Rtabnetsp: an R package for retrieving São Paulo State health status indicators, Brazil*

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Abstract

Health status indicators are an important tool for monitoring the performance of public health actions, identifying trends and priority regions for resource allocation. An R package was developed in order to increase the feasibility of handling and analyzing health status indicator data. The rtabnetsp package requests data from TabNet servers on the São Paulo State Department of Health website, retrieving and preprocessing the data for user manipulation. This article presents the rtabnetsp package and its functions, installation and use; as well as providing examples of its functionalities, which involve listing and searching among available indicators, selecting desired content and obtaining data aggregated according to regionalization level held on the data matrix, enabling greater agility in tasks regarding public health management in the state of São Paulo.

Keywords: Software; Electronic Data Processing; Health Status Indicators; Health Information Systems; Health Management.

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Introduction

Ever since the Brazilian National Health System (SUS) was implanted, systematic analysis of health data and information has been considered fundamental for evaluating its performance. This process assists System-related decision making and actions to be carried out, as well as service programming and planning, resource allocation and distribution, in addition to evaluation of the impact of interventions undertaken.[1,2]

> *The rtabnetsp package is capable of accessing health status indicators available via the TabNet platform on the webpage of the São Paulo State Health Department.*

Given the importance of the theme, expanding access to data and structured information has been a worldwide priority when planning health information systems[3] and, consequently, one of the main work areas of the SUS Information Technology Department (Datasus). Datasus currently makes available data obtained from Ministry of Health information systems by means of interfaces, such as TabDOS (DOS version), TabWin (Windows version), TabNet (internet version) and TabSQL (Oracle database version).[4] These tools enable users to manipulate DBF type database files, this being the default file extension of tabulatable database files on which case notification records are held on the different information systems, thus enabling interested parties to tabulate and calculate health status indicators, at different levels of aggregation, such as the municipal, state or federal levels.

On the other hand, the types of software mentioned above have inherent limitations, such as operating system restrictions and manipulation difficulties, data visualization and analysis via the platform. The open source R statistical software is a tool that is able to extend these functionalities and is appropriate for diverse analysis needs.

Some of the tools developed using R language are able to retrieve data from SUS information systems in the form of microdata, such as *microdatasus*.[5] However, in the case of aggregated data, such as health status indicators, no specific tool exists other than TabNet manual retrieval or calculations using microdata.

Within this context, the decision was taken to develop an R package called rtabnetsp, capable of accessing health status indicators available via the TabNet platform on the webpage of the São Paulo State Health Department (SES/SP) and downloading pre-calculated indicator data for the desired period, region and level of aggregation.

The objective of this article was to present the rtabnetsp package and its functions, installation procedures and use; in addition to examples of its functionalities, which enable visualization, searches and selection of contents of interest from a list of indicators, in order to obtain the results desired and thus enabling greater agility in tasks regarding public health management in the state of São Paulo.

Methods

The rtabnetsp package was developed using R language for versions later than version 3.4.4. R is a statistical programming language of excellence, developed as an open source software,[6] for manipulation, analysis and graphic visualization of data, as well as being expandable through use of 'packages', i.e. libraries to organize and standardize extra R functions, each of which is developed for a specific purpose. Moreover, use of R packages as tools to acquire or handle public health-related data is becoming frequent.[5,7,8]

For this presentation, we considered the indicator matrix of the Health Systems Performance Evaluation Project (*Projeto de Avaliação de Desempenho de Sistemas de Saúde* - PROADESS),[9] given that health status indicators are fundamental for socio-spatial analyses of the health situation in Brazil.[10] The list of indicators available on TabNet on the SES/SP webpage is shown in Table 1. The indicators are calculated following the methodology adopted by the Interagency Health Information Network (RIPSA) (http://tabnet.datasus.gov.br/tabdata/livroidb/2ed/indicadores.pdf).[11]

Table 1 – List of indicators available from the rtabnetsp package default address (http://portal.saude.sp.gov.br/links/matriz)

Identifier number (ID) in the package	Indicator name	Number of subindicators	Period available
1	1b – Population according to the São Paulo State Data Analysis System Foundation (SEADE)	1	2000-2020
2	2 – Demographic density according to the Brazilian Institute of Geography and Statistics (IBGE) Demographic Census	3	2000-2010
3	3 – Degree of urbanization according to the Brazilian Institute of Geography and Statistics (IBGE) Demographic Census	3	2000-2010
4	4 – Population growth rate (2000-2010) according to the Brazilian Institute of Geography and Statistics (IBGE) Demographic Census	3	2010-2010
5	5 – Proportion of elderly people	3	2000-2018
6	6 – Gross birth rate	3	2000-2018
7	7 and 8 – Percentage of municipalities with fewer than 10,000 inhabitants and with more than 10,000 inhabitants	2	2010-2018
8	Proportion (%) of municipalities in groups 4 and 5, by São Paulo State Health Region, Regional Health Department and Regional Health Care Networks – 2008 a 2014 – version 2016	1	2008-2014
9	10 – Current gross domestic product (GDP) per capita in BRL (R$)	3	2000-2017
10	11-13 – Infant mortality rate and components	11	2000-2019
11	14 – Maternal mortality ratio	3	2000-2018
12	15-17 – Neoplasm mortality rate	47	2000-2019
13	18 – Circulatory system disease mortality rate	6	2000-2019
14	19 – External causes mortality rate	17	2000-2019
15	20-23 – Percentage of deaths from defined causes	18	2000-2019
16	24 and 25 – Percentage of live births with low birth weight	5	2000-2019
17	26 – Percentage of childbirths among mothers under 20 years old	3	2000-2018
18	27a – Case fatality rate for severe forms of dengue (FHD + SCD + DCC)	3	2000-2011
19	27b – Dengue case fatality rate	3	2012-2018
20	28 – AIDS incidence rate	3	2000-2018
21	29 – Congenital syphilis incidence rate	3	2007-2018
22	30 – Prevalence of dialysis patients	3	2000-2017
23	31a – SUS Beds per 1,000 inhabitants	3	2005-2019
24	31b – SES Beds per 1,000 inhabitant in the SUS-dependent population	3	2005-2017
25	32 – Percentage of SUS Beds in intensive care units (ICU)	3	2014-2019
26	33 – Primary Health Care coverage	3	2006-2018
27	34 – Community Health Agent coverage	3	2000-2017
28	35 – Proportion of live births to mothers who had 7 or more prenatal checkups	3	2000-2019
29	36a – Percentage SUS hospitalization among total resident population	3	2000-2018
30	36b – Percentage SUS hospitalization among total resident population for SUS-dependent population	3	2000-2018
31	37a – Ratio of cytopathology tests for cervical cancer among women aged 25-64	4	2008-2019
32	37b – Ratio of cytopathology tests for cervical cancer among women aged 25-64 in the SUS dependent population	4	2008-2019
33	38 – Quadrivalent vaccine coverage (up to 2012) and pentavalent vaccine coverage (with effect from 2013) in children under 1 year old	3	2000-2018

To be continue

Continuation

Table 1 – List of indicators available from the rtabnetsp package default address (http://portal.saude.sp.gov.br/links/matriz)

Identifier number (ID) in the package	Indicator name	Number of subindicators	Period available
34	39 – Average medical consultations per inhabitant in primary care specialties	3	2000-2017
35	40 – Proportion of urgent consultations per primary care consultations	3	2000-2017
36	41 – Coverage of 1st programmatic dental consultation	3	2000-2016
37	42 – Percentage of hospitalization for Primary ambulatory care sensitive conditions	3	2000-2018
38	43 – Stroke hospitalization rate in people aged over 40	3	2000-2019
39	44 – Femur fracture hospitalization rate in people aged over 60	3	2000-2018
40	45a – Percentage of cesarean sections – Total (Live Birth Information System [Sinasc])	3	2000-2018
41	45b – Percentage of cesarean sections on the SUS (Hospital Information System [SIH/SUS])	4	2000-2018
42	46 – Psychosocial Care Center coverage	9	2012-2018
43	47a – Supplementary Health coverage	3	2000-2019
44	47b – Estimated SUS-dependent population (based on Supplementary Health)	4	2000-2019
45	48 – Proportion of cured new cases of bacilliferous pulmonary tuberculosis	3	2000-2018
46	49 – Proportion of cured new diagnosed leprosy cases	3	2001-2017
47	50-52 – Water treatment quality index, according to bacteriological, chlorine and fluoride parameters	9	2008-2016
48	53 – Health expenditure *per capita*	3	2000-2017
49	54a – Ratio of breast screening among women aged 50-69	4	2010-2018

Pacote	*Hiperlink*	Função
httr	https://cran.r-project.org/web/packages/httr/httr.pdf	Makes HTTP requests to the TabNet server
xml2	https://cran.r-project.org/web/packages/xml2/xml2.pdf	*Page scraping*
rvest	https://cran.r-project.org/web/packages/rvest/rvest.pdf	
stringi	https://cran.r-project.org/web/packages/stringi/stringi.pdf	Text manipulation and coding treatment for Windows-1252 standard (https://encoding.spec.whatwg.org/#windows-1252)
purrr	https://cran.r-project.org/web/packages/purrr/purrr.pdf	Treatment of HTTP request exceptions
tidyr	https://cran.r-project.org/web/packages/tidyr/tidyr.pdf	Data manipulation and treatment
dplyr	https://cran.r-project.org/web/packages/dplyr/dplyr.pdf	
ggplot2	https://cran.r-project.org/web/packages/ggplot2/ggplot2.pdf	Building choropleth graphs from the data obtained
sf	https://cran.r-project.org/web/packages/sf/sf.pdf	Cartographic representation
RColorBrewer	https://cran.r-project.org/web/packages/RColorBrewer/RColorBrewer.pdf	Color palette, for cartographic representation

Figure 1 – Dependence on other R packages used in rtabnetsp

Rtabnetsp has brought together practical functions for visualizing, exploring and obtaining SES/SP TabNet health status indicator data. The package is available on the GitHub platform (https://github.com/), by accessing this link: https://github.com/joaohmorais/rtabnetsp.

With regard to its technical aspects, rtabnetsp uses other package dependencies as listed in Figure 1.

Installing R

Access the R webpage (https://www.r-project.org/) and install R following the installation instructions. Before moving on to the next step, the devtools package needs to be installed (https://cran.r-project.org/web/packages/devtools/devtools.pdf) on R.

Installing the rtabnetsp package on R

The rtabnetsp package has to be installed via its repository on the GitHub website (https://github.com/joaohmorais/rtabnetsp). With R open, type:

```
devtools::install_github("joaohmorais/rtabnetsp")
```

Loading the rtabnetsp package on R

In order to start using rtabnetsp, load the package by typing:

```
library("rtabnetsp")
```

This makes the rtabnetsp package available for use. This step needs to be performed each time R has been booted.

Rtabnetsp package functions

Rtabnetsp retrieves health status indicators via the SES/SP webpage. The health status indicators are calculated using RIPSA standardized formulae,[7] and can be loaded per municipality (município), Regional Health Department (DRS), Health Region (RS) and Regional Health Care Networks (RRAS) in São Paulo State.

The complete list of indicators provided by rtabnetsp can be obtained by typing this command:

```
tabnet_index()$Nomes
```

indicator_list() function

```
indicator_list(url= "http://portal.saude.sp.gov.br/links/matriz")
```

The indicator_list() function retrieves the list of indicators available on the TabNet page, along with their respective identification numbers, called IDs, which are used to choose the indicators. When this function is run, it explores a given URL – whereby the SES/SP TabNet address is defined as the default – and retrieves health status indicator names and links identified on the page.

indicator_search() function

```
indicator_search(keywords, url = "http://portal.saude.sp.gov.br/links/matriz")
```

A page's list of indicators can also be consulted by searching for a specific indicator. The indicator_search() function displays a list with the name and ID of each indicator, and the title corresponding to the term in the "keywords" parameter. It should be noted that this function does not distinguish between uppercase and lowercase letters, but rather differentiates between characters that do or do not have accents.

view_indicator() function

```
view_indicator(indicator_index, url = "http://portal.saude.sp.gov.br/links/matriz", timeout = 1)
```

Once the indicator to be visualized has been defined, it is important to check its available levels of aggregation, periods and contents, before making a request for data. The view_indicator() function returns a list containing information on levels of aggregation, periods (years) and contents. It should be noted that an indicator can have different contents, differentiated by subindicators: e.g. the 'external causes mortality rate' indicator has subindicators, such as 'deaths from homicide', 'deaths from suicide' and other causes, which are available on TabNet. In order to use this function, the indicator's ID number must be informed as the "indicador_index".

The "timeout" parameter appears in several functions and represents the time, in seconds, during which the connection will remain open for retrieving

information from the indicator's page, so as to avoid insisting on connections that do not provide return. The "timeout" default is 1 second, although this time span needs to be adjusted in the event of slow connections.

indicator_df() function

indicator_df(indicator_index, region = NULL, subindicator = NULL, years = NULL, onlyMostRecent = FALSE, url = "http://portal.saude.sp.gov.br/*links*/matriz", timeout = 1)

The indicator_df() function is that which does in fact make the request for data for an indicator in a given period and level of aggregation. The indicator's ID is input to the function as the "indicator_index". The next step is to inform the level of aggregation for the "region", using the term '*Município*' (Municipality), '*Região de Saúde*' (Health Region), '*RRAS*' (Regional Health Care Network) or '*DRS*' (Regional Health Department). If this is not informed, the function will automatically take the first available level as the default level (i.e. '*Município*', in the majority of cases). Similarly, the contents of the indicator (subindicador) can be specified in the "subindicator" parameter, as can the period desired, in "years"; if this content is not specified, the function will default to the indicator's last available subindicator, for all the periods available. The function also has an "onlyMostRecent" logical parameter (i.e. "TRUE" or "FALSE"), which, if "TRUE", will only retrieve the observations for the most recent among the years available, or among those specified by using the "years" parameter.

Once the function has been run, the user will receive a data matrix with an identification code and the name of each region, the year of observation and the value of the indicator observed.

fetch_all() function

fetch_all(region = "Município", url = "http://portal.saude.sp.gov.br/*links*/matriz", timeout = 1)

In some types of analyses the need exists to work with several or even all the indicators available. The fetch_all() function meets this need by grouping together all the indicators for the same data matrix. The desired level of regionalization can be specified again using the "region" parameter. In response, the user obtains a new data matrix with an identification number and the name of each region, the year of observation,

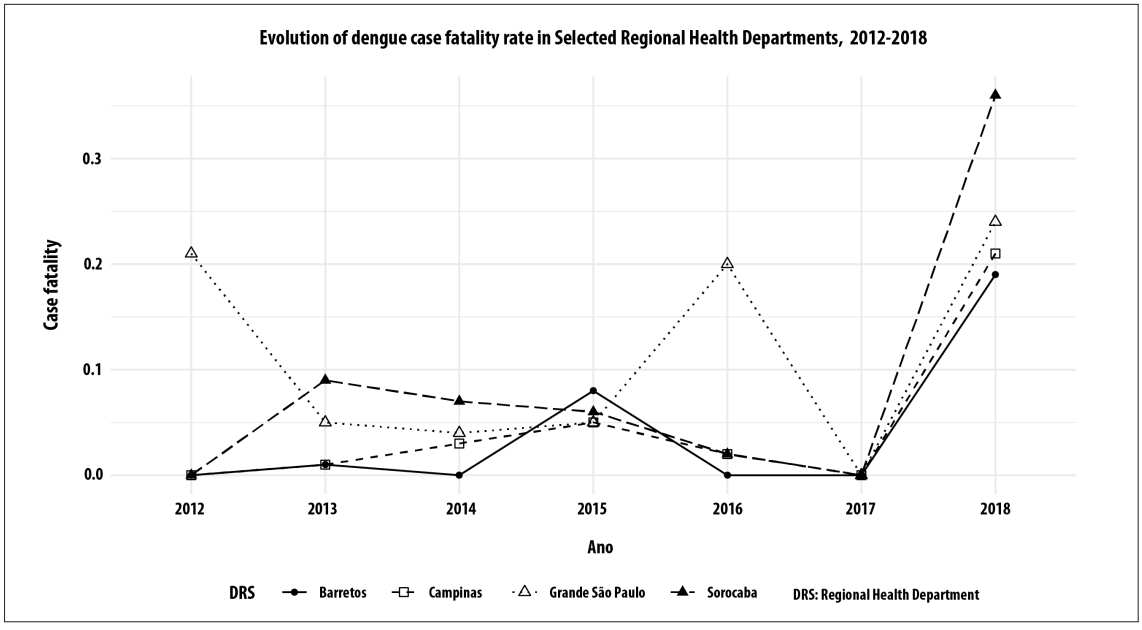

Figure 2 – Example of line graphs, built using dengue case fatality data retrieved by rtabnetsp, for four São Paulo Regional Health Departments, 2012-2018

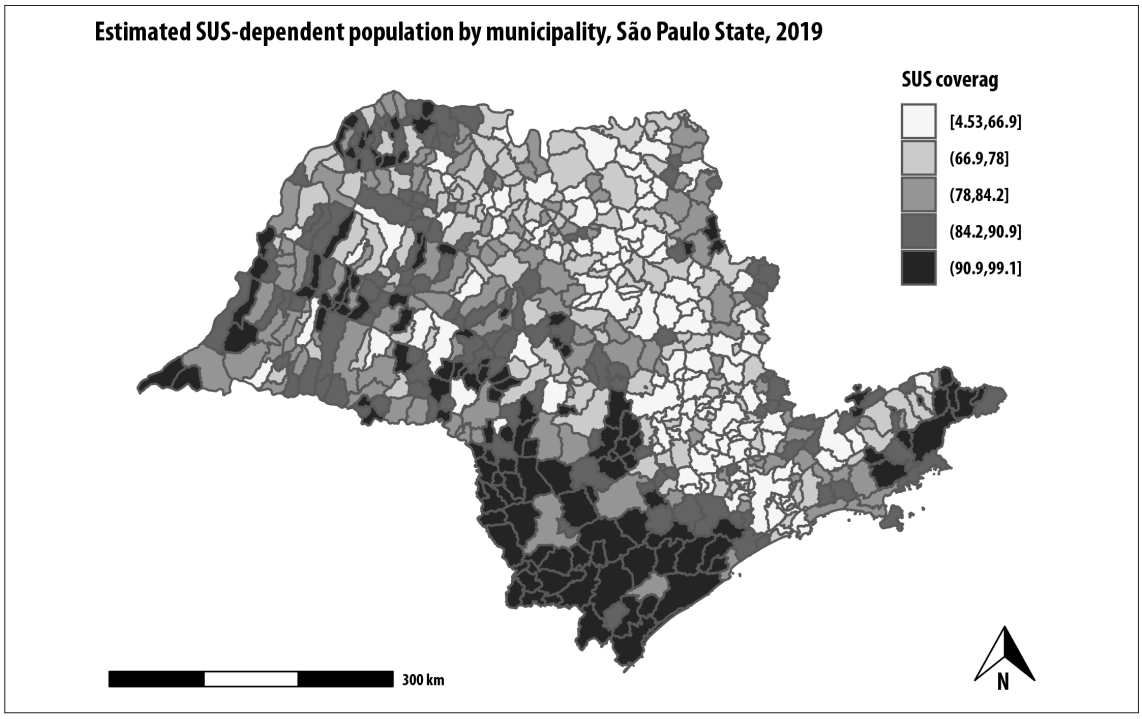

Figure 3 – Choropleth map of the population dependent on the Brazilian National Health System (SUS), by municipality of São Paulo State, drawn by the rtabnetsp package

the names of the indicator and subindicator in question, and the value observed. It is important to note that this function attends to several server requests, one for each indicator, and may take several minutes to run.

tabnet_map() function

tabnet_map(indicator_index, region = "Município", subindicator = NULL, years = NULL, label = FALSE, nBins = NULL, palette = "Purples", title = NULL)

Finally, a choropleth map can be obtained based on an indicator's data, using the tabnet_map() functions, the parameters of which are similar to those of the tabnet_df() function, in which one can specify the desired indicator ID, level of aggregation, contents and period. Moreover, this function supports the following parameters: "label", which can be true or false, indicating whether the user wants the names of the regions on the map; "nBins", through which one can define the number of intervals (between 3 and 9) into which the indicator's values will be defined; "palette", which enables the map's color palette to be personalized, in accordance with the RColorBrewer package (https://cran.r-project.org/web/packages/RColorBrewer/RColorBrewer.pdf); and "title", for defining the title of the map.

Ethical considerations

The rtabnetsp package was developed within the scope of the project entitled 'Development of an R/Shiny application to assist with visualizing and analyzing health status indicators in the state of São Paulo', which was approved by the Federal University of São Paulo Research Ethics Committee: Certificate of Submission for Ethical Appraisal No. 94098718.7.0000.5505, issued on September 20th 2018.

Results

This section presents hypothetical situations common to the health service management context, providing illustrative examples of the rtabnetsp functions used in the process.

Situation 1 – Temporal visualization of the dengue case fatality rate by Regional Health Department

This first scenario intends to enable visualization of the dengue case fatality rate since 2012 in four specific Regional Health Departments (DRS): Grande São Paulo; Campinas; Barretos; and Sorocaba. Once rtabnetsp has been loaded in R, the first step is to find the desired indicator:

```
> indicator_search("dengue")
[1] "18 – Taxa de letalidade por formas graves de
dengue até 2011 (FHD+SCD+DCC)"
[2] "19 – Taxa de letalidade de dengue (a partir
de 2012)"
```

As we want recent data, we will opt for indicator ID 19 – Dengue case fatality rate (with effect from 2012). Following this, we will check the levels of aggregation and periods available for the indicator:

```
> view_indicator(19)
$Indicator.Name
[1] "19 – Taxa de letalidade de dengue "
$Indicator.URL
[1] "http://tabnet.saude.sp.gov.br/deftohtm.
exe?tabnet/ind27b_matriz.def"
$Available.Regions
[1] "Município" "DRS" "DRS/Reg Saude" "DRS/
Mun" "RRAS" "RRAS-Reg Saude" "RRAS-
Municipio"
[8] "Região de Saúde" "Reg Saúde/Mun"
$Available.Years
[1] "2018" "2017" "2016" "2015" "2014" "2013"
"2012"
$Available.Subindicators
[1] "Óbitos" "Total de Casos" "Tx Letalidade
Dengue"
```

Based on this information, we will check for the availability of data for this indicator for all years from 2012 to 2018, as well as the desired regionalization (DRS). The desired subindicator is the last on the list: the fatality rate. We will therefore use the indicator_df() function to retrieve the data for this indicator and save them in a data matrix:

```
> dados <- indicator_df(19, region = "DRS")
> head(dados)
id DRS                          Year Value
1 3501 Grande São Paulo         2012 0.21
2 3502 Araçatuba                2012 0.07
3 3503 Araraquara               2012 0.00
4 3504 Baixada Santista         2012 0.09
5 3505 Barretos                 2012 0.00
6 3506 Bauru                    2012 0.00
```

Thus we have a data matrix saved in the "data" element, with the identification codes and names of the DRS, year of occurrence and the value of the indicator in that year and in that DRS. A line graph can be used to visualize the trend of the indicator over the years between the desired DRS. The ggplot2 package enables the line graph to be drawn using the data matrix obtained. The result is illustrated in Figure 2: the evolution of the dengue case fatality rates can be seen in the period from 2012 to 2018, in the selected DRS: Grande São Paulo, Campinas, Barretos and Sorocaba. It can be seen, for example, that there is an increase in dengue fatality in Grande São Paulo in 2016, and in Sorocaba in 2018.

```
recorte.DRS <- c("Grande São Paulo",
"Campinas", "Barretos", "Sorocaba")
dados <- dados[dados$DRS %in% recorte.DRS,]
ggplot(data=dados, aes(x=Ano, y=Valor,
group=DRS)) +
geom_line(aes(linetype = DRS)) +
geom_point(aes(shape = DRS)) +
theme_minimal() +
theme(legend.position = "bottom", plot.title =
element_text(hjust = 0.5)) +
labs(x = "Ano", y = "Letalidade") +
ggtitle("Evolução da taxa de letalidade de dengue
nos DRS selecionados, \nde 2012 a 2018")
```

Situation 2 – Spatial visualization of the SUS-dependent population

In another scenario, we want to visualize the spatial distribution of SUS-dependent population coverage among the municipalities of the state of São Paulo. Similarly to the previous hypothetical situation,

we have to locate the identification number of the indicator we want:

```
> indicator_search("dependente")
[1] "24 – Leitos SUS por 1.000 habitantes para a
população SUS-dependente"
[2] "30 – Percentual de internação da população
residente para a população SUS-dependente"
[3] "32 – Razão de exames citopatológicos
cérvico-vaginais para a população SUS-
dependente"
[4] "44 – Estimativa da população SUS-
dependente (com Base na Saúde Suplementar)"
```

The tabnet_map() function can be used to draw a choropleth map of the indicator. By default, the function will retrieve data from the municipal level and for the most recent available year. There is therefore no need to specify, via the function's parameters, either the level of aggregation or the period desired. We reiterate that dependence on the sf package is needed for this function. Figure 3 shows the map generated by this function, showing the spatial distribution of SUS-dependent population coverage.

```
> tabnet_map(44, nBins = 5, palette = "Greys", title
  = "Estimativa da população SUS dependente por
      município. Estado de São Paulo, 2019.")
```

Discussion

The rtabnetsp package enables practical retrieval of health status indicator data available on the São Paulo State Health Department webpage, directly to R, where they can be manipulated. In both the situations presented as examples, it was possible to accompany use of descriptive analysis resources involving only a few commands within the program. The development of the rtabnetsp package meets the intention of health surveillance to increase information accessibility, enabling systematic analyses in the area of health service management.

Rtabnetsp differs from other packages already covered by the literature, in terms of retrieving information from Ministry of Health information systems. The microdatasus package,[5] for example, obtains data on occurrence from the DBF files available on each database made available by Datasus.

The package presented in this study develops a web scraping operation in order to retrieve data already tabulated by the existing TabNet tool. This method is more advantageous for analyzing aggregated data, providing the process with greater agility and reliability, given that the data have already been tabulated by the TabNet system.

We believe that the development of rtabnetsp has met its main objective: to facilitate access to and analysis of indicators and to assist health service decision making in the state of São Paulo. The package also has the potential to contribute to the development of other software, designed for working with health data as well as the possibility of its being used as a mediator for applications that need such data and which seek to monitor indicators.

Author's contributions

Morais JHA and Martins CB contributed to the study concept and design, analysis and interpretation of the results, drafting and critically reviewing the contents of the manuscript. Konstantyner TCRO contributed to the analysis and interpretation of the data, drafting and critically reviewing the contents of the manuscript. Fazenda AL and Sala A contributed to the concept and design of the study, drafting and critically reviewing the contents of the manuscript. All the authors have approved the final version of the manuscript and are responsible for all aspects thereof, including the guarantee of its accuracy and integrity.

References

1. Hartz ZMA, Silva LMV. Avaliação em saúde: dos modelos teóricos à prática na avaliação de programas e sistemas de saúde [Internet]. Salvador: EDUFBA; Rio de Janeiro; Editora FIOCRUZ; 2005 [citado 2020 jun 19]. Disponível em: http://books.scielo.org/id/xzdnf
2. van Panhuis WG, Paul P, Emerson C, Grefenstette J, Wilder R, Herbst AJ, et al. A systematic review of barriers to data sharing in public health. BMC Public Health [Internet]. 2014 Dec [cited 2020 Aug 22];14(1). Available from: https://doi.org/10.1186/1471-2458-14-1144
3. Health Metrics Organization. World Health Organization - WHO. Framework and standards for country health information systems [Internet]. 2nd ed. Geneva: World Health Organization; 2008 [cited 2020 Aug 23]. Available from: https://apps.who.int/iris/handle/10665/43872
4. Ministério da Saúde (BR). Datasus: trajetória 1991 – 2002 [Internet]. Brasília: Ministério da Saúde; 2002 [citado 2020 jun 17]. Disponível em: http://www.saude.gov.br/bvs/publicacoes/trajetoria_datasus.pdf
5. Saldanha RF, Bastos RR, Barcellos C. Microdatasus: pacote para download e pré-processamento de microdados do Departamento de Informática do SUS (DATASUS). Cad Saúde Pública [Internet]. 2019 set [citado 2020 jun 17];35(9). Disponível em: https://doi.org/10.1590/0102-311x00032419
6. R Development Core Team. A language and environment for statistical computing: reference index [Internet]. Vienna: R Foundation for Statistical Computing; 2010 [cited 2020 Jun 17]. Available from: http://www.polsci.wvu.edu/duval/PS603/Notes/R/fullrefman.pdf
7. Nedel FB. Pacote csapAIH: a lista brasileira de internações por condições sensíveis à atenção primária no programa R. Epidemiol Serv Saúde [Internet]. 2019 [citado 2020 ago 24];28(2):e2019084. Disponível em: https://doi.org/10.5123/s1679-49742019000200021
8. Rocha TAH, Silva NC, Amaral PVM, Barbosa ACQ, Vissoci JRN, Thomaz EBAF, et al. Geolocalização de internações cadastradas no Sistema de Informações Hospitalares do Sistema Único de Saúde: uma solução baseada no programa estatístico R. Epidemiol Serv Saúde [Internet]. 2018 [citado 2020 ago 24];27(4):e2017444. Disponível em: https://doi.org/10.5123/s1679-49742018000400016
9. Viacava F, Ugá MAD, Porto S, Laguardia J, Moreira RS. Avaliação de desempenho de sistemas de saúde: um modelo de análise. Ciênc Saúde Coletiva [Internet]. 2012 abr [citado 2020 nov 26];17(4):921-34. Disponível em: https://doi.org/10.1590/S1413-81232012000400014
10. Barcellos CC, Sabroza PC, Peiter P, Iñiguez Rojas L. Organização espacial, saúde e qualidade de vida: análise espacial e uso de indicadores na avaliação de situações de saúde. Inf Epidemiol SUS [Internet]. 2002 set [citado 2020 jun 17];11(3):129-38. Disponível em: https://www.arca.fiocruz.br/handle/icict/713
11. Rede Interagencial de Informações para a Saúde, organizador. Indicadores básicos para a saúde no Brasil: conceitos e aplicações [Internet]. 2. ed. Brasília: Organização Pan-Americana da Saúde; 2008 [citado 2020 nov 26]. 349 p. Disponível em: http://tabnet.datasus.gov.br/tabdata/livroidb/2ed/indicadores.pdf

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