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Large-scale Sporting Events and the Spread of COVID-19 in USA: The Case of the 2021 NFL Super Bowl, in Tampa, FL

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***Abstract*—After that the USA had dealt with a strong wave of COVID-19 infections, driven by the Alpha variant, the NFL Super Bowl event took place: February 7, 2021, in Tampa, Florida. In this context, we have studied the dynamics of the decrease/increase rate of the new daily SARS-COV-2 infections in all the 51 states, before/after that event, investigating the role that this event may have played in the spread of the virus. Using a piecewise linear regression, extending from the end of January 2021 till the end of February 2021, we found that, following a peak of the infections occurred approximately on the mid of January 2021 and a subsequent decreasing infection trend enjoyed by almost all the 51 states, this trend was inverted into an increasing one in 27 of those states (53%), within two weeks since the day of that sport event. Nonetheless, a new *counter-inversion* of the infections was registered, from an increasing to a decreasing trend, after some few more weeks, thus providing evidence in favor of the hypothesis that a major sport event alone may not have the strength to ignite new, stable and severe surges of COVID-19 infections.**

Keywords— SARS-COV-2; Piecewise linear regression; 2021 NFL SuperBowl; Major sporting events; Health informatics

I. INTRODUCTION

At the beginning of 2021, the USA saw a brief respite of the COVID-19 pandemic, probably driven by the effects of the vaccinations that started in that period. In particular, after a peak of almost 250,000 new daily infections (7 day rolling average) suffered on January 14, 2021, a decreasing rate of the infections was observed in almost all the 51 states comprising the country. This was the scenario in which the NFL Superbowl took place on February 7, 2021 in Tampa, Florida.

At that point, the decision to allow a major sporting event like a NFL Superbowl followed by millions of supporters nationwide, with consequent massive people gatherings in pubs and public spaces, in such a delicate time, triggered a debate on the problems it would have caused. Nonetheless, the competition took place, leaving each single state some freedom on the restrictions to apply (e.g., a maximum number of supporters was imposed at the Raymond James Stadium in Tampa).

This short paper has focused on the temporal period when this 2021 Super Bowl took place in the USA, investigating on the inversion of the decreasing trend of the SARS-COV-2 infection timeseries (which had previously peaked on January 14, 2021) and on its possible link with the aforementioned major sport event. To investigate this hypothesis, we analyzed the daily timeseries of the new SARS-COV-2 cases (7 day rolling average) registered in each state of the country, looking for a possible inversion of the original declining trend into an increasing one, to occur after a couple of weeks after the 2021 Super Bowl. The window of a couple of weeks was motivated by the typical incubation time of the virus.

Inspired by the works described in [1-4], we used a piecewise linear regression to study the dynamics of the increasing/decreasing infection trends. We admit this is a very simplified method, resulting in a model consisting of a point of interest, typically fixed at the beginning of a certain week, and two segments, whose slopes represent the increase/decrease rate before and after the points of interest.

It should be noted that this type of analysis is observational in nature, and it can be used just to determine if the exposure to the specific risk factor under observation, given in this case by the frequent mass gatherings following the Super Bowl events, might have correlated with the particular outcome of the virus spread in the USA.

With this type of study, obviously, one cannot demonstrate any cause and effect, but just making preliminary inferences on the nature of the phenomenon under investigation.

After this premise, we can anticipate that 27 out of 51 states (53%) had a reversal from a decreasing to an increasing trend of the SARS-COV-2 infection rate which was temporally coincident with the Superbowl, in the sense that

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this inversion occurred within two weeks after the 2021 Super Bowl. Nonetheless, it should be noticed that a new *counter-inversion* of the infections was registered from an increasing to a decreasing trend, after some few more weeks, thus revealing that the Superbowl alone had not had the strength to ignite a new surge of COVID-19 infections in the USA.

The remainder of the paper is structured as follows. In the next Section, we summarize the method and the data we have used, along with their sources. Section III finally concludes this paper, presenting our final considerations.

II. Data, Methods and Results

The timeframe for this study starts two weeks before the day of the Super Bowl (February 7, 2021) and ends two weeks after that event. All data regarding the COVID-19 infections were collected from an online Covid-19 cases repository termed *usafacts.org*, in turn available online at: https://usafacts.org/visualizations/coronavirus-covid-19-spread-map [5]. Those data were then confirmed by visiting the official CDC web site [6].

Finally, the window of a couple of weeks after which checking if the dynamics of diffusion of SARS-COV-2 had changed was motivated by the typical incubation time of the virus as indicated in [7].

To be noticed is the fact that the timeseries of the daily confirmed cases were smoothed using a rolling average with a 7-day long window to remove the periodicity patterns of the various testing and registering case processes. As to patient and public involvement, patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this study.

All data have come from publicly available repositories, where they are stored in an aggregated and anonymized format.

As to the method employed to analyze those data, we used a linear piecewise regression inspired by the works described in [1-4]. In essence, we decided a fixed point (corresponding to a given day of a certain week) in correspondence of which we checked the rate of the infection curve, to verify if it was growing or falling down, before/after that fixed point (i.e., day).

Basically, we fitted a simplified regression model where the dependent variable was the number of new daily confirmed SARS-COV-2 cases, and the independent variable was just the number of days since the beginning of our temporal window of interest.

As a result, we obtained two segments, before/after the fixed point, whose slopes describe the increasing/decreasing trend of the SARS-COV-2 infections. It is worth noticing that our interest was not in modeling the spread of the virus with the maximum precision, but rather finding if the corresponding slope before/after a given day reflected a decrease/increase trend.

Not only, but it should be also considered that our type of study has been observational in nature, and that it can be only used to determine if the specific risk factor under observation, given by the frequent mass gatherings, following the Superbowl, might have correlated with the particular outcome of the virus spread in the USA.

It should be clear, in fact, that with this type of study, we cannot demonstrate any cause and effect, but just making preliminary inferences on the nature of the phenomenon under investigation.

To better demonstrate how our method works in practice, we provide six different examples of use, taking the graphical form of the following Figures 1, 2, 3, 4, 5 and 6.

The first two examples (Figures 1 and 2, respectively) deal with the states of Colorado and Minnesota. and show that after two weeks since the Superbowl (yellow vertical bar, February 21, 2021) the rate of COVID-19 infections has reverted from a decrease into an increasing trend for both states.

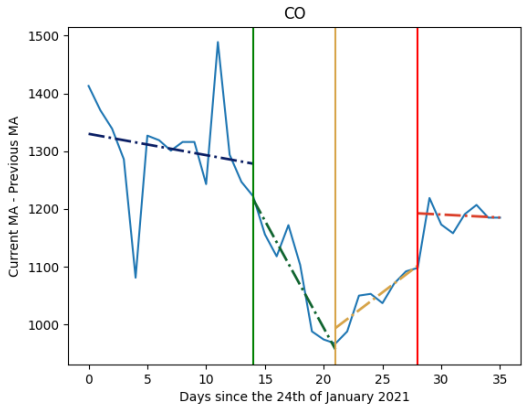

Fig. 1. Colorado: after two weeks since the Superbowl (yellow vertical bar) the rate of COVID-19 infections has reverted from a decreasing into an increasing trend.

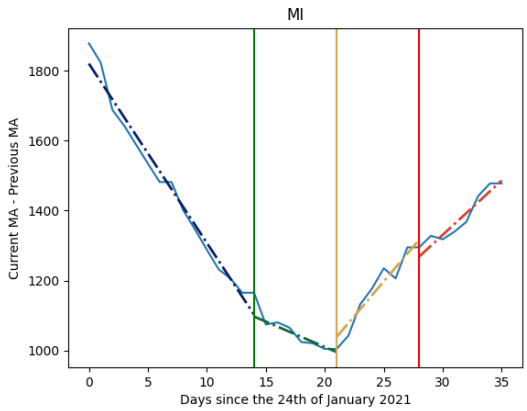

Fig. 2. Minnesota: after two weeks since the Superbowl (yellow vertical bar) the rate of COVID-19 infections has reverted from a decrease into an increasing trend.

Two further examples (Figures 3 and 4, respectively) treat the cases of the states of Texas and Arizona.

They show that:

i) after two weeks since the Superbowl (yellow vertical bar, February 21, 2021) the rate of COVID-19 infections is reverted from a decreasing into an increasing trend for both states, and

ii) ii) starting from the red vertical bar (February 28, 2021), the rate of the new infections reflects again a declining trend for both states.

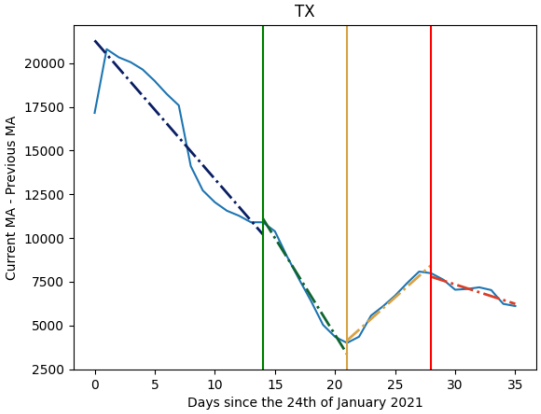

Fig. 3. Texas: after two weeks since the Superbowl (yellow vertical bar) the rate of COVID-19 infections has reverted from a decrease into an increasing trend. Starting from the red vertical bar, the rate of the new infections reflects again a declining trend.

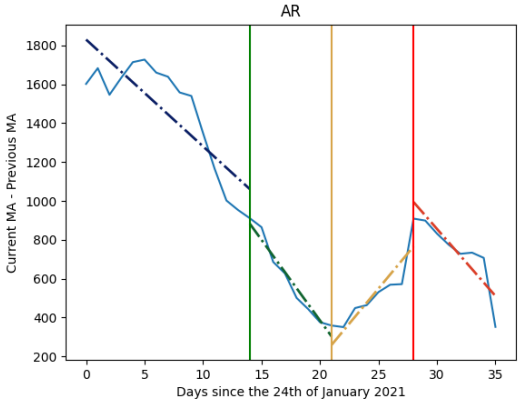

Fig. 4. Arizona: after two weeks since the Superbowl (yellow vertical bar) the rate of COVID-19 infections has reverted from a decrease into an increasing trend. Starting from the red vertical bar, the rate of the new infections reflects again a declining trend.

The two final examples (Figures 5 and 6, respectively) are concerned with the cases of the states of Kentucky and Kansas.

Different from all the previous examples we have shown so far, this is the case of two states where our linear regression analysis provides no evidence of a reversal from a decreasing trend to an increasing one of the new SARS-COV-2 infection rate, after two weeks from the Super Bowl, thus revealing that no all the states have suffered of a COVID-19 diffusion, following this large-scale sporting event.

For the sake of clarity and conciseness, it is not the case of showing here the plots of all the 51 states comprising the USA, yet we provide a concise summary of the results under the form of the following Table 1.

The Table summarizes the results we obtained with the data and methodology explained before.

In essence: before the Superbowl, 49 out of the 51 states (96%) enjoyed a declining trend in the SARS-COV-2 infection rate (second column in Table 1).

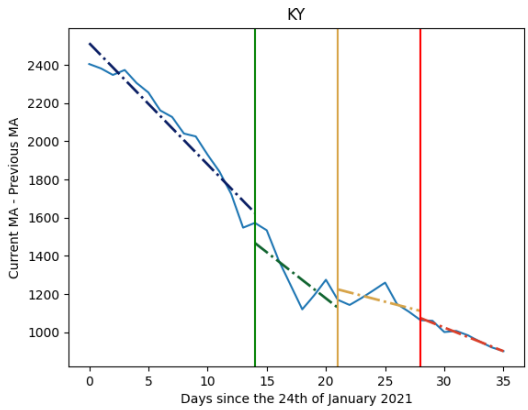

Fig. 5. Kentucky: after two weeks since the Superbowl (yellow vertical bar) the rate of the COVID-19 infections maintains its decreasing trend.

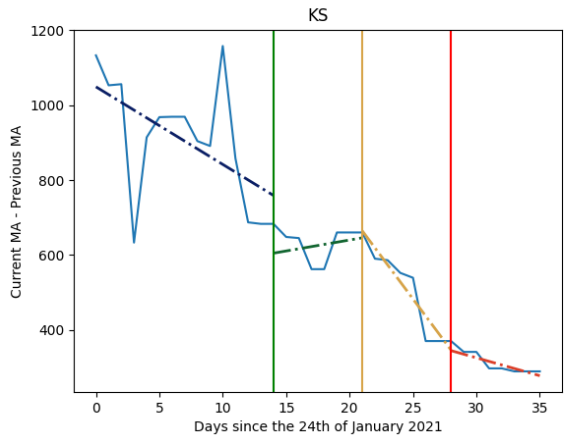

Fig. 6. Kansas: after two weeks since the Superbowl (yellow vertical bar) the rate of the COVID-19 infections maintains its decreasing trend.

After the Superbowl, 27 out of 51 states (53%) have shown a reversal from the decreasing trend of the infection rate into an increasing one, within two weeks since the event of interest (fourth column in Table 1). After some more weeks (essentially in late March 2021) 43 of the 51 states reflected again a decreasing trend in the SARS-COV-2 infection rate (fifth column in Table 1). At that time, the only states still suffering from an increasing trend in the infection rate were the following: Alabama, District of Columbia, Michigan, Nebraska, New York, North Dakota, Pennsylvania, Rhode Island.

For the interested readers, we provide the list of all the states that experienced a reversal from a decreasing to an increasing trend of the infection rate after to weeks since the Super Bowl event, precisely: Alabama, Arizona, Arkansas, Colorado, Connecticut, Delaware, District of Columbia, Georgia, Hawaii, Idaho, Illinois, Iowa, Louisiana, Maine, Maryland, Michigan, Minnesota, Mississippi, Nebraska,

Nevada, New Jersey, New York, Pennsylvania, South Dakota, Tennessee, Texas, West Virginia.

All the other states did not revert the infection rate from a decreasing to an increasing trend, namely: Alaska, California, Florida, Indiana, Kansas, Kentucky, Massachusetts, Missouri, Montana, New Hampshire, New Mexico, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Rhode Island, South Carolina, Utah, Vermont, Virginia, Washington, Wisconsin, Wyoming.

TABLE 1: SUMMARY OF RESULTS

Number of States	Before	1st Week	2nd Week	Beyond
INCREASE	2	9	27	8
DECREASE	49	42	24	43
TOTAL	51	51	51	51
% INCREASE	4%	18%	53%	16%
% DECREASE	96%	82%	47%	84%

As a conclusion, we can observe that the major sport event of interest (the 2021 Superbowl) has represented a kind of spike in the diffusion of COVID-19 in the USA, causing a majority of states to invert their daily infection rate from a decreasing to an increasing trend within two weeks.

Nonetheless, after some more weeks almost all the states had returned to a stable COVID-19 diffusion trend, thus questioning the fact that a major sport event alone may have the strength to start a strong wave of SARS-COV-2 infections [8-25].

III. CONCLUSIONS

We have studied the dynamics of the decrease/increase daily SARS-COV-2 infection rate in all the 51 USA states, before/after the 2021 Superbowl, investigating the role that this event may have played in the spread of the virus. Using a piecewise linear regression extending from the end of January 2021 till the end of February 2021, we have found that, following a peak of the infections happened approximately on the mid of January 2021 and a subsequent decreasing infection trend, enjoyed by almost all the 51 states, this trend was then inverted into an increasing one in 27 of them (53%) within two weeks since the Superbowl. Nonetheless, a new *counter-inversion* of the SARS-COV-2 infection rate was registered, turning from an increasing to a decreasing rate after some few more weeks, thus providing evidence in favor of the thesis that a major sport event alone may not have the strength to ignite new, stable surges of SARS-COV-2 infections, in general. Obvious limitations of this work are the use of a simplified data analysis technique (i.e., piecewise linear regression) and the short period of observation (i.e., one month) after the Superbowl.

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