

Business Intelligence applied to Emergency Medical Services in the Lombardy region during SARS-CoV-2 epidemic

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Summary. *Background and aim of the work:* On the 21st of February, the first patient was tested positive for SARS-CoV-2 at Codogno hospital in the Lombardy region. From that date, the Regional Emergency Medical Services (EMS) Trust (AREU) of the Lombardy region decided to apply Business Intelligence (BI) to the management of EMS during the epidemic. The aim of the study is to assess in this context the impact of BI on EMS management outcomes. *Methods:* Since the beginning of the COVID-19 outbreak, AREU is using BI daily to track the number of first aid requests received from 112. BI analyses the number of requests that have been classified as respiratory and/or infectious episodes during the telephone dispatch interview. Moreover, BI allows identifying the numerical trend of episodes in each municipality (increasing, stable, decreasing). *Results:* AREU decides to reallocate in the territory the resources based on real-time data recorded and elaborated by BI. Indeed, based on that data, the numbers of vehicles and personnel have been implemented in the municipalities that registered more episodes and where the clusters are supposed to be. BI has been of paramount importance in taking timely decisions on the management of EMS during COVID-19 outbreak. *Conclusions:* Even if there is little evidence-based literature focused on BI impact on health care, this study suggests that BI can be usefully applied to promptly identify clusters and patterns of the SARS-CoV-2 epidemic and, consequently, make informed decisions that can improve EMS management response to the outbreak. (www.actabiomedica.it)

Keywords: Business Intelligence, Emergency Medical Services, SARS-CoV-2, COVID-19, coronavirus, Italy

Introduction

In Italy, emergency medical services (EMS) are under Public Health Authorities control in each Region. Lombardy Region is the most populated Italian region with a resident population of approximately 11 million people and a territory of 23,861 square kilometres with 1,544 municipalities distributed in 12 provinces. Since 2008, Lombardy is covered by the Regional EMS Trust (AREU, Azienda Regionale Emergenza Urgenza) that takes care of the pre-hospital Emer-

gency and Urgency medical services (1). AREU has its Headquarters in Milan and consist of 12 provincial Joints Territorial Departments (AAT, *Articolazioni Aziendali Territoriali*) and 4 regional Emergency Medical Service Dispatch Centres (SOREU, *Sale Operative Regionali Emergenza Urgenza*) (Fig.1). AREU's main role is to coordinate and ensure territorial first aid by means of 265 ambulances with a crew of 2-3 rescuers qualified to perform Basic Life Support manoeuvres, 50 Intermediate Rescue Vehicles (ambulance or car) with a nurse, 59 Advanced Rescue Vehicles with

a physician certified to perform Advanced Life Support (ALS) and 5 helicopters with ALS crewmembers. Each SOREU (based respectively in Bergamo, Como, Milano and Pavia), receives first aid requests for its designated territory answering the emergency number 112 (Public Safety Answering Point 1).

These requests are processed by the SOREU technical staff, which strictly follow a structured decision tree during the telephone dispatch interview. The interview leads the staff to classify the main health reason for the first aid request, e.g. respiratory, infectious, cardiovascular or trauma. Consequently, the in charge SOREU decides which vehicle and team to dispatch for the rescue.

Since its establishment in 2008, AREU has applied Business Intelligence (BI) to monitor its activity and improve its efficiency. Chen et al. (2) define Business Intelligence and Analytics as the “techniques, technologies, systems, practices, methodologies, and applications that analyse critical business data to help an enterprise better understand its business and market and make timely business decisions”. Therefore, the BI expected benefits in health care include: easier access to data, time savings, improved decision making, improved outcomes, and improved financial performance. Lowen L et al. (3) conducted a systematic review examining the impact of BI on the health sector. The study demonstrated there is little evidence-based literature focused on BI impact on organizational decision-making and performance within health care.

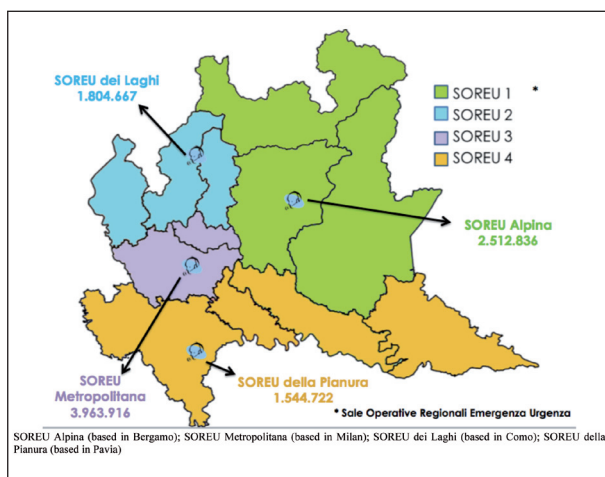


Figure 1. Area and inhabitants covered by the 4 regional EMS dispatch centres (SOREU)

However, they found that there is some evidence that BI does improve decision-making. The aim of this study, hence, is to assess if BI, which allows access to real-time information, can enable front line managers to promptly make informed decisions to drive system improvements also in critical times such as an epidemic.

Methods

From February 2020, when the first epidemic cluster of Novel Coronavirus (COVID-19) appeared in Lombardy (4-7), AREU decided to apply BI to the management of the EMS using real-time data. Indeed, BI records the number of requests received from each SOREU which have been classified as respiratory and/or infectious episodes during the telephonic interview. The BI keeps track of all the requests that reached each SOREU from their designated territory 24 hours a day every day of the week. These data show the number of first aid calls from specific areas of the region for respiratory or infectious health problems. AREU decides to use these figures to estimate where the contagion was occurring and consequently used them to better allocate the resources (vehicles and human resources) in the territory. Furthermore, BI allows comparing the number of episodes that are being registered with the data of previous days, which is crucial to verify if real-time figures match the forecast model in each area.

Moreover, AREU have been monitoring the pattern of the epidemic over time using the following BI model. The BI model analyses the trend of respiratory and/or infectious episodes registered in each pre-set group of municipalities (8). As SARS-CoV-2 is still spreading in the region, the BI will be updated and improved daily to ameliorate the EMS.

BI model:

E = number of the respiratory and/or infectious episodes reported the day before

m_{preC} = mean of the respiratory and/or infectious episodes from 20/01/2020 to 16/02/2020

m_{5gg} = mean of the respiratory and/or infectious episodes during the previous 5 days

σ = standard deviation

Rules:

grey: “no spread of SARS-CoV-2” if

$$(E-m_{preC}) \leq (2\sigma_{m_{preC}})$$

red: “increasing trend spread of SARS-CoV-2” if

$$(E-m_{preC}) > (2\sigma_{m_{preC}}) \text{ and } (E-m_{5gg}) > (\sigma_{m_{5gg}})$$

yellow: “stable trend spread of SARS-CoV-2” if

$$(E-m_{preC}) > (2\sigma_{m_{preC}}) \text{ and}$$

$$(-\sigma_{m_{5gg}}) \leq (E-m_{5gg}) \leq (\sigma_{m_{5gg}})$$

green: “decreasing trend spread of SARS-CoV-2” if

$$(E-m_{preC}) > (2\sigma_{m_{preC}}) \text{ and } (E-m_{5gg}) < (-\sigma_{m_{5gg}})$$

Results

From the 21st of February (Fig.2), when a 38-year-old man was tested positive for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) at Codogno hospital, BI has been recording the number of first aid request for respiratory and/or infectious episodes registered daily in each regional Emergency Medical Service Dispatch Centre SOREU.

Based on these data, since the beginning of the outbreak (Fig.2), AREU decided to increase the number of vehicles in service, adding 80 more vehicles for the outbreak response in the Lombardy region.

Moreover, AREU applied BI to create a map with the cumulative number of respiratory and/or infectious episodes in each pre-set group of municipalities (Fig.3). This map has been updated daily since 21st of February. Moreover, the map (Fig.3) has been compared with the map that National Civil Protection Department (*Protezione Civile*) publishes daily (Fig.4), which reports the cumulative prevalence of COV-

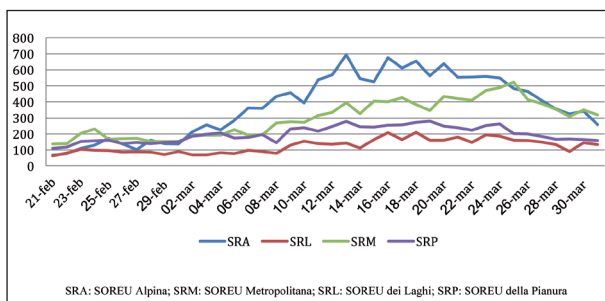


Figure 2. Number of first aid requests for respiratory and/or infectious episodes registered daily in each regional Emergency Medical Service Dispatch Centre (SOREU)

ID-19 in each Lombardy municipality. The comparison shows that the map with the cumulative number of daily respiratory and/or infectious episodes tracked by AREU corresponds to the cumulative prevalence data on the territory reported by *Protezione Civile*. These finding suggest that the number of first aid requests for respiratory and/or infectious episodes during the SARS-CoV-2 epidemic are strictly connected with the number of positive cases of COVID-19 and can indicate well where the clusters are.

Furthermore, AREU has been monitoring daily the pattern of the epidemic using the BI model explained in the methods section that reveals the dynamics of the spread of COVID-19. Figure 5 depicts

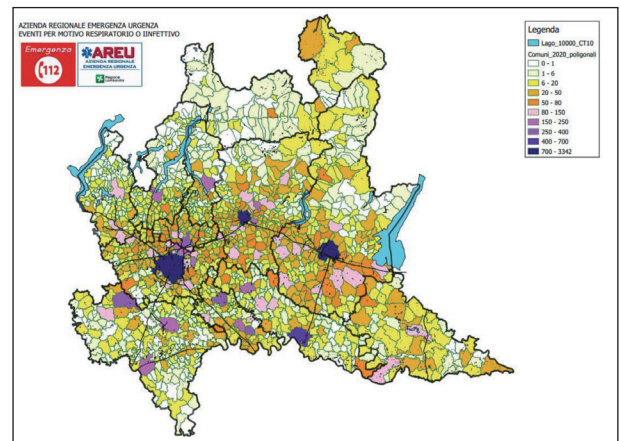


Figure 3. Cumulative number of respiratory and/or infectious episodes in each pre-set group of municipalities (updated on the 26th March)

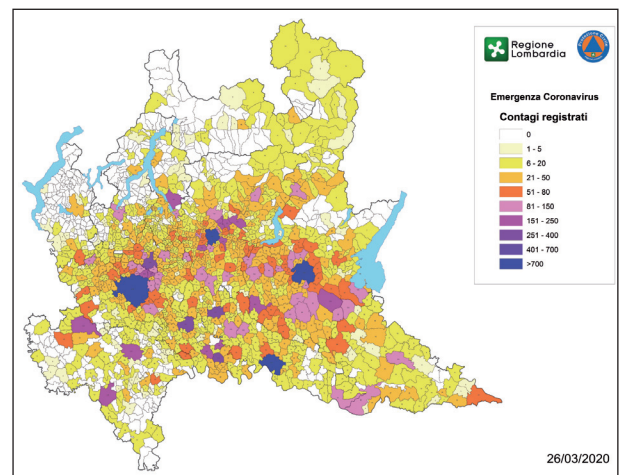


Figure 4. Prevalence map of patients with SARS-CoV-2 published daily by National Civil Protection Department: 26 March

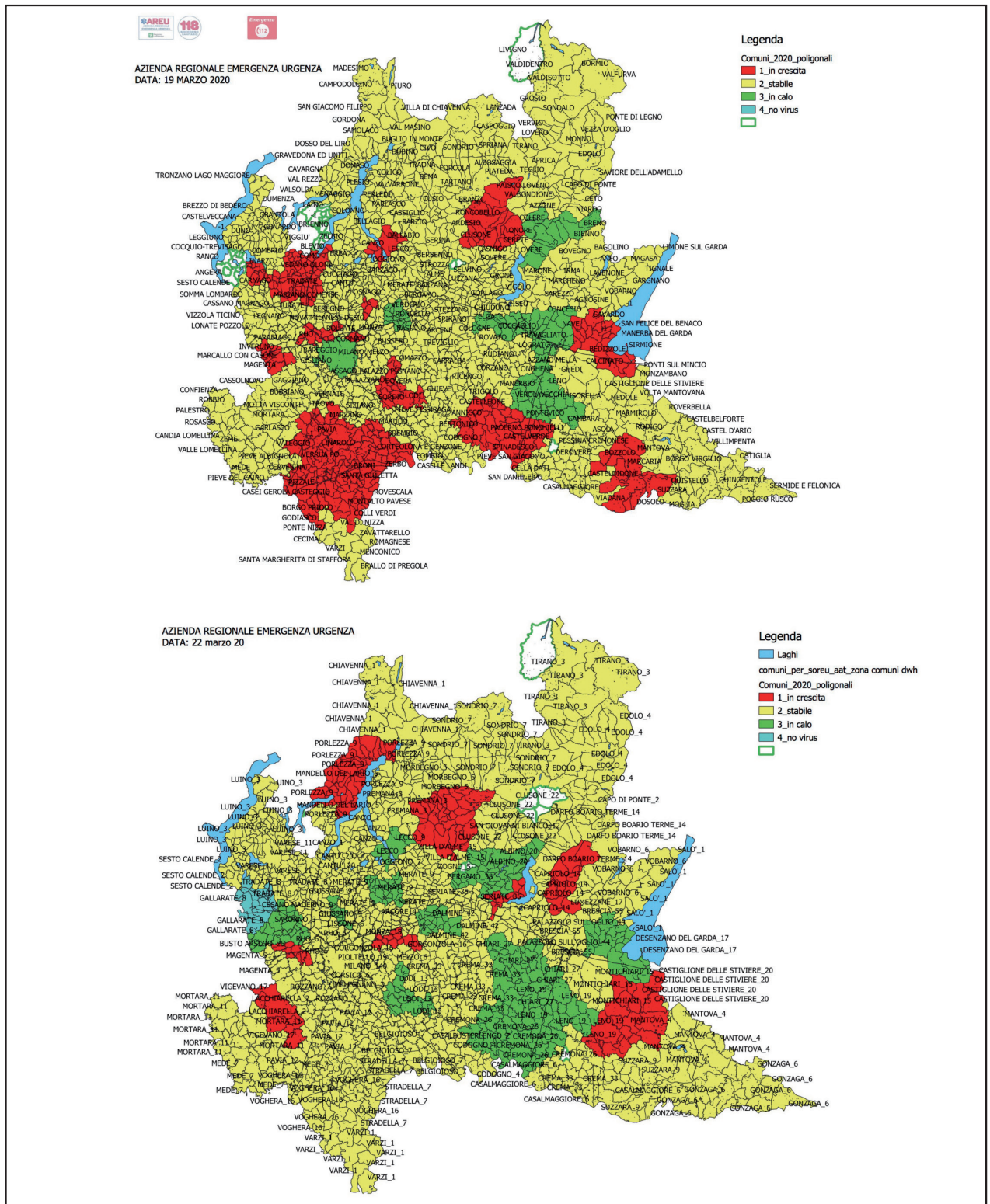


Figure 5. Daily trend of the number of respiratory and/or infectious episodes in each pre-set group of municipalities: 19 March and 22 March

the results of the BI model explained in the methods: in red the pre-set group of municipalities with an increasing trend, in yellow the ones with a stable trend and in green those with a decreasing trend. These figures (Fig.5) helped AREU to reallocate daily vehicles and personnel in the territory to improve the response in the areas where it is more needed.

Later, AREU analysed the number of respiratory and/or infectious episodes in 2 municipalities (Figure 6) in areas with clusters of COVID-19: Codogno (Lodi) with 15.962 inhabitants, Albino (Bergamo) with 17.772 inhabitants. The results showed that in both municipalities the number of respiratory and/or infectious episodes increased and reached its peak 17 days.

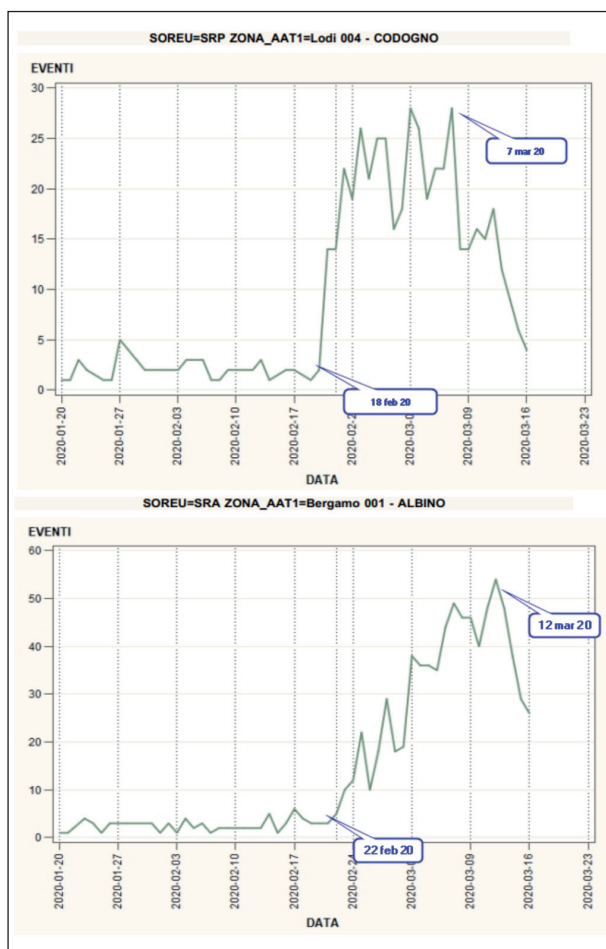


Figure 6. Number of first aid requests for respiratory and/or infectious episodes in Codogno and Albino

Discussion

The study confirms that digital solutions have been relevant for the COVID-19 outbreak management response and they will be even more in the future (9-11). Business intelligence refers to use of various technologies and tools enabling to access and analyse to improve and optimize decisions and performance. Indeed, the main purpose of BI is to provide stakeholders with useful information and analysis to aid decision-making (12). The application of BI to the management of EMS in the Lombardy region during SARS-CoV-2 epidemic from its very beginning has been decisive to reorganize the resources and act timely. Data recorded and analysed through the BI have been of paramount importance, because they revealed the number of first aid calls coming from specific areas of the region, clearly showing where the contagion was occurring in real-time. Indeed, BI allowed to gather information about the dynamics of the outbreak in a shorter time compared to the analysis of the data on the number of hospitalised patient or positive swab, which need hours or even days to be collected. The results of the application of BI to EMS had been extremely useful for AREU because it gives an hourly insight on the EMS activity in the Lombardy region, which has led to taking timely crucial decisions on the management of EMS.

Conclusion

As the number of people infected with SARS-CoV-2 is increasing very quickly around the entire globe, new solutions to emerging health care management problems will need to be solved to deal with the epidemic while avoiding the collapse of health systems. Indeed, BI can provide real-time data on how the epidemic is spreading and where are the clusters. These data are fundamental for the response of health care delivery, especially for SARS-CoV-2, a virus that has spread extremely quickly all over Lombardy, causing a sharp rise in patient's hospitalisations and deaths.

In conclusion, BI applied to EMS has been very helpful to improve epidemic management and accelerate the decision-making process for the outbreak

response. We believe it should be a priority to keep researching on the application of digital solutions to the challenges that we are facing during the first pandemic of in the Digital Era.

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