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Original Research

Telephone calls to emergency medical service as a tool to predict influenza-like illness: A 10-year study

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A R T I C L E I N F O

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A B S T R A C T

Objectives: Influenza-like illness (ILI) refers to the set of symptoms associated with seasonal influenza infection. In Italy, the syndromic surveillance system RespiVirNet uses both epidemiological and virological data to monitor ILI incidence with a weekly cadence. To estimate ILI incidence in real time, several countries adopted surveillance systems which include data from the emergency-urgency (E-U) system. The aim of this study was to evaluate the relationship between the number of calls for respiratory symptoms to the E-U system and the regional incidence of ILI cases identified by the Italian syndromic surveillance system.
Study design: Retrospective observational cohort study
Methods: We analyzed data in the Lombardy region for the flu season from 2014 to 2024, excluding the COVID-19 pandemic period (from 2020 to 2022). We performed a linear regression analysis considering ILI incidence as the dependent variable and the percentage of respiratory calls to the E-U system as the independent variable.
Results: Statistical analysis showed a positive correlation ($r = 0.70$), with a statistically significant coefficient of 1.34 (p-value <0.001) and R^2 of 0.50.
Conclusions: The observed correlation highlights the potential use of prehospital E-U system data in the surveillance systems of infectious diseases by using real-time data, encouraging future research to explore the limits and possibilities of an integrated surveillance system.

1. Introduction

Influenza-like illness (ILI) is a clinical term used to describe the set of symptoms typically associated with seasonal influenza infection. It is defined by the European Center for Disease Control (ECDC) as a syndrome with a sudden onset of at least one systemic symptom and at least one respiratory symptom.[1] ILI is an umbrella definition comprising several different respiratory pathogens with the same clinical presentation, including influenza virus and coronavirus (comprising SARS-CoV-2 virus).[2–5] It is estimated that seasonal influenza causes annually up to 650,000 deaths worldwide,[6,7] making it a significant global public health concern.

In order to adopt the appropriate public health measures, the early detection of infectious diseases is necessary to act quickly and to guide decision making processes.[8,9] Traditional surveillance systems are based on microbiological testing performed in laboratories, which provide precise results and are vital to identify circulating pathogens and possibly new mutations of concern,[1] but the collection of biological samples and their analysis takes time; therefore, they are often integrated with broader epidemiological surveillance systems, based on the presence of ILI symptoms in the population reported by a network of sentinel health workers.[10,11] In 2014 the World Health Organization (WHO) released the WHO Global Epidemiological Surveillance Standards for Influenza, in which a sentinel surveillance system based on routine collection of epidemiological and virological data is recommended.[12]

Due to the known limits of sentinel surveillance system, including their time delay between the onset of symptoms and the actual registration of the case in the system, the WHO Public Health Research Agenda for Influenza, published in 2017, encourages research aimed at identifying more sensitive, specific, cost-effective and operationally convenient surveillance and detection strategies.[13] Following this

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stream of research, in the past years there has been a surge of interest on the possibility of using the emergency system as a source of surveillance data, with telephonic triage as a potential adjunctive tool for the ILI surveillance system.[14,15] Moreover, in the recent years several studies evaluated new ILI indicators, such as the search trend for keywords on internet,[16,17] the number of calls or accesses to emergency departments for ILI symptoms,[18–22] participatory systems with self-reported symptoms among the population.[23,24] or the sale-trend for over the counter medications.[25]

To perform a syndromic surveillance of ILI following WHO guidelines, the Italian Ministry of Health created RespiVirNet, a combined surveillance system integrating both virological and epidemiological data. The epidemiological surveillance system is based on a network of selected primary healthcare physicians and pediatricians reporting on a weekly basis new case of ILI among their patients, covering around 4 % of the total Italian population. Data from the virological and epidemiological networks are processed at a national level and released in a weekly bulletin, reporting the estimated incidence of ILI by region and age range.[26]

As with most surveillance systems, despite the use of epidemiological data from the territory there is a time gap of almost two weeks between the clinical onset of symptoms and when the data becomes available in the final national report of cases.[22] Among all the new afore-mentioned ILI indicators, the number of calls to the emergency department for respiratory symptoms could be the most immediate and easily traceable. In fact, in the Italian territory it is possible to call the national hotline 112 to request urgent medical assistance; operators responding to the call will send a medical vehicle to the reported location, which will then transport the patient to a nearby hospital. Several factors could influence the decision to use this emergency system instead of primary healthcare.[27–29] The whole process is recorded in real time on an informatic registry, providing a valuable source of information and a potential tool to monitor ILI's incidence trends in a timely manner.

The aim of this paper is to analyze the relationship between the number of calls for respiratory symptoms to the emergency department of the Italian Lombardy region and the regional incidence of ILI cases identified by the RespiVirNet system.

2. Methods

This is a retrospective observational cohort study. The study was conducted according to the principles of the Declaration of Helsinki and was approved by the AREU general health authority.

2.1. Emergency medical system in lombardy

Lombardy is the largest Italian region, with 9.96 million inhabitants and an area of 23,863 km^2. In Lombardy, prehospital emergency management is mandated to the Regional Agency for Emergencies and Urgencies (AREU), which coordinates all the emergency requests using wheeled vehicles or helicopters. On average, each year AREU operation center processes about 1.3 million calls for clinical emergencies and deploys a vehicle in 80 % of cases.[30]

2.2. Data register

Data regarding emergency calls was retrieved from the regional registry SAS-AREU. For this purpose, we used the proportion of calls where the main complaint was listed as "respiratory infection" or "respiratory problem" out of the total number of calls to the emergency system in the 24 h.

ILI incidence was collected from the regional ILI weekly report produced by the RespiVirNet surveillance system, available to the public on the Health Regional Authority website.[31] The RespiVirNet system is based on a sentinel network of general practitioners who report aggregated data on new cases of ILI among their patients at a weekly cadence. All data are collected and processed by the national and regional health authorities and made available to the public through the publication of a weekly bulletin.

We collected and analyzed data from January 1, 2014 to February 29, 2024 for the flu season, which in Italy is from November to February. Data from 2020 to 2022 was excluded, as it coincided with the peak of the COVID-19 pandemic in Lombardy.

2.3. Statistical analysis

Continuous variables are presented as mean and standard deviation (SD). Continuous variables were tested for normality using the Kolmogorov-Smirnov test. A scatterplot exploratory analysis was performed to visualize the relationship between the two variables.[32,33] Statistical analyses were performed using Pearson's correlation coefficient (r) to measure the strength and direction of the linear association between the two variables; the correlation was considered strong if the coefficient was >0.7, moderate if between 0.3 and 0.7 and weak if <0.3.[32–34] A univariable linear regression model was performed, to estimate how changes in one independent variable predict changes in the other dependent variable. The linear regression model represents the dependent variable using a straight line, expressed by equation $Y = a + bX$, where a is the y-intercept (the value of the dependent variable when $X = 0$), and b is the slope, indicating the rate of change in the dependent variable for each unit increase in the independent variable.[32–35] We considered the percentage of respiratory calls over the total calls to the E-U system in 24 h as the independent variable and weekly ILI incidence reported by RespiVirNet surveillance system as the dependent variable. Results were expressed as a coefficient with 95 % confidence intervals (95 % CI). Differences were considered significant when $p < 0.05$. The representative linear model was also determined by calculating the R^2 of the model. SAS enterprise version 8.3 was used for this purpose.

3. Results

We analyzed 130 weeks, for a total of 901 days. During the observed period the regional emergency medical system managed 2,013,743 calls. The mean number of calls per day was 2235.0, with a standard deviation (SD) of 234.0. The percentage of calls for respiratory symptoms ranged from 7.60 % to 24.27 %. The overall total number of calls listing "respiratory problem" or "infectious problem" as the main symptom was 251,905 (12.5 % of the total number of calls), with a daily mean of 280.0 and a standard deviation (SD) of 80.7. In the evaluated timeframe, ILI incidence ranged from 0.0 to 20.5. The mean ILI incidence was 5.9 for every 1000 inhabitants with a standard deviation (SD) of 4.5.

Figs. 1 and 2 show the temporal distribution of calls for respiratory symptoms and of ILI incidence in the population. In Fig. 3 ILI incidence and the rate of calls for respiratory symptoms were plotted together.

The correlation analysis between the rate of calls for respiratory events and the incidence of ILI in the general population resulted in a strong positive correlation between the two variables ($r = 0.70$), suggesting a concrete connection between the occurrence of respiratory syndromes and the use of E-U systems.

We calculated the corresponding linear regression model (Fig. 4). As indicated by the p-value <0.001, the model resulted in a statistically significant coefficient of 1.34 with an adjusted $R^2 = 0.50$.

4. Discussion

4.1. Data interpretation and implications

This study provides a comprehensive vision of the epidemiological trends in ILI incidence. As illustrated in Figs. 1 and 2, during winter months there is an increase in both the percentage of calls for respiratory problems to the E-U system and in the incidence of ILI, with yearly

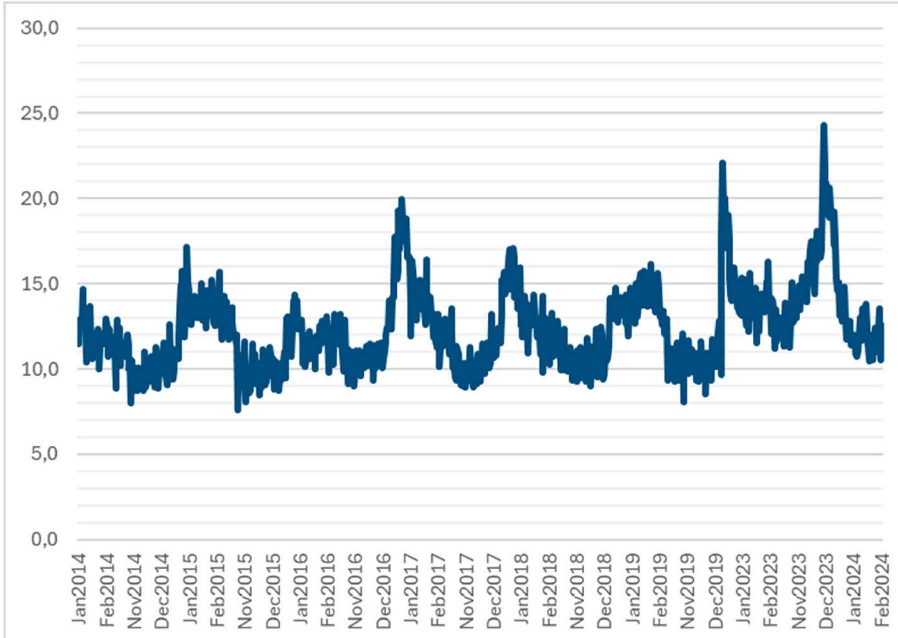


Fig. 1. Temporal trend of the percentage of calls for respiratory events out of the total number of calls handled by the E-U system, calculated over a 24-h period.

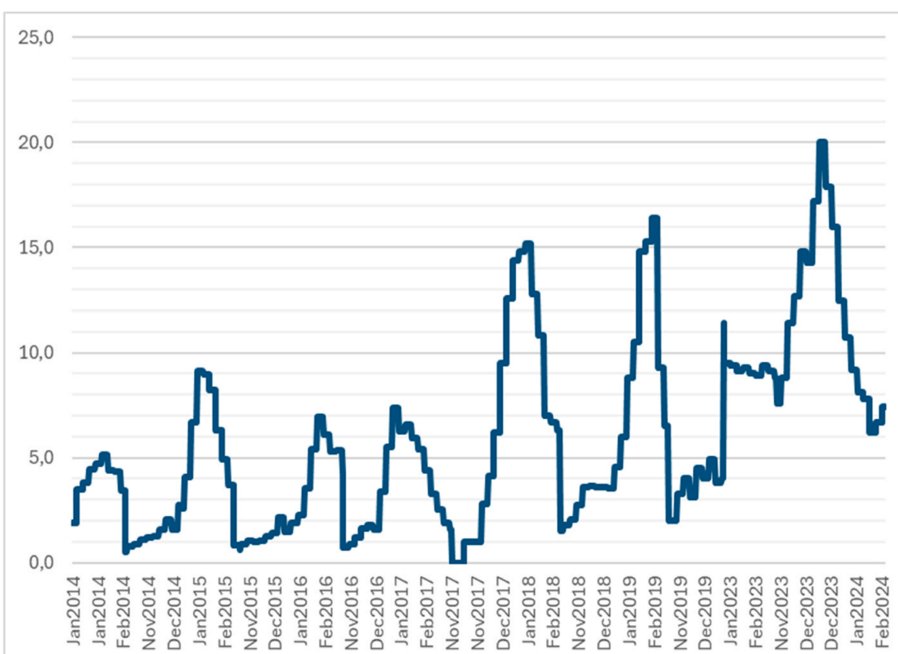


Fig. 2. Weekly value of ILI incidence per 1000 inhabitants.

fluctuations that could be explained by differences in the circulating pathogens. Given the high incidence of ILI during the winter season (with a peak of 20.5 cases every 1000 inhabitants in 2023), it would be of interest to policymakers to be able to intercept in real-time even the slightest variation in their incidence, as it would be reflected by a consistent increase in the total number of cases. Indeed, the presented result indicates that by taking into account data from the calls to E-U system it is possible to describe a large part of the variation in incidence of ILI. The strength of this indicator lies in its timeliness, as one of the limits of the current ILI surveillance system is the delay of two weeks between the occurrence of cases and the release of the surveillance bulletin. Our findings suggest that the development of a model integrating data from E-U respiratory events into the current surveillance system could improve the overall readiness of the system. As highlighted in Fig. 3, peaks in ILI incidence are reflected by a concomitant increase in the request of assistance for respiratory symptoms. It is worth noting that despite the simultaneous increase, the surveillance system RespiVirNet requires around two weeks to process cases and to provide an estimate of ILI incidence, while the inputs from the E-U system are available immediately. The analyzed data shows an overall increase in the incidence of ILI over the years. Notably, the observed increase in incidence is accompanied by an increased overlap with the trends of calls to the E-U system. This increased concordance in data from RespiVirNet and prehospital emergency setting could point to an

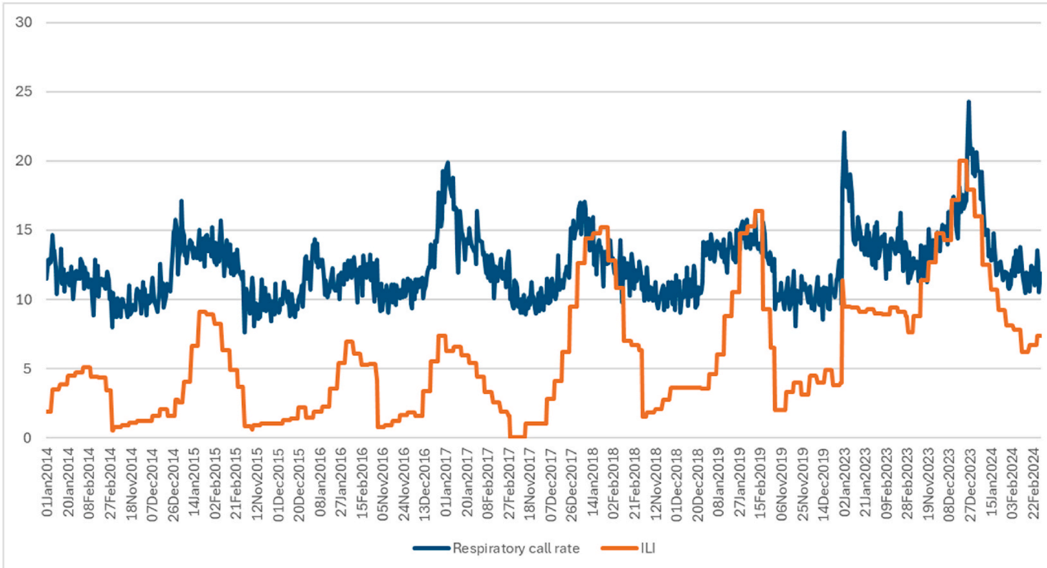
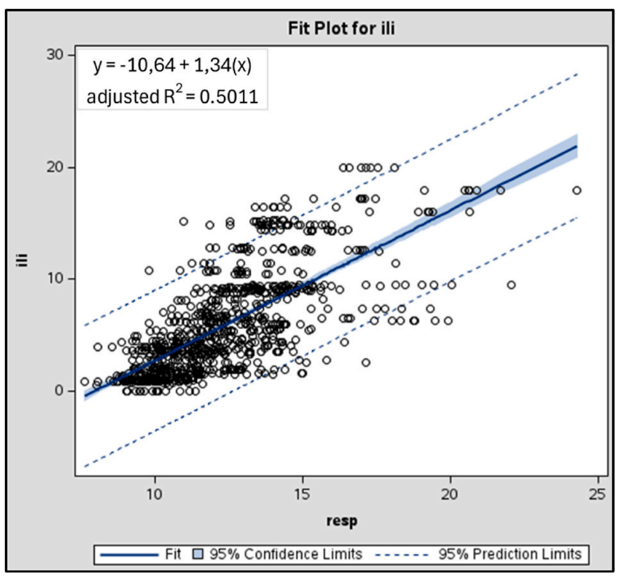


Fig. 3. Temporal comparison between the rate of calls to E-U system for respiratory symptoms and ILI's incidence.



Dependent variable: ILI incidence

Independent variable	Coefficient	95% CI	*p-value*
% respiratory calls	1.34	1.25 - 1.43	<0.001

Fig. 4. Linear regression model between the percentage of respiratory events out of the total events managed by the EU system (resp) and ILI incidence (ili).

overall improvement in the detection power of the syndromic surveillance system.

The presented results provide a useful insight into the relationship between the use of the prehospital E-U system and the incidence of ILI in the population. In particular, the developed linear regression model proved this relationship to be statistically significant, with a strong positive correlation. These findings imply that changes in the use of the E-U system reflect variations in the actual incidence of respiratory diseases, highlighting the potential role of emergency dispatch services in syndromic surveillance for respiratory diseases. Indeed, this link was exploited during the COVID-19 pandemic, when the sudden and unexpected rise of cases required the use of immediate and intuitive indicators to estimate the incidence in the population, therefore the percentage of calls for respiratory problems to the emergency system was used as a tool to monitor both the trend in incidence and the strain on the healthcare system.[36,37] Given the obtained results, this monitoring activity should continue in the post pandemic phase to assist the healthcare system during its recovery.[38,39]

Several international contexts have explored the role of data from ambulance dispatch services as a possible tool in syndromic surveillance systems,[23,40–42] proving to be a valuable source of epidemiological information in real-time. Our results are coherent with other studies analysing the correlation between emergency medical system call centres and influenza surveillance systems.[23,43] therefore, this work fits in the current literature landscape, further expanding the evidence on novel indicators used to monitor changes in the baseline incidence of infectious diseases.

Furthermore, it is worth considering that one of the main focuses of ILI surveillance is to monitor their impact on health systems, including the emergency departments. The emergency departments are among the most affected systems during seasonal peaks of respiratory diseases, therefore, to improve their resilience, it is of particular interest to closely monitor any increase in their use due to respiratory symptoms in order to prevent further stress on the system and to have an outlook on the actual severity of the spectrum of presentation of seasonal respiratory illnesses.[44,45]

The ability to intercept in a timely manner a surge in ILI and, more in general, in infectious diseases cases could possibly increase the resilience and ability of health systems to adapt and react, helping policy makers in their decisions by directing the allocation of resources, providing useful data to the monitoring system and by integrating data from the different healthcare settings.

4.2. Strengths and limitations

Our model based on the E-U system can describe a portion of the natural variability of the phenomenon, with a global outlook on the spectrum of severity of the disease. It is important to consider that the total number of cases intercepted by the surveillance system is only the tip of the iceberg, since a large portion of ILI tends to present with mild symptoms and are therefore not reported by the patients. Therefore, the use of E-U system data gives an important perspective in terms of severity and changes to the baseline of emergency use of healthcare, reflecting the underlying changes in incidence for the portion of cases presenting with minor symptoms which remains beyond the reach of this system. Most importantly, the presented data suggest that the E-U system can detect these variations almost in real time, providing data two weeks in advance with respect to traditional surveillance system.

A possible limitation of this study is the lack of analysis of external factors such as temperature, humidity, seasonality, variations in the composition of circulating pathogens and mass-gathering events. These potentially confounding factors could account for a certain variability in the presence of respiratory symptoms in the general population, leading to difficulties in estimating the real burden of ILI without considering their yearly variations. On the other hand, Lombardy is the largest and most populated Italian region. The prehospital E-U system coordinated by AREU handles each year around 1.3 million calls, providing a solid amount of data that reflects the emergency healthcare needs of the whole region. The analyzed data covered a time span of 10 years, and the peak covid-19 pandemic was excluded to avoid potential biases. The length of this observation period minimizes yearly oscillations and captures a clear picture of the epidemiological situation during the winter months, providing a unique perspective into the needs of the citizens which contact the prehospital emergency system. The E-U system is an important actor in the complex interplay of structures forming healthcare systems, therefore the data about its use should be interpreted keeping in mind its peculiarity and role in the overall system, without taking them out of their context.

4.3. Future perspectives

We suggest that future research should focus on exploring and integrating data from urgent and non-urgent care with the aim of expanding the current syndromic surveillance systems. Furthermore, data from calls to the E-U system or emergency department accesses could be a useful tool not only for respiratory syndromes, but in general as a tool to monitor changes in infectious diseases incidence. It would be desirable to direct future research to the aim of creating an integrated healthcare monitoring system capable of incorporating health data from the territory, hospital and emergency setting to provide a comprehensive overview of changes in diseases incidence.

4.4. Conclusions

In conclusion, the results showed that emergency department calls might be a valuable public health tool to monitor the incidence of ILI, potentially increasing the timeliness of syndromic surveillance systems. The observed correlation provides ground for further research in this field, suggesting that surveillance systems could benefit from the expansion of their monitoring tools to include new assets. Future research should aim to investigate the integration between traditional and newer surveillance tools to achieve the most informative and precise combination of indicators, addressing potential limits and confounding factors.

Author statements

Ethical approval

The authors declare that the work reported did not require ethics approval because it did not involve animal or human participation.

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Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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