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Exploring the gap between notified and diagnosed cases of Foodborne Diseases: evidence from a time-trend analysis in Italy

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Keywords: Foodborne Diseases; Notification of Infectious Diseases; COVID-19 pandemic.
Parole chiave: Malattie Trasmesse da Alimenti; Notifica di Malattie Infettive; Pandemia di COVID-19.

Abstract

Background. *Foodborne diseases are a major global public health concern, causing significant morbidity and mortality worldwide. The COVID-19 pandemic has had widespread effects on various aspects of life, including the food supply chain, potentially impacting the incidence of foodborne diseases. This study aims to analyze the differences between notified and diagnosed cases and investigate the potential impact of the COVID-19 pandemic on foodborne diseases in the metropolitan area of Bologna, Italy.*
Study Design. *A retrospective time trend analysis from two databases was conducted.*
Methods. *The Local Health Authority of Bologna collected data re/Emilia-Romagna Region on the infectious disease reporting system over a six-year period (2017-2022), which included three years of the COVID-19 pandemic. This data was compared with information collected during the same period at the microbiology laboratory serving the entire metropolitan area of Bologna. Statistical methods included percent change calculations, binomial tests, annual averages, gender and age stratification, and trend analysis with regression.*
Results. *An increase (+34.4%, P-value ≤0.01) in notified cases during the pandemic - compared to the pre-pandemic period - was found. However, no differences were observed in diagnosed cases when comparing the two periods. The year 2021 saw a significant increase in reported cases of foodborne diseases among schoolers (+300.0%) and workers (+133.3%) compared to 2020. On the other hand, diagnosed cases decreased significantly in 2020 (-19.1%, P<0.01) and increased in 2021 (+21.9%, P<0.01). In absolute terms, a stark difference was observed between notified and diagnosed cases across all the study years (2017–2022).*
Conclusions. *This study highlights the discrepancy between notified and diagnosed cases of foodborne diseases and how the COVID-19 pandemic has increased reporting without affecting transmission. These findings contribute to the ongoing discussion on improving foodborne disease reporting systems.*

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Introduction

Foodborne diseases pose a significant threat to global public health, causing a substantial burden of morbidity and mortality worldwide (1-3). According to the World Health Organization (WHO), foodborne diseases affect almost one in ten people worldwide, resulting in approximately 600 million cases and 420,000 deaths annually (4). These illnesses are caused by various pathogens, including bacteria, viruses, parasites, toxins, and chemicals that can contaminate food at any stage of production, processing, and distribution (5).

The COVID-19 pandemic has impacted many aspects of our lives, including the food supply chain (6, 7). The impact of the pandemic on food systems has been extensive, with disruptions in food production, distribution, and consumption, leading to changes in demand and altered consumer behavior. These changes may have affected the incidence of foodborne diseases, potentially increasing risks or altering transmission patterns, but the extent and nature of this impact are not yet fully understood (8).

Accurate reporting is crucial, as it allows for identifying and tracking outbreaks, enabling public health agencies and authorities to implement appropriate control measures (9). Additionally, it enables researchers to study the epidemiology of foodborne diseases, leading to a better understanding of their causes and risk factors (10). However, the reliability of this data depends heavily on the consistency and completeness of reporting, which may have been compromised during the pandemic due to various factors, such as overwhelmed healthcare systems and shifts in public health priorities.

To address these uncertainties, we conducted a time-trend analysis in the Local Healthcare Authority (LHA) of Bologna, which is located in the north of Italy, has a population of over 870,000 inhabitants and extends over an area including 45 municipalities (11). To evaluate any underreporting of potentially foodborne transmitted diseases, we conducted a comparative analysis between SMI (*Sorveglianza malattie infettive* [Reporting System for Infectious Diseases]) and MU (*Microbiology Unit – IRCCS Azienda ospedaliero-universitaria di Bologna*). The SMI system collects data from cases notified by doctors in the region whenever a case is diagnosed. The MU database contains the data of each patient after carrying out the laboratory diagnosis.

This study aimed to report epidemiological trends in foodborne diseases in Bologna over six years, including three years marked by the COVID-19 pandemic. Specifically, the study aimed to detect potential discrepancies between cases notified by the doctors to the LHA and those diagnosed by the microbiological laboratory. Additionally, we wanted to understand whether the COVID-19 pandemic affected the reporting of foodborne diseases. Ultimately, this study seeks to highlight potential gaps in the current reporting system and propose strategies to enhance the accuracy and reliability of foodborne disease surveillance in the post-pandemic era.

Methods

Data for this retrospective study were collected through the SMI and MU. The SMI system is a central notification system that collects data from cases reported by medical doctors in the region of Emilia-Romagna upon diagnosis (12, 13). The MU (microbiology metropolitan laboratory serving as the primary local laboratory) database contains data for each patient after a diagnosis.

Our data covered the period from January 1, 2017 to December 31, 2022 (six years). The SMI labeled the specific types of foodborne diseases that we collected data on as *Salmonella* infections, *Shigella spp.*, *Norwalk* virus, *Campylobacter spp.*, *enteropathogenic Escherichia coli* (EPEC), *Yersinia enterocolitis*, or *Shigella sonnei*.

Percent changes in cases of foodborne disease in 2020–2022 relative to the previous three-year period (2017–2019) were calculated as $(x_t - x_{t-1}) \times 100 / x_{t-1}$. Assuming the simplest comparative situation in which the denominators are equal and indefinitely large, the statistical significance of the change was assessed using a conditional binomial probability test based on the fact that if $x = x_{t-1} + x_t$, where x_{t-1} and x_t are independent Poisson random variables, then $x_t | x \sim$ Binomial $(x; 0.5)$. This means that x_t was tested as a proportion of $x = x_{t-1} + x_t$ against a Binomial $(x; 0.5)$. Exact *P*-values were computed based on the binomial distribution (14). Cases notified to the SMI and diagnosed by the MU were summarized as annual averages and analyzed separately. Analyses were also stratified by gender and age group, that is, preschoolers (0–5 years), schoolers (6–18 years), workers (19–65 years) and retirees (>65 years).

In a secondary analysis, we used the same approach to estimate the percentage change in annual cases of foodborne disease. Lastly, the time trend in the annual percentage of notified cases over-diagnosed cases

was assessed using a linear regression model with variance-weighted least squares (15).

The pandemic years were defined in line with the WHO, considering the 2017–2019 period as non-pandemic and the 2020–2022 period as pandemic (16). All data were analyzed using Stata 17 (StataCorp. 2021. *Stata Statistical Software: Release 17.* College Station, TX: StataCorp LLC). The significance level was set at 0.05, and all tests were two-sided.

Emilia-Romagna's health administrative data are pseudonymized at the regional statistical office before analysis. Each individual is assigned a unique patient identifier, eliminating the possibility to trace the patient's identity or access other sensitive data. According to Article 9 of the General Data Protection Regulation (EU Regulation 2016/679), pseudonymized administrative data can be used without specific written informed consent when patient information is collected for healthcare management, quality evaluation, and improvement. Moreover, because the elaborations presented in this work are part of the surveillance activities of a public health institute, no institutional review board approval was required.

Results

We observed 436 notified cases (source: SMI) between 2017 and 2022 and 2,482 diagnosed cases (source: MU) over the same period.

Table 1 summarizes the comparative analysis between 2017–2019 and 2020–2022, which showed an increase in the total number of foodborne diseases reported in the LHA of Bologna despite the lack of differences in diagnosed cases. During the COVID-19 pandemic years, there was a significant 34.4% increase in overall notified cases (P-value≤0.01). When examining gender differences, only males exhibited a statistically significant change, with an increase of 52.6% (P-value≤0.001); the change in reported cases among females, on the other hand, was negligible (+14.6%, P-value>0.05). Analysis stratified by age group revealed statistically significant changes in reported cases in the working-age and preschool populations, with increases of 71.8% (P-value≤0.01) and 52.9% (P-value≤0.05), respectively. MU data did not confirm these changes.

Table 2 provides a comprehensive overview of the annual notified cases of foodborne disease in the LHA of Bologna from 2017 to 2022, stratified by age group. A substantial increase of 300.0% (P-value≤0.001) was observed in schoolers aged 6–18 years in 2021, compared to 2020. Conversely, a significant decrease in notified cases (−77.8%, P-value≤0.001) was observed in the same population in 2020 relative to 2019. The category of *workers* witnessed a statistically significant increase in 2021 compared to the previous year (+133.3%, P-value≤0.05).

Discrepancies between notified and diagnosed cases were observed in all years, as shown in Table 1 and Table 3. The only significant change in SMI-reported cases was in 2021, with an increase of 60.7% (P-value≤0.01), while there were statistically significant results in 2020 (−19.1%, P-value≤0.01)

Table 1 - Average Annual Cases of Foodborne Disease Notified to the SMI in the Local Healthcare Authority of Bologna and Diagnosed by the Microbiology Unit in 2017–2019 vs. 2020–2022, Overall and by Gender and Age Group.

	SMI Notified Cases				MU Diagnosed Cases			
	2017/19	2020/22	Δ%	*P*-value	2017/19	2020/22	Δ%	*P*-value
All	62.0	83.3	+34.4	0.002	427.7	399.7	−6.5	0.096
Gender								
Male	32.3	49.3	+52.6	0.001	236.3	225.3	−4.7	0.390
Female	29.7	34.0	+14.6	0.385	191.3	174.3	−8.9	0.131
Age group, y								
Preschoolers (0–5)	17.0	26.0	+52.9	0.022	113.0	103.7	−8.3	0.290
Schoolers (6–18)	15.0	15.7	+4.4	0.917	88.7	90.7	+2.3	0.829
Workers (19–65)	13.0	22.3	+71.8	0.008	132.7	117.0	−11.8	0.093
Retirees (>65)	17.0	19.3	+13.7	0.566	93.3	88.3	−5.4	0.549

Abbreviations: SMI, *Sorveglianza Malattie Infettive* (Reporting System for Infectious Diseases);
MU, *Microbiology Unit (IRCCS Azienda Ospedaliero-Universitaria di Bologna).*

Table 2 - Annual Cases of Foodborne Disease Notified to the SMI in the Local Healthcare Authority of Bologna from 2017 to 2022, by Age Group.

Year	Preschoolers (0–5 y)		Schoolers (6–18 y)		Workers (19–65 y)		Retirees (>65 y)	
	n	Δ%	*n*	Δ%	*n*	Δ%	*n*	Δ%
2017	14	—	6	—	8	—	19	—
2018	21	+50.0	12	+100.0	17	+112.5	14	−26.3
2019	16	−23.8	27	+125.0*	14	−17.6	18	+28.6
2020	24	+50.0	6	−77.8***	12	−14.3	19	+5.6
2021	21	−12.5	24	+300.0***	28	+133.3*	25	+31.6
2022	33	+57.1	17	−29.2	27	−3.6	14	−44.0

* Significant at the 5% level.
** Significant at the 1% level.
*** Significant at the 0.1% level.
Notes: Percentage changes are calculated relative to the previous year.
Abbreviations: SMI, *Sorveglianza Malattie Infettive* (Reporting System for Infectious Diseases).

and 2021 (+21.9%, *P*-value≤0.01) for MU-diagnosed cases.

Lastly, a positive linear trend with an annual change of +2.2% (P-value≤0.001) was observed in the percentage of SMI notified cases relative to the number of positive MU tests (Figure 1), the only notable exception being the year 2020.

Discussion

The data analyzed in this study reveal a steady uptrend in the incidence of reported foodborne illnesses over the years. An anomaly was observed in 2020 when there was a noticeable decline in such cases. This deviation has been corroborated by the findings of Ray et al., 2020 (8). Subsequent data highlight a marked resurgence in cases the following year, aligning with the observations documented in the EU One Health 2021 report (17). Despite this positive trend in notified cases, the significant difference in absolute terms between lab-diagnosed and doctors' reported cases during 2017–2022 underscores the limitations of current reporting mechanisms.

Recent reports from the European Center for Disease Prevention and Control (ECDC) enable us to compare the data from this study with the European data from 2022. In 2022, several countries reported a stable trend in Campylobacteriosis cases compared to 2021, albeit lower than pre-pandemic levels (18). The number of confirmed cases of Hepatitis A in 2022 was like those in 2020 and 2021, significantly lower than in pre-COVID-19 years (19). Additionally, the number of reported Listeriosis cases in 2022 reached the maximum since observation began in the EU/EEA (20). While an increase in Salmonellosis cases

Table 3 - Annual Cases of Foodborne Disease Notified to the SMI and Diagnosed by the Microbiology Unit in the Local Healthcare Authority of Bologna from 2017 to 2022.

Year	SMI Notified Cases			MU Diagnosed Cases		
	n	Δ%	*P*-value	*n*	Δ%	*P*-value
2017	47	—	—	391	—	—
2018	64	+36.2	0.128	441	+12.8	0.089
2019	75	+17.2	0.396	451	+2.3	0.763
2020	61	−18.7	0.265	365	−19.1	0.003
2021	98	+60.7	0.004	445	+21.9	0.005
2022	91	−7.1	0.663	389	−12.6	0.057

Notes: Percentage changes are calculated relative to the previous year.
Abbreviations: SMI, *Sorveglianza Malattie Infettive* (Reporting System for Infectious Diseases); MU, *Microbiology Unit (IRCCS Azienda Ospedaliero-Universitaria di Bologna)*.

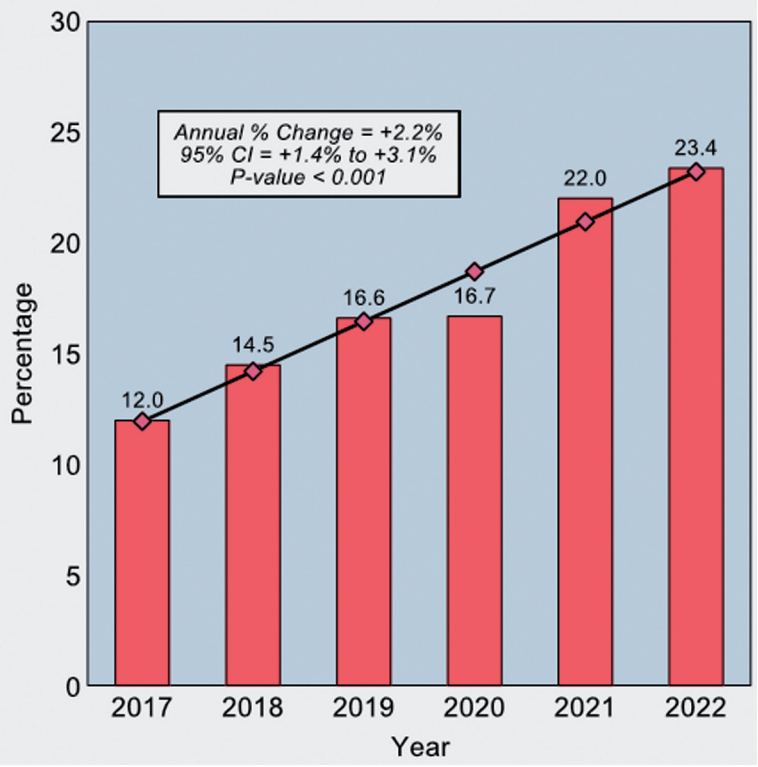

Figure 1 - Foodborne Diseases Notified to the SMI over the Number of Positive Laboratory Tests in the Local Healthcare Authority of Bologna between 2017 and 2022.
Notes: The time trend was assessed using a linear regression model with variance-weighted least squares.
Abbreviations: SMI, *Sorveglianza Malattie Infettive* (Reporting System for Infectious Diseases).

was recorded compared to the previous year of 5.4%, it marked a 16.8% decrease from pre-COVID levels in 2019 (21). Moreover, 2022 witnessed a 25% rise in Shiga toxin-producing Escherichia coli (STEC) infections in EU/EEA countries compared to the previous year (22). The cases of Shigellosis have been progressively increasing from 2020 to 2022, approaching the levels seen before the COVID-19 pandemic. However, there was a significant decrease in reported cases in 2020 and 2021 related to previous years (23). Furthermore, there was a 22.2% increase in reported cases of Yersiniosis in 2022, surpassing the numbers seen before the COVID-19 pandemic in 2018–2019 (24).

As previously reported, the three-year pandemic from 2020 to 2022 requires an in-depth analysis to explain the observed inconsistent trends. The scientific literature provides numerous examples of a decline in reporting infectious diseases during the COVID-19 pandemic (25-29). Several potential explanations could be considered, such as the impact of the pandemic on data collection and reporting systems and the use of non-pharmaceutical measures implemented from 2020 onwards. Furthermore, the closure of workplaces, schools, and restaurants caused by the stay-at-home policy may have contributed to a limited spread of these diseases (8, 30-32). Additionally, the observed 34.4% increase in reporting to the LHA during the pandemic, contrasted with a slight decline in laboratory diagnosis data, suggests that heightened focus on infectious disease reporting during COVID-19 may have influenced healthcare workers' reporting behavior, potentially leading to an increased propensity to report cases.

To significantly reduce bureaucracy and streamline the reporting process, it is imperative to establish a direct reporting mechanism where laboratories communicate infectious disease data directly to LHAs. By eliminating unnecessary intermediaries, this approach will ensure that critical information flows swiftly from the point of data generation to those responsible for public health decision-making. This direct line of communication would not only cut down on the time delays typically associated with multi-step reporting processes but also reduce the risk of data distortion or loss that may occur when information

passes through multiple channels.

With laboratories reporting directly to LHAs, the process would become more efficient and less prone to bureaucratic slowdowns. This efficiency allows public health officials to respond more rapidly to emerging threats, receiving real-time data without the administrative bottlenecks that often plague traditional reporting systems. Moreover, this streamlined approach would enable a more agile response to outbreaks, where timely data can be the difference between containment and widespread transmission.

Implementing direct laboratory-to-LHA reporting also fosters greater accountability. Laboratories would be responsible for the accuracy and promptness of the data they provide, knowing that any delays or inaccuracies have immediate implications for public health. This accountability would drive improvements in the quality of data reported, further enhancing the overall effectiveness of the public health surveillance system.

Foodborne diseases pose a significant public health concern, and physicians should be well-versed in diagnosing and managing them (33, 34). Vigilance against these illnesses is crucial, given their potential for severe complications, especially among susceptible populations (35), such as the elderly (36).

Further research is needed to understand the reasons behind the gap between notified cases and diagnoses and to determine whether this trend is present in other regions of Italy or the world (37).

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Competing interests: There are no conflicts of interest to declare
Ethics approval: This study complies with the Declaration of Helsinki. According to Article 9 of the General Data Protection Regulation (EU Regulation 2016/679), pseudonymized administrative data can be used without specific written informed consent when patient information is collected for healthcare management, quality evaluation, and improvement. Moreover, because the elaborations presented in this work are part of a public health institute's surveillance activities, no institutional review board approval was required.

Riassunto

Esplorare il divario tra casi notificati e diagnosticati di Malattie Trasmesse dagli Alimenti: evidenze da un'analisi dell'andamento temporale in Italia

Introduzione. Le malattie trasmesse da alimenti rappresentano un grave problema di salute pubblica a livello globale, causando una significativa morbilità e mortalità in tutto il mondo. La pandemia di COVID-19 ha avuto effetti su vari aspetti della vita, compresa la catena di approvvigionamento alimentare, con un potenziale impatto sull'incidenza delle malattie di origine alimentare. Questo studio si propone di analizzare le differenze tra casi notificati e casi diagnosticati e di indagare il potenziale impatto della pandemia di COVID-19 sulle malattie trasmesse da alimenti nell'area metropolitana di Bologna, Italia.

Disegno dello Studio. È stata condotta un'analisi retrospettiva dell'andamento temporale usando due fonti informative.

Metodi. L'Azienda USL di Bologna ha raccolto i dati attraverso il sistema di segnalazione delle malattie infettive dell'Emilia-Romagna nell'arco di sei anni (2017-2022), compresi tre anni di pandemia di COVID-19. Questi dati sono stati confrontati con le informazioni raccolte nello stesso periodo presso il laboratorio di microbiologia che serve l'intera area metropolitana di Bologna. I metodi statistici includono variazioni percentuali, test binomiali, medie annuali, stratificazione per genere ed età, e modelli di regressione.

Risultati. È stato riscontrato un aumento (+34,4%, P≤0,01) dei casi notificati durante la pandemia rispetto al periodo pre-pandemico. Tuttavia, non sono state osservate differenze nei casi diagnosticati confrontando i due periodi. L'anno 2021 ha visto un aumento significativo dei casi segnalati di malattie trasmesse da alimenti tra la popolazione in età scolare (+300,0%) e in età lavorativa (+133,3%) rispetto al 2020. D'altra parte, i casi diagnosticati sono diminuiti significativamente nel 2020 (-19,1%, P<0,01) e aumentati nel 2021 (+21,9%, P<0,01). È stata riscontrata una netta differenza, in termini assoluti, tra i casi notificati e quelli diagnosticati in tutti gli anni di studio (2017-2022).

Conclusioni. Questo studio evidenzia la discrepanza tra i casi notificati e quelli diagnosticati di malattie trasmesse dagli alimenti e di come la pandemia di COVID-19 ha incrementato le notifiche senza influenzare la loro trasmissione. Questi risultati contribuiscono alla discussione in corso sul miglioramento dei sistemi di segnalazione delle malattie trasmesse dagli alimenti.

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