Universidade de Lisboa
Faculdade de Farmácia

Data Insights for Future Health

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Monografia orientada pelo Professor Doutor Rui Miguel Dias Loureiro,
Professor Auxiliar Convidado

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Trabalho Final de Mestrado Integrado em Ciências Farmacêuticas apresentado à Universidade de Lisboa através da Faculdade de Farmácia

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Resumo

A dor osteoarticular é um problema significativo de saúde global que tem atraído a atenção da comunidade científica devido à sua potencial ligação às condições meteorológicas.

Apesar de vários estudos aprofundados, continua a não haver um consenso claro sobre este tema. Esta inconclusividade pode resultar da complexidade tanto das condições meteorológicas como da perceção da dor. Dada a natureza subjetiva inerentemente das experiências de dor, marcada por variações interindividuais significativas, é imperativo considerar esta variabilidade ao investigar a associação entre a dor osteoarticular e os fatores meteorológicos.

Muitos indivíduos com doenças reumáticas acreditam que as condições meteorológicas influenciam os seus sintomas, e que as temperaturas frias e os ambientes húmidos são geralmente considerados como tendo um impacto mais significativo. A compreensão desta relação pode melhorar o controlo das dores osteoarticulares, as intervenções médicas e os ajustes do estilo de vida dos pacientes.

Este estudo destaca a importância de investigar o impacto das condições meteorológicas na dor osteoarticular e nas doenças reumáticas, utilizando dados da Ilha da Madeira e da Ilha do Porto Santo, entre 2018 e 2022. O objetivo deste estudo é ultrapassar as limitações de estudos anteriores, que se baseavam frequentemente em questionários online subjetivos, com amostras pequenas e sem ter em conta fatores psicológicos.

Este estudo encontrou uma potencial correlação entre as variações de temperatura e humidade e a prevalência de doenças reumáticas, em diferentes municípios. Padrões de prevalência semelhantes em municípios com condições meteorológicas semelhantes sugerem que os fatores meteorológicos podem influenciar a prevalência de doenças reumáticas no Arquipélago da Madeira.

Agrupar municípios com taxas de prevalência semelhantes oferece vantagens em investigação, na saúde pública e na afetação de recursos, assegurando uma atribuição eficiente de recursos a grupos específicos e que se adaptada às alterações das taxas de prevalência ao longo do tempo.

Em última análise, esta abordagem visa otimizar o impacto na saúde pública através de uma gestão eficiente das doenças reumáticas. É importante notar que são necessárias mais investigações para validar os resultados deste estudo e explorar outros parâmetros meteorológicos que possam influenciar as taxas de prevalência das doenças reumáticas.

Palavras-chave: Dor osteoarticular; Condições meteorológicas; Doenças reumáticas; Prevalência; Alocação de recursos

Abstract

Osteoarticular pain is a significant global health concern that has garnered scientific community attention due to its potential connection to meteorological conditions.

Despite several extensive studies, a clear consensus remains elusive on this topic. This inconclusiveness may stem from the complexity of both meteorological conditions and pain perception. Given the inherently subjective nature of pain experiences, marked by significant interindividual variation, it is imperative to consider this variability when probing the association between osteoarticular pain and meteorological factors.

Many individuals with rheumatic conditions believe that weather influence their symptoms and cold temperatures and damp environments are commonly perceived as having the most significant impact. Understanding this relationship could improve osteoarticular pain management, medical interventions, and lifestyle adjustments for patients.

This study highlights the importance of investigating the impact of weather conditions on osteoarticular pain and rheumatic diseases, using real-world data from Madeira Island and Porto Santo Island between 2018 and 2022. The aim of this study is to overcome the limitations of previous studies, which were often based on subjective online questionnaires, with small samples and did not take psychological factors into account.

This study found a potential correlation between variations in temperature and humidity and the prevalence of rheumatic diseases in different municipalities. Similar prevalence patterns in municipalities with similar weather conditions suggest that meteorological factors may influence the prevalence of rheumatic diseases in the Madeira Archipelago.

Grouping municipalities with similar prevalence rates offers advantages in research, public health, and resource allocation, ensuring efficient allocation of resources to specific groups and adapting to changing prevalence rates over time. Ultimately, this approach aims to optimize public health impact by efficiently managing rheumatic diseases.

It is important to note that further research is required to validate these findings and explore other meteorological parameters that may influence the prevalence rates of rheumatic diseases.

Keywords: Osteoarticular pain; Meteorological conditions; Rheumatic diseases; Prevalence; Resource allocation

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List of Abbreviations

DREM – *Direção Regional de Estatística da Madeira*

GP - General Practitioner

HRQoL - health-related quality of life

IPMA - *Instituto Português do Mar e da Atmosfera*

MRD - Rheumatic and Musculoskeletal Disease

MSK - musculoskeletal

OA - Osteoarthritis

RA - rheumatoid arthritis

RD - rheumatic diseases

RH_med - average relative humidity

RS - Rheumatology Service

SESARAM - *Serviço de Saúde da Região Autónoma da Madeira*

Tair_med - average air temperature

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1. Introduction

Individuals experiencing chronic pain often mention that alterations in weather conditions affect the intensity of their pain (1,2).

Earlier investigations into individuals with chronic pain have evidenced a connection between pain reports and meteorological variables (3,4). However, there is limited exploration of this relationship in different climatic regions (1).

Osteoarticular pain represent a significant health issue affecting a significant proportion of the adult population worldwide (5), and its connection to meteorological conditions has drawn scientific attention (6). Despite the considerable attention directed towards this topic, many studies have reached inconsistent conclusions. (7).

The inconclusiveness of these studies could be attributed to the multifaceted nature of both meteorological conditions and pain perception (1).

Pain, especially that associated with arthritic conditions, is a highly subjective experience influenced by various individual factors (8,9), making it challenging to establish a universal cause-and-effect relationship with meteorological variables. Moreover, meteorological conditions themselves are intricate, involving a wide range of factors such as temperature, humidity, barometric pressure, and even seasonal changes, all of which can influence pain perception in diverse ways. Additionally, the underlying mechanisms that might explain the potential association remain a subject of ongoing investigation (10).

This lack of definitive findings fuels ongoing dynamic debate among scientific community, clinicians, and health experts and drives innovative methodologies, advanced data analysis, and broader contextual factors into consideration (11).

If a clear connection were established between meteorological conditions and pain, it could lead to better pain management strategies, more informed medical interventions, and even lifestyle adjustments for those affected.

A substantial number of individuals with rheumatic conditions assert that they experience exacerbated symptoms either prior or during shifts in weather patterns (12). In a study conducted by Jamison, a weather and pain questionnaire was administered to 558 chronic pain patients, revealing that 68% of participants believed their pain was influenced by weather fluctuations (1). Among these respondents, 53% indicated that their pain intensified preceding weather shifts, 62% reported pain exacerbation during weather changes, while a mere 11% noted pain intensification subsequent to weather alterations (1). Cold temperatures (60.7%) and damp environments (72.8%) were perceived as having the most pronounced impact on pain perception (1).

In a similar investigation by Shutty distributed a weather and pain questionnaire to 70 individuals enduring chronic pain, revealing that an overwhelming 97% of participants reported a discernible connection between weather changes and their pain levels (13).

Similarly, Hendler delved into this topic, discovering that a noteworthy percentage, ranging from 50% to 100%, of chronic pain patients across diverse diagnoses consistently experienced that their pain intensified with shifting weather conditions (14).

For centuries, individuals with rheumatic conditions living in colder mid-latitude climates have sought arthritis treatment in subtropical regions (11,15). This involves international physiotherapy for 4 weeks by multidisciplinary teams specializing in rheumatology (16), frequently in regions like the Mediterranean with consistently warm and stable climates (17,18).

The presence of stable barometric pressure, low humidity levels, relatively elevated average temperatures and abundant daily sunshine has been deemed optimal for individuals with rheumatic conditions, as these factors are believed to potentially increase their ability to engage in physical exercises (17).

A notable proportion of individuals with musculoskeletal conditions, ranging 62% to 97%, hold the belief that weather patterns exert an influence on their pain experiences (11).

Previous comprehensive analyses of existing literature on this subject have typically focused on investigating only one (12,19,20) or two (21) specific musculoskeletal conditions, namely osteoarthritis (OA) and rheumatoid arthritis (RA). While certain reviews contend that the prevailing evidence does not substantiate a connection between weather and (12,22) pain others indicate a link, although from a statistical and clinical point of view it is debatable (19,20,23,24).

1.1. The complex universe of rheumatic diseases

Among the most common chronic non-communicable diseases are rheumatic diseases (RD), also known as musculoskeletal (MSK) diseases (25). The categorization of RD can take various approaches, a convenient classification is based on their inherent characteristics and depends on their nature (26). They include over 200 degenerative, metabolic, inflammatory and autoimmune disorders that primarily affect the musculoskeletal (MSK) system (27,28).

RD cause discomfort and pain, resulting in restricted movement and function in one or multiple regions of the MSK system (29).

Chronic rheumatic conditions impact not only those with high life expectancy, but also extending to various demographic groups (30,31). They represent a major social and economic challenge to societies worldwide, being the leading cause of disability in developed countries and requiring a significant allocation of health and social resources (32,33).

Rheumatic disorders are classified by their chronic and progressive nature (34). They result in harm to the musculoskeletal system, contributing to patient incapacitation (35). Patients' quality of life is significantly reduced by these conditions (36). Several studies have shown that people with MSK conditions have lower levels of health-related quality of life (HRQoL) than people with other chronic conditions (37,38). Patients with osteoarthritis (OA), rheumatoid arthritis (RA), osteoporosis and fibromyalgia have been reported to experience the lowest HRQoL within the spectrum of RD (39).

Rheumatic issues concerning the musculoskeletal system are prevalent, and impact approximately 30–40% of the population in Europe, with over 100 million individuals experiencing such symptoms (40).

There are two forms of rheumatism based on their underlying disease process: non-inflammatory and inflammatory disorders (41).

Non-inflammatory disorders are occasionally referred to as post-traumatic arthritis (42), “mechanical arthritis” (43) or “degenerative arthritis” (44,45).

Non-inflammatory forms of arthritis primarily result from wear and tear on the joints and surrounding tissues (46,47). Unlike inflammatory arthritis, which involves an immune response causing inflammation in the joints, non-inflammatory arthritis is characterized by the breakdown of joint structures over time, confined to the affected joints (48,49). Although the exact causes of these arthritis types remain somewhat elusive, several significant risk factors have been identified, including genetic predisposition, body weight, and joint overuse (50–52).

In certain diseases, inflammatory processes become evident and are characterized by the five classic indicators of inflammation, which encompass redness, pain, warmth, swelling and loss of function (53,54).

Diagnosing these conditions can be challenging due to the wide array of symptoms, especially during the initial phases, which may not exhibit distinctive characteristics (55).

As recommended by the Portuguese Society of Rheumatology, the presence of pain, stiffness or swelling in a joint for more than 15 days makes it necessary to consult a rheumatologist. This enables early diagnosis and more effective treatment (56).

Although each rheumatic disease has specific risk factors, there are some that are common to the various diseases, such as age, smoking, obesity, taking certain drugs and excessive alcohol consumption (57).

1.2. Rheumatic diseases in Portugal

The EpiReumaPt study, an epidemiological study involving interviews with around 10,000 Portuguese people, made it possible to estimate the prevalence of rheumatic diseases in the Portuguese population.

The most prevalent diseases in the population are low back pain (26.4%), osteoarthrosis (19.1%), periarticular pathology (15.8%) and osteoporosis (10.1%).

Within inflammatory diseases, spondyloarthritis is the most prevalent disease (1.6%), followed by rheumatoid arthritis (0.7%). This study also demonstrated that patients with Rheumatic and Musculoskeletal Disease (MRD) have lower quality of life, worse physical function and mental health, and consume more health resources compared to individuals without MRD.

1.3. The economic burden of rheumatic diseases

The economic impact of RD is staggering, encompassing both direct and indirect expenses (58). Direct costs pertain to the allocation of resources for diagnosis, treatment and illness management (59). In contrast, indirect costs encompass the loss of productivity and the morbidity and mortality associated with the illness, which result in premature retirement as a consequence of these diseases (60,61).

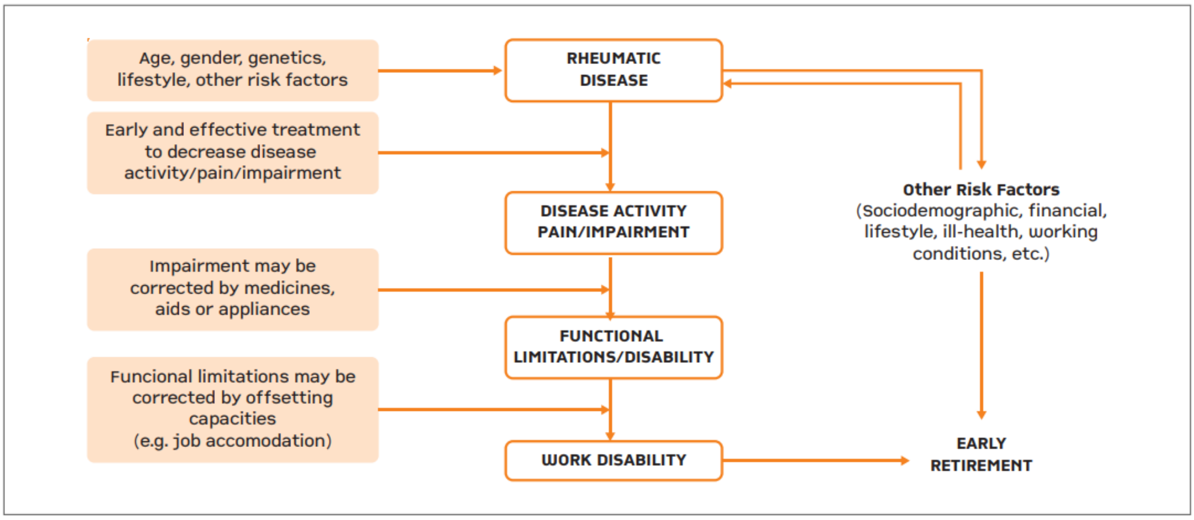

Figure 1. Relationship between RD and early retirement, from Laires PA, Gouveia M, Canhão H (62)

Understanding the indirect expenses associated with chronic pain is a crucial for minimizing the impact of chronic pain on the health and well-being of the Portuguese population (58).

With regard to healthcare costs, it is estimated that the total annual costs in Portugal for medical consultations for patients with MRD are approximately 1.6 billion euros. The costs of physiotherapy treatments are estimated at 220 million euros and productivity losses due to absences from work by rheumatic patients are estimated at around 204 million euros. The figures presented demonstrate the enormous prevalence, relevance and individual, social and economic impact of MRDs.

1.4. A picture of rheumatic diseases in Madeira Island

Although the Autonomous Regions of Madeira are not part of the National Network of Hospital Specialities and Rheumatology Referrals, as they have their own Regional Health Services, they have also developed their rheumatology care resources over the last few years

Among the respondents to the 4th National Health Survey 2005/2006 who declared that they had rheumatic disease, 91.2 % in *Portugal Continental*, 92.8% in the *Açores* and 93.8% in *Madeira* said that the source of the diagnosis was a doctor or nurse. In *Portugal Continental* and *Madeira*, these pathologies were more common in the age group of 85 and over (48.6% and 31.0%, respectively).

This survey also found that the lifetime prevalence of rheumatic disease was higher among women in all age groups. In women, rheumatic diseases were more prevalent in the group aged 85 and over, in *Portugal Continental* and *Madeira* (54.0% and 34.2% respectively).

In men, rheumatic diseases most frequently affected residents between 75 and 84 years of age (40.6% on the *Portugal Continetal*; 35.2% in the *Açores* and 25.1% in *Madeira*).

2. Objectives

The core objective of this study is to investigate the potential causal relationship between osteoarticular pain and meteorological conditions.

Despite numerous published articles on this subject, definitive conclusions are lacking, leaving significant questions open: Do changes in climatic factors really influence osteoarticular pain? Are there people sensitive to the weather and how does it affect those who suffer from rheumatic diseases?

A common limitation found in most existing studies is that they usually use online questionnaires to measure the levels of pain reported by individuals. Pain is a subjective experience (63–65), varying from person to person, and it is important to take this into account when investigating the relationship between osteoarticular pain and weather conditions.

In previous studies, there was limited consideration of psychological. Among rheumatic patients, it is a prevalent belief that weather influences their symptoms, particularly associating cold and damp conditions with worsened joint pain. Even if participants were unaware of the study's hypothesis, they could instinctively link their arthritis symptoms to observable weather conditions, possibly introducing bias when responding to questionnaires (21).

Another limitation lies in the limited sample sizes of most studies, typically comprising fewer than 100 participants . This small sample size undermines the representativeness and reliability of their findings.

The lack of cross-checking of annual meteorological data with reported pain levels or the number of rheumatic patients in different climate zones ends up biasing the results and makes it difficult to identify a clear relationship or its absence.

In this context, the necessity emerges to approach this issue from a different perspective, adopting a more comprehensive methodology to data collection and analysis. This study aims to adjust data collection to reality, not based on data collected in questionnaires, but on public meteorological and demographic data, as well as data from the hospital rheumatology service. The sample of this study is the population living on Madeira Island and Porto Santo Island and the data collected is from the last 5 years, namely between 2018 and 2022.

3. Materials and Methods

3.1. Sample selection and characterization

The starting point was the population living on Madeira Island and Porto Santo Island, since the Health Service of the Autonomous Region of Madeira, known as SESARAM, is an integrated unit for the provision of health care, based in Funchal. It has all the centralized information of the different units and services in the region, a useful tool that allows the scientific activity carried out in the institution to be considered as a whole, and disseminated in a single and organized way, in digital format (66).

Another reason for choosing this location as a study site is the climate of the Madeira Archipelago, which is geographically located in the subtropical region, with a mild climate in both winter and summer, except in the highest areas, where lower temperatures are observed (67,68). The moderating effect of the sea on temperatures is evident in the reduced temperature range observed on the islands (67).

Throughout Madeira Island we find the so-called microclimates, being known as the island of the four seasons (69). The large mountains and air currents from various directions mean that the climate is different in each city. Normally, the south is always the hottest part of the island (69). As we move north, the temperature drops and in the interior of the island, where the areas are higher, the temperatures tend to be lower and even with some precipitation (69).

3.2. Study

3.2.1. Study characterization

Considering that there was no direct interaction with patients in the rheumatology department, the study is classified as exploratory and observational.

From an epidemiological perspective, this research is characterized as descriptive and cross-sectional, as it examines the occurrence of specific characteristics in a defined population and during a specific time frame, involving diverse individuals.

3.2.2. Study location and duration

Data were collected from the Rheumatology service, meteorological and demographic, all referring to the Madeira Archipelago, namely Madeira Island and Porto Santo Island. The data collected corresponded to a period of 5 years, specifically between 1 January 2018 and 31 December 2022.

3.3. Data collection

3.3.1. Rheumatology service data

Rheumatology is a medical speciality that diagnoses and treats conditions affecting the joints, muscles and bones. In this context, rheumatology data from the hospital service was requested from SESARAM. They provided the total number of users of this service from 2018 to 2022, as well as the number of users by gender, age group and city.

The data requested includes the following details:

- Total number of patients, thus obtaining an overview of how many patients sought and were seen by the rheumatology service during this five-year period.
- Number of patients by gender, as it is useful to know how many male and female patients used the rheumatology service separately.
- Number of patients by age group, which helps to understand the age distribution of patients. They were divided into 9 age groups: 0-9 years, 10-19 years, 20-29 years, 30-39 years, 40-49 years, 50-59 years, 60-69 years, 70-79 years and over 80 years.
- Number of patients by municipality of residence, to find out where patients come from geographically, and then match with demographic and meteorological data, both by municipality.

In total, 1080 data were collected and subsequently analyzed. Attachment 1 shows the data provided by SESARAM and example of how the data from the rheumatology service were processed.

3.3.1.2. Ethical considerations

This study was submitted to and approved by the SESARAM authorities: the Board of Directors, the Scientific Committee, and the Ethics Committee.

It was not necessary for patients in the rheumatology department to sign an informed consent form, as the patients' medical records and personal data were not accessed. All the data collected was used only for the purpose of this research, always guaranteeing the anonymity of the participants.

3.3.2. Demographic data

There are two sources of demographic data being considered: the "Pordata" website and the “DREM”, a madeira government website." These sources provide demographic data for specific regions in the Madeira Archipelago.

The aim was to collect public data from official government sources, and since it comes from the official website of the Regional Directorate of Statistics of Madeira (DREM), an official statistics portal, this source was chosen to obtain reliable data.

On this website it is possible to download all the information for each year through an Excel file, which contains not only demographic indicators by municipality, but also other indicators concerning birth, mortality, marriage, divorce, and the foreign population.

The collected demographic data will be used for analysis. Specifically, the focus will be on understanding the distribution of the population and the various age groups within each municipality in the Madeira region.

The demographic data collected was given into 18 groups: 0-4 year, 4-9 years, 10-14 years, 15-19 years, 20-24 years, 25-29 years, 30-34 years, 35-39 years, 40-44 years, 45-49 years, 50-54 years, 55-59 years, 60-64 years, 65-69 years, 70-74 years, 75-79 years, 80-84 years and over 85 years.

It should be noted that the demographic data did not have the same age range as the rheumatology data. Therefore, it is necessary convert and adjust the age groups in the demographic data to match the age groups present in the rheumatology data.

The age range scale chosen for this transformation involves grouping ages in intervals of 9 years. This means that the age groups in the demographic data have been organized into groups such as: 0-9 years, 10-19 years, 20-29 years, 30-39 years, 40-49 years, 50-59 years, 60-69 years, 70-79 years and over 80 years.

3.3.3. Meteorological data

The director of the Funchal Meteorological Observatory of the Portuguese Institute of the Sea and Atmosphere (IPMA), Victor Prior, provided meteorological data for Archipelago, by hourly frequency and for a period of 5 years, from 2018 to 2022.

Each measuring station corresponds to a number and is located in a specific municipality.

A variety of data was provided, not just temperature, humidity and precipitation. The following table shows all the meteorological parameters provided.

Cpo	Name	Unit	Numerical magnitude	Dim.	Description
	Station Number		Integer	8	
	Year	-	Integer	4	Year to which the information relates, since 1996
	Month	-	Integer	2	Month to which the information refers
	Day	-	Integer	2	Day of the month to which the information relates
0	Hour	-	Integer	2	Time to which the information relates
1	Pr_ST_med	hPa	Decimal	6	Average atmospheric pressure at station level
2	Pr_St_mx	hPa	Decimal	6	Maximum pressure at station level
3	Pr_St_mn	hPa	Decimal	6	Minimum pressure at station level
4	Pr_St_stdv	hPa	Decimal	4	Standard deviation of atmospheric pressure at station level
5	Pr_Sl_med	hPa	Decimal	6	Mean atmospheric pressure at mean sea level or mean geopotential 850hPa for station above 1000m
6	Pr_Sl_mx	hPa	Decimal	6	Maximum atmospheric pressure at mean sea level or maximum geopotential 850hPa for station above 1000m
7	Pr_Sl_mn	hPa	Decimal	6	Minimum atmospheric pressure at mean sea

					level or minimumgeopotential 850hPa for station above 1000m
8	Pr_Sl_stdv	hPa	Decimal	4	Standard deviation of mean sea level pressure or geopotential 850hPa for station above 1000m
9	Pr_Vr3h	hPa	Decimal	4	Variation of atmospheric pressure in the last 3 hours
10	Pr_Td	-	Integer	4	Pressure trend in the last 3 hours
11	Tair_inst	ºC	Decimal	5	Instantaneous air temperature at 1.5m
12	**Tair_med**	**ºC**	**Decimal**	**5**	**Average air temperature at 1.5m**
13	Tair_max	ºC	Decimal	5	Maximum air temperature at 1.5m
14	Tair_min	ºC	Decimal	5	Minimum air temperature at 1.5m
15	Tair_stdv	ºC	Decimal	4	Standard deviation of air temperature at 1.5m
16	RH_inst	%	Integer	4	Instantaneous relative humidity
17	**RH_med**	**%**	**Integer**	**4**	**Average relative humidity**
18	RH_max	%	Integer	4	Maximum relative humidity
19	RH_min	%	Integer	4	Minimum relative humidity
20	RH_stdv	%	Integer	4	Standard deviation of relative humidity
21	TW_inst	ºC	Decimal	5	Instantaneous temperature of wet thermometer
22	TW_med	ºC	Decimal	5	Average temperature of wet thermometer
23	TW_max	ºC	Decimal	5	Maximum wet thermometer temperature
24	TW_min	ºC	Decimal	5	Minimum wet thermometer temperature
25	TW_stdv	ºC	Decimal	4	Standard deviation of wet thermometer temperature
26	TD_inst	ºC	Decimal	5	Instantaneous dew point temperature
27	TD_med	ºC	Decimal	5	Average dew point temperature
28	TD_max	ºC	Decimal	5	Maximum dew point temperature
29	TD_min	ºC	Decimal	5	Minimum dew point temperature
30	TD_stdv	ºC	Decimal	4	Standard deviation of dew point temperature
31	E_inst	hPa	Decimal	5	Instantaneous vapour pressure
32	E_med	hPa	Decimal	5	Average vapour pressure
33	E_max	hPa	Decimal	5	Maximum vapour pressure

34	E_min	hPa	Decimal	5	Minimum vapour pressure
35	E_stdv	hPa	Decimal	4	Standard deviation of vapour pressure
36	dd_med	º	Integer	4	Mean wind direction
37	dd_ff_max	º	Integer	4	Maximum wind direction
38	dd_stdv	º	Integer	4	Standard deviation of wind direction
39	dd_pre	-	Integer	4	Prevailing wind direction => 0-calm 1-NE 2-E 3-SE 4-S 5-SW 6-W 7-NW 8-N 9-undefined
40	ff_med	m/s	Decimal	5	Mean wind intensity
41	ff_max	m/s	Decimal	5	Maximum instantaneous wind intensity
42	ff_stdv	m/s	Decimal	4	Standard deviation of wind intensity
43	T+05_med	ºC	Decimal	5	Mean air temperature at +0.05m
44	T+05_max	ºC	Decimal	5	Maximum air temperature at +0.05m
45	T+05_min	ºC	Decimal	5	Minimum air temperature at +0.05m
46	T+05_stdv	ºC	Decimal	4	Standard deviation of air temperature at +0.05m
47	T-05_med	ºC	Decimal	5	Average air temperature at -0.05m
48	T-05_max	ºC	Decimal	5	Maximum air temperature at -0.05m
49	T-05_min	ºC	Decimal	5	Minimum air temperature at -0.05m
50	T-05_stdv	ºC	Decimal	4	Standard deviation of air temperature at -0.05m
51	T-10_med	ºC	Decimal	5	Average air temperature at -0.10m
52	T-10_max	ºC	Decimal	5	Maximum air temperature at -0.10m
53	T-10_min	ºC	Decimal	5	Minimum air temperature at -0.10m
54	T-20_med	ºC	Decimal	5	Average air temperature at -0.20m
55	T-20_max	ºC	Decimal	5	Maximum air temperature at -0.20m
56	T-20_min	ºC	Decimal	5	Minimum air temperature at -0.20m
57	T-50_med	ºC	Decimal	5	Temperatura média do ar a -0,50m
58	T-100_med	ºC	Decimal	5	Average air temperature at -1.00m
59	RRR_dur	min.	Integer	4	Duration of precipitation
60	RRR_qt	mm	Decimal	5	Amount of precipitation
61	RRR_intmax	mm/h	Decimal	5	Maximum "instantaneous" intensity of precipitation

62	RG_total	KJ/m2	Decimal	6	Total global radiation
63	RG_max	KJ/m2	Decimal	6	Maximum global radiation in one minute
64	RG_min	KJ/m2	Decimal	6	Minimum global radiation in one minute
65	RD_total	KJ/m2	Decimal	6	Total diffuse radiation
66	RD_max	KJ/m2	Decimal	6	Maximum diffuse radiation in one minute
67	RD_min	KJ/m2	Decimal	6	Minimum diffuse radiation in one minute
For the magnitudes indicated as "Decimal", the values have to be divided by 10. Examples: +0180 = 18.0 ; +0026 = 2.6 -990 e -99: failing fields					

Table 1. Description of meteorological data

3.4. Statistical analysis

After obtaining the data from the rheumatology service provided by SESARAM, the demographic data taken from the official statistics portal of the regional government and the meteorological data provided by the IPMA, which was crucial to the development of this study, all this data was processed in Microsoft 365® Office Excel® for Microsoft Windows 11, version 23.08 (64-bit).

4. Results and Discussion

4.1. Meteorological data

As previously mentioned, cold temperatures and humid environments seem to have a greater association with pain intensity (1). Therefore, from the data made available by the IPMA, the focus was on analyzing the average air temperature (Tair_med) and average relative humidity (RH_med) data from the municipalities of Madeira Island and Porto Santo Island (**Table 2**), in order to find out if there is any causal relationship with the number of patients in the Rheumatology service.

The following table shows the name of all meteorological stations and their corresponding number, as well as the station type, latitude, longitude, municipality and whether or not it was analyzed.

Number	Name	Station type	Latitude	Longitude	City	Analyzed
520	Selvagem Grande	Automatic Climatological Station	30,145369	-15,871041	-	
521	Santa Catarina - Aerodrome	Main Automatic Station	32,693166	-16,776208	Santa Cruz	✓
522	Funchal - Observatory	Main Automatic Station	32,647525	-16,892483	Funchal	✓
524	Porto Santo - Aerodrome	Main Automatic Station	33,071458	-16,348483	Porto Santo	✓
956	Porto Moniz	Automatic Climatological Station	32,867350	-17,167950	Porto Moniz	✓
960	Ponta de S. Jorge	Automatic Climatological Station	32,834469	-16,906219	Santana	✓
965	Santana	Automatic Climatological Station	32,808238	-16,886416	Santana	
967	São Vicente	Automatic Climatological Station	32,800183	-17,044722	São Vicente	✓
970	Bica da Cana	Automatic Climatological	32,756469	-17,057688	Ponta do Sol	

		Station				
971	Funchal - Lido	Urban Automatic Station	32,636550	-16,935591	Funchal	
972	Pico Alto	Automatic Climatological Station	32,694444	-16,903888	Funchal	
973	Chão do Areeiro	Automatic Climatological Station	32,722075	-16,916233	Funchal	
974	Pico do Areeiro	Automatic Climatological Station	32,735233	-16,928316	Santana	
975	Santo da Serra	Automatic Climatological Station	32,725897	-16,816822	Machic o	✓
978	Caniçal - São Lourenço	Automatic Climatological Station	32,748433	-16,706605	Machic o	
980	Lombo da Terça	Automatic Climatological Station	32,831450	-17,202086	Porto Moniz	
984	Quinta Grande	Automatic Climatological Station	32,662972	-17,015036	Câmara de Lobos	✓
986	Lugar de Baixo	Automatic Climatological Station	32,681227	-17,092750	Ponta do Sol	✓
990	Ponta do Pargo	Automatic Climatological Station	32,813841	-17,263213	Calheta	✓

Table 2. List of meteorological stations in the Madeira Archipelago

Data were provided from 19 meteorological stations in the Madeira Archipelago (Table 2).

The meteorological stations were analyzed based on their geographical interest and whether or not they had inhabitants, so 9 of the 19 meteorological stations were analyzed (Figure 2 and Figure 3).

For example, it makes no sense to analyze the station 520, in *Selvagem Grande*, which is a nature reserve, because it has no resident population, except for the two security guards and the two members of the maritime police (70).

Stations 960 and 965 are located in the same municipality, so station 960 was chosen because it is further north.

Station 971 was not analyzed because in the municipality of Funchal there is another meteorological station - station 522 - with more research interest because it is the main station and there are more inhabitants at those coordinates.

There are remote areas of Madeira, such as *Pico do Arieiro*, at an altitude of 1818 meters, where there is no point in analyzing them, as due to their location there are no residents in those municipalities.

Stations 970, 972, 973, 974, 978 and 980 were also not analyzed because there are no residents there.

Figure 2. Satellite image of Madeira Island with the coordinates of the meteorological stations analyzed, via Google Earth

Figure 3. Satellite image of Porto Santo Island with the coordinates of the meteorological stations analyzed, via Google Earth

For each meteorological station, 67 meteorological parameters (Table 1) were observed per hour, which gives a total of 630 720 data analyzed per station (Table 3).

In total, 9 meteorological stations on Madeira Island and 1 meteorological station on Porto Santo Island were treated, totaling 6 307 200 data analyzed.

Month	Number of data processed
January	53568
February	48384
March	53568
April	51840
May	53568
June	51840
July	53568
August	53568
September	51840

October	53568
November	51840
December	53568
Total	**630720**

Table 3. Data analyzed monthly for a meteorological station

4.1.1. Scale of meteorological data

The goal is to compare and correlate the data from the rheumatology service with meteorological data.

However, the data from the rheumatology service was provided by year. In other words, it is not possible to check user access to the service by day, week or month.

To obtain a meaningful comparison and analysis between the two datasets, it is necessary to transform the meteorological data to the same time scale of the rheumatological data. In this case, the transformation involves aggregating the meteorological data by year.

After analyzing the hourly air temperature (Tair_med) and relative humidity (RH_med), it was necessary to calculate the monthly average and then the annual average for each year (2018, 2019, 2020, 2021 and 2022). This transformation process was performed separately for each weather station.

Attachment 3 shows an example of the monthly and annual average of the meteorological data.

The annual averages of all meteorological stations were then compiled (**Table 4 and 5**) and a graph was created for the averages of air temperature (**Figure 4**) and another graph for relative humidity (**Figure 5)**.

Municipality	Air Temperature (ºC)				
	2018	2019	2020	2021	2022
Calheta	17,3	17,9	17,9	18,0	18,0
Câmara de Lobos	16,1	16,6	16,7	16,4	16,7
Funchal	19,5	20,1	20,2	19,9	20,1
Machico	13,1	13,6	13,8	13,7	13,8
Ponta do Sol	19,6	20,3	20,2	20,2	20,4
Porto Santo	18,6	19,1	19,2	19,1	19,2
Porto Moniz	18,9	19,2	19,9	19,9	19,6
Santana	17,1	17,5	17,3	17,4	17,5
Santa Cruz	19,2	19,7	19,8	19,7	19,6
São Vicente	17,5	17,9	18,0	17,5	17,8

Table 4. Average annual air temperature for each meteorological station

Municipality	Relative Humidity (%)				
	2018	2019	2020	2021	2022
Calheta	78,55	76,40	75,65	76,03	75,61
Câmara de Lobos	71,02	68,93	70,83	70,19	70,92
Funchal	66,57	63,91	65,55	64,14	64,94
Machico	84,92	83,25	71,70		
Ponta do Sol	67,40	64,58	66,19	66,56	66,98
Porto Santo	75,60	74,73	76,26	75,83	75,82
Porto Moniz	72,79	70,88	70,11	74,05	69,96
Santana	85,62	85,00	86,93	87,33	87,72
Santa Cruz	68,37	66,79	68,14	67,01	65,41
São Vicente	78,02	75,63	78,26	75,05	75,75

Color legend:

- value disregarded
- lack of data

Table 5. Average annual relative humidity for each meteorological station

Regarding the municipality of Machico (station 975), in 2022 there are no hourly data for average relative humidity (RH_med), so it was not possible to realize the annual average due to this failure.

Also at this weather station, although RH_med data is available for 2021, there are many hourly gaps in the months of February, May, June, August, September, October and December, with 791 hourly data missing, which corresponds to around 33 days. When the annual average was analyzed, it was found that this corresponded to 51.2% RH_med, which when compared to the previous three years shows a drop of around 34% compared to the average for those years, which corresponded to 79.9% Rh_med. This difference is significant and leads to a large discrepancy in values. It was necessary to exclude the annual average for 2021, as it did not correspond to a real value due to the hourly failures in that year.

In order to better visualize the data in both tables, graphs were made to see which weather station had the lowest average air temperature and which had the highest average relative humidity.

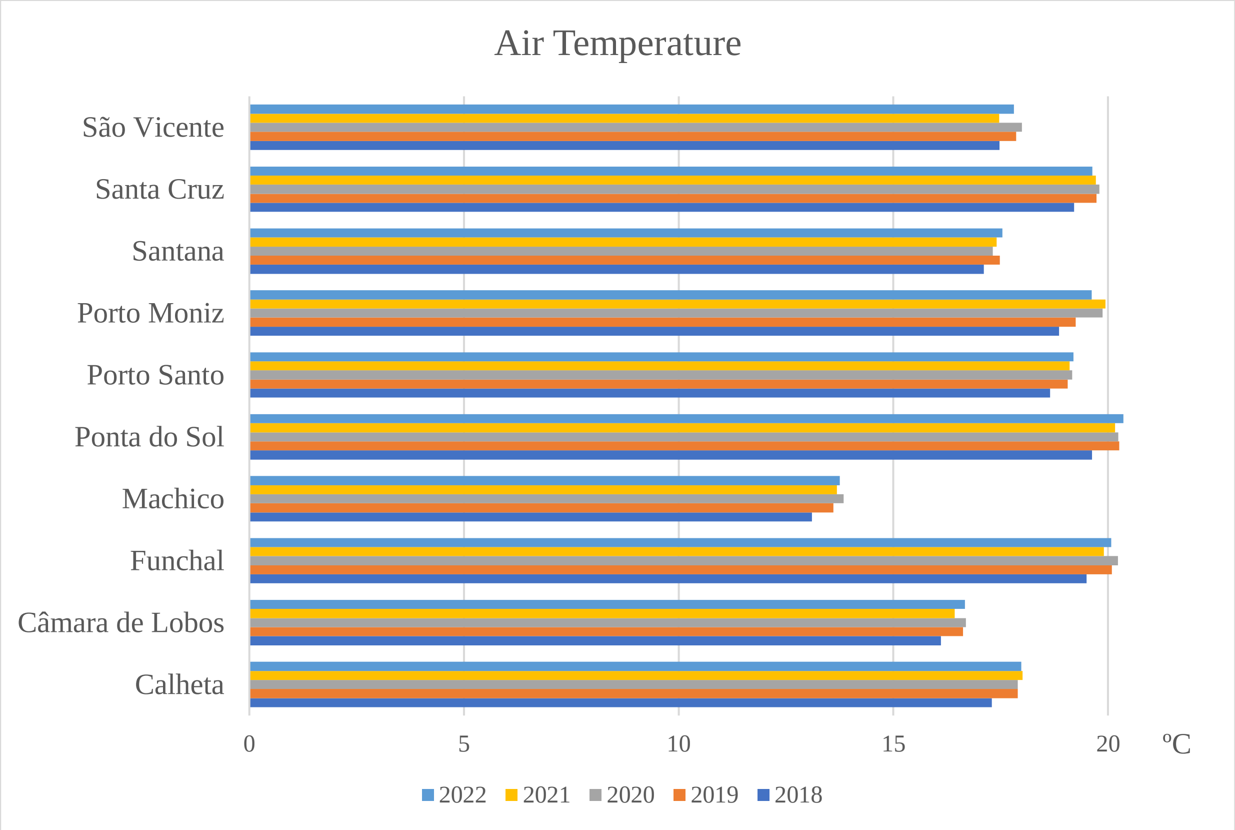

Figure 4. Annual average relative humidity

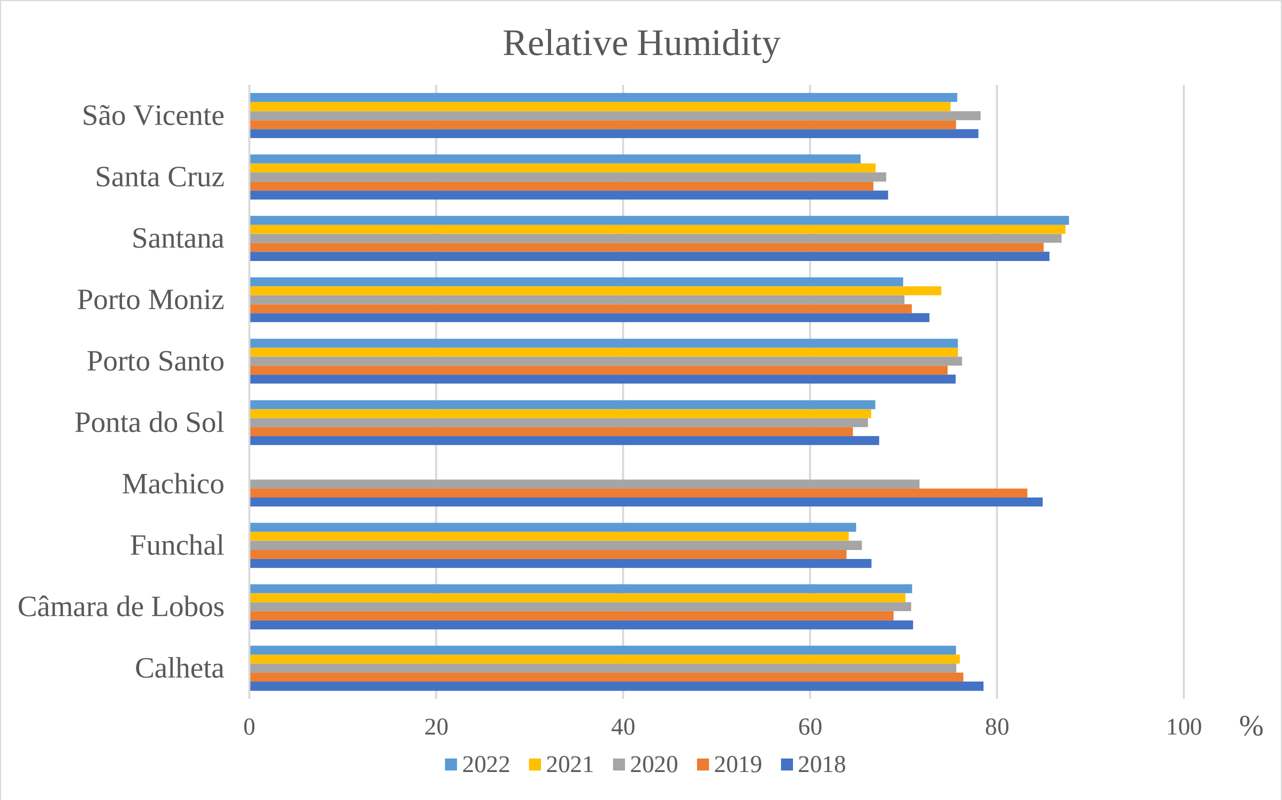

Figure 5. Annual average relative humidity

4.2. Rheumatology service and demographic data

The scientific literature suggests that women are more predisposed to developing rheumatic diseases (71,72).

We also know that the Portuguese population has a higher percentage of women than men (73,73,74).

Given the greater prevalence of rheumatic diseases in women or the higher proportion of women in the population, it would be expected that there would be more female than male patients in the rheumatology service (RS). It would be useful to understand whether this number is actually higher due to the susceptibility of these rheumatic diseases in women, taking into account demographic bias.

With this in mind, demographic data was collected to determine the proportion of patients of each age group and gender in the general population. This analysis helps determine whether the observed pattern aligns with the expected pattern based on these factors.

Through demographic data and the subsequent creation of population pyramid graphs from 2018 to 2022 for each municipality, it was possible to see the distribution of the population by gender and age group (Attachment 2).

The prevalence of rheumatic diseases by municipality was also calculated, taking into account the total number of residents and the number of users of the RS.

Municipality	Parameters	2018	2019	2020	2021	2022
Calheta	Total number of people	10865	10867	10833	10968	10962
	Total number of SR patients	63	69	55	59	71
	Prevalence	**0,6%**	**0,6%**	**0,5%**	**0,5%**	**0,6%**
Câmara de Lobos	Total number of people	33732	33675	33639	32349	32416
	Total number of SR patients	181	217	205	188	234
	Prevalence	**0,5%**	**0,6%**	**0,6%**	**0,6%**	**0,7%**
Funchal	Total number of people	104129	104024	103754	106401	106429
	Total number of SR patients	799	888	848	806	947
	Prevalence	**0,8%**	**0,9%**	**0,8%**	**0,8%**	**0,9%**
Machico	Total number of people	20094	19981	19870	19617	19508
	Total number of SR patients	176	199	186	154	178
	Prevalence	**0,9%**	**1,0%**	**0,9%**	**0,8%**	**0,9%**
Ponta do Sol	Total number of people	8544	8593	8554	8474	8518
	Total number of SR patients	57	49	54	49	51
	Prevalence	**0,7%**	**0,6%**	**0,6%**	**0,6%**	**0,6%**
Porto Moniz	Total number of people	2350	2342	2312	2493	2499
	Total number of SR patients	16	15	20	16	20
	Prevalence	**0,7%**	**0,6%**	**0,9%**	**0,6%**	**0,8%**
Ribeira Brava	Total number of people	12411	12435	12356	12828	12854
	Total number of SR	81	97	114	95	103

	patients					
	Prevalence	**0,65%**	**0,78%**	**0,92%**	**0,74%**	**0,80%**
Santa Cruz	Total number of SR patients	44744	45281	45647	42964	43416
	Total number of SR patients	254	302	285	295	350
	Prevalence	**0,57%**	**0,67%**	**0,62%**	**0,69%**	**0,81%**
Santana	Total number of people	6750	6711	6648	6527	6452
	Total number of SR patients	26	32	35	30	29
	Prevalence	**0,4%**	**0,5%**	**0,5%**	**0,5%**	**0,4%**
São Vicente	Total number of people	5150	5143	5113	4863	4859
	Total number of SR patients	30	27	28	21	21
	Prevalence	**0,6%**	**0,5%**	**0,5%**	**0,4%**	**0,4%**
Porto Santo	Total number of people	5176	5202	5197	5209	5346
	Total number of SR patients	46	57	50	49	51
	Prevalence	**0,9%**	**1,1%**	**1,0%**	**0,9%**	**1,0%**

Table 6. Prevalence of rheumatic diseases by municipality

Porto Santo is the municipality with the highest prevalence rate. On the basis that meteorological conditions have an impact on rheumatic patients, it would be expected that Machico or Santana would have a higher prevalence rate, since Machico has the lowest annual air temperature averages (Figure 4) and Santana the highest annual relative humidity averages (Figure 5).

It is possible to verify that Machico is the second municipality with the highest prevalence, however Santana is the municipality with the lowest prevalence of rheumatic diseases, which is not as expected.

The third municipality with the highest prevalence is Funchal, but on checking figures 4 and 5, it is one of the places with the highest temperatures and lowest humidity.

The data in table 6 does not corroborate the data in the graphs of air temperature and relative humidity (Figures 4 and 5), so it is not possible to say that low air temperature and high humidity influence the number of patients accessing the rheumatology service.

When analyzing the prevalence of each municipality with Tair and RH data (Attachment X4), it was notice a consistent pattern certain municipalities. To simplify the analysis, municipalities with similar trends in the prevalence rate were aggregated to see if this pattern in prevalence could be based on geographical proximity, shared characteristics, or any other relevant factors.

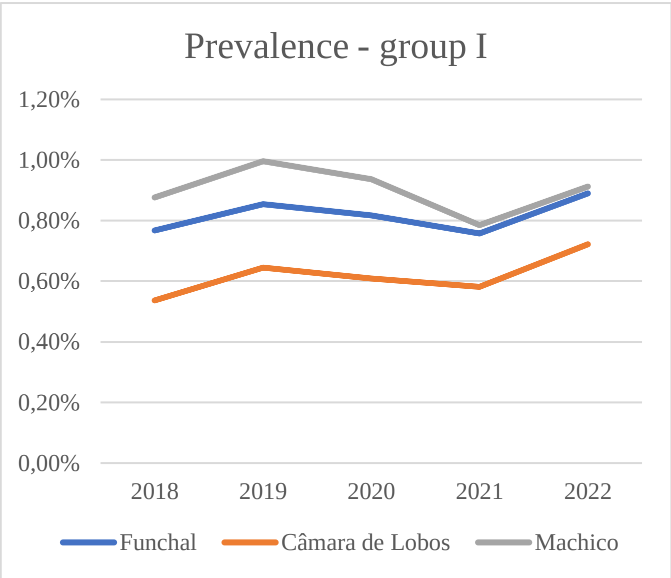

Figure 4. Prevalence trend, group I

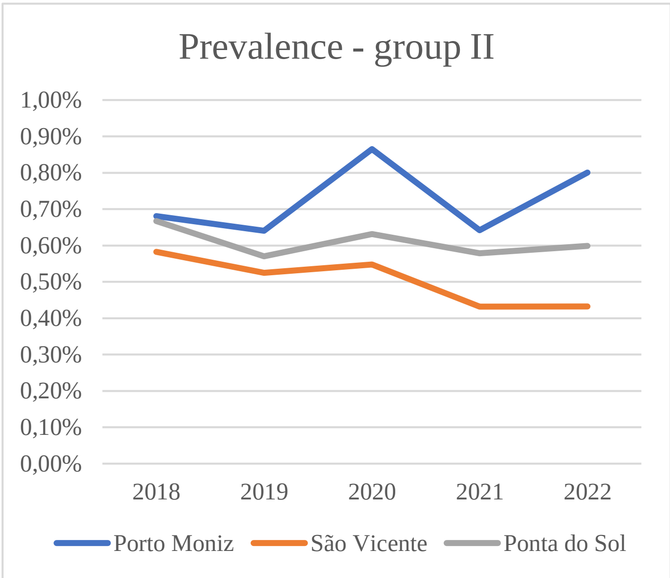

Figure 5. Prevalence trend, group II

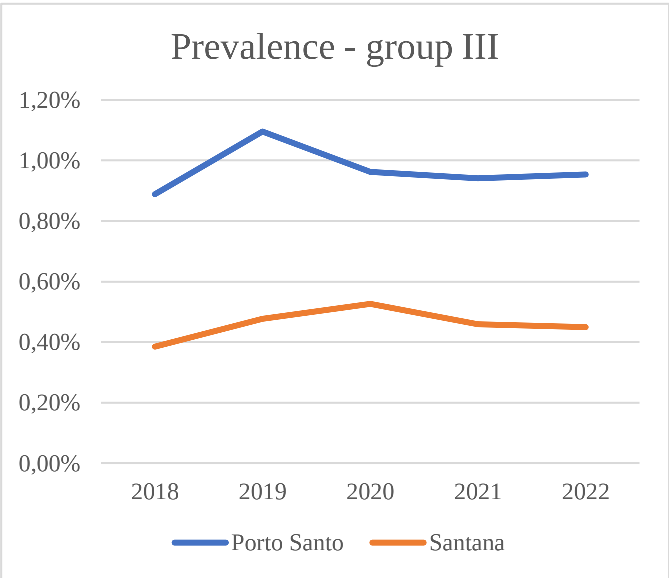

Figure 6. Prevalence trend, group III

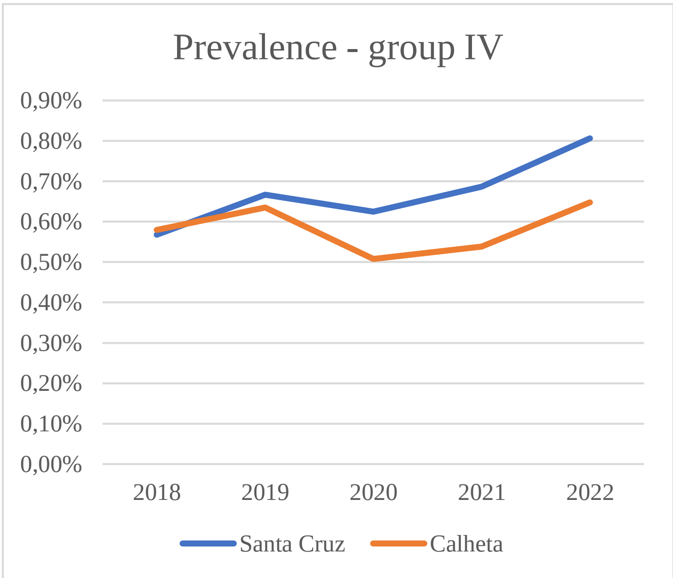

Figure 7. Prevalence trend, group IV

4.3. Demographic, rheumatology and meteorological data

After aggregating municipalities based on prevalence trends, these groups were placed on the map to see if there is any geographic proximity (**Figure 10**).

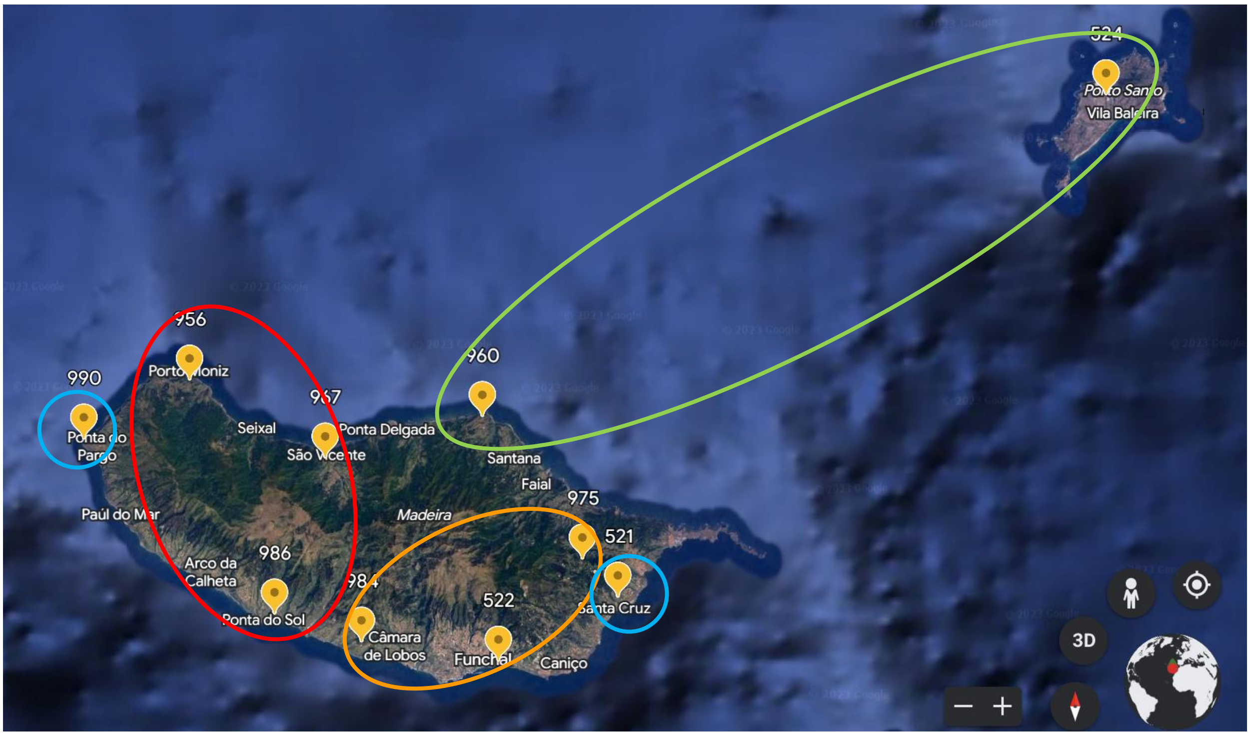

Figure 8. Geographic proximity based on prevalence trend

Color legend:

- Group I
- Group II
- Group III
- Group IV

It is clear that the groups with the same prevalence pattern are geographically close, with the exception of group IV, which is at both ends of Madeira Island.

It was then analyzed whether there is any similarity in the Tair and RH data in the previously aggregated groups.

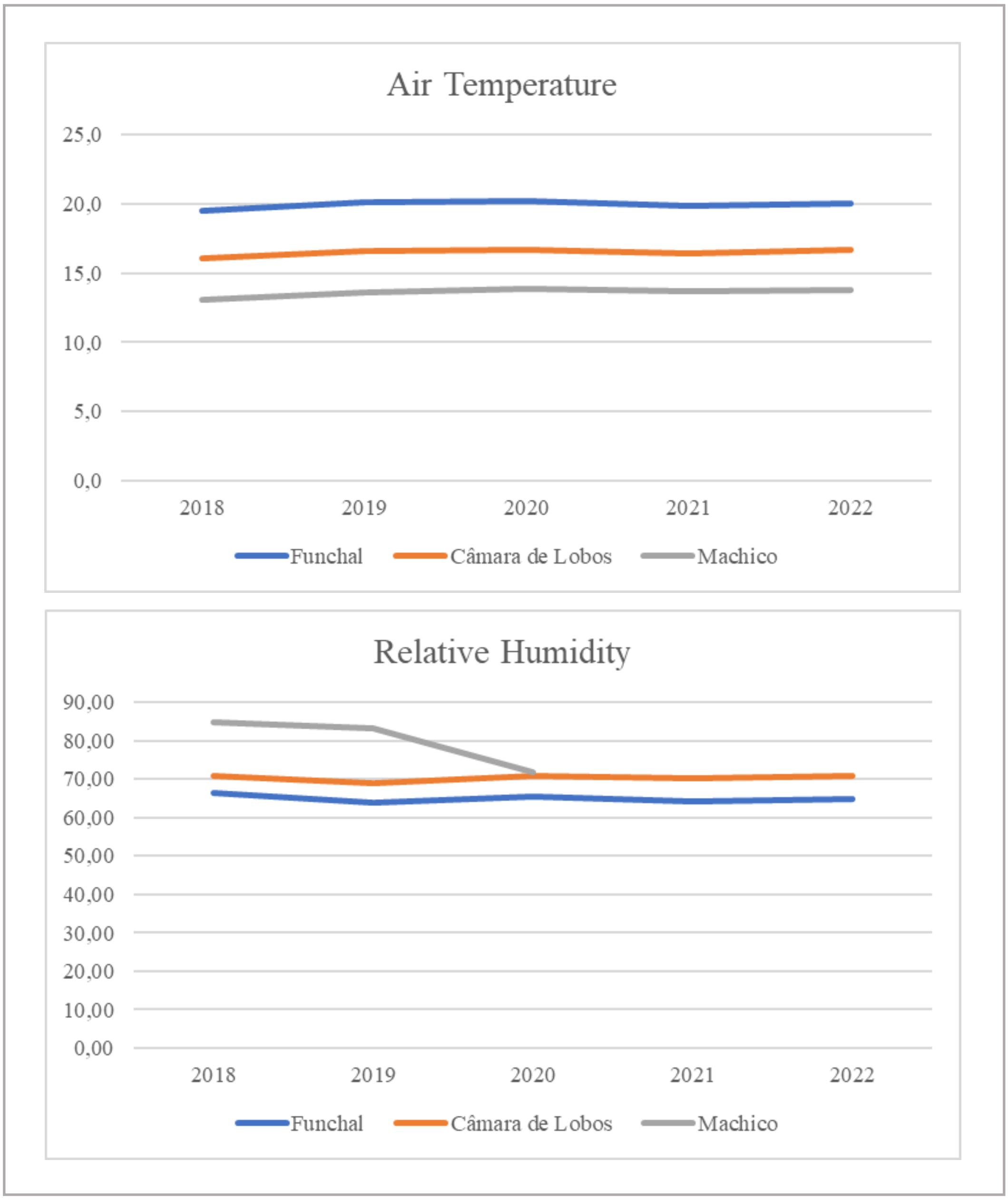

Figure 9. Annual average of meteorological stations, group I

It should be noted that there are many gaps in the relative humidity data for the municipality of Machico, so the RH graph may not match expectations.

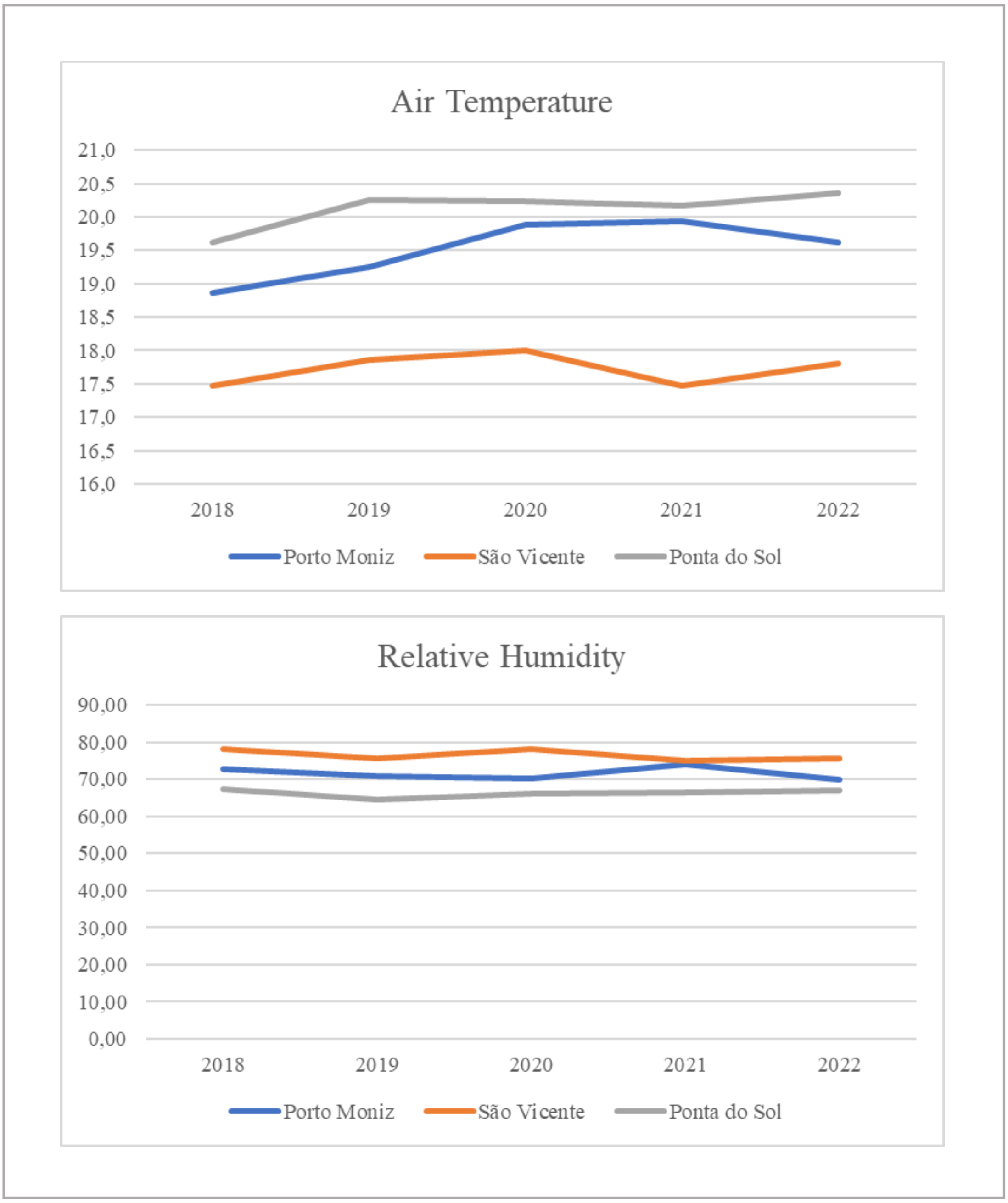

Figure 10. Annual average of meteorological stations, group II

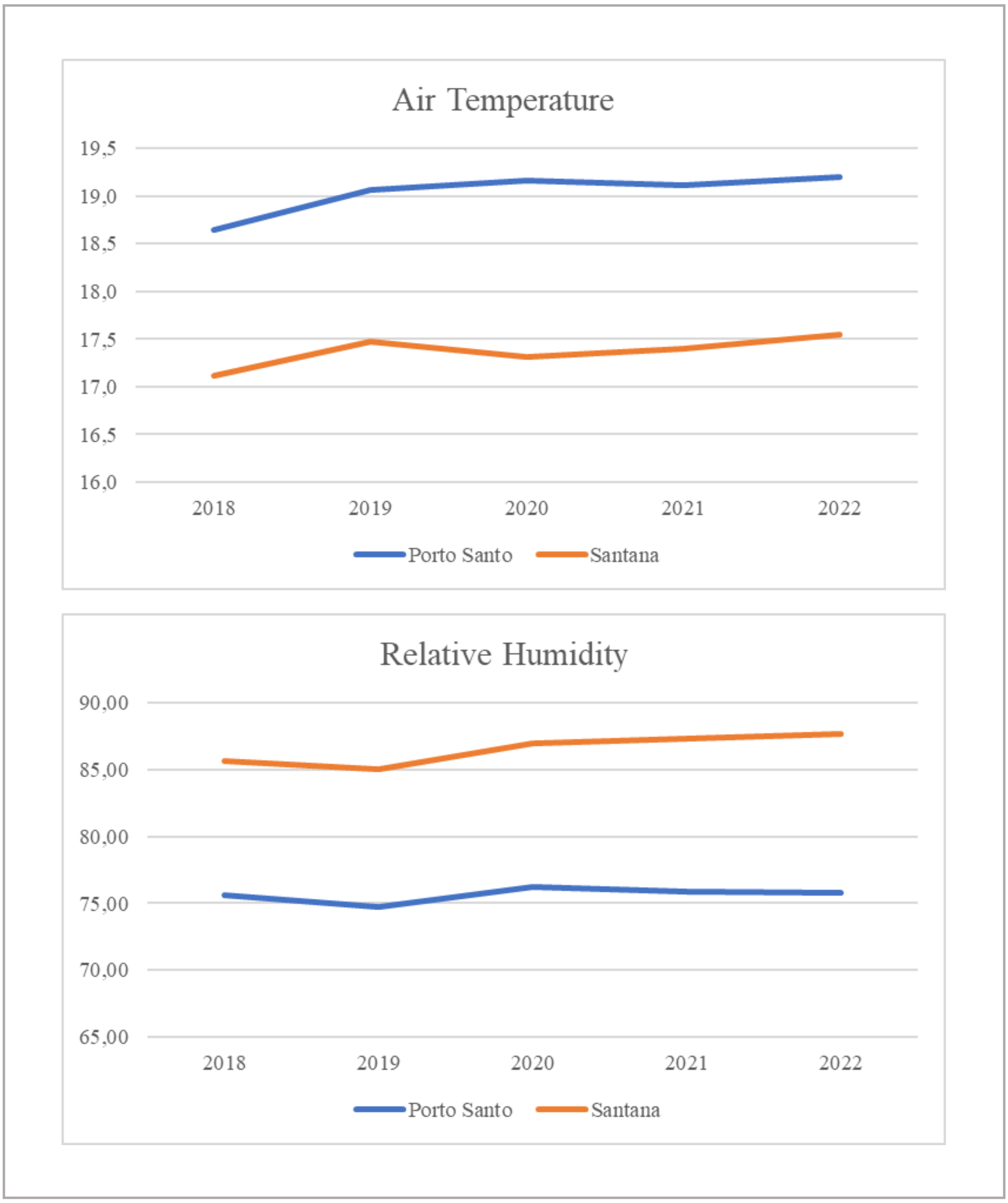

Figure 11. Annual average of meteorological stations, group III

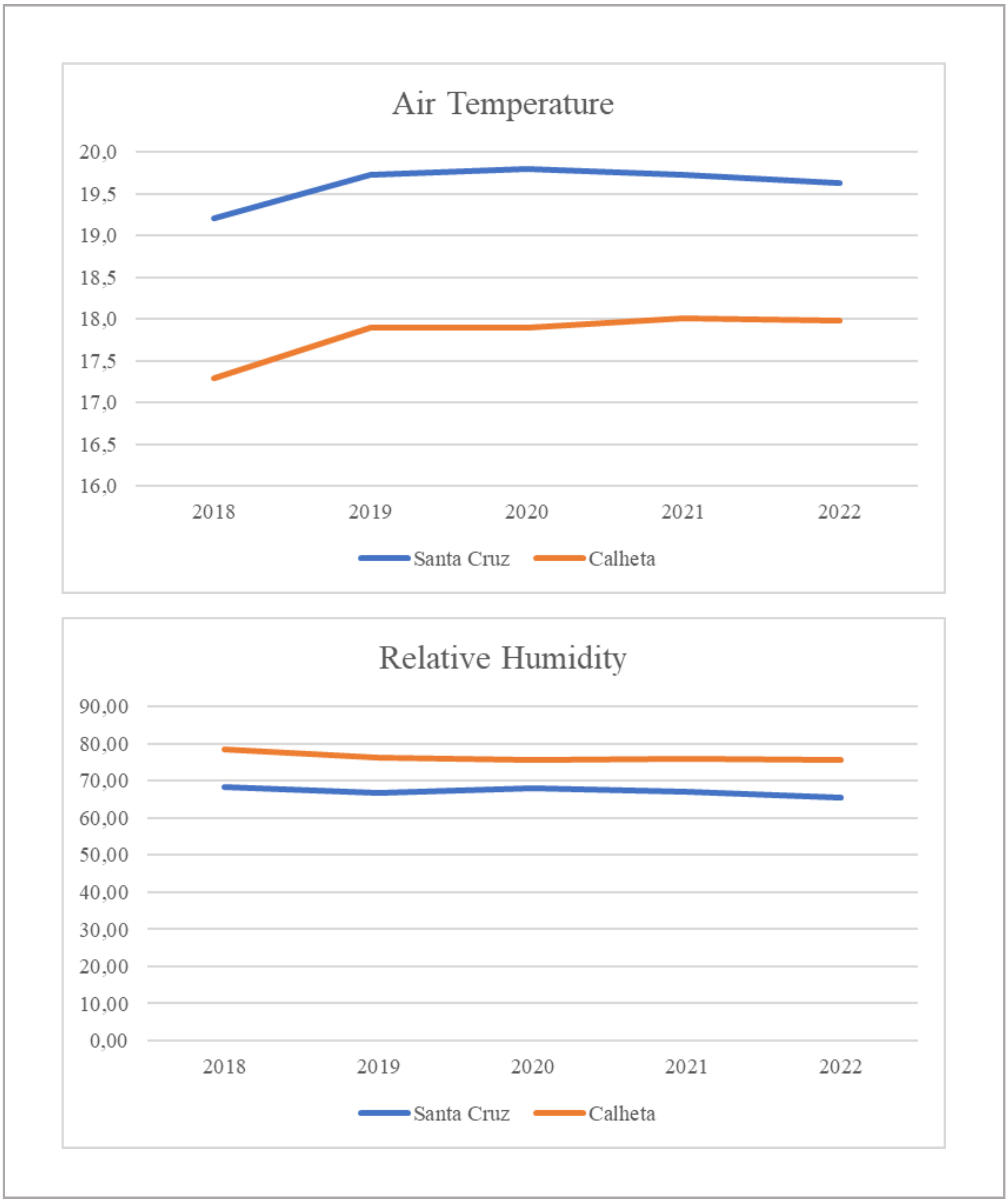

Figure 12. Annual average of meteorological stations, group IV

It can be confirmed that the, in fact, the grouped municipalities exhibit comparable variations in both Tair and RH.

The key finding is that municipalities experiencing the same fluctuations in Tair and RH also exhibit the same pattern in prevalence. In other words, when Tair and RH follow similar trends across municipalities, the prevalence rate of rheumatic diseases in those municipalities tends to follow a similar pattern.

Grouping municipalities allows for more straightforward comparisons. It becomes easier to compare the characteristics, needs, and outcomes of municipalities within the same group.

This comparative analysis can provide valuable insights and help identify common factors or determinants that contribute to the observed prevalence.

When municipalities that are geographically close and with similar prevalence rates are grouped together, it effectively increases the sample size within each group. When dealing with smaller groups, statistical tests may have limited power to detect significant differences. Grouping municipalities increases the sample size within each group, enhancing the reliability of statistical findings. This makes it easier to identify patterns, trends, or differences that are statistically significant because the data is more homogenous within each group.

More robust statistical results provide a stronger foundation for decision-making in healthcare. Policymakers can make more informed choices about resource allocation, intervention strategies, and policy development.

In the context of healthcare, having more reliable data allows for the allocation of resources where they are most needed.

Dividing municipalities into four groups based on prevalence rates, and subsequently allocating resources within each group based on the municipality with the highest, average, and lowest prevalence rates is a strategic approach to resource allocation in healthcare and public health.

Healthcare disparities can exist between municipalities, especially in regions with varying socioeconomic conditions. This approach helps in addressing such disparities by ensuring that resources are distributed equitably based on the level of need. It aims to reduce health inequalities and promote fairness in resource allocation.

High-prevalence areas require more resources to manage the greater number of cases. Meanwhile, low-prevalence areas can receive sufficient but not excessive resources, preventing resource wastage.

This approach is adaptable and can be subject to change depending on the conditions. If the prevalence rates shift over time, resources can be adjusted accordingly, ensuring a responsive and flexible allocation strategy.

Health professionals in municipalities with different prevalence rates can collaborate and share best practices. High-prevalence areas may have developed effective strategies for managing rheumatic diseases that can be shared with others. This collaborative aspect fosters learning and improvement in healthcare delivery.

By tracking the outcomes of resource allocation within each group, it becomes easier to evaluate the effectiveness of interventions. This feedback loop helps in refining resource allocation strategies over time to maximize impact.

4.4. Limitations

This study was based on patients in the rheumatology service. One limitation is the fact that patients with osteoarticular pain do not always resort to hospital services or a specialist.

In many cases, patients do not have immediate access to rheumatologists. Instead, they initially go to a general practitioner (GP) when they experience rheumatic symptoms. It is the GP's responsibility to determine whether a referral to a specialist, such as a rheumatologist, another specialist doctor or a physiotherapist, is necessary (75).

It is also necessary to take into account that the diagnosis is often not made by a specialist, but by a GP (76), and that sometimes, their diagnosis does not agree with the rheumatologist's diagnosis and therefore they are not referred to this service (77).

There are other specialties that could be included in future studies, such as orthopedics, pain therapy and physiatry, as they would have a wider scope and not just focus on a hospital service.

One of the biggest challenges in processing the data provided was that there were gaps in the middle, i.e. it could not be processed so automatically, using Excel's automatic tools, but more manually, since in order to average the Tair and RH, I couldn't select all the data, but rather confirm them one by one and then select. Without a doubt, the meteorological data took the longest to process.

5. Conclusions

This study highlights the importance of addressing the impact of weather conditions on osteoarticular pain and rheumatic diseases, emphasizing the need for further research in this area.

The study conducted on the population of Madeira Island and Porto Santo Island between 2018 and 2022 takes a novel approach by using real-world data sources such as public meteorological and demographic data, as well as data from the hospital rheumatology service, which adds a more accurate and realistic perspective compared to questionnaire-based data.

One significant finding from this study was the correlation between variations in temperature and humidity and the prevalence rate of rheumatic diseases in different municipalities.

By identifying municipalities with similar prevalence patterns and linking them to similar meteorological conditions, the study provided evidence of a potential connection between weather parameters and rheumatic diseases.

When municipalities show similar weather-related patterns, their prevalence rates tend to follow suit, suggesting that meteorological conditions may indeed influence the prevalence of rheumatic diseases in the Madeira Archipelago.

The interpretation drawn from this correlation is that weather conditions, specifically Tair and RH, could be contributing factors or influencing variables for the prevalence of theses conditions.

Grouping municipalities that have the same prevalence rate for one or more specific conditions, in this study prevalence of rheumatic diseases, can offer several advantages in various contexts, particularly in research, public health, resource allocation, and policy planning.

When municipalities with similar prevalence rates are grouped together, resource allocation becomes more efficient. Public health interventions, funding, and resources can be targeted at specific groups rather than dispersed across many municipalities, ensuring that resources are directed where they are most needed.

Prevalence rates can change over time due to various factors, including public health interventions. Resource allocation strategies should be flexible to adapt to these changes.

Ultimately, this approach aims to maximize the public health impact by ensuring that resources are used efficiently and effectively to manage rheumatic diseases.

In conclusion, this study highlights the need for to continue investigating the connection between weather conditions and rheumatic diseases, offering promising insights into potential factors affecting these conditions but also emphasizing the need for further research to solidify these findings.

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7. Attachments

7.1. Attachment 1

Shows the data provided by SESARAM and example of how the data from the rheumatology service were processed.

Ano 2022

Concelho de Residência	FEMININO 0 - 9 anos	10 a 19 anos	20 a 29 anos	30 a 39 anos	40 a 49 anos	50 a 59 anos	60 a 59 anos	70 a 79 anos	80 e mais anos	FEMININO Total	MASCULINO 0 - 9 anos	10 a 19 anos	20 a 29 anos	30 a 39 anos	40 a 49 anos	50 a 59 anos	60 a 59 anos	70 a 79 anos	80 e mais anos	MASCULINO Total	Total Geral
CALHETA		2	1	4	5	12	17	7	2	50		1	4	1	2	5	4	3	1	21	71
CÂMARA DE LOBOS	3	11	6	15	28	48	40	16	4	171		6	3	9	10	13	10	10	2	63	234
FORA DA RAM / OUTROS	1		1			2				4			1			1	1			3	7
FUNCHAL	9	30	20	28	122	176	198	107	34	724	2	8	8	15	36	43	61	37	13	223	947
MACHICO	4	5	7	12	13	39	43	20	6	149	2	2	2	2	7	3	7	4		29	178
PONTA DO SOL		2	2	4	6	8	3	6		31	1	2	1	2	3	7	1	2	1	20	51
PORTO MONIZ				1	4	6	2	4	1	18							1	1		2	20
PORTO SANTO		1		2	7	12	7	3	3	35		1			3	1	6	5		16	51
RIBEIRA BRAVA		1	1	3	7	21	22	14	1	70	1	1	4	4	5	9	6	1	2	33	103
SANTA CRUZ	6	7	18	20	54	74	45	20	8	252	3	3	8	10	17	23	22	10	2	98	350
SANTANA		1	1	3	4	5	6	2	2	24					3		2			5	29
SÃO VICENTE		1			1	6	4	1	1	14		2			3		2			7	21
Total Geral	**23**	**61**	**57**	**92**	**251**	**409**	**387**	**200**	**62**	**1542**	**9**	**26**	**31**	**43**	**89**	**105**	**123**	**73**	**21**	**520**	**2062**

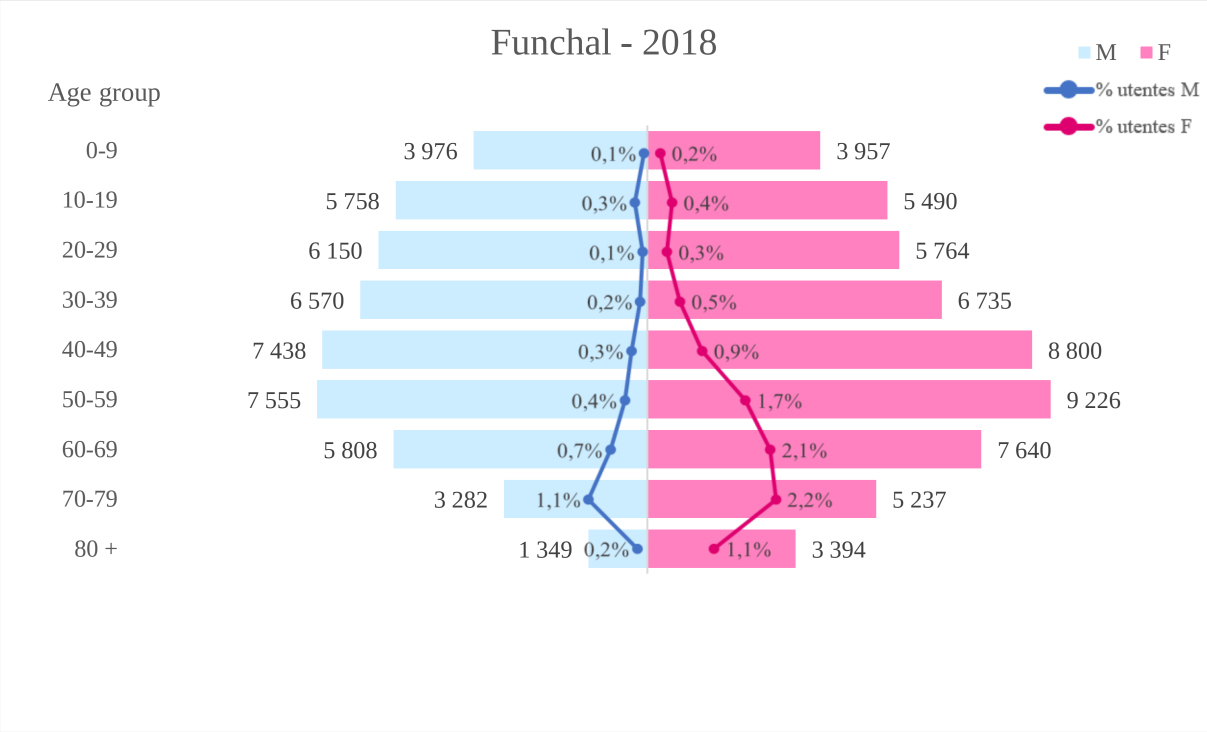
Ano 2021

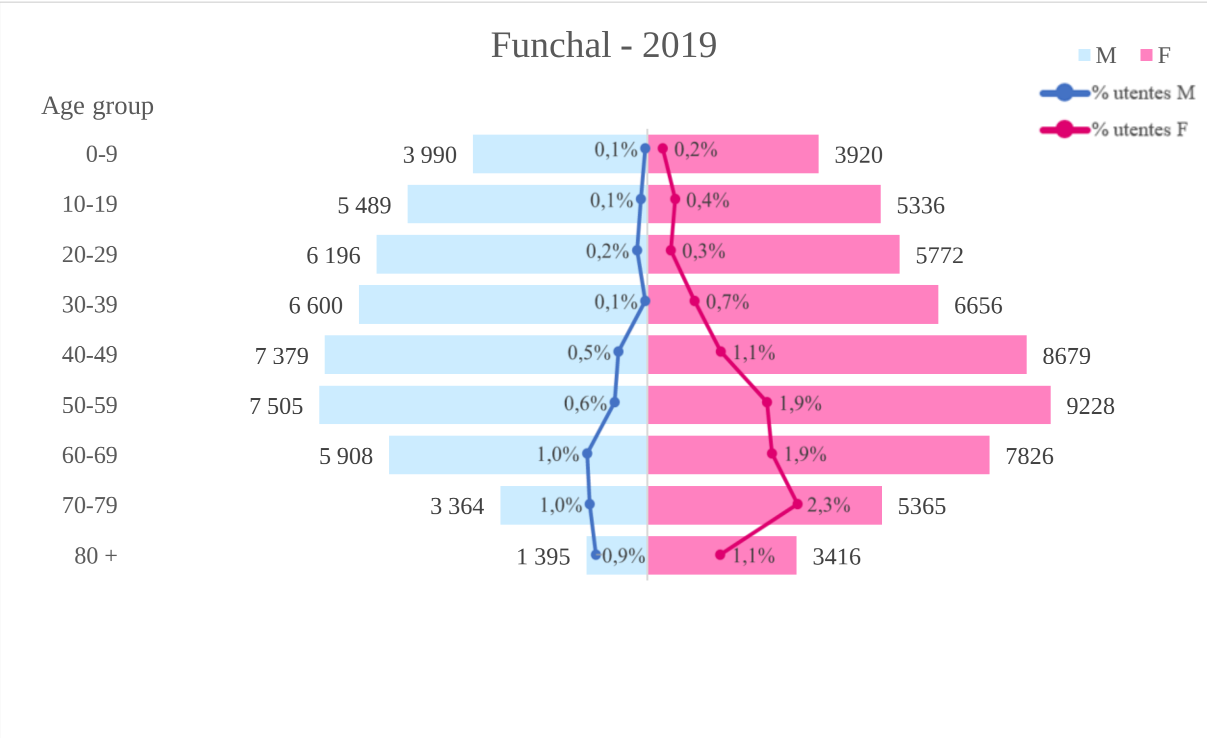
Concelho de Residência	FEMININO 0 - 9 anos	10 a 19 anos	20 a 29 anos	30 a 39 anos	40 a 49 anos	50 a 59 anos	60 a 59 anos	70 a 79 anos	80 e mais anos	FEMININO Total	MASCULINO 0 - 9 anos	10 a 19 anos	20 a 29 anos	30 a 39 anos	40 a 49 anos	50 a 59 anos	60 a 59 anos	70 a 79 anos	80 e mais anos	MASCULINO Total	Total Geral
CALHETA		3		4	2	11	11	7	3	41			1	3	1	5	5	3		18	59
CÂMARA DE LOBOS	6	6	8	14	17	34	32	11	7	135	2	5	2	6	5	14	9	8	2	53	188
FORA DA RAM / OUTROS			2		1	1	1	1		6			1				1	1		3	9
FUNCHAL	5	29	15	47	91	133	144	95	39	598	3	12	10	18	29	39	46	36	15	208	806
MACHICO	3	3	4	6	11	35	45	12	4	123	3	4	3	3	7	2	8	1		31	154
PONTA DO SOL		1	4	5	5	6	5	8		34		3	1	1	2	5		2	1	15	49
PORTO MONIZ		1		2	2	4	1	3	1	14						1		1		2	16
PORTO SANTO			1	3	7	10	9	4	3	37					3	2	4	3		12	49
RIBEIRA BRAVA		3	1	3	9	17	18	12	5	68			2	2	7	6	7	1	2	27	95
SANTA CRUZ	5	5	22	14	39	61	35	16	11	208	2	4	7	8	17	22	14	10	3	87	295
SANTANA		2	1	3	2	4	7	3	1	23		1			3	1	1	1		7	30
SÃO VICENTE		2			2	4	1	1	1	11		3			3	1	3			10	21

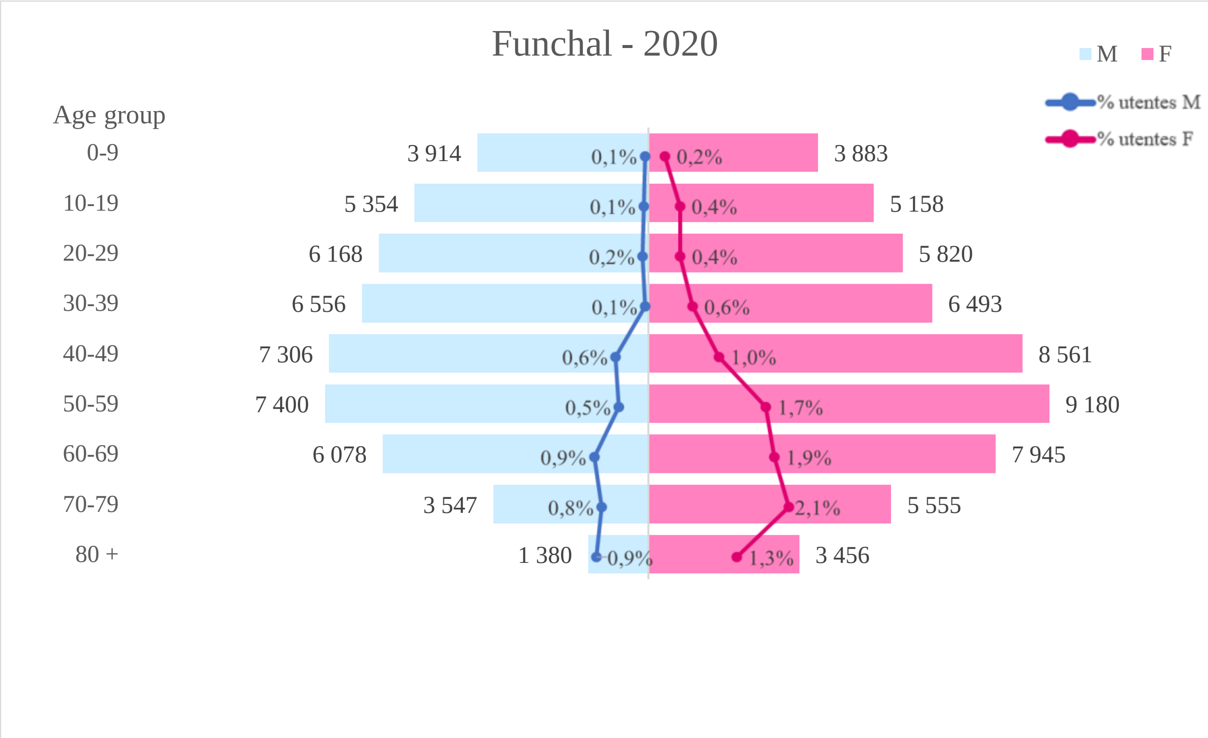
		0 (Female) 1 (Male)	129	399	400	656	1479	2321	2216	1357	454
Year	Municipality	0/1	0 - 9 anos	10 a 19 an	20 a 29 an	30 a 39 an	40 a 49 an	50 a 59 an	60 a 59 an	70 a 79 an	80 +
2022	CALHETA	0	0	2	1	4	5	12	17	7	2
2022	CÂMARA DE LOBOS	0	3	11	6	15	28	48	40	16	4
2022	FORA DA RAM / OUTROS	0	1	0	1	0	0	2	0	0	0
2022	FUNCHAL	0	9	30	20	28	122	176	198	107	34
2022	MACHICO	0	4	5	7	12	13	39	43	20	6
2022	PONTA DO SOL	0	0	2	2	4	6	8	3	6	0
2022	PORTO MONIZ	0	0	0	0	1	4	6	2	4	1
2022	PORTO SANTO	0	0	1	0	2	7	12	7	3	3
2022	RIBEIRA BRAVA	0	0	1	1	3	7	21	22	14	1
2022	SANTA CRUZ	0	6	7	18	20	54	74	45	20	8
2022	SANTANA	0	0	1	1	3	4	5	6	2	2
2022	SÃO VICENTE	0	0	1	0	0	1	6	4	1	1
2022	CALHETA	1	0	1	4	1	2	5	4	3	1
2022	CÂMARA DE LOBOS	1	0	6	3	9	10	13	10	10	2
2022	FORA DA RAM / OUTROS	1	0	0	1	0	0	1	1	0	0
2022	FUNCHAL	1	2	8	8	15	36	43	61	37	13

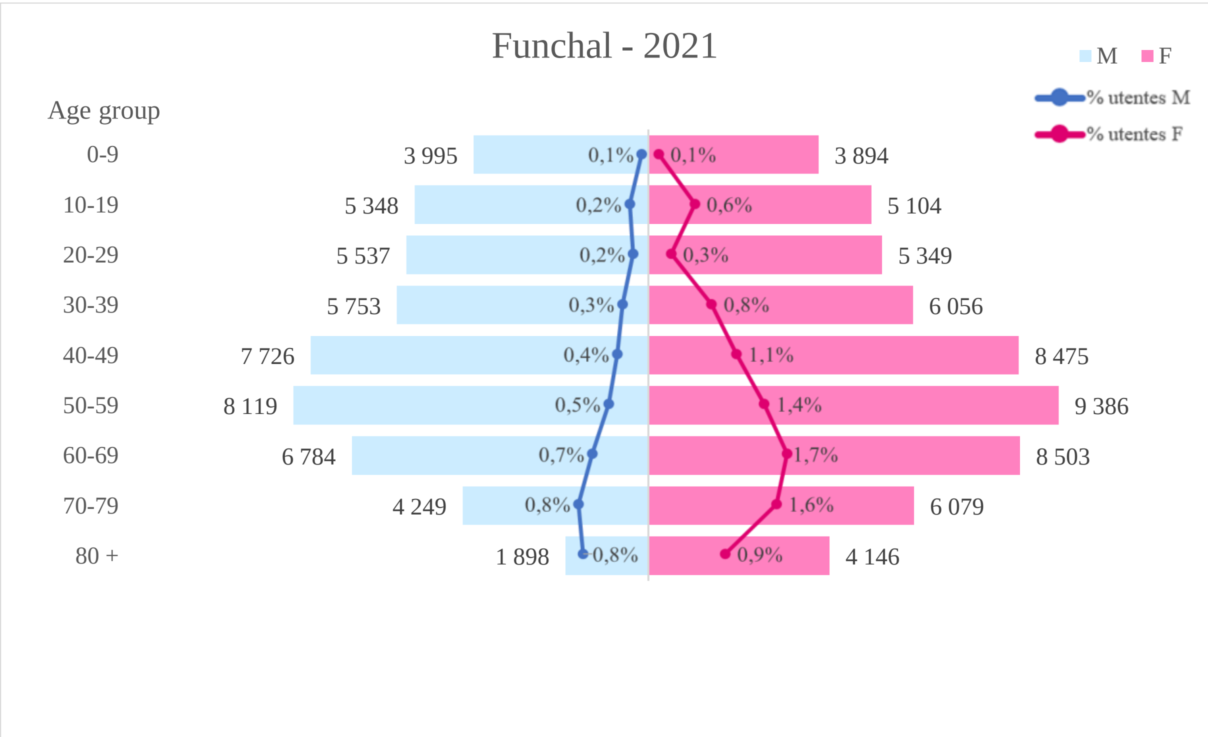
7.2. Attachment 2

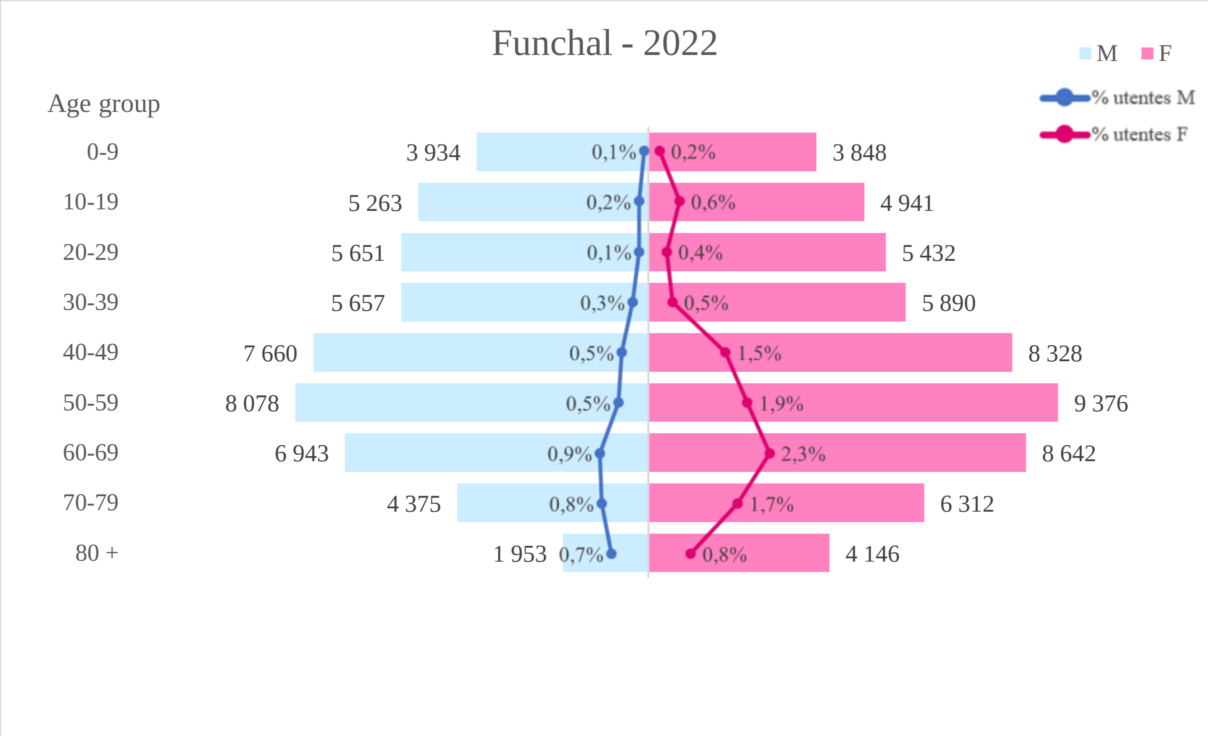
Examples of population pyramid graphs from 2018 to 2022 for two municipalities with the proportion (%) of the resident population accessing the Rheumatology service, by age group and sex

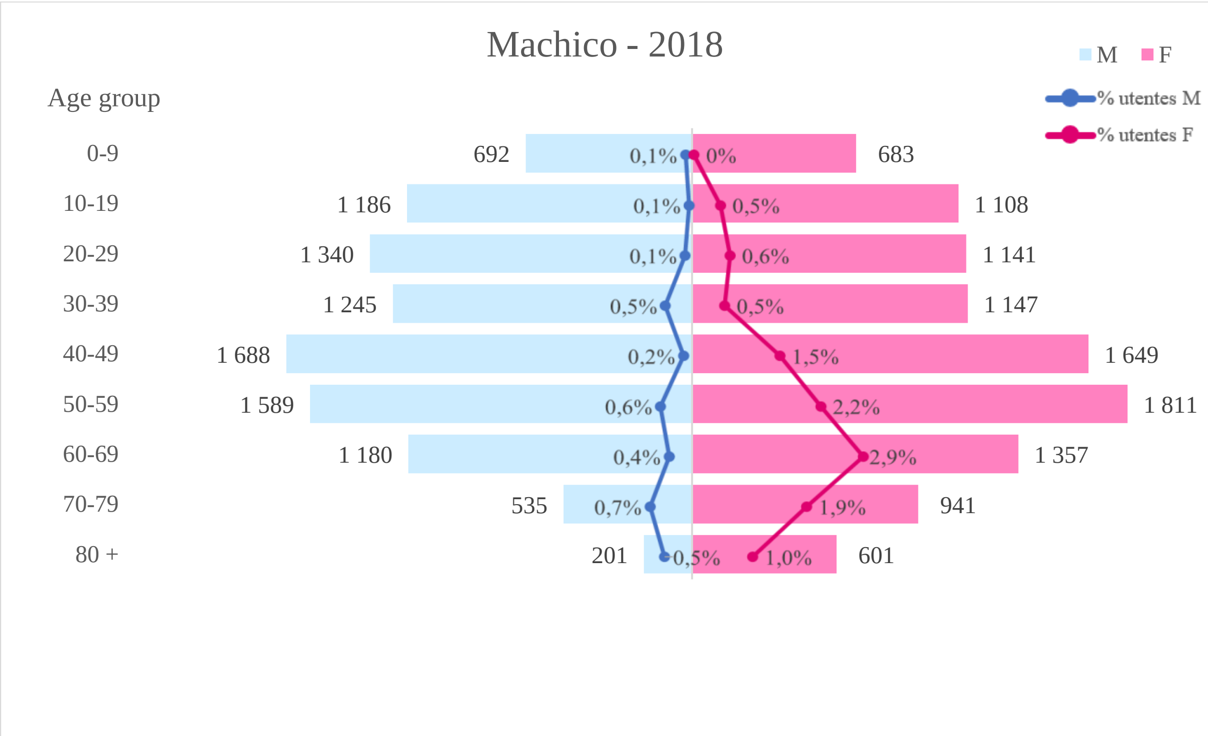


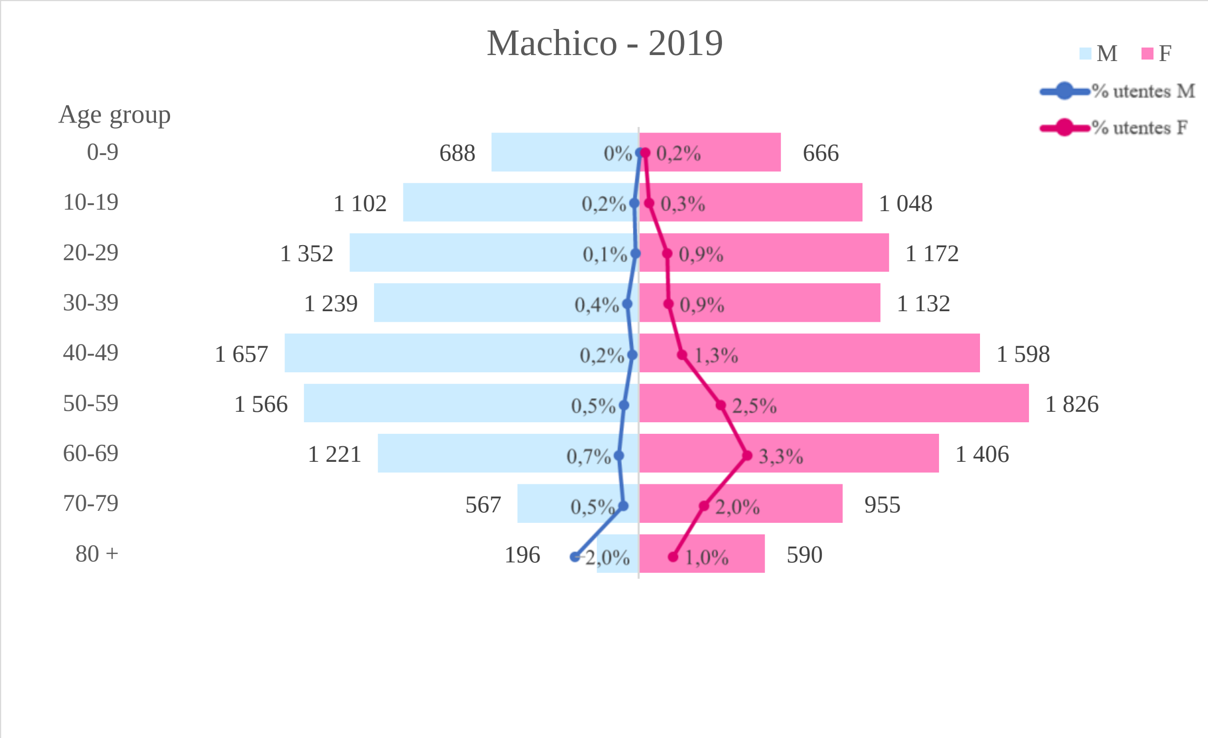



Funchal - 2020
M
F
% utentes M
% utentes F
Age group
0-9
10-19
20-29
30-39
40-49
50-59
60-69
70-79
80 +
3 914
5 354
6 168
6 556
7 306
7 400
6 078
3 547
1 380
0,1%
0,1%
0,2%
0,1%
0,6%
0,5%
0,9%
0,8%
0,9%
0,2%
0,4%
0,4%
0,6%
1,0%
1,7%
1,9%
2,1%
1,3%
3 883
5 158
5 820
6 493
8 561
9 180
7 945
5 555
3 456

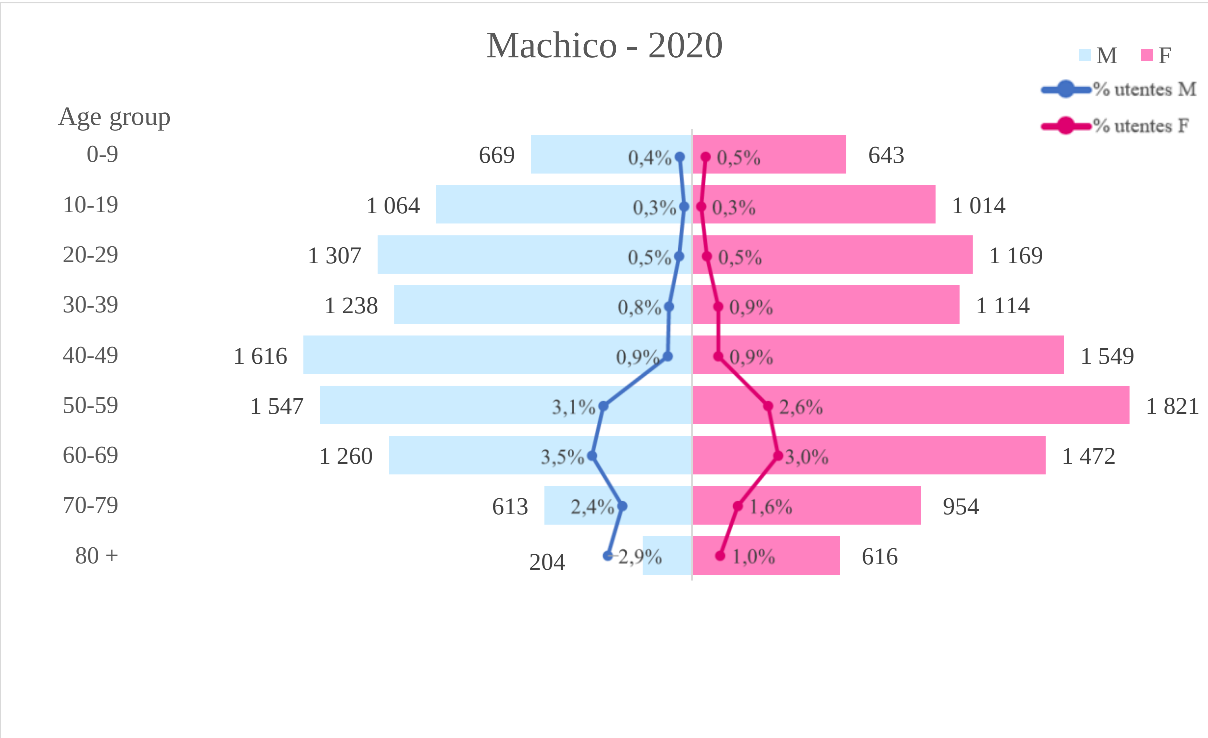

Funchal - 2021
M
F
% utentes M
% utentes F
Age group
0-9
10-19
20-29
30-39
40-49
50-59
60-69
70-79
80 +
3 995
5 348
5 537
5 753
7 726
8 119
6 784
4 249
1 898
0,1%
0,2%
0,2%
0,3%
0,4%
0,5%
0,7%
0,8%
0,8%
0,1%
0,6%
0,3%
0,8%
1,1%
1,4%
1,7%
1,6%
0,9%
3 894
5 104
5 349
6 056
8 475
9 386
8 503
6 079
4 146


Funchal - 2022
M
F
% utentes M
% utentes F
Age group
0-9
10-19
20-29
30-39
40-49
50-59
60-69
70-79
80 +
3 934
0,1%
0,2%
3 848
5 263
0,2%
0,6%
4 941
5 651
0,1%
0,4%
5 432
5 657
0,3%
0,5%
5 890
7 660
0,5%
1,5%
8 328
8 078
0,5%
1,9%
9 376
6 943
0,9%
2,3%
8 642
4 375
0,8%
1,7%
6 312
1 953
0,7%
0,8%
4 146


Machico - 2018
M
F
% utentes M
% utentes F
Age group
0-9
10-19
20-29
30-39
40-49
50-59
60-69
70-79
80 +
692
0,1%
0%
683
1 186
0,1%
0,5%
1 108
1 340
0,1%
0,6%
1 141
1 245
0,5%
0,5%
1 147
1 688
0,2%
1,5%
1 649
1 589
0,6%
2,2%
1 811
1 180
0,4%
2,9%
1 357
535
0,7%
1,9%
941
201
0,5%
1,0%
601



Machico - 2019
M
F
% utentes M
% utentes F
Age group
0-9
10-19
20-29
30-39
40-49
50-59
60-69
70-79
80 +
688
1 102
1 352
1 239
1 657
1 566
1 221
567
196
0%
0,2%
0,1%
0,4%
0,2%
0,5%
0,7%
0,5%
-2,0%
0,2%
0,3%
0,9%
0,9%
1,3%
2,5%
3,3%
2,0%
1,0%
666
1 048
1 172
1 132
1 598
1 826
1 406
955
590



Machico - 2020
M
F
% utentes M
% utentes F
Age group
0-9
10-19
20-29
30-39
40-49
50-59
60-69
70-79
80 +
669
1 064
1 307
1 238
1 616
1 547
1 260
613
204
0,4%
0,3%
0,5%
0,8%
0,9%
3,1%
3,5%
2,4%
-2,9%
0,5%
0,3%
0,5%
0,9%
0,9%
2,6%
3,0%
1,6%
1,0%
643
1 014
1 169
1 114
1 549
1 821
1 472
954
616

7.3. Attachment 3

Example of the data sheet provided by IPMA

A1 | 01210990 2018 01 01 00 -00990 -00990 -00990 -990 -00990 -00990 -00990 -990 -990 -990 +0164 +0163 +0165 +0161 +001 +083 +081 +083 +078 +000 +0146 +0144 +0146 +

	A
1	01210990 2018 01 01 00 -00990 -00990 -00990 -990 -00990 -00990 -00990 -990 -990 -990 +0164 +0163 +0165 +0161 +001 +083 +081 +083 +078 +000 +0146 +0144 +0146 +0141 +001 +0135 +0131 +0135 +0126 +002 +0155 +
2	01210990 2018 01 01 01 -00990 -00990 -00990 -990 -00990 -00990 -00990 -990 -990 -990 +0162 +0160 +0164 +0155 +003 +077 +084 +086 +077 +002 +0139 +0143 +0146 +0138 +002 +0123 +0132 +0136 +0123 +003 +0143 +
3	01210990 2018 01 01 02 -00990 -00990 -00990 -990 -00990 -00990 -00990 -990 -990 -990 +0165 +0163 +0166 +0161 +001 +071 +074 +078 +071 +001 +0133 +0136 +0141 +0133 +002 +0111 +0117 +0125 +0111 +004 +0132 +
4	01210990 2018 01 01 03 -00990 -00990 -00990 -990 -00990 -00990 -00990 -990 -990 -990 +0158 +0160 +0165 +0155 +003 +082 +075 +082 +066 +001 +0139 +0134 +0139 +0127 +003 +0127 +0115 +0126 +0105 +005 +0146 +
5	01210990 2018 01 01 04 -00990 -00990 -00990 -990 -00990 -00990 -00990 -990 -990 -990 +0153 +0158 +0159 +0153 +002 +084 +084 +085 +081 +000 +0137 +0141 +0144 +0138 +002 +0127 +0130 +0134 +0126 +002 +0146 +
6	01210990 2018 01 01 05 -00990 -00990 -00990 -990 -00990 -00990 -00990 -990 -990 -990 +0155 +0148 +0156 +0142 +004 +084 +081 +085 +075 +000 +0140 +0129 +0140 +0120 +006 +0129 +0116 +0130 +0104 +008 +0149 +
7	01210990 2018 01 01 06 -00990 -00990 -00990 -990 -00990 -00990 -00990 -990 -990 -990 +0155 +0155 +0158 +0152 +002 +086 +084 +086 +082 +000 +0140 +0139 +0142 +0135 +002 +0131 +0128 +0132 +0122 +002 +0150 +
8	01210990 2018 01 01 07 -00990 -00990 -00990 -990 -00990 -00990 -00990 -990 -990 -990 +0140 +0147 +0155 +0140 +006 +084 +085 +086 +083 +000 +0125 +0133 +0141 +0125 +006 +0113 +0122 +0131 +0114 +006 +0134 +
9	01210990 2018 01 01 08 -00990 -00990 -00990 -990 -00990 -00990 -00990 -990 -990 -990 +0139 +0139 +0143 +0134 +002 +084 +083 +085 +080 +001 +0123 +0123 +0128 +0118 +003 +0112 +0111 +0118 +0105 +003 +0133 +
10	01210990 2018 01 01 09 -00990 -00990 -00990 -990 -00990 -00990 -00990 -990 -990 -990 +0160 +0147 +0161 +0139 +007 +079 +081 +086 +077 +001 +0139 +0129 +0141 +0122 +006 +0124 +0115 +0127 +0108 +006 +0144 +
11	01210990 2018 01 01 10 -00990 -00990 -00990 -990 -00990 -00990 -00990 -990 -990 -990 +0172 +0163 +0172 +0158 +003 +075 +077 +080 +074 +001 +0145 +0139 +0145 +0136 +002 +0128 +0123 +0128 +0120 +002 +0147 +
12	01210990 2018 01 01 11 -00990 -00990 -00990 -990 -00990 -00990 -00990 -990 -990 -990 +0182 +0173 +0182 +0168 +003 +074 +075 +076 +073 +001 +0153 +0146 +0152 +0141 +003 +0134 +0128 +0134 +0123 +003 +0154 +
13	01210990 2018 01 01 12 -00990 -00990 -00990 -990 -00990 -00990 -00990 -990 -990 -990 +0186 +0184 +0187 +0179 +002 +072 +074 +077 +070 +000 +0155 +0155 +0157 +0152 +001 +0135 +0136 +0141 +0133 +002 +0155 +
14	01210990 2018 01 01 13 -00990 -00990 -00990 -990 -00990 -00990 -00990 -990 -990 -990 +0186 +0189 +0199 +0183 +004 +071 +072 +074 +068 +001 +0154 +0157 +0163 +0153 +002 +0133 +0137 +0142 +0133 +002 +0153 +
15	01210990 2018 01 01 14 -00990 -00990 -00990 -990 -00990 -00990 -00990 -990 -990 -990 +0202 +0190 +0202 +0181 +006 +064 +071 +074 +064 +001 +0160 +0156 +0161 +0152 +003 +0133 +0135 +0141 +0131 +002 +0152 +
16	01210990 2018 01 01 15 -00990 -00990 -00990 -990 -00990 -00990 -00990 -990 -990 -990 +0197 +0200 +0205 +0196 +002 +068 +066 +068 +062 +001 +0159 +0159 +0163 +0155 +001 +0136 +0133 +0138 +0129 +002 +0155 +
17	01210990 2018 01 01 16 -00990 -00990 -00990 -990 -00990 -00990 -00990 -990 -990 -990 +0198 +0202 +0210 +0197 +003 +067 +065 +068 +062 +001 +0159 +0160 +0165 +0157 +002 +0136 +0134 +0139 +0130 +002 +0155 +
18	01210990 2018 01 01 17 -00990 -00990 -00990 -990 -00990 -00990 -00990 -990 -990 -990 +0200 +0199 +0206 +0193 +003 +069 +069 +071 +066 +001 +0164 +0162 +0167 +0159 +002 +0142 +0140 +0144 +0135 +002 +0161 +
19	01210990 2018 01 01 18 -00990 -00990 -00990 -990 -00990 -00990 -00990 -990 -990 -990 +0179 +0189 +0200 +0179 +005 +077 +073 +077 +067 +000 +0154 +0157 +0164 +0154 +002 +0138 +0138 +0142 +0136 +001 +0158 +
20	01210990 2018 01 01 19 -00990 -00990 -00990 -990 -00990 -00990 -00990 -990 -990 -990 +0168 +0172 +0180 +0168 +004 +079 +078 +080 +076 +000 +0146 +0149 +0155 +0146 +002 +0131 +0134 +0140 +0131 +002 +0151 +

2018_JAN

7.4. Attachment 4

Shows an example of the monthly and annual average of the meteorological data processed.

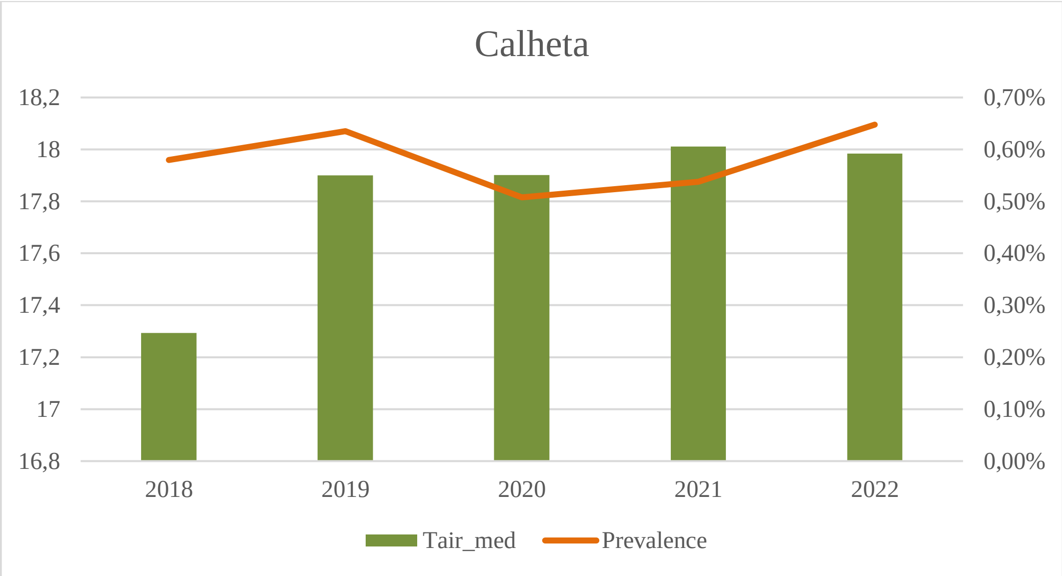
	Avarage	
	Tair_med	RH_med
jan/18	14,8703	76,11828
fev/18	13,42232	79,99256
mar/18	15,17083	83,8078
abr/18	14,89639	80,44444
mai/18	15,41169	78,15591
jun/18	18,09806	82,25278
jul/18	20,42258	75,25134
ago/18	21,57702	73,9664
set/18	21,18889	75,30694
out/18	19,23091	80,17339
nov/18	16,52486	81,12083
dez/18	16,70255	75,99328
YEAR 2018	17,29303	78,54866
jan/19	14,31653	74,33065
fev/19	15,05134	69,45685
mar/19	15,16237	76,77957
abr/19	15,11181	77,17222
mai/19	17,75981	76,3293
jun/19	18,94139	76,43611
jul/19	20,49368	77,33737
ago/19	22,22298	77,31452
set/19	21,00417	75,00139
out/19	19,93024	79,10081
nov/19	17,98944	81,04583
dez/19	16,8246	76,4664
YEAR 2019	17,9007	76,39758

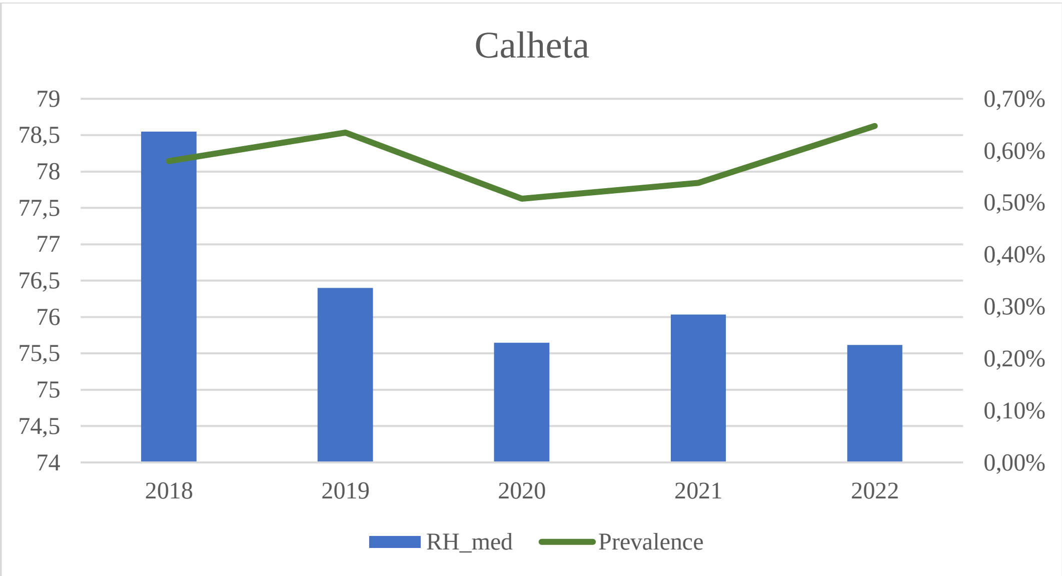
	Avarage	
	Tair_med	RH_med
jan/20	15,28535	74,32124
fev/20	16,8921	71,31034
mar/20	15,27863	76,60349
abr/20	15,95875	82,275
mai/20	17,89691	77,44624
jun/20	19,35778	79,175
jul/20	20,422	70,20918
ago/20	22,0251	74,83266
set/20	20,05097	71,13889
out/20	19,26089	76,63575
nov/20	17,00195	77,62901
dez/20	15,38602	76,18683
YEAR 2020	17,90137	75,64697
jan/21	14,33483	78,90309
fev/21	14,40193	80,76339
mar/21	14,48657	71,5346
abr/21	16,26861	82,18611
mai/21	17,88105	72,18414
jun/21	18,88694	73,69861
jul/21	21,11828	76,16667
ago/21	22,43642	74,28226
set/21	21,60362	77,02503
out/21	20,40941	75,38575
nov/21	17,67889	73,40833
dez/21	16,62177	76,85081
YEAR 2021	18,01069	76,0324

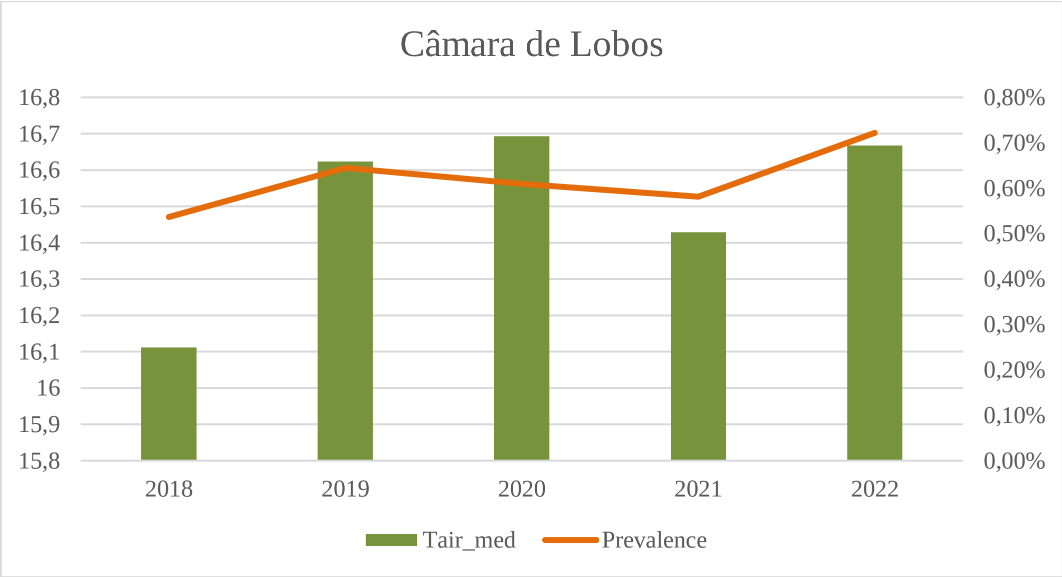
	Avarage	
	Tair_med	RH_med
jan/22	16,25062	67,74555
fev/22	15,78069	74,05988
mar/22	14,67066	76,607
abr/22	15,51269	75,85774
mai/22	17,93728	76,96904
jun/22	18,50081	67,61057
jul/22	20,35841	72,61777
ago/22	20,59542	73,79784
set/22	21,06384	77,54242
out/22	19,68363	77,71214
nov/22	18,79487	87,53846
dez/22	16,6578	79,31048
YEAR 2022	17,98389	75,61408

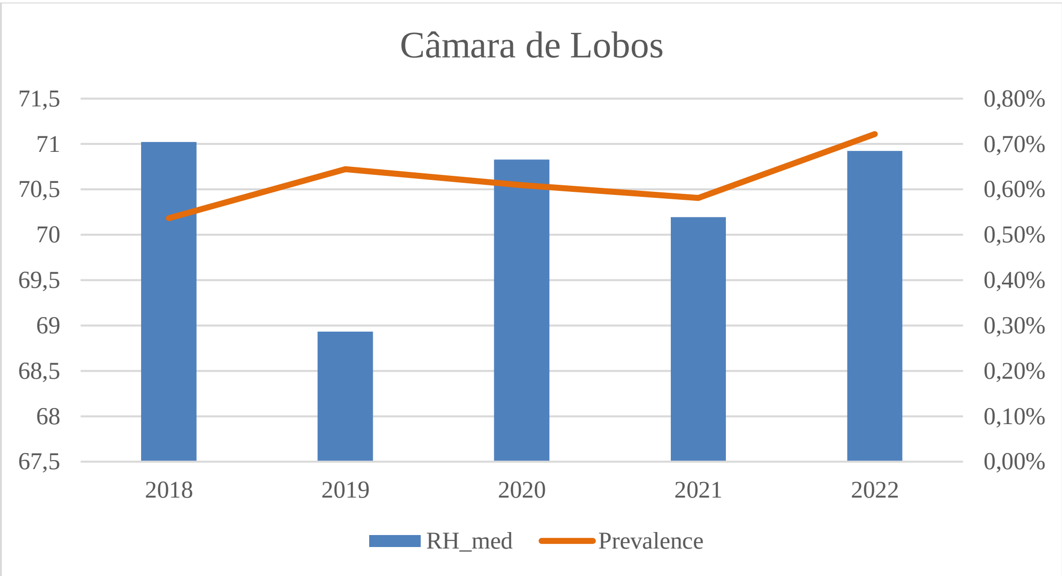
7.5. Attachment 5

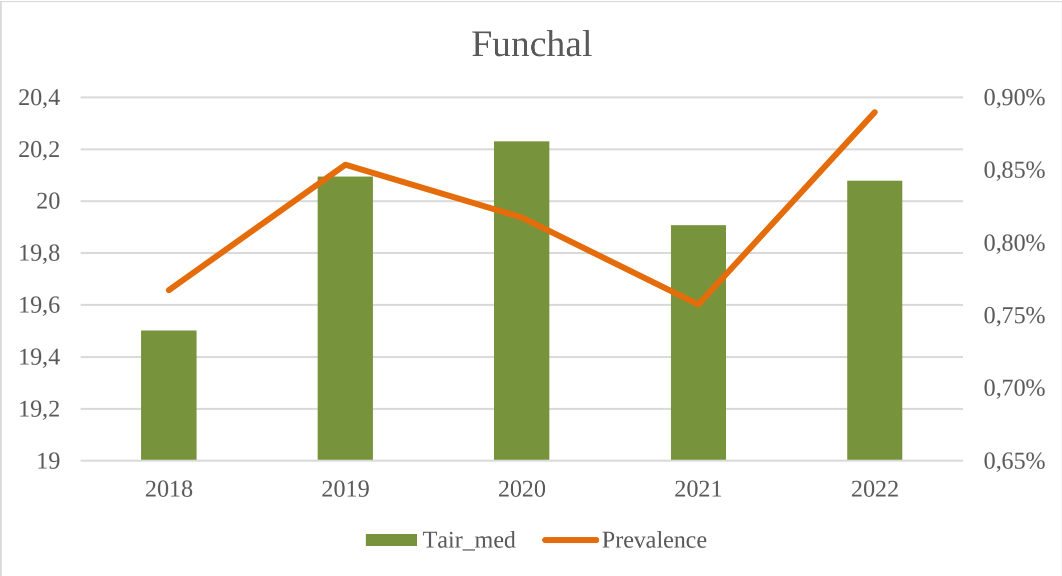
Prevalence of each municipality with Tair and RH data, by year.

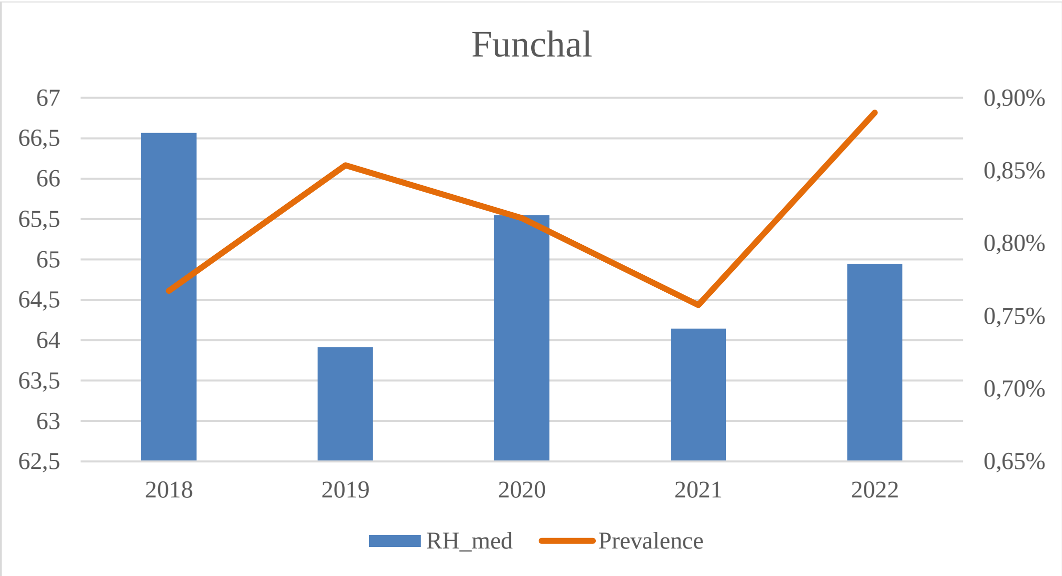


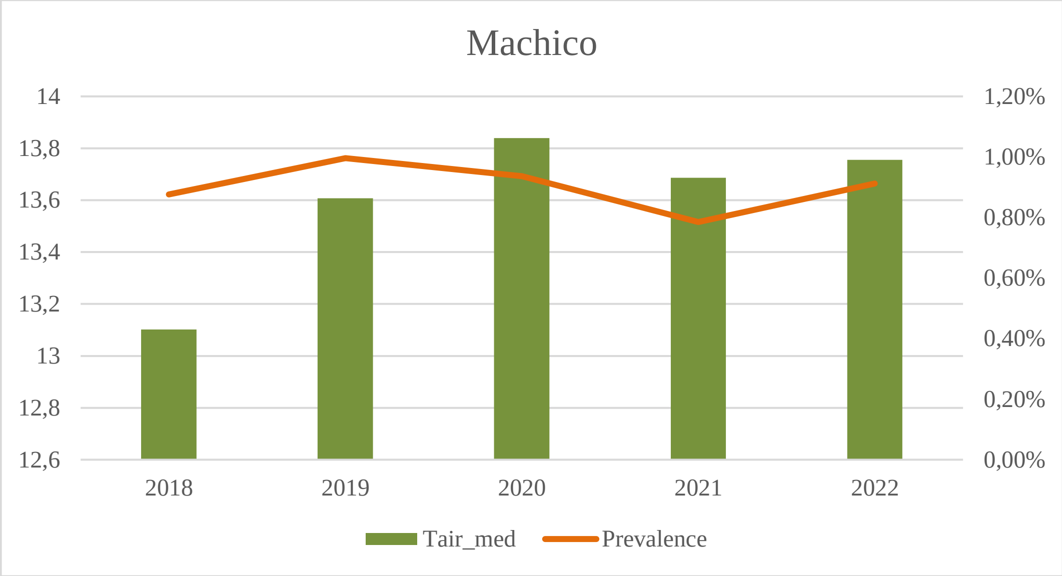



Câmara de Lobos
16,8
16,7
16,6
16,5
16,4
16,3
16,2
16,1
16
15,9
15,8
0,80%
0,70%
0,60%
0,50%
0,40%
0,30%
0,20%
0,10%
0,00%
2018
2019
2020
2021
2022
Tair_med
Prevalence

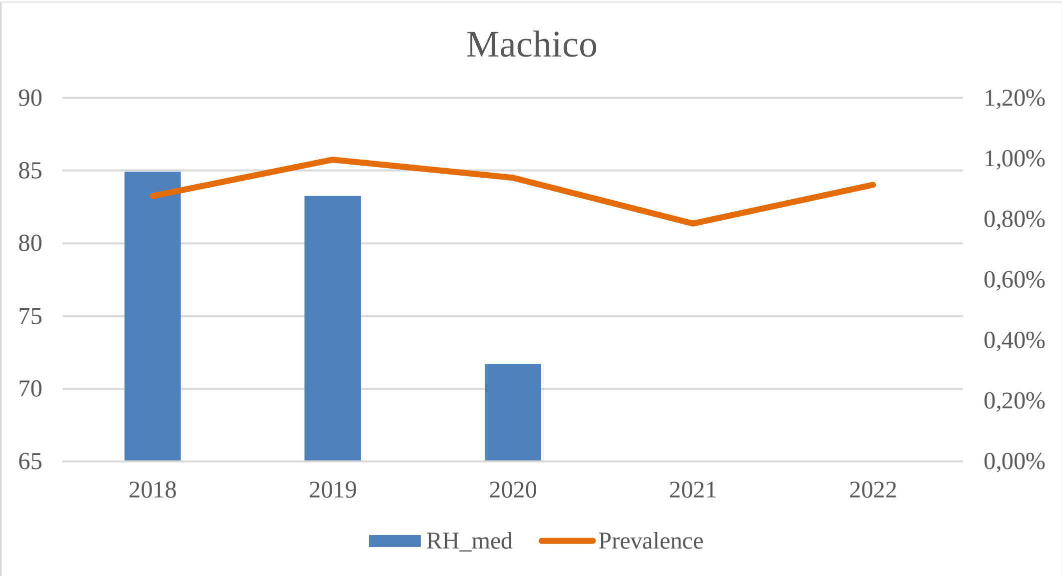

Câmara de Lobos
71,5
71
70,5
70
69,5
69
68,5
68
67,5
0,80%
0,70%
0,60%
0,50%
0,40%
0,30%
0,20%
0,10%
0,00%
2018
2019
2020
2021
2022
RH_med
Prevalence


Funchal
20,4
20,2
20
19,8
19,6
19,4
19,2
19
0,90%
0,85%
0,80%
0,75%
0,70%
0,65%
2018
2019
2020
2021
2022
Tair_med
Prevalence

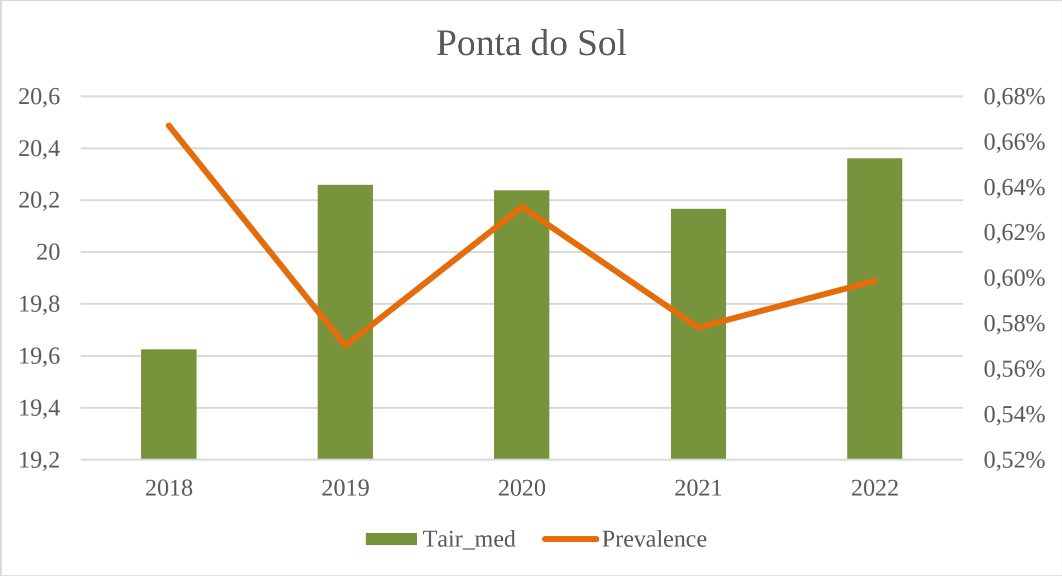

Funchal
67
66,5
66
65,5
65
64,5
64
63,5
63
62,5
0,90%
0,85%
0,80%
0,75%
0,70%
0,65%
2018
2019
2020
2021
2022
RH_med
Prevalence



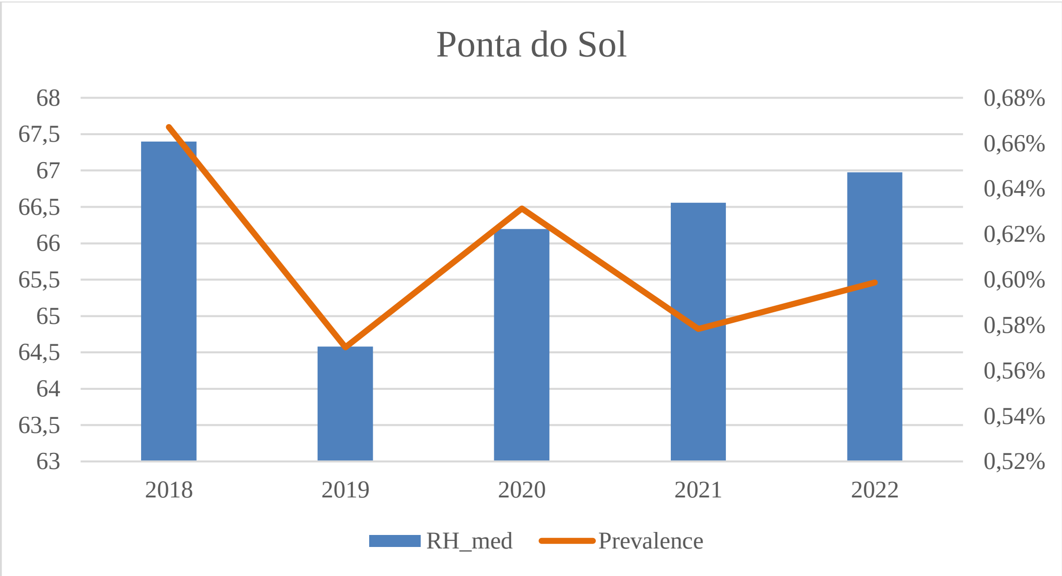
Machico
14
13,8
13,6
13,4
13,2
13
12,8
12,6
1,20%
1,00%
0,80%
0,60%
0,40%
0,20%
0,00%
2018
2019
2020
2021
2022
Tair_med
Prevalence



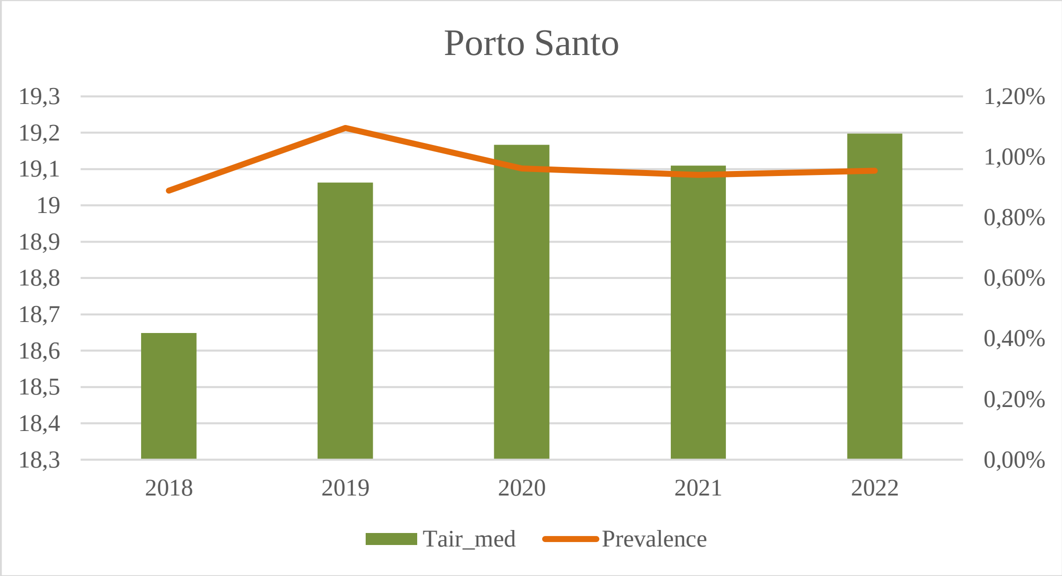
Machico
90
85
80
75
70
65
1,20%
1,00%
0,80%
0,60%
0,40%
0,20%
0,00%
2018
2019
2020
2021
2022
RH_med
Prevalence

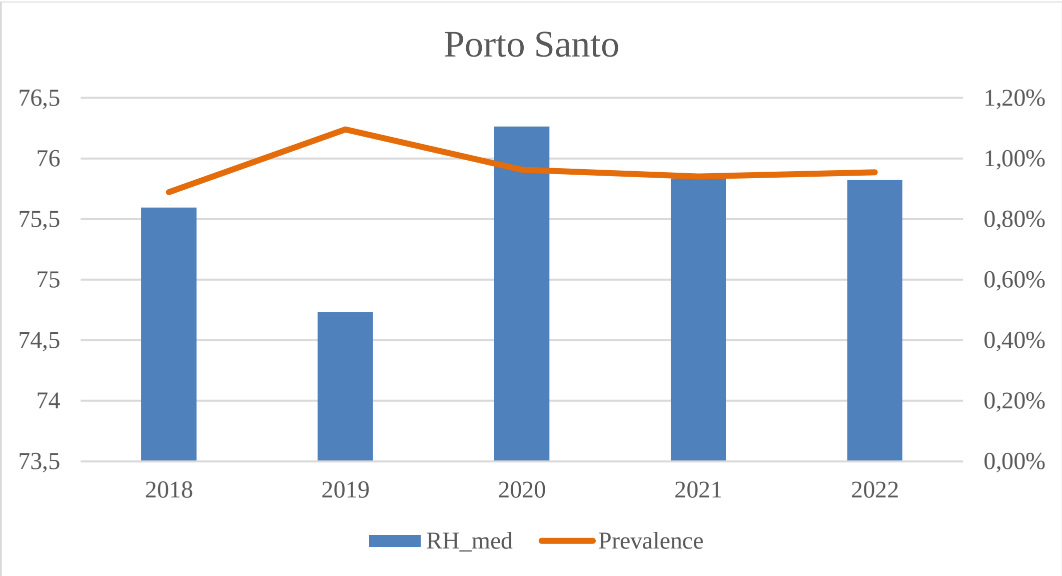


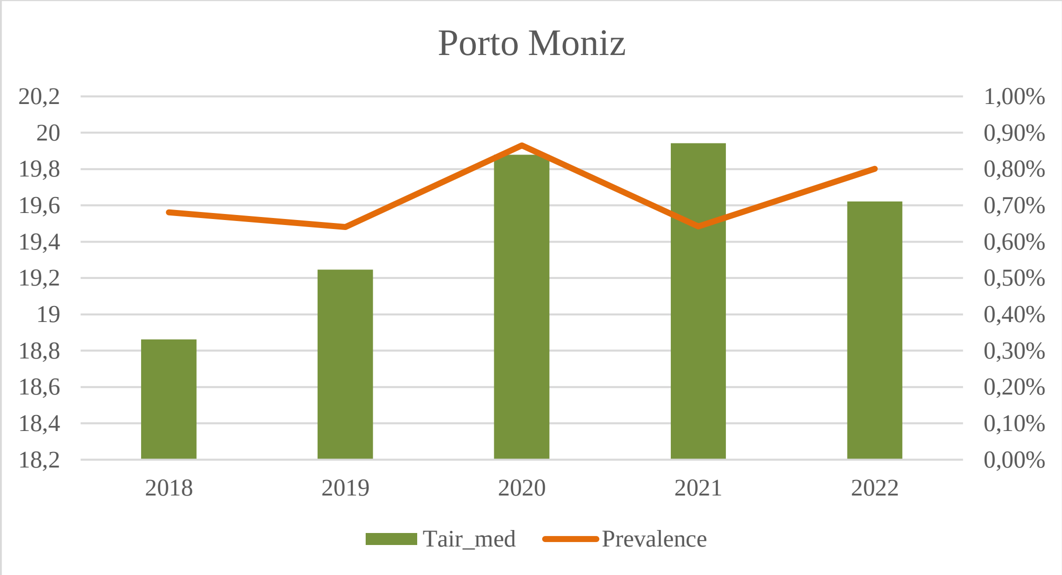
Ponta do Sol
20,6
20,4
20,2
20
19,8
19,6
19,4
19,2
0,68%
0,66%
0,64%
0,62%
0,60%
0,58%
0,56%
0,54%
0,52%
2018
2019
2020
2021
2022
Tair_med
Prevalence



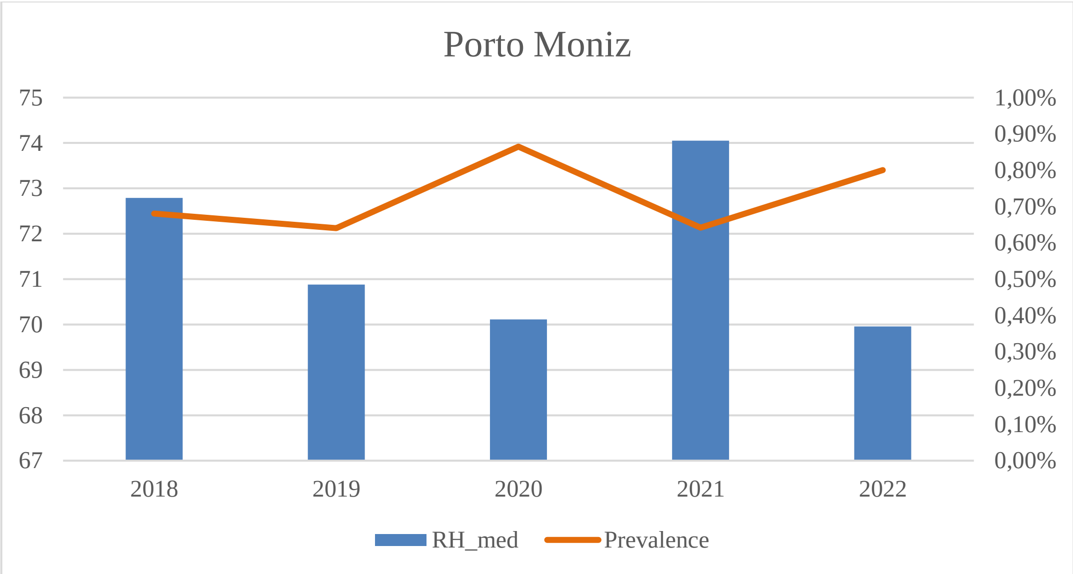
Ponta do Sol
68
67,5
67
66,5
66
65,5
65
64,5
64
63,5
63
0,68%
0,66%
0,64%
0,62%
0,60%
0,58%
0,56%
0,54%
0,52%
2018
2019
2020
2021
2022
RH_med
Prevalence


Porto Santo
19,3
19,2
19,1
19
18,9
18,8
18,7
18,6
18,5
18,4
18,3
1,20%
1,00%
0,80%
0,60%
0,40%
0,20%
0,00%
2018
2019
2020
2021
2022
Tair_med
Prevalence

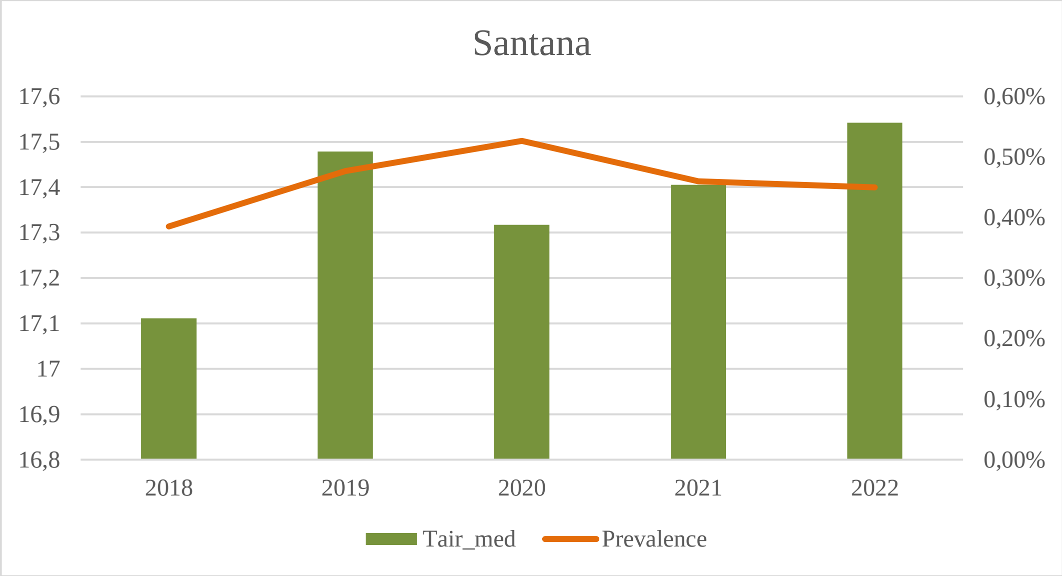

Porto Santo
76,5
76
75,5
75
74,5
74
73,5
1,20%
1,00%
0,80%
0,60%
0,40%
0,20%
0,00%
2018
2019
2020
2021
2022
RH_med
Prevalence

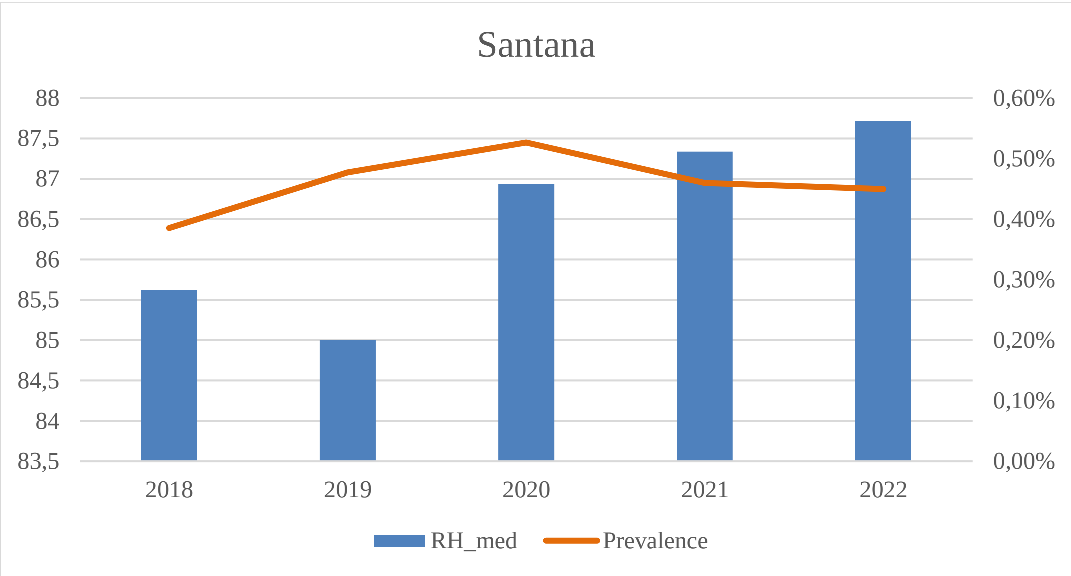


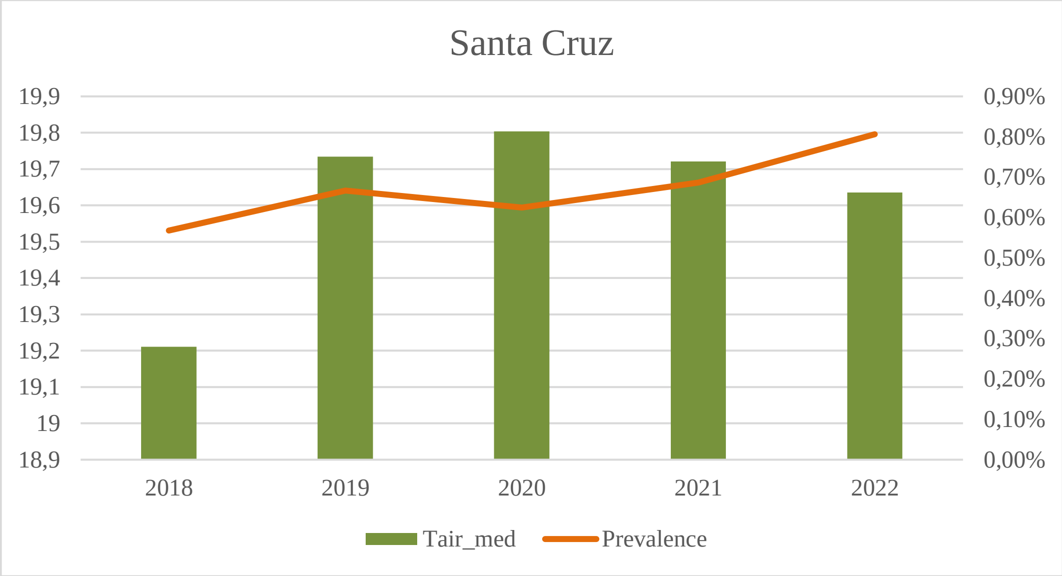
Porto Moniz
20,2
20
19,8
19,6
19,4
19,2
19
18,8
18,6
18,4
18,2
1,00%
0,90%
0,80%
0,70%
0,60%
0,50%
0,40%
0,30%
0,20%
0,10%
0,00%
2018
2019
2020
2021
2022
Tair_med
Prevalence

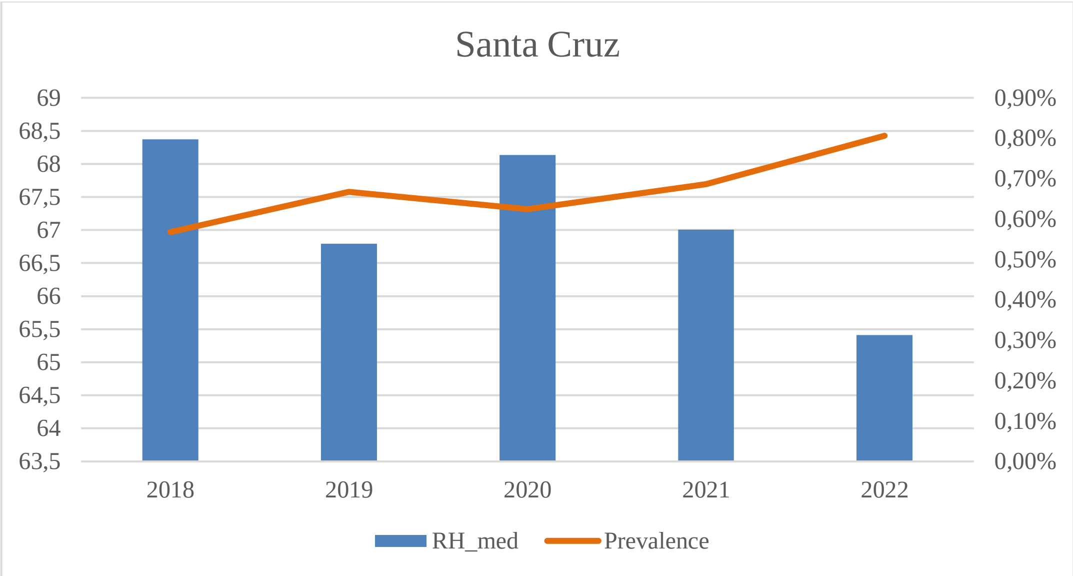


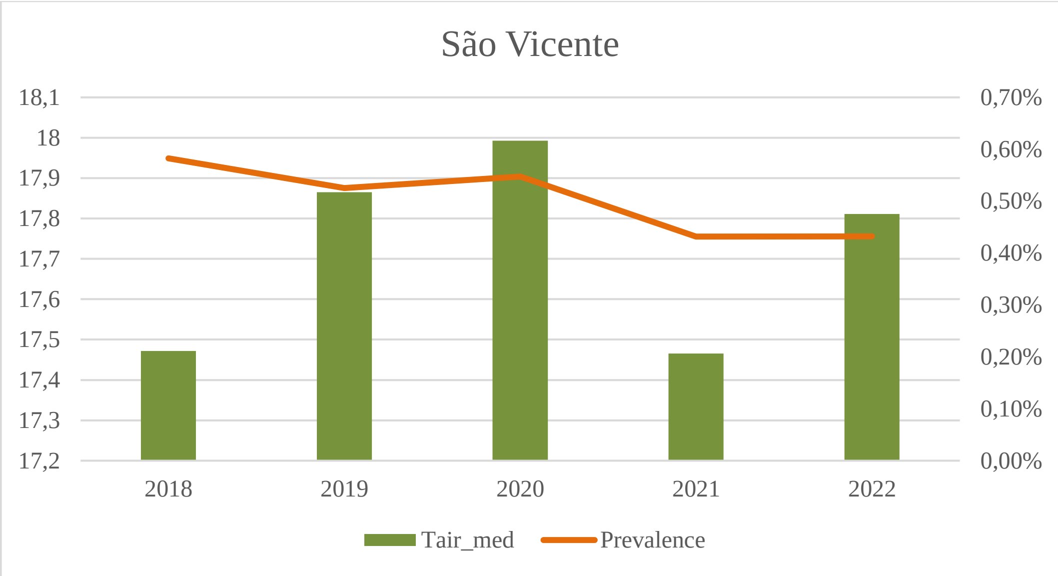
Porto Moniz
75
74
73
72
71
70
69
68
67
1,00%
0,90%
0,80%
0,70%
0,60%
0,50%
0,40%
0,30%
0,20%
0,10%
0,00%
2018
2019
2020
2021
2022
RH_med
Prevalence

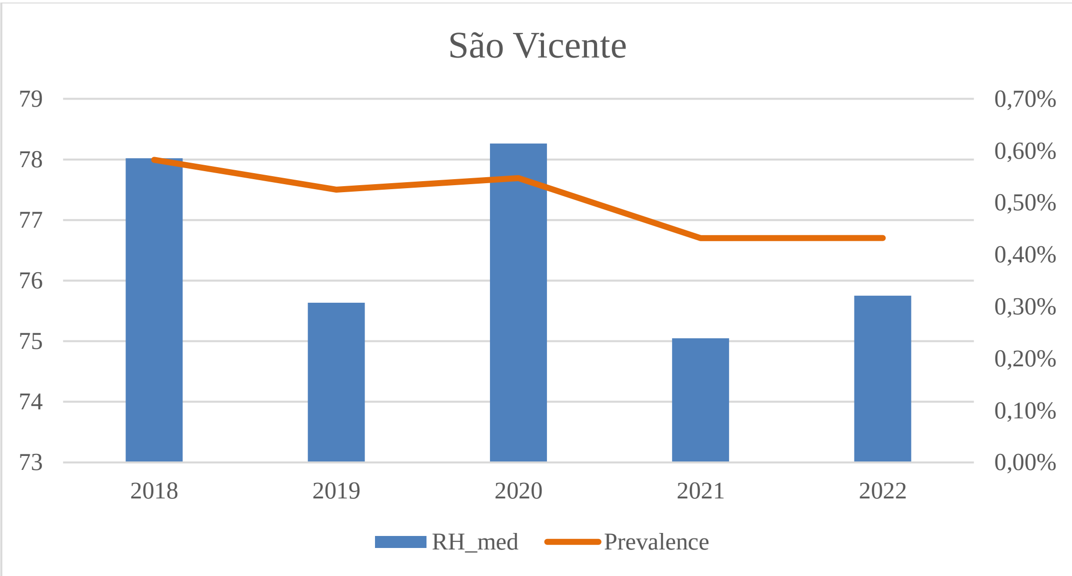

Santana
17,6
17,5
17,4
17,3
17,2
17,1
17
16,9
16,8
0,60%
0,50%
0,40%
0,30%
0,20%
0,10%
0,00%
2018
2019
2020
2021
2022
Tair_med
Prevalence


Santana
88
87,5
87
86,5
86
85,5
85
84,5
84
83,5
0,60%
0,50%
0,40%
0,30%
0,20%
0,10%
0,00%
2018
2019
2020
2021
2022
RH_med
Prevalence


Santa Cruz
19,9
19,8
19,7
19,6
19,5
19,4
19,3
19,2
19,1
19
18,9
0,90%
0,80%
0,70%
0,60%
0,50%
0,40%
0,30%
0,20%
0,10%
0,00%
2018
2019
2020
2021
2022
Tair_med
Prevalence


Santa Cruz
69
68,5
68
67,5
67
66,5
66
65,5
65
64,5
64
63,5
0,90%
0,80%
0,70%
0,60%
0,50%
0,40%
0,30%
0,20%
0,10%
0,00%
2018
2019
2020
2021
2022
RH_med
Prevalence


São Vicente
18,1
18
17,9
17,8
17,7
17,6
17,5
17,4
17,3
17,2
0,70%
0,60%
0,50%
0,40%
0,30%
0,20%
0,10%
0,00%
2018
2019
2020
2021
2022
Tair_med
Prevalence


São Vicente
79
78
77
76
75
74
73
0,70%
0,60%
0,50%
0,40%
0,30%
0,20%
0,10%
0,00%
2018
2019
2020
2021
2022
RH_med
Prevalence