COVID-19

Impact of the COVID-19 pandemic on infectious diseases reporting

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Keywords

Public health • Epidemiology • Notifiable diseases • Infectious disease • Surveillance • COVID-19 pandemic

Summary

Introduction. *COVID-19 pandemic had impacted the reporting of notifiable communicable diseases. Since the beginning of the pandemic and the introduction of relate public health measures, notifications for most notifiable diseases have declined compared to previous years. In this study, we aim to quantify the changes in the incidences of notifiable infectious diseases during and after the pandemic in Siracusa Local Health Authority, Italy.*
Methods. *We collected and analysed the infectious disease notifications made in two different three-years periods, 2017-2019 and 2020-2022 in Siracusa Local Health Authority, Italy. Descriptive statistics were used to find the percentages and the 95% confidence interval (CI). Exact "F-tests" was performed to compare the mean values between the studied periods to evaluate the hypothesis that the number of reported cases would not differ significantly between the two periods. Significance was assessed at the $p < 0.05$ level.*
Results. *The total number of notifications significantly decreased by 69.3% in the pandemic period compared to the pre-pandemic one, with the highest reduction of air-borne transmission diseases (-86.5%), followed by food-borne diseases (-68.2%) and sexually transmitted diseases (-39.3%). Conversely, an increase in number of notifications was found only for legionellosis.*
Conclusions. *The COVID-19 pandemic had the potential to influence communicable disease reporting at multiple points. While the effects could vary considerably, the results would be expected to reduce the number and the detection of notifiable cases. Included would be changes in exposures, diagnostic testing, reporting to public health agencies, and public health investigations.*

Introduction

The COVID-19 pandemic has had a fundamental impact on health services [1-3] and the epidemiology of other infectious diseases worldwide [4].
In response to the ongoing COVID-19 pandemic, a variety of public health interventions have been implemented worldwide to mitigate its impact, including nonpharmaceutical interventions (NPIs), as social distancing, mask-wearing, shelter-in-place, travel restrictions, school closure [5].
While pharmaceutical interventions generally target specific pathogens, NPIs can act on a broad spectrum of infectious pathogens. Tough these measures, initially specifically aiming for COVID-19, might have significant impact on other infectious diseases [4].
There is growing global evidence suggesting that NPIs are associated with decreased rates of COVID-19 and non–COVID-19 infectious diseases, and thus a decreased burden associated with seasonal influenza, other upper and lower respiratory infections, and food-borne diseases [6, 7].
Generally, those studies focused solely on respiratory pathogens such as influenza virus and respiratory syncytial virus. Although respiratory pathogens were likely affected the most by the NPIs, pathogens with other transmission modes, *e.g.,* gastrointestinal, sexually transmitted, or even vector-borne diseases, could have also been affected as the unprecedented changes in human movement and behavioral patterns might have changed exposure levels.
Surveillance of infectious diseases lays the foundation for their possible control [8]. In Italy, infectious disease surveillance is based on the Mandatory Reporting System, that pursuant to Ministerial Decree of 15 December 1990 - "Infectious and Transmissible Diseases Information System", involves the mandatory reporting by doctors of cases of the many infectious diseases [9]. The information flow for infectious diseases starts from the periphery and converge towards the centre for Regional, National and Supranational reporting. The infectious disease reporting system has been activated reporting of probable or confirmed cases of an infectious disease is made by local General Practitioners (GPs), Primary Care Pediatricians (PCPs), or hospital physicians. In addition to this general system, there are other specific surveillance systems at national level, such as those for legionellosis, influenza and viral hepatitis [10]. This mandatory notification system allows for a continuous analysis at a central and local level.
We have already analysed the impact of the pandemic on health services, such as vaccinations in Siracusa LHA different papers [11, 12]. In this paper, we aim to quantify the changes in the transmission, diagnosis and notifications of notifiable infectious diseases with different transmission modes before, during, and after the first wave of COVID-19 in Siracusa Local Health

Authority (LHA), Italy, by analysing the reported cases and their characteristics during the pandemic (2020-2022), in comparison to the pre-pandemic phase (2017-2019).

Methods

This study is a retrospective analysis of data previously generated from the infectious disease notifications in Siracusa LHA of two different three-year periods 2017-2019 (pre-pandemic period, from 1 January 2017 to 31 December 2019) and 2020-2022 (pandemic period, from 1 January 2020 to 31 December 2022). We compared annual case numbers and case characteristics in the pre-pandemic period and in the pandemic period.

Considering the average population, the resident population decreased by 1.8%, from 394,315 in the years 2017-2019 to 387,105 in the years 2020-2022. Just under a third of the residents lived in the city of Siracusa, provincial capital with about 116.635 residents. The territory is divided into four health districts.

The 29 infectious diseases examined are listed in Table I. We categorised the included notifiable diseases according to their main mode of transmission and vaccination availability. We included at least one disease per mode of transmission, considering public health relevance in Italy. Grouping the diseases according to their transmission modes, we evaluated the notification trend of the following groups of diseases (Tab. I): airborne/droplets/aerosol of contaminated water diseases (viral meningitis, herpes zoster-shingles, legionellosis, invasive bacterial diseases, measles, mumps, pertussis, rubella, scarlet fever, tuberculosis, chickenpox); fecal-oral/contaminated food or water diseases (brucellosis, hepatitis A, hepatitis E, typhoid fever and paratyphoid fever, non-typhoid salmonellosis, food poisoning, listeriosis); sexual/blood-borne/body fluids/transplacental diseases (hepatitis B, hepatitis C, HIV, syphilis, congenital syphilis); vector-borne diseases (visceral leishmaniasis, malaria, rickettsiosis); direct contact diseases (pediculosis, scabies); transmission through skin wound diseases (tetanus).

The diagnostic methods, that differ according to the category of infectious disease, such as polymerase

Tab. I. Main mode of transmission or acquisition and vaccination availability of notifiable infectious diseases included.

Disease/Infection	Main mode of transmission	Vaccination availability*	Compared to pre-COVID-19
Brucellosis	Fecal-oral transmission	No	Lower
Chickenpox	Airborne transmission	Yes	Lower
Congenital syphilis	Transplacental	No	Lower
Food poisoning	Contaminated food or water	No	Comparable
Hepatitis A	Fecal-oral transmission	Yes	Lower
Hepatitis B	Sexually transmitted and via body fluids	Yes	Comparable
Hepatitis C	Blood-borne	No	Lower
Hepatitis E	Fecal-oral transmission	No	Comparable
Herpes zoster-shingles	Airborne transmission	Yes	Comparable
HIV	Sexually transmitted and via body fluids	No	Lower
Invasive bacterial diseases (IBDs)	Airborne transmission	Yes	Lower
Legionellosis	Inhalation of contaminated aerosol	No	Higher
Listeriosis	Contaminated food or water	No	Comparable
Malaria	Vector-borne	No	Comparable
Measles	Airborne transmission	Yes	Lower
Mumps	Airborne transmission	Yes	Lower
Non-typhoid salmonellosis	Contaminated food or water	No	Comparable
Pediculosis	Direct contact	No	Comparable
Pertussis	Airborne transmission	Yes	Comparable
Rickettsiosis	Vector-borne	No	Lower
Rubella	Airborne transmission	Yes	Comparable
Scabies	Direct contact	No	Comparable
Scarlet Fever	Airborne transmission	No	Lower
Syphilis	Sexually transmitted and via body fluids	No	Comparable
Tetanus	Transmission through skin wound	Yes	Comparable
Tuberculosis	Airborne transmission	Yes	Lower
Typhoid and paratyphoid fever	Contaminated food or water	Yes	Comparable
Viral meningitis	Airborne transmission	No	Comparable
Visceral leishmaniasis	Vector-borne	No	Comparable

* Routinely administered in Italy.

chain reaction testing, antigen testing, or clinical diagnosis [13], did not change during the study period for each infectious disease included in the study.

All the notifications made by the local physicians are managed and insert into the IT platforms of the general and specifically dedicated national websites (PREMAL) by the Epidemiology Unit of the local Health Department. The notification data collected by these systems were used to obtain disease incidence values, considering the resident population per each year to make a difference between the pre-pandemic and the pandemic period. Resident population was obtained according to ISTAT data (Italian National Statistical Institute).

Descriptive statistics were used to find the percentages and the 95% confidence interval (CI). Exact "F-tests" was performed to compare the mean values between the studied periods to evaluate the hypothesis that the number of reported cases would not differ significantly between the two periods. Significance was assessed at the $p < 0.05$ level.

Results

Between January 2017 and December 2022, a total of 1,162 notifications of infectious diseases were reported: 273 cases were notified in the pandemic period (2020-2022), compared to 889 cases of the pre-pandemic one (2017-2019), with a percentage decrease of -69.3% ($p < 0.0001$) (Tab II).

We calculated the incidence rates (IR) based on resident population. Specifically, in the pre-pandemic period (2017-2019), the average IR was 75.2/100,000 ± 7.5 (95% CI: 67.7-82.7) while, in the pandemic period, the average IR was 23.5/100,000 ± 2.4 (95% CI: 21.1-25.9). Therefore, a significant percentage decrease of -68.8% between the average values of the two periods incidences was detected ($p < 0.00001$).

Of all diseases included in the study period, 25 of them (86.2%) reported a decrease in reported cases during the COVID-19 pandemic, and in 12 of them (41.4%) the decline was statistically significant. In contrast, 4 diseases (13.8%) reported an increase in reported

Tab. II. Comparison between the absolute numbers of the infectious disease notifications made in the pre-pandemic (2017-2019) and pandemic (2020-2022) periods, with corresponding absolute changes (Δ n), percentage changes (Δ %) and statistical significance.

Disease/Infection	Absolute number of reported cases		Δ n	Δ %	Fisher test
	2017-2019	2020-2022			
Brucellosis	36	0	-36	-100,0%	p < 0.00001
Chickenpox	54	20	-34	-63,0%	p < 0.0001
Congenital syphilis	12	0	-12	-100,0%	p < 0.0005
Food poisoning	3	9	6	+200,0%	ns
Hepatitis A	17	0	-17	-100,0%	p <.05
Hepatitis B	4	1	-3	-75,0%	ns
Hepatitis C	8	1	-7	-87,5%	p = 0.0391
Hepatitis E	2	0	-2	-100,0%	ns
Herpes zoster-shingles	2	1	-1	-50,0%	ns
HIV	62	40	-22	-35,5%	p = 0.0379
Invasive bacterial diseases (ibds)	12	2	-10	-83,3%	p = 0.013
Legionellosis	0	9	9	+100%	p = 0.0018
Listeriosis	1	1	0	0,0%	ns
Malaria	2	1	-1	-50,0%	ns
Measles	291	1	-290	-99,7%	p < 0.00001
Mumps	12	3	-9	-75,0%	p = 0.0353
Non-typhoid salmonellosis	22	12	-10	-45,5%	ns
Pediculosis	11	5	-6	-54,5%	ns
Pertussis	6	2	-4	-66,7%	ns
Rickettsiosis	32	6	-26	-81,3%	p < 0.05.
Rubella	1	0	-1	-100,0%	ns
Scabies	100	94	-6	-6,0%	ns
Scarlet fever	109	12	-97	-89,0%	p < 0.00001
Syphilis	21	23	2	+9,5%	ns
Tetanus	1	1	0	0,0%	ns
Tuberculosis	58	23	-35	-60,3%	p < 0.0001
Typhoid fever and paratyphoid fever	4	5	1	+25,0%	ns.
Viral meningitis	4	1	-3	0,0%	ns
Visceral leishmaniasis	2	0	-2	-100,0%	ns
Total	**889**	**273**	**-616**	**-69,3%**	**p < 0.00001**

cases, one of them (3.4%) with statistical significance (legionellosis) (Tab. I).
Grouping the diseases according to their transmission modes, those with the greatest reduction in reported cases were airborne/droplets/aerosol of contaminated water diseases (-86.5%, $p < 0.00001$), followed by fecal-oral/contaminated food or water diseases (-68.2%, $p < 0.00001$), sexual/blood-borne/body fluids/ transplacental diseases (-39.3%, $p = 0.0022$), and finally those transmitted by direct contact (-10.8%, ns).
Of the 12 infectious diseases with a significant decrease in the mean number of reported cases during the pandemic period, 6 diseases (50.0%) are characterized by airborne or droplets transmission (Tab. II). A significant increase in the number of reported cases during the pandemic was observed only for legionellosis, while an increase trend, but without statistical significance, was observed for food poisoning, syphilis, typhoid and paratyphoid fever.

Airborne/droplets/aerosol of contaminated water diseases

Measles was the disease with the most notified overall over the entire reporting period and by far the most notified among airborne diseases, with, however, a significant reduction of 99.7% from 2017-2019 to 2020-2022 ($p < 0.00001$).
Scarlet fever was the second most notified airborne disease; again, there was a significant reduction in incidence in the years 2020-2022 (-89.0%, $p < 0.00001$), compared to the previous.
Tuberculosis reported a highly significant decrease of -60.3% between the pre-pandemic period and the pandemic one ($p < 0.00001$), as the same for chickenpox (-63.0%; $p < 0.00001$).
Vaccine-preventable invasive bacterial diseases (caused by *Neisseria meningitidis*, *Streptococcus pneumoniae* and *Haemophilus influenzae*) had registered a decrease of -83.3% ($p < 0.05$) in the pandemic period.
Rubella was present with only 1 case in the pre-pandemic period and no case was notified in the pandemic one. In contrast, for legionellosis we recorded 9 cases in the years 2020-2022 *vs* no cases in the period 2017-2019 ($p = 0.0018$).

Fecal-oral/contaminated food or water diseases

The most notified foodborne disease was brucellosis (36 cases), for which no-one case was recorded in the years 2020-2022 ($p < 0.00001$). Hepatitis A ($p < 0.05$) and hepatitis E (ns) followed a similar trend, with 100.0% of reduction in the latter period. For Hepatitis A, an outbreak of 5 cases was reported in 2017 in a primary school affecting people coming back from Morocco.Non-typhoid salmonellosis cases were constantly notified, with a reduction from the first period to the second one (-45.5%, ns). Also, typhoid and paratyphoid fever cases were constantly notified (4 cases in pre-pandemic period and 5 cases in the pandemic one).

Sexual/blood-borne/body fluids/ transplacental diseases

HIV infection registered the largest number of cases in this group of diseases (102 cases), followed by syphilis. For HIV infection, there was a 35.5% reduction ($p = 0.0379$), while for syphilis there were 2 more cases in the 2020-2022 years compared to the 2017-2019 years (+9.5%, ns).
Both hepatitis B (-75.0%, ns) and hepatitis C (-87.5%, $p = 0.0391$) experienced a reduction in the post-pandemic period compared to pre-pandemic one.
Congenital syphilis (12 cases) experienced a 100% reduction in the post-pandemic period compared to the previous period ($p < 0.0005$).

Vector-borne diseases

Rickettsiosis, endemically present in this territory, has recorded a significant reduction comparing the 2020-22 period to the 2017-2019 period (-81.3%, $p < 0.05$). Two cases were notified for visceral leishmaniasis and malaria (all import cases for the latter) in the pre-pandemic period, while no case (-100%) and 1 case (-50%) was notified in the post-pandemic period, respectively.

Direct contact diseases

Pediculosis and scabies were constantly notified and the average number of cases of the two study periods remained overlapping for both the diseases. Overall, scabies was the second infection more notified after measles. Pediculosis recorded a percentage decrease of 54.5% from 2017-2019 to 2020-2022.

Transmission through skin wound diseases

During all the study period, two tetanus cases were overall notified, one in both periods, which interested the age group > 65 years old in both cases. One death was reported.

Vaccination availability

Comparing the two study periods, all the vaccine-preventable diseases (VPDs) showed an incidence decreased almost double compared to non VPDs (-87.2% *vs* -49.9%, $p < 0.00001$). In more details: measles -290 cases (-99.7%), chickenpox -34 cases (-63.0%), hepatitis A -17 cases (-100%), invasive bacterial diseases (IBDs) -10 cases (-83.3%), mumps -9 cases (-75.0%), pertussis -4 cases (-66.7%); hepatitis B -3 cases (-75%).

Discussion

In this study, we reported the impact of the COVID-19 pandemic on the endemic status of other 29 infectious diseases in Siracusa Local Health Authority, Italy. Specifically, we observed an abrupt decline in the number of many reported infectious diseases.
As already reported, infectious disease with airborne route of transmission experienced the greatest reduction between the two different three-year study

periods. Airborne infectious diseases and COVID-19 share similar routes of transmission; therefore, the widespread of NPIs, such as restrictions on gatherings and international travel, physical distancing, mandatory mask wearing and school closures, implemented to prevent COVID-19 are likely to have prevented other infectious diseases circulation as well. During 2017–2019 period, a resurgence of measles was being observed both in the EU/EEA, during which Italy accounted for almost 30% of the over 18,000 reported cases [14]. As a result, mandatory vaccination for measles (and other diseases such as mumps, rubella and chickenpox) was introduced in Italy for all newborns from 2017 [15]. Given the above, however, we can rule out the possibility that this reduction is entirely due to the pandemic, as a decline in the incidence of the disease was observed in Italy as early as the third quarter of 2019, thus well before the onset of the pandemic [16]. Our data are in line with the national data; indeed, we recorded 19 cases in 2017, 269 cases in 2018 and only 3 cases in 2019, while only one case was recorded in pandemic period (2020).

Some infectious diseases have had a rebound outbreak in 2022 after decreased incidence in 2020. It's the case of food poisoning infections, that showed outbreaks in 2022 after decreased incidences in 2020 (9 cases *vs* no case; $p = 0.0019$). A similar trend was observed for scabies and pediculosis, although without any statistical significance.

No (routinary) vaccinations are available for the diseases with a higher number of cases during the pandemic period; conversely, none of the 12 vaccine-preventable diseases included in the study showed increased incidences during the COVID-19 pandemic. Our findings indicate a sustainable suppression of VPDs also beyond the lifting of restrictions. This included measles, mumps, rubella, pertussis, meningococcal and pneumococcal diseases.

Pandemic containment measures, instead, have play a more important role in reducing the notifications of varicella, scarlet fever and IBDs infections. For the latter, we can also assume an important role played by the drastic decrease of influenza cases occurred in Italy during the 2020-2021 season [17], given that some bacterial diseases, including Streptococcus pneumoniae, can occur as complication of influenza, especially in the elderly and fragile people [18].

Regarding food-borne diseases, the closure of restaurants and food service providers in schools, hotels, and catering businesses has resulted in more eating at home than away from home. Such shift resulted in lower rates of foodborne illnesses, especially the pathogens associated with restaurant settings [19]. Furthermore, international travel restrictions have decreased infections associated with such activities. These policies and regulations and changes in hygiene behaviours, such as increased handwashing, likely reduced exposure to foodborne pathogens. Studies have shown that washing hands before preparing food increased by at least 20% during the COVID-19 pandemic [20].

COVID-19 pandemic and NPIs likely modulated the incidences of vector-borne diseases in at least two more ways in addition to altering healthcare-seeking behaviour. The restrictions on human mobility inevitably reduced people's outdoor activities and hence lowered their exposure to vectors and animal hosts of vector-borne or zoonotic diseases. Meanwhile, restrictions and screening of international travellers dramatically reduced the number of imported cases.

Less variation of sexually transmitted or bloodborne diseases was observed in comparison with respiratory diseases and gastrointestinal or enteroviral diseases, possibly due to the difference in their transmission modes. However, sexually transmitted infections remain a significant public health concern, even in the face of a pandemic. The syphilis has been constantly present in our territory during the last years. This is in line with data from different countries where syphilis has been a resurgent disease especially in some particularly at-risk group of population [21, 22].

A separate mention has to be made for scabies, which experienced the smallest decrease in notifications compared to the pre-pandemic period (-6.0%). Generally, scabies has been thought to occur only sporadically, but in the last two decades, there has been an increase in published papers indicating that disease is occurring more frequently [23]. It's possible that the pandemic could have exacerbated an already existing situation characterized by a general increasing trend linked to various variable. This situation is in line with what reported by other countries where an analogous increase was detected in last years [23-27].

Legionellosis was the only infection with a significant increase in reported cases in the pandemic period compared with the previous one in our study. These data are in line with national data: in Italy, in 2022 the incidence of legionellosis increased from previous years, returning to pre-pandemic incidence values [26, 27]. In Europe, the reporting rate of legionellosis cases also increased in 2021 compared to 2020, reaching the highest level ever recorded by ECDC surveillance. Italy, France, Spain and Germany account for 75% of all reported cases [28]. The cause of the recent increase in the reporting rate in Europe remains unknown. It is possible that it is associated with the lifting of COVID-19 restrictions, as travel-associated infections decreased significantly in 2020 compared to the years before the COVID-19 pandemic. Changes in building occupancy and water use altered the demand on public water systems during the COVID-19 pandemic, potentially impacting the risk of Legionella growth in areas with reduced water flow or loss of disinfectant residuals [29]. When buildings are reopened after the lockout, it is essential that water systems are not put back into operation without considering the risks of Legionnaires' disease. The risk of the presence of waterborne pathogens, such as legionella bacteria, increases due to conditions that may have been created during the shutdown. In addition, as a result of the pandemic, the possibility exists that more people may be susceptible to Legionnaires' disease due to a compromised respiratory system during or after infection with COVID-19.

Our findings of a remarkable and significant decrease of notifications of infectious diseases in the pandemic

period are in line with what reported by previous evidence [30-43]. Such reports suggest that the COVID-19 strategy has led to similar control of other infectious diseases, mainly comprising those transmitted by airborne/droplets or contact, in many countries.

The COVID-19 pandemic has led to lifestyle changes worldwide. Individual and public health measures against COVID-19 are considered to have contributed to the control of many infectious diseases [44-49].

The reasons for these observations are likely to be multifactorial, and our analyses of surveillance data cannot determine with certainty to which extent decreases in disease reporting were due to a true decrease in transmission or whether the decrease was only due to a decrease in diagnosis. While the effects could vary considerably, the results would be expected to reduce the number and the detection of notifiable cases. Included would be changes in exposures, diagnostic testing, reporting to public health agencies, and public health investigations. However, by assessing diseases with different modes of transmission, we can derive hypotheses regarding the reasons for the reduction in case numbers. There may have been a decrease in transmission, and thus a true decrease of cases, for several notifiable diseases as a consequence of the COVID-19 NPIs as indicated by the decrease in chickenpox, IBDs, mumps, scarlet fever cases in pandemic period. These diseases are mainly transmitted via direct close contact, *i.e.* airborne, via droplets. Hence, as described, NPIs such as increased hand and cough hygiene, physical distancing, contact restrictions and the closure of schools and daycare centres, probably also reduced infections caused by transmission via direct close contact [4].

The COVID-19 pandemic had the potential to influence communicable disease reporting at multiple points. First, decreasing the viral circulation following to a lower people movement, specifically during the lockdown. Individuals restricting their activities could result in fewer exposures to communicable diseases. Closure of schools and public areas could reduce the risk of exposure to respiratory diseases such as influenza and pertussis. Closure of restaurants could reduce large foodborne disease outbreaks. Reduced domestic and international travel could in turn reduce a wide range of exposures. The pandemic led to in fewer in-person visits to healthcare facilities including for non-respiratory symptoms. Secondly, public health measures put in place to control the pandemic, such as physical distancing, international and local travel restrictions, lockdowns, mask-wearing and handwashing, would have also affected the spread of other infectious diseases, particularly respiratory viruses [50]. As already reported, many infectious diseases, especially air-borne infectious diseases, and COVID-19 share similar routes of transmission; therefore, the widespread of NPIs implemented to prevent COVID-19 are likely to have prevented other infectious diseases circulation as well.

However, despite strong and valid evidences highlight the key role played by the pandemic and by the counter measures in the reduction of infectious disease notifications, we cannot exclude a possible role of the widespread phenomenon of underreporting, a well-known malpractice present in ordinary situations [50, 51], that it could be stressed in the extraordinary situation given by the pandemic. Another impact was suspension of Public Health Laboratories' capacity for strain typing for a while, interfering with the ability to detect outbreaks [51, 52]. Without laboratory testing, the cause of any possible infection would remain undetermined and unreported. Finally, people may have been less likely than usual to seek medical care for relatively minor illnesses, leading to under-diagnosis and under-reporting for some diseases. It is difficult to determine the relative contribution of these various factors to the declines [53].

Surveillance is the backbone of any disease control program [54]. Surveillance is "the ongoing systematic collection, analysis, interpretation and dissemination of data regarding a health-related event; for doing actions" [55]. It is essential for evaluating the impact of an intervention, such as mass vaccination, on a population. It can also act as a fairly sensitive system for the early detection of outbreaks. The importance of an organized notification system coordinating the surveillance of infectious diseases has been widely shown by the COVID-19 pandemic, when surveillance systems have been widely used worldwide as cornerstone in the fight against COVID-19 pandemic [56, 57, 58]. The pandemic highlighted the need for strengthened surveillance data to accurately track the distribution of infectious diseases for informing public health responses to improve infection prevention and control.

The COVID-19 pandemic has brought both challenges and opportunities in surveillance [59, 60]. Yet, gaps in surveillance, from the local to the global, continue to leave the world vulnerable to infectious hazards. The COVID-19 pandemic revealed that various healthcare systems in the world are fundamentally weak. Compared with many developed countries, the ability of less developed countries to tackle a pandemic seems to be much lower and the medical system in those nations is frequently grossly inadequate. Some disease outbreaks, if not detected and controlled at an early stage, have the potential to turn into an epidemic or even a pandemic, which can disrupt the commercial growth of the nation and the health of human resources. The health and well-being of people around the world continue to be challenged by infectious hazards. The progression of COVID-19 has proven that "no one is safe until everyone is safe" in this interconnected world.

This study has several limitations that should be kept in mind. First, this is an observational study; thus, our results should be interpreted as associations of COVID-19 pandemic and NPIs with, rather than causal effect on, reducing transmission of non-COVID-19 infectious diseases. Second, the assessment of just two time periods (pre-pandemic and pandemic) could represent a simplified approach of assessing effects of the pandemic. During the pandemic period, there were various, sometimes overlapping COVID-19-related

developments (new variants, newly introduced vaccines or vaccination recommendations, new NPIs and changing perception of the pandemic in the population), that, probably, had different impacts on the healthcare system and on healthcare-seeking behaviour, and consequently on the diagnosis and notification of other infectious diseases. As it is difficult to disentangle these effects, we chose the pragmatic approach of assessing only one pandemic period. Third, this study did not include all the infectious diseases, but only those and for which there were a sufficient number of notifications to allow appropriate statistical analysis, to avoid that the small numbers of reported cases could have been affected by the sporadic outbreaks. Other study limitations include the omission of data on incidence of influenza and other data such as seasonal trends, effect of vaccination, and changes in the sensitivity of surveillance due to insufficient data availability.

With our study we hope to contribute to a better understanding and interpretation of the local epidemiology of infectious diseases other than COVID-19 during and after pandemics. To the best of our knowledge, very few publications have analysed the "new" endemic status of infectious diseases considering the changes brought by the pandemic at the local level. Generally, those studies focused solely on respiratory pathogens such as influenza virus and respiratory syncytial virus. Although respiratory pathogens were likely affected the most by the NPIs, pathogens with other transmission modes, *e.g.,* gastrointestinal, sexually transmitted, or even vector-borne diseases, could have also been affected as the unprecedented changes in human movement and behavioral patterns might have changed exposure levels. In our opinion, the local level analysis is very useful to understand the "new endemic status" of the other infectious diseases after the pandemic in our territory.

These findings could be used to inform scientific decisions about possible future epidemics and to organize appropriate public health responses, such as vaccinations or other measures.

Conclusions

In conclusion, we comprehensively describe the epidemiological characteristics of infectious diseases and analyse the difference before and after the epidemic of COVID-19 in Siracusa LHA.

The study showed that during the COVID-19 pandemic, particularly in 2020 and in 2021 and to a lesser extent also in 2022, there were significantly fewer cases of notifiable diseases other than COVID-19 in Siracusa LHA. This decrease was particularly marked for airborne infectious diseases, but it involved almost every infectious disease. Various factors should be considered when evaluating possible reasons for this decline, including under diagnosis, under-reporting and decreased transmission. The magnitude of the observed decrease in incidence and its temporal coincidence with the introduction of national lockdown measures suggest that our findings represent a real decline of infectious diseases, but besides a real decrease in transmission, there may have been under-detection for some diseases, which might have been due by such extraordinary situation given by the pandemic, due to the huge load of healthcare professionals involved, for the most part, in managing the pandemic.

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Conflicts of interest statement

The authors declare no conflict of interest.

Authors' contributions

Conceptualization, FC; methodology, FC; acquisition of data, FC, EDP, CR; formal analysis and interpretation of data, FC, FB; writing - original draft preparation, FC; writing - review and editing, FC, FB; statistical analysis, FC; supervision and project administration, FC, EDP, MLC. All authors have read and agreed to the submitted version of the manuscript.

References

[1] World Health Organization (WHO). Pulse survey on continuity of essential health services during the COVID-19 pandemic: interim report, 27 August 2020 Geneva: WHO 2020. Available at: https://www.who.int/publications/i/item/ WHO-2019-nCoV-EHS_continuity-survey-2020.1 (Accessed on: 30/01/2024).

[2] World Health Organization (WHO). The impact of the COVID-19 pandemic on noncommunicable disease resources and services: results of a rapid assessment. Geneva: WHO 2020. Available at: https://www.who.int/publications/i/item/9789240010291 (Accessed on: 30/01/2024).

[3] World Health Organization (WHO). COVID-19 continues to disrupt essential health services in 90% of countries. Geneva: WHO 2021. Available at: https://www.who.int/news/ item/23-04-2021-COVID-19-continues-to-disrupt-essentialhealth- services-in-90-of-countries (Accessed on: 30/01/2024).

[4] Oh KB, Doherty TM, Vetter V, Bonanni P. Lifting non-pharmaceutical interventions following the COVID-19 pandemic - the quiet before the storm? Expert Rev Vaccines 2022;21:1541-53. https://doi.org/10.1080/14760584.2022.2117693.

[5] Mader S, Rüttenauer T. The effects of non-pharmaceutical interventions on COVID-19 mortality: a generalized synthetic control approach across 169 countries. Front Public Health 2022;10:820642. https://doi.org/10.3389/fpubh.2022.820642. Erratum in: Front Public Health 2023;11:1186935.

[6] Sacri AS, De Serres G, Quach C, Boulianne N, Valiquette L, Skowronski DM. Transmission of acute gastroenteritis and respiratory illness from children to parents. Pediatr Infect Dis J 2014;33:583-8. https://doi.org/10.1097/INF.0000000000000220.

[7] Oh DY, Buda S, Biere B, Reiche J, Schlosser F, Duwe S, Wedde M, von Kleist M, Mielke M, Wolff T, Dürrwald R. Trends in respiratory virus circulation following COVID-19-targeted

nonpharmaceutical interventions in Germany, January - September 2020: analysis of national surveillance data. Lancet Reg Health Eur 2021;6:100112. https://doi.org/10.1016/j.lanepe.2021.100112.

[8] Noah N. Surveillance of infectious diseases. Encyclopedia of Virology 2021:247-255. https://doi.org/10.1016/B978-0-12-814515-9.00068-0.

[9] Ministero della Salute. Decreto Ministeriale 15 dicembre 1990-Sistema informativo delle malattie infettive e diffusive. 1990. Available at: https://www.esteri.it/mae/resource/doc/2020/03/decreto_9_marzoeng.pdf (Accessed on: 20/11/2023).

[10] Il sistema di sorveglianza routinario per le malattie infettive (Sistema informativo malattie infettive, Simi). Available at: https://www.epicentro.iss.it/infettive/sorveglianza (Accessed on: 20/11/2023).

[11] Contarino F, Di Pietro E, Randazzo C, Bella F, Contrino ML. Effectiveness of a vaccine recovery plan after the COVID-19 pandemic in the Siracusa Local Health Authority, Italy. Results of one year follow-up. J Prev Med Hyg 2023;64:E289-97. https://doi.org/10.15167/2421-4248/jpmh2023.64.3.3001.

[12] Contarino F, Di Pietro E, Bella F, Randazzo C, Contrino ML. Childhood immunization coverage during the COVID-19 pandemic in the province of Siracusa, Italy. J Prev Med Hyg 2022;63:E513-9. https://doi.org/10.15167/2421-4248/jpmh2022.63.4.2587.

[13] Istituto Superiore di Sanità. Infectious Diseases Department. Available at: https://www.iss.it/web/iss-en/infectious-diseases (Accessed on: 29/01/2024).

[14] European Centre for Disease Prevention and Control. Measles. In: ECDC. Annual epidemiological report for 2019. Stockholm: ECDC 2020.

[15] Ministero della Salute. Conversione in legge, con modificazioni, del decreto-legge 7 giugno 2017, n. 73, recante disposizioni urgenti in materia di prevenzione vaccinale. 2017. Available at: https:// www.trovanorme.salute.gov.it/norme/dettaglioAtto?id=60201 (Accessed on: 28/01/2024).

[16] Filia A, Bella A, Del Manso M, Baggieri M, Marchi A, Bucci P, Magurano F, Nicoletti L, Rota MC. Morbillo & Rosolia News, N. 58 gennaio 2020. Available at: http://www.epicentro.iss.it/problemi/morbillo/bollettino.asp (Accessed on: 28/01/2024).

[17] Istituto Superiore di Sanità (ISS). Rapporto della sorveglianza integrata dell'influenza. 2021. Available at: https://www.epicentro. iss.it/influenza/flunews20-21 (Accessed on: 28/01/2024).

[18] Siegel SJ, Roche AM, Weiser JN. Influenza promotes pneumococcal growth during coinfection by providing host sialylated substrates as a nutrient source. Cell Host Microbe. 2014;16:55-67. https://doi.org/10.1016/j.chom.2014.06.005.

[19] Akil L, Ahmad HA. Socioeconomic impacts of COVID-19 pandemic on foodborne illnesses in the United States. Eur J Environ Public Health 2023;7:em0128. https://doi.org/10.29333/ejeph/12585.

[20] Görür N, Topalcengiz Z. Food safety knowledge, hygiene practices, and eating attitudes of academics and university students during the coronavirus (COVID-19) pandemic in Turkey. J Food Saf 2021;41:e12926. https://doi.org/10.1111/jfs.12926.

[21] Ukai T, Kakimoto K, Kawahata T, Miyama T, Iritani N, Motomura K. Resurgence of syphilis in 2022 amongst heterosexual men and women in Osaka, Japan. Clin Microbiol Infect 2023;29:396-7. https://doi.org/10.1016/j.cmi.2022.11.010.

[22] Amerson EH, Castillo Valladares HB, Leslie KS. Resurgence of Syphilis in the US-USPSTF Reaffirms Screening Guidelines. JAMA Dermatol. 2022;158:1241-3. https://doi.org/10.1001/jamadermatol.2022.3499.

[23] Ažđajić MD, Bešlić I, Gašić A, Ferara N, Pedić L, Lugović-Mihić L. Increased Scabies Incidence at the Beginning of the 21st Century: What Do Reports from Europe and the World Show? Life 2022;12:1598. https://doi.org/10.3390/life12101598.

[24] van Deursen B, Hooiveld M, Marks S, Snijdewind I, van den Kerkhof H, Wintermans B, Bom B, Schimmer B, Fanoy E. Increasing incidence of reported scabies infestations in the Netherlands, 2011-2021. PLoS One 2022;17:e0268865. https://doi.org/10.1371/journal.pone.0268865.

[25] Redondo-Bravo L, Fernandez-Martinez B, Gómez-Barroso D, Gherasim A, García-Gómez M, Benito A, Herrador Z. Scabies in Spain? A comprehensive epidemiological picture. PLoS One. 2021;16:e0258780. https://doi.org/10.1371/journal.pone.0258780.

[26] Rota MC, Caporali MG, Bella A, Scaturro M, Giannitelli S, Ricci ML. I risultati del sistema di sorveglianza della legionellosi nel 2021. Boll Epidemiol Naz 2022;3:30-7. https://doi.org/10.53225/BEN_045. Errata corrige in: Boll Epidemiol Naz 2022;3:30-7. https://doi.org/10.53225/BEN_047.

[27] Rota MC, Caporali MG, Bella A, Scaturro M, Giannitelli S, Ricci ML. I risultati del sistema di sorveglianza della legionellosi nel 2021. Boll Epidemiol Naz 2023;4:25-32. https://doi.org/10.53225/BEN_062.

[28] European Centre for Disease Prevention and Control. Legionnaires' disease. In: ECDC. Annual Epidemiological Report for 2021. Stockholm: ECDC 2023. Available at: https://www.ecdc.europa.eu/sites/default/files/documents/legionnaires-disease-annual-epidemiological-report-2021.pdf (Accessed on: 02/02/2024).

[29] Kunz JM, Hannapel E, Vander Kelen P, Hils J, Hoover ER, Edens C. Effects of the COVID-19 pandemic on legionella water management program performance across a United States lodging organization. Int J Environ Res Public Health 2023;20:6885. https://doi.org/ 10.3390/ijerph20196885.

[30] Chen B, Wang M, Huang X, Xie M, Pan L, Liu H, Liu Z, Zhou P. Changes in Incidence of Notifiable Infectious Diseases in China Under the Prevention and Control Measures of COVID-19. Front Public Health 2021;9:728768. https://doi.org/10.3389/fpubh.2021.728768.

[31] Geng MJ, Zhang HY, Yu LJ, Wang T, Che TL, Xu Q, Jiang BG, Chen JJ, Hay SI, Li ZJ, Gao GF, Wang LP, Yang Y, Fang LQ, Liu W. Changes in notifiable infectious disease incidence in China during the COVID-19 pandemic, Nat Commun 2021;12:6923. https://doi.org/10.1038/s41467-021-27292-7.

[32] Ullrich A, Schranz M, Rexroth U, Hamouda O, Schaade L, Diercke M, Boender TS; Robert Koch's Infectious Disease Surveillance Group. Impact of the COVID-19 pandemic and associated non-pharmaceutical interventions on other notifiable infectious diseases in Germany: An analysis of national surveillance data during week 1-2016 - week 32-2020. Lancet Reg Health Eur 2021;6:100103. https://doi.org/10.1016/j.lanepe.2021.100103.

[33] Sohail A, Cheng AC, McGuinness SL, Leder K. The epidemiology of notifiable diseases in Australia and the impact of the COVID-19 pandemic, 2012–2022. BMC Global and Public Health 2024;2:1. https://doi.org/10.1186/s44263-023-00029-y.

[34] Redlberger-Fritz M, Kundi M, Aberle SW, Puchhammer-Stöckl E. Significant impact of nationwide SARS-CoV-2 lockdown measures on the circulation of other respiratory virus infections in Austria. J Clin Virol 2021;137:104795. https://doi.org/10.1016/j.jcv.2021.104795.

[35] Nash K, Lai J, Sandhu K, Chandan JS, Shantikumar S, Ogunlayi F, Coleman PC. Impact of national COVID-19 restrictions on incidence of notifiable communicable diseases in England: an interrupted time series analysis. BMC Public Health 2022;22:2318. https://doi.org/10.1186/s12889-022-14796-0.

[36] Li H, Ling F, Zhang S, Liu Y, Wang C, Lin H, Sun J, Wu Y. Comparison of 19 major infectious diseases during COVID-19 epidemic and previous years in Zhejiang, implications for prevention measures. BMC Infect Dis 2022;22:296. https://doi.org/10.1186/s12879-022-07301-w.

[37] van de Berg S, Charles T, Dörre A, Katz K, Böhm S. Epidemiology of common infectious diseases before and during the COVID-19 pandemic in Bavaria, Germany, 2016 to 2021: an analysis of routine surveillance data. Euro Surveill 2023;28:2300030. https://doi.org/10.2807/1560-7917.ES.2023.28.41.2300030.

[38] Hayes LJ, Uri H, Bojkova D, Cinatl J Jr, Wass MN, Michaelis M. Impact of the COVID-19 pandemic on the circulation

of other pathogens in England. J Med Virol 2023;95:e28401. https://doi.org/10.1002/jmv.28401.

[39] Komori A, Mori H, Naito T. The impact of the COVID-19 pandemic on other infections differs by their route of transmission: A retrospective, observational study in Japan. J Infect Chemother 2022;28:1700-3. https://doi.org/10.1016/j.jiac.2022.08.02.

[40] Hirae K, Hoshina T, Koga H. Impact of the COVID-19 pandemic on the epidemiology of other communicable diseases in Japan. International Journal of Infectious Diseases 2023;128: 265-271. https://doi.org/10.1016/j.ijid.2023.01.013.

[41] Facciolà A, Laganà A, Genovese G, Romeo B, Sidoti S, D'Andrea G, Raco C, Visalli G, DI Pietro A. Impact of the COVID-19 pandemic on the infectious disease epidemiology. J Prev Med Hyg 2023;64:E274-82. https://doi.org/10.15167/2421-4248/jpmh2023.64.3.2904.

[42] Rotulo GA, Percivale B, Molteni M, Naim A, Brisca G, Piccotti E, Castagnola E. The impact of COVID-19 lockdown on infectious diseases epidemiology: The experience of a tertiary Italian Pediatric Emergency Department. Am J Emerg Med 2021;43:115-7. https://doi.org/10.1016/j.ajem.2021.01.065.

[43] Facchin G, Bella A, Del Manso M, Rota MC, Filia A. Decline in reported measles cases in Italy in the COVID-19 era, January 2020 - July 2022: The need to prevent a resurgence upon lifting non-pharmaceutical pandemic measures. Vaccine 2023;41:1286-9. https://doi.org/10.1016/j.vaccine.2023.01.021.

[44] Angoulvant F, Ouldali N, Yang DD, Filser M, Gajdos V, Rybak A, Guedj R, Soussan-Banini V, Basmaci R, Lefevre-Utile A, Brun-Ney D, Beaujouan L, Skurnik D. Coronavirus Disease 2019 Pandemic: impact caused by school closure and national lockdown on pediatric visits and admissions for viral and nonviral infections-a time series analysis. Clin Infect Dis 2021;72:319-22. https://doi.org/10.1093/cid/ciaa710.

[45] Hatoun J, Correa ET, Donahue SMA, Vernacchio L. Social Distancing for COVID-19 and diagnoses of other infectious diseases in children. Pediatrics 2020:146. https://doi.org/10.1542/peds.2020-006460.

[46] Xiao J, Dai J, Hu J, Liu T, Gong D, Li X, Kang M, Zhou Y, Li Y, Quan Y, He G, Zhong R, Zhu Z, Huang Q, Zhang Y, Huang J, Du Q, Li Y, Song T, Hu W, Zhong H, Ma W. Co-benefits of nonpharmaceutical intervention against COVID-19 on infectious diseases in China: A large population-based observational study. Lancet Reg Health West Pac 2021;17:100282. https://doi.org/10.1016/j.lanwpc.2021.100282.

[47] Lai CC, Chen SY, Yen MY, Lee PI, Ko WC, Hsueh PR. The impact of the coronavirus disease 2019 epidemic on notifiable infectious diseases in Taiwan: S database analysis. Travel Med Infect Dis 2021;40:101997. https://doi.org/10.1016/j.tmaid.2021.101997.

[48] Bright A, Glynn-Robinson AJ, Kane S, Wright R, Saul N. The effect of COVID-19 public health measures on nationally notifiable diseases in Australia: preliminary analysis. Commun Dis Intell 2020;44. https://doi.org/10.33321/cdi.2020.44.85.

[49] Sullivan SG, Carlson S, Cheng AC, Chilver MB, Dwyer DE, Irwin M, Kok J, Macartney K, MacLachlan J, Minney-Smith C, Smith D, Stocks N, Taylor J, Barr IG. Where has all the influenza gone? The impact of COVID-19 on the circulation of influenza and other respiratory viruses, Australia, March to September 2020. Euro Surveill 2020;25:2001847. https://doi.org/10.2807/1560-7917.ES.2020.25.47.2001847.

[50] Gibbons CL, Mangen MJ, Plass D, Havelaar AH, Brooke RJ, Kramarz P, Peterson KL, Stuurman AL, Cassini A, Fèvre EM, Kretzschmar ME; Burden of Communicable diseases in Europe (BCoDE) consortium. Measuring underreporting and under-ascertainment in infectious disease datasets: a comparison of methods. BMC Public Health 2014;14:147. https://doi.org/10.1186/1471-2458-14-147.

[51] Charlton CL, Hull N, Sloma CR, Bonifas M, Johnson M, Strain AK, Wolford T, Staley S, Perkins C, Razzaque R, Courtney C, Bind EP. How To Prepare for the Unexpected: a Public Health Laboratory Response. Clin Microbiol Rev 2021;34:e00183-20. https://doi.org/10.1128/CMR.00183-20.

[52] A Monthly Bulletin on Epidemiology and Public Health Practice in Washington. epiTRENS 2021:26. Available at: https://doh.wa.gov/sites/default/files/legacy/Documents/5100//420-002-epitrends2021-01.pdf (Accessed on: 28/01/2024).

[53] Australian Institute of Health and Welfare (2022) Infectious and communicable diseases, AIHW, Australian Government. Available at: https://www.aihw.gov.au/reports/australias-health/infectious-and-communicable-diseases (Accessed on: 28/01/2024).

[54] Simonsen L, Gog JR, Olson D, Viboud C. Infectious disease surveillance in the big data era: towards faster and locally relevant systems. J Infect Dis 2016;214:S380-5. https://doi.org/10.1093/infdis/jiw376.

[55] Ibrahim NK. Epidemiologic surveillance for controlling COVID-19 pandemic: types, challenges and implications. J Infect Public Health 2020;13:1630-8. https://doi.org/10.1016/j.jiph.2020.07.019.

[56] de Lusignan S, Lopez Bernal J, Zambon M, Akinyemi O, Amirthalingam G, Andrews N, Borrow R, Byford R, Charlett A, Dabrera G, Ellis J, Elliot AJ, Feher M, Ferreira F, Krajenbrink E, Leach J, Linley E, Liyanage H, Okusi C, Ramsay M, Smith G, Sherlock J, Thomas N, Tripathy M, Williams J, Howsam G, Joy M, Hobbs R. Emergence of a Novel Coronavirus (COVID-19): Protocol for Extending Surveillance Used by the Royal College of General Practitioners Research and Surveillance Centre and Public Health England. JMIR Public Health Surveill 2020;6:e18606. https://doi.org/10.2196/18606.

[57] Sakib MN, Butt ZA, Morita PP, Oremus M, Fong GT, Hall PA. Considerations for an individual-level population notification system for pandemic response: a review and prototype. J Med Internet Res 2020;22:e19930. https://doi.org/10.2196/19930. Erratum in: J Med Internet Res 2020;22:e21634.

[58] Adebisi YA, Rabe A, Lucero-Prisno Iii DE. COVID-19 surveillance systems in African countries. Health Promot Perspect 2021;11:382-92. https://doi.org/10.34172/hpp.2021.49.

[59] Future surveillance for epidemic and pandemic diseases: a 2023 perspective. Geneva: World Health Organization 2023. Available at: https://iris.who.int/bitstream/handle/10665/374992/9789240080959-eng.pdf?sequence=1 (Accessed on: 07/02/2024).

[60] World Health Organization. Rapid review of WHO COVID-19 surveillance: External review, 27 October 2021. Geneva: WHO 2021. Available at: https://cdn.who.int/media/docs/default-source/2021-dha-docs/rapid-review-of-who-COVID-19-surveillance.pdf?sfvrsn=a640902c_1&download=true (Accessed on: 07/02/2024).

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