



Research article

Drawing a parallel between the trend of confirmed COVID-19 deaths in the winters of 2022/2023 and 2023/2024 in Italy, with a prediction

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Abstract: We studied the weekly number and the growth/decline rates of COVID-19 deaths of the period from October 31, 2022, to February 9, 2023, in Italy. We found that the COVID-19 winter wave reached its peak during the three holiday weeks from December 16, 2022, to January 5, 2023, and it was definitely trending downward, returning to the same number of deaths as the end of October 2022, in the first week February 2023. During this period of 15 weeks, that wave caused a number of deaths as large as 8,526. Its average growth rate was +7.89% deaths per week (10 weeks), while the average weekly decline rate was -15.85% (5 weeks). At the time of writing of this paper, Italy has been experiencing a new COVID-19 wave, with the latest 7 weekly bulletins (October 26, 2023 – December 13, 2023) showing that deaths have climbed from 148 to 322. The weekly growth rate had risen by +14.08% deaths, on average. Hypothesizing that this 2023/2024 wave will have a total duration similar to that of 2022/2023, with comparable extensions of both the growth period and the decline period and similar growth/decline rates, we predict that the number of COVID-19 deaths of the period from the end of October 2023 to the beginning of February 2024 should be less than 4100. A preliminary assessment of this forecast, based on 11 of the 15 weeks of the period, has already confirmed the accuracy of this approach.

Keywords: COVID-19; confirmed deaths; winter holiday season; Italy; prediction; public health

1. Introduction

During the 2022/2023 autumn-winter season in Italy, we observed a typical recurring pattern in the curve of the daily confirmed COVID-19 deaths. In fact, the number of daily deaths began to

increase after schools' opening (end of September 2022) [1]. Then, this increasing trend stabilized around a quite high value of 200-300 weekly deaths by the beginning of October 2022. Afterwards, winter came in Italy with a combination of meteorological, social, and environmental factors, including (i) lower temperatures; (ii) several holiday periods, such as All Saints' Day and All Souls' Day (November 1–2), the Feast of the Immaculate Conception (December 8), and Christmas and New Year's festivities (December 24–January 6); and (iii) people gathering in closed spaces.

It is well known that within a gathering in which many people take part, the presence of infected persons is highly likely. This can spark infections in the gathering, as the spread of COVID-19 occurs via airborne particles and droplets. In addition, in a gathering, infected individuals have more opportunities to come in close proximity to other people, resulting in a higher infection rate than in other situations. Moreover, after a gathering, the participants return to their lives, thus contributing to the spread of the epidemic throughout society [2,3].

As a result of this series of festivities and consequent gatherings of people, the curve of daily confirmed COVID-19 deaths started a new climb around the end of October 2022. A peak was registered around the beginning of January 2023, exactly ten weeks after the climb began, with a weekly number of deaths as large as 800 in those three holiday weeks. After that peak, a quite rapid downward trend began, which stabilized in almost five weeks, returning to approximately the same number of confirmed COVID-19 deaths as when the wave had started at the end of October: 200–300 deaths.

In the end, during this observed period of fifteen weeks, that 2022/2023 COVID-19 wave caused a number of deaths as large as 8,526, with (a) an average number of weekly deaths equal to 568, (b) an average growth rate of +7.89% deaths per week (for ten consecutive weeks), and (c) "an average decline rate of -15.85 deaths per week (for five consecutive weeks). All those data are officially available at the web site of the Italian Ministry of Health, which publishes, on a regular weekly basis, its epidemiological bulletins [4].

The situation we have summarized has a visual counterpart in Figure 1, where the daily new confirmed COVID-19 deaths (per million people) in Italy is plotted over the period that goes from the end of August 2022 to the middle of April 2023. In particular, the two leftmost black thin vertical bars in Figure 1 demarcate the period when schools opened (middle of September to the beginning of October 2022). The green thick bar marks the period when All Saints' Day and All Souls' Day events occurred (beginning of November 2022). The yellow thick bar marks the period corresponding to the Feast of the Immaculate Conception (December 8), and the blue thick bar marks the beginning of the period of Christmas and New Year's festivities. The curve also shows, very clearly, all the increasing and decreasing trends we have described before. The curve represented in Figure 1, with all its data, has been drawn using the open data source made available by the Our World in Data initiative [5].

The aim of this study is to analyze the weekly number and the growth/decline rates of COVID-19 deaths of the 2022/2023 COVID-19 winter season, along with the periods in time when it peaked and then declined, thus reaching a stable situation. All this effort has been done with the intent to project those numeric figures onto the recent Italian COVID-19 situation, which has experienced a resurgence in cases and deaths in the winter season of 2023–2024, starting again at end of October, in 2023.

At the time of writing of this paper (December 15, 2023), in fact, we knew that in the period from October 26, 2023, to December 14, 2023, comprising seven consecutive weeks, weekly COVID-19 deaths have climbed from 148 to 322, with an average weekly growth rate of +14.08%, as confirmed by the corresponding seven Ministry bulletins [4].

The final objective of this study was to predict the death toll in Italy due to the 2023–2024 winter

COVID-19 wave (from the last week of October 2022 to first week of February 2024), under the hypothesis that it would have a duration similar to that of 2022/2023 (fifteen weeks) with comparable values of (i) the durations of the growth period (ten weeks) and the decline period (five weeks) and (ii) the growth/decline rates.

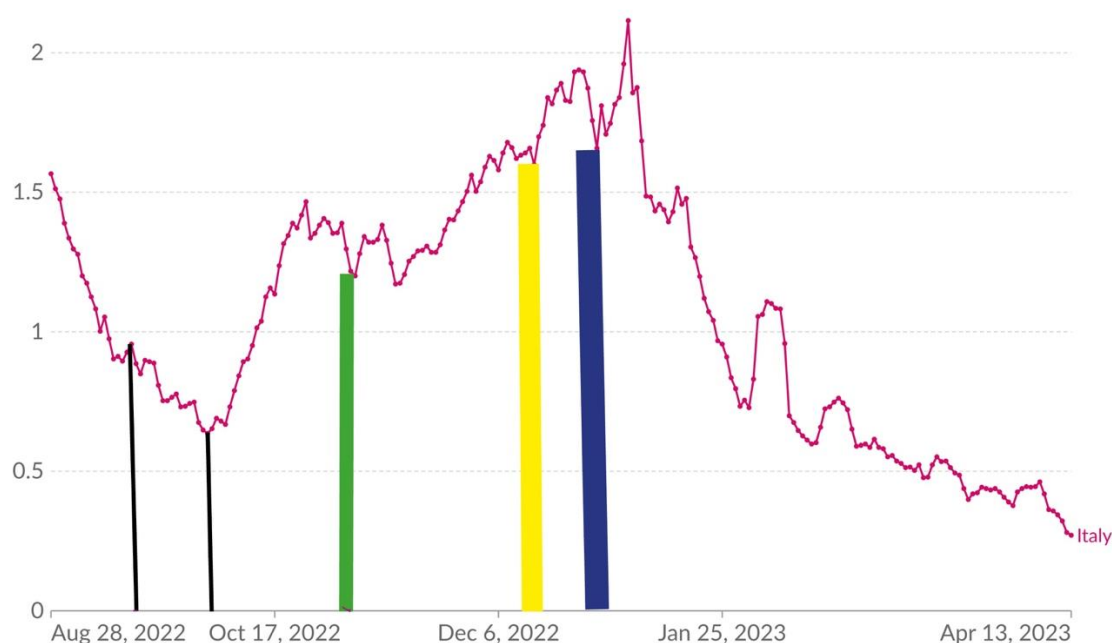


Figure 1. Daily new confirmed COVID-19 deaths per million people in Italy. On the y-axis is the 7-day rolling average of weekly deaths relative to Italian population. On the x-axis, the period: end of August 2022 – mid of April, 2023. Source: Our World in Data (2023).

In simple words, we have tried to use a method based on the concept of the so-called *predictive analogy*, where the fundamental idea is that future events and outcomes can be forecast by comparing them to past experiences and patterns. This approach requires drawing parallels between similar situations to predict an event or a trend [6,7]. We know very well that this approach is subject to many limitations and runs the risk of failure. Nonetheless, we have decided to use neither the traditional COVID-19 spread indicators of the classical SIR and SEIR models nor alternative but simpler regression models [8], because recent studies have shown that more basic and intuitive metrics can establish a better correlation than traditional indicators with both the number of hospitalized patients and deaths during a COVID-19 epidemic [9–14]. Even if epidemiologists may remain skeptical about the use of those basic metrics for carrying out real-time surveillance, we are confident that our approach can still be useful to predict deaths over an adequate period of time, essentially because it is not influenced by the large number of asymptomatic carriers, which remain unknown and have often contributed in the past to the failure of traditional epidemiological methods used to model COVID-19 diffusion.

In conclusion, we have used analogy, in this context, to compare two analogs (the two COVID-19 winter waves occurring in two consecutive years in Italy) and then to predict the number of deaths based on the observed similarities and parallels. The numbers of this prediction have been anticipated in the Abstract and will be explained in detail in the Results section, along with a preliminary

assessment that seems to confirm the validity of the approach.

The remainder of this paper is the following. In the Materials and Methods section, we describe where our data come from, along with the methodology that we have used to analyze them in order to make our prediction. In the subsequent Results section, we describe the results we have obtained, and then the Discussion section, we describe both the advantages and the limitations of our approach. Finally, the Conclusions section terminates our paper.

2. Materials and methods

2.1. Sources of data

In this section, we provide sufficient details to allow readers to replicate our results. To begin, it is worth revealing the source of data we have used for our study. We have already anticipated that they have all been drawn mostly from one official source: the Italian Ministry of Health. More specifically, this institute issues, on a weekly basis, a comprehensive bulletin where the numbers of confirmed COVID-19 deaths are published [4]. As an alternative source of data, in case the primary web site of the Ministry of Health is unavailable, it is also possible to refer to the official web site of the Italian Broadcast Television, which simply provides a mirror of those official data [15]. Obviously, even if we know that, because of varying protocols and decisions in the attribution of the cause of death, the number of confirmed deaths may slightly vary over time, these bulletins provide the official numbers of the COVID-19 deaths registered by the Italian health authorities.

In summary, the public repositories with all data used in this paper are available at

<https://www.salute.gov.it/portale/nuovocoronavirus/archivioBollettiniNuovoCoronavirus.jsp>

(Italian Health Ministry) and

<https://www.rainews.it/ran24/speciali/2020/covid19/> (Italian Rai Broadcaster).

At the time of writing of the first draft of this paper (December 15, 2023), the main source of data represented by the Italian Ministry of Health comprised 59 weekly bulletins, from the week of October 28–November 3, 2022, until the latest week of December 6–December 14, 2023. In all these bulletins, a table was reported, filled with a weekly update of a variety of COVID-19 indicators. In addition to many others, the number of the weekly confirmed deaths is clearly shown.

2.2. Method of analysis

Inspired by the information portrayed in Figure 1 above, where the beginning, the end, and the peak of the COVID-19 winter wave of 2022/2023 were reported, we decided to use a method based on “historical analogies” to analyze the available data, as well as to cast a new prediction. A few words are in order to introduce this method.

As already anticipated in the Introduction, this kind of model has roots in several scientific fields, from product marketing to software adoption [6,7], with the idea of drawing parallels between phenomena and then modeling one based on an imitation of the other [16]. The decision of whether two phenomena follow the same behavior depends on their similarities and differences and can be made by an expert or by a pool of experts. In this sense, it is very similar to the Delphi method, which is a systematic process of forecasting using the collective opinion of recognized experts [17,18]. It is not by chance that the technique of developing consensus among experts using the Delphi approach

has gained acceptance in diverse fields of medicine. Obviously, the obtained results do not allow the use of traditional methods of hypothesis testing (e.g., p-values) as the values do not come from a distribution to test but should be intended as points of reference, as a trend that the new phenomenon is supposed to follow.

A recent use of this methodology for forecasting is in the field of technology, where active attempts have been developed to predict life cycles of given technology products, based on observations of what was written in news, papers, patents, and other publications related to that kind of technology and published some time before. Historical analogy has been applied for estimating the Korean plug-in hybrid electric vehicle market, and it has emerged as a promising new dimension for forecasting [19].

Along this line of sense, many researchers are (re)considering analogies as a good method for empirically predicting outcomes, under specific circumstances. We will discuss the circumstances that make this method applicable in our case in the Discussion section.

2.3. Implementation of the method

After the above abstract description of the “forecast by analogy” methodology, we come to the practical procedure we have implemented, which is as follows: First, we downloaded from the web site of the Italian Ministry of Health all fifteen bulletins corresponding to the fifteen weeks of interest for the winter season of 2022/2023.

They were the following: (1) October 28–November 3, 2022; (2) November 4–November 10, 2022; (3) November 11–November 17, 2022; (4) November 18–November 24, 2022; (5) November 24–December 1, 2022; (6) December 2–December 8, 2022; (7) December 9–December 15, 2022; (8) December 16–December 22, 2022; (9) December 23–December 29, 2022; (10) December 30, 2022–January 5, 2023; (11) January 6–January 12, 2023; (12) January 13–January 19, 2023; (13) January 20–January 26, 2023; (14) January 27–February 2, 2023; (15) February 3–February 9, 2023.

From those fifteen bulletins, we extracted the fifteen values of the weekly deaths, and then we computed the percent changes for each consecutive pair of values, comparing the most recent value in the series with the previous one.

In particular, we called these values *weekly growth rate* when we were examining the ascending phase of the COVID-19 wave or *weekly decline rate* when the descending phase of the wave was under examination.

More specifically, both the aforementioned values were calculated based on the following formula:

$$\text{Percent change of weekly deaths} = (((ND(i)/ND(i - 1)) * 100) - 100)\% \quad (1)$$

The meanings of the variables $ND(i)$ and $ND(i - 1)$ are as follows. $ND(i)$ indicates the number of deaths of a given week i , while $ND(i - 1)$ represents the number of deaths registered during the week that precedes week i . Obviously, the sign of the result will naturally be positive or negative depending on whether $ND(i)$ is, respectively, greater than or less than $ND(i - 1)$.

All this has produced an ordered series of fourteen different values of the percentage changes of weekly deaths corresponding to the fifteen weeks under study. Of the first nine of these values, we computed the average, obtaining the average weekly growth rate of weekly deaths during the ten consecutive weeks when the curve of 2022/2023 was in its increasing phase. Similarly, of the last five values, we computed the average and took the absolute value, obtaining the average weekly decline rate of weekly deaths during the five consecutive weeks when the curve of deaths of 2022/2023 had

declined down to its initial baseline (value of the baseline: approximately 200-300 weekly deaths).

At that point, we repeated the same procedure above for the seven bulletins issued by the Italian Health Ministry for the seven weeks of the 2023/2024 period available at the time of writing of the first draft of this paper (December 15, 2023). Specifically, we started by downloading the bulletins of the following weeks: (1) October 26–November 1, 2023; (2) November 2–November 8, 2023; (3) November 9–November 15, 2023; (4) November 16–November 22, 2023; (5) November 23–November 29, 2023; (6) November 30–December 6, 2023; (7) December 7–December 14, 2023.

From these seven bulletins, we extracted the seven actual values of the weekly COVID-19 deaths, and then we computed the percentage changes of weekly deaths, based on the same formula (1) above. We obtained a series of six values of the weekly percentage changes of the weekly deaths, relative to the seven consecutive weeks of the 2023/2024 infection period (which was still in its increasing phase, at the date of December 15, 2023). Finally, we computed the average of these six values.

We are nearly ready to make our prediction. To summarize, we remind that we could count on the series of the weekly percentage changes of weekly deaths for 2022/2023, composed of fourteen values, plus (1) an average percentage of the first nine values of the series above (we call this value the *average weekly growth rate*), relative to the first ten consecutive weeks when the curve of the deaths of 2022/2023 was climbing, and (2) an average percentage of the last five values of the series above (called *average weekly decline rate*), relative to the last five weeks when the curve of deaths of 2022/2023 was definitely in its downward phase. Finally, we also had all fifteen actual values of the number of deaths experienced during the entire period of fifteen weeks mentioned above.

For 2023/2024, instead, at the time of writing the first draft of our paper (15 December 2023), we had only seven actual values of the number of deaths experienced during the period of seven weeks from the end of October 2023 till the middle of December 2023. Moreover, we had a series of only six percentage changes of weekly deaths (which are relative to the seven consecutive weeks of the current season of 2023/2024, till the middle of December 2023). Obviously, we also have the average of the values of this series (called the *average weekly growth rate*).

The problem to solve now is how to predict the eight remaining actual weekly values of COVID-19 deaths for the period which goes from the middle of December 2023 to the beginning of February 2024, thus yielding a full series of fifteen values.

There are two alternatives to achieve this result, based on the concept of analogy and built on two different sets of assumptions. We will term the first set of assumptions as Assumption A and the second one as Assumption B.

Under the conditions of Assumption A, we take as valid the following hypotheses: (i) The COVID-19 wave of the 2023/2024 season will have a duration similar to that of 2022/2023 (fifteen weeks). (ii) A comparable extension of both the growing period (ten weeks) and of the decline period (five weeks) will occur. (iii) We will use the *average weekly growth rate* of 2022/2023 and the *average weekly decline rate* of 2022/2023 to calculate, respectively, (1) the predicted values of COVID-19 deaths for the three remaining weeks of the 2023/2024 season, still supposed to be in its ascending phase, and (2) the predicted values of COVID-19 deaths for the last five weeks of the descending phase of the 2023/2024 season.

Under the hypotheses of Assumption B, conditions (i) and (ii) still hold unchanged, but there is a difference in condition (iii): The idea is to use an estimate of the *average weekly growth rate* of the 2023/2024 season, computed with only the first seven weeks of the 2023/2024 season (from the end of October to the middle of December 2023), as a basis for prediction of all eight remaining values of

the season (middle of December 2023 to the beginning of February 2024).

With this change in condition (iii), the additional problem emerges of how to estimate the *average weekly decline rate* for the last five weeks of the descending phase of the COVID-19 wave of 2023/2024, starting only from the estimation of the *average weekly growth rate* of the 2023/2024 season, (computed, in turn, on the basis of values relative to the first seven weeks till the middle of December 2023). To solve this problem, one can adopt the following strategy.

We take (i) the (percentage) *average weekly growth rate* of 2022/2023 (call it $X\%$, for the sake of brevity) and (ii) the (percentage) *average weekly decline rate* of 2022/2023 (call it $Y\%$, for the sake of brevity), and then we calculate the percentage change between X and Y , using the formula below:

$$\text{Percentage change between } X \text{ and } Y = ((\text{abs}(Y/X) * 100) - 100)\% \quad (2)$$

At that point, we know that on average for 2022/2023, the change between the growth ($X\%$) and decline ($Y\%$) trends was equal to a given percentage quantity computed with the above formula (2) and equal to, say, $W\%$, where W is positive or negative depending on whether $\text{abs}(Y)$ is greater than X or less than X , respectively.

The idea is to exploit this value $W\%$ and the estimate of the (percentage) *average weekly growth rate* of 2023/2024 we have already computed with only the first seven weeks of 2023/2024 (call it $Z\%$). To obtain an estimate of the *average weekly decline rate* of 2023/2024, we can proceed as follows.

With W and Z , we can compute a new value $K\% = ((Z * W) / 100)\%$. Roughly speaking, K represents the amount by which we should increment Z to obtain a decline trend analogous to that experienced in the previous season. Consequently, with $K\%$, we can obtain an estimate of the (percentage) *average weekly decline rate* for 2023/2024 (call it $Q\%$), by applying the following formula:

$$Q\% = (Z + K)\% \quad (3)$$

Now, we can apply the estimate $Z\%$ of the (percentage) *average weekly growth rate* of the 2023/2024 season to the three weeks from December 22, 2023, to January 4, 2024, and obtain the three predicted values of the COVID-19 deaths for those three weeks.

Then, we can apply the value ($-Q\%$) of the (percentage) *average weekly decline rate* of the 2023/2024 season to the last five weeks of the series, corresponding to the period from January 5 to February 7, 2024, thus obtaining the predicted values of the COVID-19 deaths for those five weeks that complete the period of interest. As intended since the beginning of this study, these eight predictions cover the entire period from December 14, 2023, to the beginning of February 2024.

All the results that can be obtained with the methods we have discussed are presented in the next section.

2.3.1. Ethics approval of research

This study uses publicly available, aggregated data that contains no private information. Therefore, ethical approval is not required.

3. Results

We now present the results we have obtained using the data and the methods described in the previous sections. They are all summarized in Table 1.

The first fact to notice is that in the first column of Table 1, all fifteen weeks of interest are listed,

both for 2022/2023 and for 2023/2024. The second column reports the numbers of confirmed weekly deaths due to COVID-19 for the 2022/2023 and 2023/2024 seasons. The values we have predicted with our model are shown with bold/italic font in the table. Specifically, on the left of the slash symbol (/), the predictions are reported which have been made under the conditions of Assumption A, while on the right are the predictions achieved under the conditions of Assumption B.

In the third column, the (percentage) changes of the weekly deaths are shown. Again, we show the predicted values in bold/italic. Also in this case, the predictions of Assumption A and of Assumption B are, respectively, shown on the left and on the right of the slash symbol (/). As to the method that builds on Assumption B, it is worth mentioning that it has returned the following values: $Z\% = 14.08\%$ and $-Q\% = -28.28\%$.

Obviously, the most important result of this study is the cumulative number of predicted deaths computed on the basis of the methods described in the previous section. It amounts to 4,024 or 3,903 COVID-19 deaths (as shown in the last row of Table 1), depending on the use of the conditions of, respectively, Assumption A or Assumption B. A detailed discussion of the relevance of this result follows in the Discussion section.

3.1. A preliminary assessment

The design of our model, the corresponding predictions, and the writing of the first draft of this manuscript date back to December 15, 2023, when we were in the seventh week (out of fifteen) of our period of investigation. Today, the date of submission of this paper (January 19, 2024), it has been four weeks since that moment. This has allowed us to compare some of the predictions we made with the actual values, communicated by the Italian Health Ministry [4, 15], of the most recent four weeks (namely, weeks 8, 9, 10, 11 of Table 1).

We have conducted a comparison between our predictions and the actual values, in terms of the cumulative number of deaths that have occurred, considering two different situations. The former is where the comparison is limited to just those most recent four weeks (weeks 8, 9, 10, 11 of Table 1), and the latter is where the entire period is taken into account since its beginning (last week of October 2023 to present), namely, weeks 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 of Table 1.

In the following Table 2, the results of this comparison are shown, with the cumulative number of actual deaths in the second column, the cumulative number of predicted deaths (under Assumption A) in the third column, and the cumulative number of predicted deaths (under Assumption B) in the fourth column. Along with the predicted numbers of deaths, we have also computed the percent error (PE) for each prediction.

Observing Table 2, we can notice that the predictions cast under Assumption A are currently very accurate, with PE in the range 1.1-2.4% for both of the situations analyzed (i.e., 4 vs. 11 weeks). Less accurate but still acceptable is the prediction made under the conditions of Assumptions B, with PE in the range 5.7-12.4%. Generally, in favor of both these predictions (i.e., Assumptions A and B) is the fact that this preliminary assessment has been conducted with the four weeks considered the most crucial for the impact of COVID-19 on the population, as they coincide with the period of Christmas and New Year's festivities. Moreover, if we consider that (i) we have had so far 3088 COVID-19 deaths, and (ii) we are four weeks away (remaining weeks: 12, 13, 14, 15) from the end of the 15-week period of interest, then the prediction of having a total amount of COVID-19 deaths less than 4100 is a very realistic guess.

Table 1. Number of COVID-19 confirmed weekly deaths and changes of the weekly deaths. In bold and italic are the predicted values. Predicted values based on Assumption A are on the left of the slash (/). Predicted values based on Assumption B are on the right of the slash symbol. Predictions start from the 8th week.

Week #	Weekly deaths: (actual/<i>predicted</i>)	Changes: (actual/<i>predicted</i>)
First line: 2022/2023	First line: 2022/2023	First line: 2022/2023
Second line: 2023/2024	Second line: 2023/2024	Second line: 2023/2024
1: Oct 28/Nov 3, 2022	1: 411	null
1: Oct 26/Nov 1, 2023	1:148	
2: Nov 4/Nov 10, 2022	2: 549	2: +33.58%
2: Nov 2/Nov 8, 2023	2:163	2: 10.13%
3: Nov 11/Nov 17, 2022	3: 533	3: -2.91%
3: Nov 9/Nov 15, 2023	3:192	3: +17.79%
4: Nov 18/Nov 24, 2022	4: 580	4: +8.81%
4: Nov 16/Nov 23, 2023	4: 235	4: +22.39%
5: Nov 24/Dec 1, 2022	5: 635	5: +9.48%
5: Nov 23/ Nov 29, 2023	5: 291	5: +23.83%
6: Dec 2/Dec 8, 2022	6: 686	6: +8.03%
6: Nov 30/Dec 6, 2023	6: 307	6: +5.50%
7: Dec 9/Dec 15, 2022	7: 719	7: +4.81%
7: Dec 7/Dec 14, 2023	7: 322	7: +4.88%
8: Dec 16/Dec 22, 2022	8: 798	8: +10.99%
8: Dec 14/Dec 20, 2023	8: 347/367	8: +7.89/14.08%
9: Dec 23/Dec 29, 2022	9: 706	9: 11.53%
9: Dec 21/Dec 27, 2023	9: 374/419	9: +7.89/14.08%
10: Dec 30, 22/Jan 5, 23	10: 775	10: +9.77%
10: Dec 28, 23/Jan 3, 24	10: 404/478	10: +7.89/14.08%
11: Jan 6/Jan 12, 23	11: 576	11: -25.68%
11: Jan 4/Jan 10, 24	11: 340/343	11: -15.85/-28.28%
12: Jan 13/ Jan19, 23	12: 495	12: -14.06%
12: Jan 11/Jan 17, 24	12: 286/246	12: -15.85/-28.28%
13: Jan 20/Jan 26, 23	13: 345	13: -30.30 -12.66%
13: Jan 18/ Jan 24, 24	13: 241/176	13: -15.85/-28.28%
14: Jan 27/Feb 2,23	14: 439	14: +27.25%
14: Jan 25/Jan 31, 24	14: 203/126	14: -15.85/-28.28%
15: Feb 3/Feb 9, 23	15: 279	15: -36.45%
15: Feb 1/Feb 7, 24	15: 171/90	15: -15.85/-28.28%
End of period of investigation	15-week period	
2022/2023: Cumulative	8,526	
number of deaths	4,024-3903	
2023/2024: Predicted		
cumulative number of deaths		

Table 2. Cumulative number of actual COVID-19 deaths in Italy (second column), cumulative number of predicted COVID-19 deaths under Assumption A (third column), cumulative number of predicted COVID-19 deaths under Assumption B (fourth column).

4-week period (Dec 14, 2023 – Jan 11, 2024): weeks 8-11	Cumulative number of actual deaths: 1430	Cumulative number of predicted deaths (Ass. A): 1465 PE: 2.4%	Cumulative number of predicted deaths (Ass. B): 1607 PE: 12.4%
11-week period (Oct 26, 2023 – Jan 11, 2024): weeks 1-11	Cumulative number of actual deaths: 3088	Cumulative number of predicted deaths: 3123 PE: 1.1%	Cumulative number of predicted deaths: 3265 PE: 5.7%

4. Discussion

Analogy is often used for comparing two analogs, based on obvious similarities between the elements that comprise the analyzed phenomena. As such, it assumes that the two phenomena of interest follow almost the same behavior, on the basis of which similar outcomes can be predicted. Obviously, the degree of similarity, on which analogy is based, is greatly influenced by the considered attributes. Needless to say, these are exactly both the strengths and the limitations of our approach. In the specific case of our study, similarities can be found, mainly, in (i) the winter period of investigation, with its meteorological conditions; (ii) the behavior of people during the winter holidays, with their typical attitudes toward gatherings; (iii) the total number of administered vaccinations, which is not greatly changed in the two periods of interest (as an example, consider that the number of boosters administered during the period October-December 2023 was as low as 1,500,000 [20], while the total number of fully vaccinated people was almost 48,000,000 in Italy since October 2022 [21]); and (iv) that although new variants are an expected part of the evolution of any virus, Omicron and its sub-variants ranked as the predominant SARS-CoV-2 strains for both the winter seasons of interest, making the situation sufficiently homogenous in both of these winter seasons [22].

Another reason in favor of use of the methodology adopted in our study is that it is based on the repetition of similar events in recent history. In our case, seasonal holidays and gatherings of people seem to be a perfect instance of this concept of repetition over different years. It is not by chance that other authors had already noticed this fact, maintaining that in Italy, the socio-medical structure developed to contain the pandemic “broke down in the summer as Italians went on holiday” [23].

Obviously, a strong limitation in using historical analogies to predict outcomes is related to the time scale used for the investigation. If the time scale is too short, the available amount of information (in our case, the number of weeks with relative deaths) could be insufficient to draw a parallel between different seasons. On the other hand, if the time scale becomes too long, this would mean that too many events, confounding factors, and unexpected accidents could play a role, thus making the model based on analogies too complex to be managed. Coming to our case, the three-month period we have investigated seems to be adequate, since it is characterized by the repetition of the already mentioned seasonal events over two different years. Instead, extending over a longer term would complicate a careful application of the analogies.

All this said, from the perspective of the parallel we have drawn, we are persuaded that our analogical study can be considered as a useful source of knowledge, especially if the values we have

predicted are thought of as simply indicating a trend or some kind of reference values. This means that we expect that our analysis may err in predicting the precise values, with predicted values which could be higher or lower than the actual ones, with equal probability [24]. Nonetheless, if we try to find sense to our predictions, we are sure that even thinking and discussing analogies may generate useful (and sometimes crucial) information.

Furthermore, it is worth noticing that the preliminary assessment we have conducted, based on a comparison between the cumulative number of actual COVID-19 deaths and the cumulative number of deaths predicted on the basis of our methodology, has already shown that our prediction is by now accurate, with a high probability of a percent error contained approximately below the value of 7%.

We also think that our findings and their implications should be discussed in a broader context. For example, the total number of COVID-19 deaths we have predicted for the period November 2023–January 2024 should be interpreted as a general sign of concern, with health authorities that should urge the public to adhere always to reasonable health guidelines and to get tested for COVID-19 if symptoms arise.

Of final interest also are two other comparisons. The first one regards our prediction and the actual number of confirmed deaths in the same time period of 2022/2023. There is a sensible difference between the two values, 8,526 vs. 4,100, thus confirming the downward trend of the epidemic in Italy. Nonetheless, it is useful to remember, as an exemplar case from the past, that a great concern was expressed by the Italian health authorities in the winter period of 1969-1970, when the so-called Asian flu (a subtype of the H3N2 flu virus) caused as many as 5,000 deaths in Italy [25, 26]. This argument is in favor of the fact that if our predicted number of deaths will actually occur, Italians need to adopt a cautious attitude, using common sense and persevering with good practices and vigilance, while avoiding giving in to an excessive feeling of paranoia.

5. Conclusions

We have drawn a parallel between the two winter periods of 2022/2023 and 2023/2024, worried by the COVID-19 infection trend that has rose up again in Italy, starting at the end of October 2023. Based on the concept of *forecast by analogy*, we have tried to estimate the possible number of deaths that could have happened in Italy in the period from the end of October 2023 to the beginning of February 2024. We found that this number could be less than 4,100. It is worth noticing that the method we used, based on *predictive analogies*, has proven to be both adequate and innovative. It has been adequate because the preliminary assessment we have conducted on 11 of the 15 weeks has already anticipated the high accuracy of the prediction, showing a percent error in the range of approximately 1–7% (regarding the cumulative number of deaths). It is highly likely that this level of accuracy (with a percent error below 7%) will be confirmed in the end, given that very few weeks are still missing and considering that the observed trend, as correctly predicted, is already in its downward phase. It is also innovative because in this specific field, to the best of our knowledge, it is the first time it is used. Nonetheless, it is important to remind that it should be applied only if one is sure that the similarities are much more than the differences when the two phenomena are compared.

Use of AI tools declaration

The author declares that he has not used artificial intelligence (AI) tools in the creation of this article.

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Informed Consent Statement

Not applicable: Neither humans nor animals nor personal data are involved in this study.

Conflict of interest

The author declares there is no conflict of interest.

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