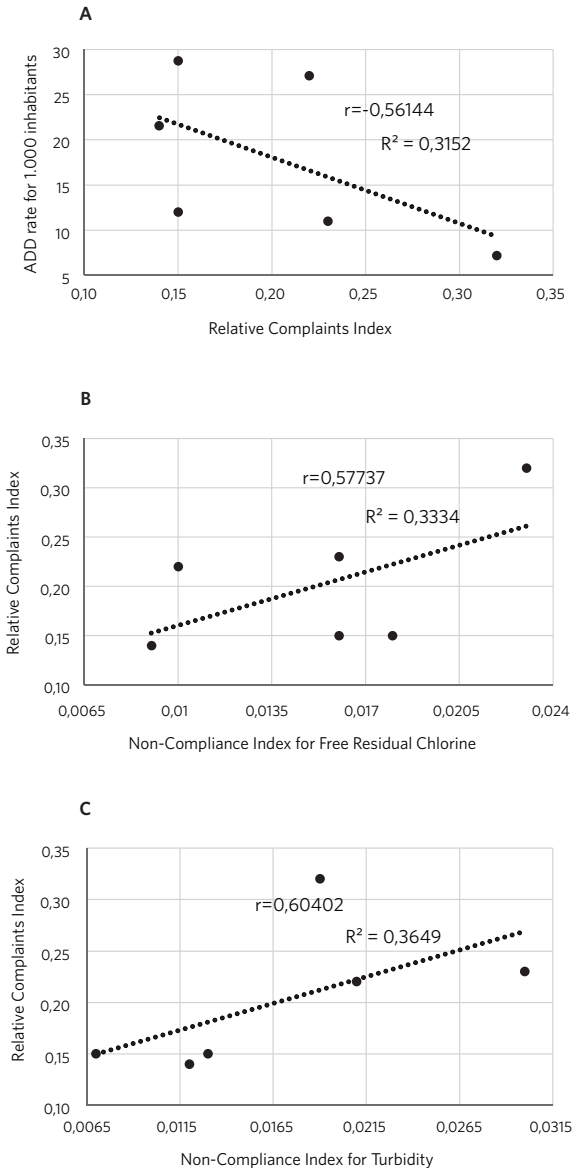
Table 2. P values obtained after the simple linear regression analysis performed between the different variables: Acute Diarrheal Disease (ADD) and Hepatitis A, Non-Compliance Indexes (NCI) and Relative Complaints Index (RCI)

Dependent Variables	Independent Variables				
	NCI				RCI
	FRC*	T**	TC***	EC****	
DDA rate	0,52	0,70	0,68	0,23	0,19
Hepatitis A rate	0,58	0,90	0,77	0,85	0,70
RCI	0,20	0,20	0,30	0,55	-

*FRC – free residual chlorine. **T – turbidity. ***TC – total coliforms; ****EC – *Escherichia Coli.*

Figure 3 shows that regression rates (R^2) were low, but are common values for this type of study. On the other hand, the Pearson (r) correlation coefficients obtained were greater than 0,50, showing that these correlations are significant.

Figure 3. Correlations (r) between the different variables that had satisfactory linear regression values (p ≤ 0,2). In (A) Acute Diarrheal Disease (ADD) rate per 1.000 inhabitants and Relative Complaints Index (r = -0,56144), (B) Relative Complaints Index and Non-Compliance Index for Free Residual Chlorine (r=0,57737), (C) Relative Complaint Index and Non-Compliance Index for Turbidity (r = 0,60402)



Linear regression statistical results showed that if a stricter significance level such as 10 or 5% (p ≤ 0,1 or 0,05) were used, for example, which is common in ecological studies, it would exclude all variables to be tested. This way, a less judicious value was adopted. Even in this condition, only the ADD (health indicator) rate correlated with the RCI. Using RCI as the dependent variable, only NCI of FRC and T were correlated *(table 2)*. This result shows the difficulty in associating environmental variables and the incidence of diseases. Queiroz, Heller and Silva[20] could not obtain a good correlation between water

quality and ADD incidence in Vitória (ES).

The ADD rate had an inverse relationship with the RCI *(figure 3A)*, indicating that the higher the number of complaints, the lower the disease rate. A likely explanation of this result would be the effectiveness of complaints by promoting improvements in the supply system and, therefore, promoting a better health condition of the population. Meisen et al.[21] also had a negative correlation between water quality and ADD, but little significant. Moreover, they failed to point out these correlations with various water characteristics. It should be noted that non-compliance does not mean that poor quality water reaches homes, but, rather, identifies system failures that may have been corrected. Probably, the monitoring performed by the company is having an effect, preventing the proliferation of ADD by the water consumed. Regarding water quality and hepatitis A, although there are reports indicating that safe water supply diminishes the prevalence of this disease[22], the studies undertaken were unable to establish correlations between these variables as also observed by da Silva and others[23].

The NCI variables of FRC and T showed a direct correlation with the RCI *(figures 3 B* and *C)*. The proliferation of microorganisms in the distribution network, in addition to favoring chlorine consumption, can promote its T and is capable of generating odor and taste changes[24], which could, besides the visual aspect, influence the increase in complaints about the water quality.

This study shows how difficult it is to obtain a safe relationship between the sanitation variables and the health conditions of the population. The fact that the monitoring of the supply network finds a non-compliance in the water quality can positively reflect the health status of the population if corrective measures are taken. An important fact is the perception of the population as a control factor, because it can reject the water when it detects some alteration. In this case, the maintenance of open routes of complaint with the concessionaire, especially in times of shortage and supply restriction, is essential to the good management of the water supply service.

Conclusions

From this study, it can be inferred that the number of non-compliance samples identified by the quality control of the concessionaire has been increasing in recent years, but the NCI for the FRC, T, TC and EC parameters has been maintained, probably due to the increase in the amount of samples collected. The number of complaints made by the population regarding the quality of distributed water (RCI) has also increased. This shows that the water reaching users presented unsatisfactory organoleptic characteristics. It is noteworthy that, during the rationing period, both NCI and RCI were higher. The number of ADD and hepatitis A diseases has been following the decreasing trend, and this shows that probably these conditions may not correspond to the water quality. The most significant correlations observed occurred between the ADD rate and the RCI inversely. The RCI had a positive correlation with the NCI of FRC and T, showing the difficulty in obtaining a correlation between the water supply conditions and the problems related to inadequate sanitation even at rationing times.

Collaborators

Castro RS (0000-0002-1974-9586)* contributed to the collection and structuring of the data, elaboration and revision of the article. Cruvinel VRN (0000-0003-1518-4167)* contributed to data structuring and revision of the article. Oliveira JLM (0000-0002-0361-3457)* contributed to data structuring, preparation and revision of the article. ■

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References

1. Davis ML, Masten SJ. Princípios de engenharia ambiental. 3.. ed. Porto Alegre: AMGH; 2016.

2. Snow J. On the mode of communication of cholera. London: John Churchill; Prince Street; Soho; 1849.

3. Tucci CEM. Gerenciamento da drenagem urbana. Rev. Bras. Recur. Hídricos. 2002; 7(1):5-27.

4. Castro JE, Heller L. Water and sanitation services: public policy and management. London: Earthscanp; 2009.

5. Façanha MC, Pinheiro AC. Comportamento das doenças diarreicas agudas em serviços de saúde de Fortaleza, Ceará, Brasil, entre 1996 e 2001. Cad. Saúde Pública. 2005; 21(1):49-54.

6. Distrito Federal. Secretaria de Saúde. Subsecretaria de Vigilância em Saúde. Boletim epidemiológico: doenças imunopreviníveis e doenças de transmissão hídrica e alimentar. Distrito Federal: NCDIA; NATHA; 2015. [acesso 2018 ago 27]. Disponível em: http://www.saude.df.gov.br/wp-conteudo/uploads/2018/05/Doen%C3%A7as-Imunopreven%C3%ADveis-e--doen%C3%A7as-de-Transmiss%C3%A3o-Hidrica-e-Alimentar-n%C2%BA-01-swtembro2015.pdf.

7. Brasil. Ministério da Saúde. Portaria nº 2.914, de 12 de dezembro de 2011. Dispõe sobre os procedimentos de controle e de vigilância da qualidade da água para consumo humano e seu padrão de potabilidade. Diário Oficial da União. 14 Dez 2011.

8. Capodeferro M, Smiderle JJ, Oliveira LAD. Mecanismos adotados pelo Distrito Federal no combate à crise hídrica. In: XXXVI Congreso Interamericano de Ingeniería Sanitaria y Ambiental; 2018 Out 28-31; Guayaquil. Equador. Associação Interamericana de Engenharia Sanitária e Ambiental. 2018.

9. Caesb. Relatório da Administração. Brasília, DF: Caesb; 2017. [acesso em 2018 set 2]. Disponível em: https://www.caesb.df.gov.br/images/arquivos_pdf/Relatorio_da_Administracao-2017.pdf.

10. Morais WA, Saleh BB, Santos WS, et al. Qualidade sanitária da água distribuída para abastecimento público em Rio Verde, Goiás, Brasil. Cad. Saúde Colet. 2016; 24(3):361-367.

11. Moraes LRS, Borja PC, Tosta CS. Qualidade de água da rede de distribuição e de beber em assentamento periurbano: estudo de caso. In: Anais do 20º Congresso Brasileiro de Engenharia sanitária e Ambiental; 1999 Set 20-25; Recife. Pernambuco: Associação Brasileira de Engenharia Sanitária e Ambiental. 1999. p. 1462-73.

12. Lazcano CA. Fallas y problemas de la desinfección urbana. In: Anais do Simposio Regional sobre Calidad del Agua: Desinfección Efectiva [internet]; 1998 out 27-29; Lima. Peru; 1998. p. 1-11. [acesso em 2018 out 5]. Disponível em: http://www.bvsde.paho.org/bvsacg/e/fulltext/simposio/ponen2.pdf.

13. Heller L, Pádua VL. Abastecimento de água para consumo humano. Minas Gerais: UFMG; 2006.

14. Brasil. Instituto Brasileiro de Geografia e Estatística. População residente enviada ao Tribunal de Contas da União. Brasil, Grandes Regiões e Unidades da Federação de 2001 a 2015 [internet]. [acesso 2018 dez 15]. Disponível em: https://www.ibge.gov.br/estatisticas-novoportal/sociais/populacao/9103-estimativas-de-populacao.html?=&t=downloads.

15. O'Connor DR. Report of the Walkerton Inquiry: Part two - A Strategy for Safe Water. 2002; Toronto, Canada [internet]. [acesso em 2018 out 20]. Disponível em: http://www.archives.gov.on.ca/en/e_records/walkerton/report2/index.html.

16. Brasil. Ministério da Saúde. Secretaria de Vigilância em Saúde. Diretriz nacional do plano de amostragem da vigilância em saúde ambiental relacionada à qualidade da água para consumo [internet]. Brasília, DF: MS; 2006. Série A: normas e manuais técnicos. [acesso 2018 dez 5]. Disponível em: http://bvsms.saude.gov.br/bvs/publicacoes/diretriz_nacional_plano_vigiagua.pdf.

17. Meneguessi GM, Mossri RM, Segatto TCV, et al. Morbimortalidade por doenças diarreicas agudas em crianças menores de 10 anos no Distrito Federal, Brasil, 2003 a 2012. Epidemiol. Serv. Saúde. 2015; 24(3):721-730.

18. Almeida FF. Influência dos fatores socioambientais, sanitários e enteropatógenos em crianças menores de 5 anos com diarreia atendidas em Unidades de Saúde do Município de Anápolis – GO. [dissertação]. Anápolis: Centro Universitário Unievangélica de Anápolis; 2016. 63 p.

19. Braga RCC, Valencia LIO, Medronho RA, et al. Estimativa de áreas de risco para hepatite A. Cad. Saúde Pública. 2008; 24(8):1743-1752.

20. Queiroz JTM, Heller L, Silva SR. Análise da correlação de ocorrência da doença diarreica aguda com a qualidade da água para consumo humano no município de Vitória – ES. Saúde Soc. 2009; 18(3):479-489.

21. Meisen MN, Bohn N, Tavares LBB, et al. Ocorrência de doenças diarréicas agudas (DDA) com a qualidade da água para consumo humano no município de Pouso Redondo – SC. Rev. Estud. Ambient. [internet]. 2011 [acesso em 2018 fev 2]; 13(2):57-67. Disponível em: http://proxy.furb.br/ojs/index.php/rea/article/viewFile/2673/1803.

22. Ferreira CT, Silveira TR. Hepatites virais: aspectos da epidemiologia e da prevenção. Rev. Bras. Epidemiol. 2004; 7(4):473-487.

23. Silva ALM. Direito do meio ambiente e dos recursos naturais. São Paulo: Revista dos Tribunais, 2005. v. 2.

24. Filho SSF, Alves R. Técnicas de avaliação de gosto e odor em águas de abastecimento: método analítico, análise sensorial e percepção dos consumidores. Eng. Sanit. Ambient. 2006; 11(4):362-370.

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