Influenza vaccination behavior and media reporting of adverse events[*]

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Abstract

We study the role of media reporting of alleged adverse effects of influenza vaccination on adults' (aged 50 or more) decisions to vaccinate against the flu. We exploit the diffusion of news linking suspected deaths to the vaccine, during the 2014 vaccination campaign in Italy. Using daily variation in news items across the 2014 campaign and the previous year campaign, unaffected by media cases, we show that media reporting decreases flu vaccination by about 2.5% (78 fewer vaccinations per day). The effect, however, is short-lived, as it fades away after approximately 10 days from the news outbreak.

Keywords: vaccination, influenza, mass media

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1. Introduction

Vaccine hesitancy has been recently included by the WHO among the *Ten Threats to Global Health* (WHO, 2019). Vaccine hesitancy refers to concerns or misconceptions about vaccines that may induce people to delay or refuse vaccination. Research on the determinants of vaccine hesitancy has mainly focused on the internet and social media (Wang et al., 2019), but traditional media too can affect individuals' attitude toward vaccination. The role of traditional media is particularly important in case of adverse events related to vaccination, when Health Authorities are in the difficult position of communicating such events to the public opinion (Ball et al. 1998).

This paper analyzes the effects of media reporting in relation to a number of suspected deaths initially attributed to the flu vaccine, on the seasonal influenza vaccination take-up. The analysis focuses on the adult population (i.e. above 50) and compares the 2014 campaign in Italy, in which the deaths occurred, with the previous vaccination campaign.

The suspected deaths occurred in November 2014, after about a month from the beginning of the campaign, and were related to two specific batches of the flu vaccine *Fluad* produced by Novartis Vaccines and Diagnostics. After these occurrences, the Italian National Medicines Agency (NMA) ruled to withdraw, on a precautionary basis, the batches from the market, and launched an investigation on their safety. A few days later, the NMA publicly declared that the deaths were unconnected with the vaccination. This case received a massive media coverage and had great resonance in the public opinion which, combined with a poorly managed risk communication, likely contributed to raise individuals' hesitancy to flu vaccination (Signorelli et al. 2015).

Several studies have assessed the relationship between media reporting of adverse events and vaccination, mainly focusing on pediatric vaccinations. Anderberg et al. (2011), Smith et al. (2008) and Chang (2017) consider the MMR vaccine-autism controversy in UK and US, Wang et al. (2016) analyze a series of adverse events of the Hepatitis B vaccine occurred in China, while Suppli et al. (2017) focus on the side effects of the HPV vaccine occurred in Denmark. All studies find a sizable and long-lasting drop in vaccine take-up or lower confidence toward vaccination following the media coverage of the events, plausibly due to the higher perceived risk associated with the immunization.

Our paper provides the first evidence on the link between media coverage of adverse events and vaccine take-up for the seasonal influenza vaccination by the adult population in Italy. Differently from the pediatric vaccinations considered in previous studies, the immunization against the flu must be repeated every year. Thus, even a short-term reduction in take-up during

a campaign may have important implications for the spread of the influenza virus during the whole season.

The analysis uses comprehensive administrative data for the Metropolitan Area of Milan on the 2013 and 2014 seasonal influenza campaigns and assesses the direct effect of the news outbreak on vaccination take-up, as well as its persistency. The empirical analysis accounts for the potential non-random occurrence of the media reporting by differencing out the levels of news and vaccination uptake occurred in the campaign not affected by the case.

Our results show that one additional news item, in newspaper and TV broadcasting, decreases the daily vaccination count by about 2.5%. The effect, however, is short-lived, as it fades away after approximately 10 days from the news outbreak.

The paper proceeds as follows: Section 2 overviews the existing literature on the topic and outlines our main contributions; Section 3 describes the background and the case under study; Section 4 describes the data; Section 5 presents the empirical strategy; Section 6 presents the results and robustness checks and discuss our findings. Finally, Section 7 concludes and derives some policy implications.

2. Media reporting and vaccination: a review

Several studies have shown the importance of news and media reporting for health-related behaviors, especially for vaccine demand (MacDonald et al. 2015). The literature has distinguished between news provided on traditional media outlets (such as newspapers and TV) on one side, and internet and social media on the other. While the use of the internet and social media has been traditionally associated with the diffusion of misinformation and fake news, traditional media have been identified as more neutral and reliable (Ball et al. 1998, Wang et al. 2019, Lehmann et al. 2013). In the context of vaccination, extensive media coverage may affect individuals' decisions in different ways: by increasing the knowledge about the immunization process (Kelly et al. 2009) or alternatively by emphasizing the risk perceptions (Ball et al. 1998).

Most studies have assessed the consequences of the media coverage of the Measles-Mumps-Rubella (MMR) vaccine controversy. The MMR vaccine controversy started in United Kingdom in 1998 when Wakefield falsely claimed a link between the MMR vaccine and autism, which was later proved to be unfounded. Andeberg et al. (2011) find that the take up of pediatric vaccinations in the UK has declined when the media coverage on the case has been higher and has started to increase again only when no claims of the MMR-autism link are observed in the media. For the US, Smith et al. (2008) find a limited effect of the media, but

Chang (2017) shows that the controversy still induced a long-lasting decline in the take up of all pediatric vaccinations for high-educated parents.

Other studies focus on the media coverage of cases of adverse events of pediatric vaccinations. Suppli et al. (2017) analyze the occurrence of adverse events of the HPV vaccine in 2013 in Denmark, while Wang et al. (2016) analyze the case of adverse events linked to the Hepatitis B vaccine occurred between December 2013 and January 2014 in China. In both cases, the use of the vaccine batch(es) associated with the adverse events was suspended, investigations on the safety of the vaccine were performed and showed no link between the cases and the vaccine. The results from both studies show that the events induced a reduction in the vaccine uptake which lasted even after Health Authorities resumed the use of the vaccine.

A couple of papers analyze the implications of media coverage for flu vaccination decisions, but none consider cases of adverse events of vaccination. Yoo et al. (2010) show that media information during the vaccination campaign in the US induces earlier vaccination and higher vaccination rate. Ma et al. (2006) report that the news on a pediatric death due to the flu during the 2003 flu season in the US leads to a much higher vaccination rate among children.

Our paper contributes to the existing literature in three ways. First, differently from Suppli et al. (2017) and Wang et al. (2016), which analyze cases related to pediatric vaccinations, our paper considers the effect of media coverage on the vaccination decisions of adult individuals. As shown in Larson et al. (2014), the number of researches on adults' vaccinations has steadily increased in the past decade, but no paper has investigated the relationship between media reporting and vaccine hesitancy for this age group.

Second, we focus on the individuals' decisions to vaccinate against seasonal influenza. To the best of our knowledge, only a few papers deal with the implications of media coverage for flu vaccination decisions, but none consider cases of adverse events during the flu vaccination season. While Yoo et al. (2010) deal with neutral information and Ma et al. (2006) consider the case of news increasing the awareness of the disease, in our case, the news about the alleged side effects of the flu vaccine may have increased the perceived risk associated with the immunization.

Third, in our analysis of the effects of media reporting on flu vaccination we account for seasonality and other confounding effects, and we use the same empirical strategy to assess the presence of persistency over time. In this respect, Yoo et al. (2010) find that the media effect on flu vaccination is short-lived, while Wang et al. (2016) show that the loss of confidence toward the HepB vaccine in China is long-lasting but they do not provide evidence on actual vaccine take-up. It is worth noting that the persistency of the media effect on vaccine take-up is particularly relevant in the context of seasonal influenza because of the relatively short spell

of the vaccination campaign: in fact, even a short-term reduction in take-up may increase the spread of the influenza infection and its epidemic effects.

3. Background

3.1 The flu vaccination program in Italy

In Italy, vaccination against seasonal influenza is regulated by the National Plan for Preventive Vaccination (NPPV), established by the Italian Ministry of Health. The flu vaccination campaign starts in mid/late October and finishes by the beginning of January, while the circulation of the influenza virus occurs between November and April of the following year (ECDC, 2017). Because the influenza virus constantly evolves, every Spring the Ministry of Health states what types of vaccine should be used in the next vaccination campaign. Then, every Italian Regional Government buys several batches of the vaccine through public auctions procedures.

The NPPV establishes that flu vaccination is provided free to categories of individuals who are at risk of complications in case of infection (i.e., individuals aged 65 or more, individuals affected by a chronic disease, individuals institutionalized in nursing homes, women in 2nd/3rd trimester of pregnancy), and, for preventive reasons, to workers in the education, health and military sectors.

In accordance with the European Medicines Agencies (EMA) Good Vigilance Practice for vaccinations, the Italian National Medicines Agency (NMA, *Agenzia Italiana del Farmaco*) is in charge of analyzing the cases of suspected adverse effects due to vaccinations, as they are reported from local Health Authorities. In particular, the identification of an "adverse event following immunization" (AEFI) includes all medical events observed after a vaccination and, in the case of flu vaccination, this refers to all events occurred within 48 hours (NMA, 2015).

3.2. The Fluad vaccine case during the 2014 campaign

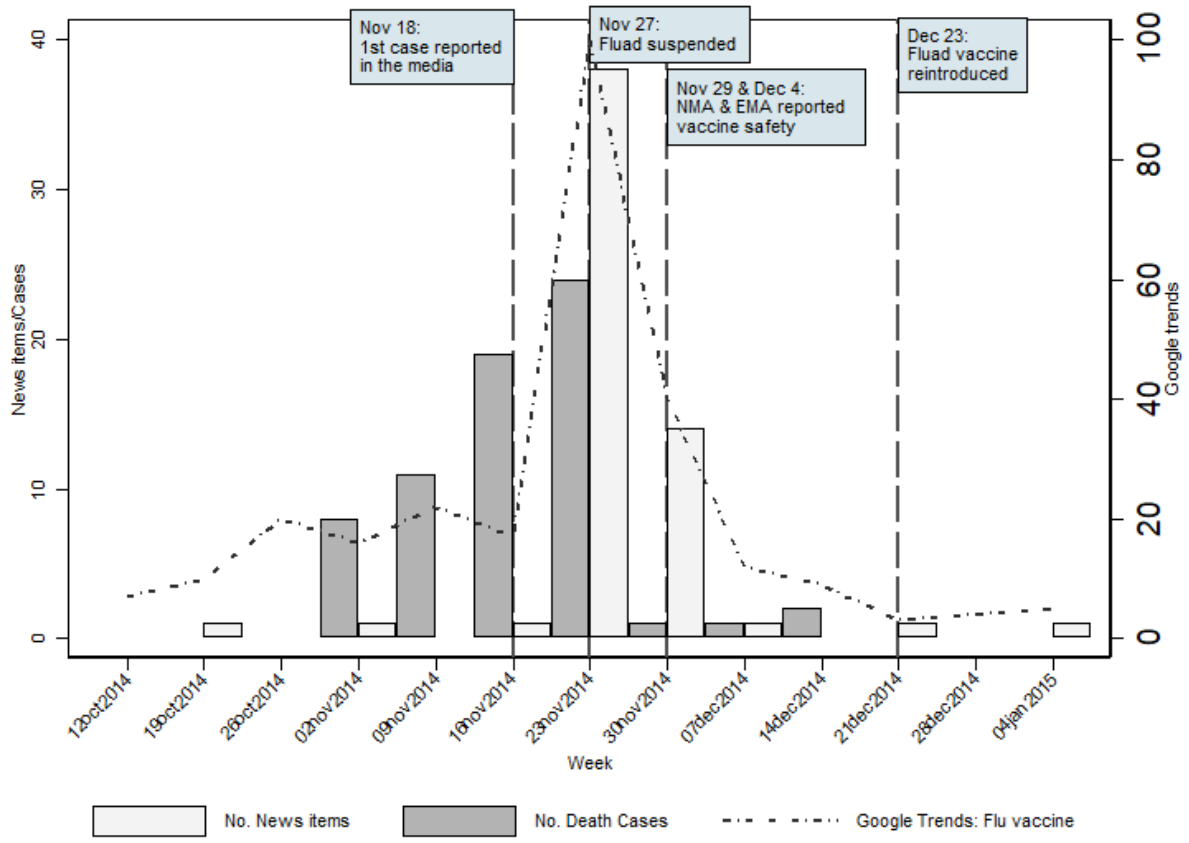
During the 2014 flu vaccination campaign, after about a month from the beginning of the vaccination campaign (mid October 2014), Health Authorities reported two death cases that had occurred in the same province (Syracuse, in the region of Sicily) after receiving the *Fluad* flu vaccine, produced by Novartis Vaccines and Diagnostics. Just a few days later, another case, occurred after the immunization with the same vaccine batch in the region of Molise, was reported to the NMA. The news about the first case appeared on the media on November 18th, and media coverage of the subsequent cases followed in the next days.

According to the guidelines detailed by the EMA (*European Medicines Agencies*) protocols, national authorities should intervene, on a precautionary basis, with the withdrawal of the product from the market and the performance of necessary investigations, in case of events geographically clustered or linked to a specific producer or batch. Since all three cases were related to the *Fluad* vaccine batches n. 142701 and n. 143301, the NMA suspended the use of these batches on November 27th, and initiated investigations aimed at checking whether the vaccine safety was compromised by some faults in the production or conservation processes (NMA, 2015). Not all regions were using the batches of the *Fluad* vaccine linked to the cases. Lombardy, Emilia Romagna and Piedmont, where the batches were not used, reassured the public that all the other producers' vaccines were safe and that the vaccination campaign could continue as before. The other regions also urged the vaccination campaign to continue, by persuading Health Authorities and the public to use alternative producers' vaccines.

After November 27th, other death cases allegedly related to the flu vaccine intake were reported to the NMA and, hence, appeared in the media. The cases had also occurred in other Italian regions (Puglia, Lazio, Tuscany, Emilia Romagna, Lombardy and Umbria) and were related to batches of the *Fluad* vaccine different from the ones already withdrawn from the market. The NMA (2015) and Signorelli et al. (2015) point out that the massive media coverage on the topic has induced an increase in the number of deaths reported as 'suspected adverse reactions'. To give an idea of the increase in AEFI reports, the number of 'adverse reactions' reported in the 2013 campaign (including all types of events, not only deaths) was 208 (corresponding to 1.8 per 100.000 vaccinations), while the same figure in the 2014 campaign was 390 (corresponding to 4 per 100.000 vaccinations) (NMA, 2013; NMA, 2015). It should be noted that, even if these cases were reported to NMA, an immediate cause-effect link between the vaccine intake and the adverse effect could not in any case be derived (NMA, 2015). Also the news coverage of the events always included the statement that the association between the 'adverse reactions' and the vaccine batches had not been proved yet.

On November 29th the first national investigations were concluded and the NMA assured that the deaths were not correlated with the vaccine intake. On December 1st, the vaccine quality was found to be compliant with the quality standards imposed by law, while on December 4th, the EMA pharmacovigilance risk assessment committee concluded that there was no evidence of any association between the reported deaths and the vaccine. Finally, on December 23rd, also the results on toxicity and sterility were negative and the two batches were re-introduced in the market (NMA, 2015).

Figure 1. News, death cases and Google trends by week during the 2014 flu vaccination campaign.



Notes. The graph shows the weekly number of news items and the number of death cases associated with the flu vaccination by week of onset of the events (y-axis to the left), as well as the Google trend index for queries on "flu vaccine" (y-axis to the right), during the 2014 campaign. The news items represent the total number of news appeared in the newspapers *Il Corriere della Sera*, *La Repubblica*, *La Stampa* and on the TV channel *SkyTg24* (see Section 4 for additional details). The weekly number of death cases associated with the flu vaccination is taken from NMA (2015), Figure 5. The Google trends index is based on a query share defined as the total query volume, divided by the total number of queries. The maximum query share in the time period is normalized to be 100.

Figure 1 reports the number of death cases by week of onset of the events and the number of news items between mid-October 2014 and beginning of January 2015. The figure shows that the number of cases increased substantially in the weeks before the withdrawal of the *Fluad* vaccine on November 27th, together with the increasing media attention on the topic, which lasted until the beginning of December 2014. The media coverage is also associated with an increase in public interests on the matter: Figure 1 reports the Google trends index for the words "flu vaccination" (*vaccino antinfluenzale* in Italian), which shows a peak around the

date of November 27th when the batches were suspended, and declines to the level before the case only after the vaccine is re-introduced.

Signorelli et al. (2015) argues that the massive media coverage is likely to have boosted public's hesitancy to be vaccinated. Official statistics from the National Health Institute report a total vaccination rate for the 2014 campaign equal to 13.6 percent, while the same figure for the 2013 campaign was 15.6, corresponding to a 12 percent reduction in the overall vaccination rate in Italy.

4. Data

In order to assess the effect of media coverage of the alleged side effects of the flu vaccine on flu vaccination take-up, we combine several data sources to obtain daily information on: (*i*) flu vaccinations; (*ii*) the media coverage of news related to flu vaccination; (*iii*) specific characteristics of each day that might have affected the individual vaccination behavior (e.g., public transportation strikes or bad weather conditions). In what follows we provide the details for each data source used.

4.1 Flu vaccinations

We retrieve the daily number of flu vaccinations (i.e., vaccination counts) from the administrative data provided by the Agency for Health Protection (AHP) of the metropolitan area of Milan (Italy). The data provides information on all flu vaccinations taken within the NPPV by residents aged 50 and more (i.e., 50 plus), during the 2013 and 2014 campaigns. We define the vaccination count (VC_{tc}) as the number of flu vaccinations in each campaign day (t) from the end of October to the beginning of January of the two campaigns (c). Notice that the data refers to all vaccination provided free to the categories listed in Section 3.1. This implies that the decision of the individual to get vaccinated is not affected by the cost of the immunization.

Before describing the other data sources, we address the issue of the representativeness of the data from the Metropolitan Area of Milan for the rest of Italy. The metropolitan area of Milan is located in the Lombardy region (North of Italy), and includes 4.2 million inhabitants. In our data, we observe that the vaccination rate for individuals aged 50 or more was 24 percent in 2013 and 22 percent in 2014. By focusing on the age group 65 plus, for which we can obtain official statistics, in our data we see a vaccination rate of 41 percent in the 2013 campaign, and of 39 percent in the 2014 campaign. The National Health Institute reports that the vaccination rate for the same age group in Italy was 55.4 percent in 2013 (48.6 percent in the Lombardy

region) and 48.6 percent in the 2014 campaign (46.3 percent in Lombardy). Thus, the comparison of our data with the official statistics suggests that the Metropolitan Area of Milan (as well as the Lombardy region) is characterized by a lower vaccination rate than the rest of Italy. This implies that our results apply to a context of a low propensity to get vaccinated against the flu. We will further discuss this issue in Section 6.3.

4.2 News items and other control variables

We collect all the news items containing the keywords "flu vaccination" (in Italian: *vaccino antinfluenzale*), either in the title or in the body of the article, appeared on the main National newspapers *Il Corriere della Sera*, *La Repubblica*, and *La Stampa*, as well as in the TV channel *SkyTG24*.

According to the official figures provided by the Agency for Press Release Distribution (*Accertamenti Diffusione Stampa*, *www.adsnotizie.it*), *Il Corriere della Sera*, *La Repubblica*, and *La Stampa* are the three most diffused general-interest Italian newspapers. To collect the news items containing the above keywords, we exploited the online archive *Factiva*© for the newspapers *La Repubblica* and *Il Corriere della Sera* (*https://professional.dowjones.com/factiva/*), and the online historical archive for the newspaper *La Stampa* (*http://www.archiviolastampa.it/*). For the newspapers *La Repubblica* and *La Stampa* the archives returned articles that appeared both on the printed and on the online versions of the newspaper, while for *Il Corriere della Sera* the archive only returned articles from the printed version. We retrieved a total of 84 articles (14 for year 2013, 70 for year 2014): 54 articles were reported by *La Repubblica* (6 for year 2013 and 48 for year 2014), and 15 articles were reported by *Il Corriere della Sera* (5 for year 2013 and 10 for year 2014), 15 were reported by *La Stampa* (3 for year 2013, 12 for year 2014).

Concerning TV broadcasting, we used *SkyTG24* an important all-news TV channel which provides a free online daily archive of past editions. We searched in the online archive, for 2013 and 2014, all days in which news about "flu vaccination" (in Italian: *vaccino antinfluenzale*) was broadcasted. On the basis of that information we construct a dummy variable which takes value one in any day a news about "flu vaccination" was broadcasted (there are no news items in 2013, while there are 5 news items in 2014: one each day from November 27th to December 1st).

In the analysis we include the news items appeared in the vaccination campaign days between the end of October and the beginning of January; this amounts to a total number of 83 news items (about 0.5 news item per day, with a peak of 20 news items on November 28th 2014, i.e., the day after the official withdrawal of the suspected batches). We then construct

our *News* variable as a 2-days moving average of the sum of all the news items appeared on the three newspapers or in the all-news TV channel, the day of the vaccination and the day before.

Notice that our *News* variable is intended to proxy for the general reporting of the media of the issue, thus not only by the three newspapers and the TV channel surveyed, but also by other newspapers and other media outlets (Eisensee and Strömberg, 2007). Notice that, while it is certainly true that news about *flu vaccination* also appeared in other newspapers and other TV channels, yet the news reported in all of them are likely to be highly correlated, such that our estimated effects also capture the overall patterns of media coverage on flu vaccination related news (Eisensee and Strömberg, 2007). In a later section, we show that our results are confirmed if the analysis is run separately for newspapers and for the TV channel.

Finally, to gain further insights on the contextual factors associated with the vaccination decision, we collected additional (day-level) information on bad weather conditions and public transportation strikes. Weather conditions were retrieved using the online archive of a major website of weather forecast (*www.IlMeteo.it*), while days of public transportation strikes were retrieved from the website of the main public transportation operator of the Milan Metropolitan Area (*ATM - Azienda di Trasporti Milanese, www.atm.it*).

4.3 Sample selection and descriptive statistics

In order to keep the individual's vaccination decision as homogenous as possible, we exclude from the vaccination count individuals with a certified disability or institutionalized in nursing homes. As a matter of fact, for these individuals the flu vaccination decision is rather different, as they are likely to receive the vaccination at their home or at the nursing institution.

Concerning the time span under study, we keep all days from the beginning to the end of each vaccination campaign, i.e., from October 22nd, 2013 to January 2nd, 2014 for the 2013 campaign, and from October 23rd, 2014 to January 3rd, 2015 for the 2014 campaign. This results in a sample of 73 days for each campaign. We then define as *campaign day* the progressive number of days for each vaccination campaign ($t=1 \dots 73$).

Table 1. Descriptive statistics.

	Estimation sample		*2013 campaign*		*2014 campaign*	
	mean	sd	mean	sd	Mean	sd
Vaccination count	3,090.3	4,156.1	3,099.4	4,253.0	3,081.2	4,086.3
News	0.548	2.416	0.11	0.336	0.986	3.355
Wind	0.014	0.117	0.027	0.164	0	0
Storm	0.034	0.182	0.027	0.164	0.041	0.2
Snow	0.014	0.117	0.014	0.117	0.014	0.117
Strike	0.027	0.164	0.014	0.117	0.041	0.2
N	146		73		73	

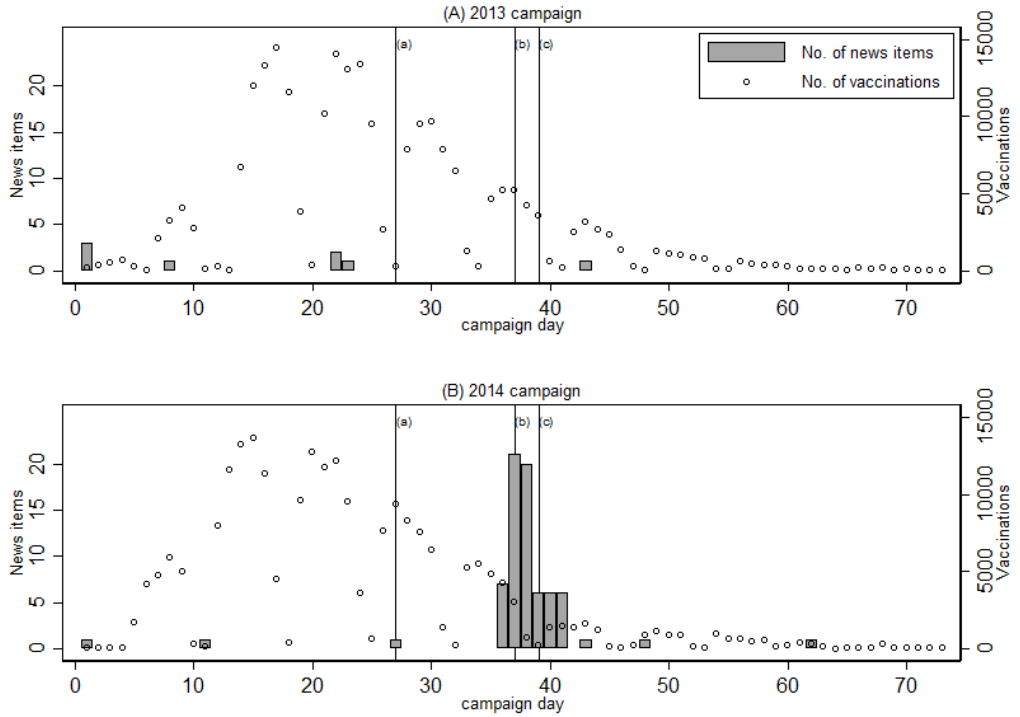
Notes. *Wind*, *Storm* and *Snow* are equal to 1 if, respectively, strong wind (>50 km/h), a storm or snow were recorded in the day; *Strike* is equal to 1 for any strike programmed by the main Local Public Transportation firm. **Sources:** AHP-Milan for vaccinations; *Il Corriere della Sera*, *La Repubblica*, *La Stampa*, and *SkyTG24* for the news; *IlMeteo.it* for the weather; *www.atm.it* for strikes.

Table 1 presents the descriptive statistics of our final sample of 146 days for the two campaigns. On average, 3,099 flu vaccinations per day were taken in the Milan Metropolitan Area in the 2013 campaign, while the same figure for the 2014 campaign is about 3,080, which seems to suggest a slightly lower value. We do not observe sizable differences in the weather conditions and the occurrence of strikes. Conversely, news coverage differs substantially, with 0.1 news items per day in the 2013 campaigns vs. almost 1 news item per day in the 2014 campaign.

5. Empirical strategy

Our aim is to estimate the effects of news about the alleged adverse effects of the flu vaccine on the daily vaccination counts. The identification of the effects of interests is hampered by two main issues: (*i*) news not related to the death cases (though still related to the flu vaccination campaign) may be reported by the media, and (*ii*) the appearance of news on the media may not be random, -- e.g., the salience of a news, which determines its media diffusion, also depends on the vaccination take-up or other features of the campaign.

Figure 2. Daily distribution of news items and flu vaccinations in the 2013 and 2014 campaigns.



Notes. The graph shows the number of news items (grey bars, left y-axis) reported in the newspapers (*Il Corriere della Sera*, *La Repubblica*, *La Stampa*) and in the TV channel *SkyTG24*, and the number of flu vaccinations (black circles, right y-axis) in each day of the 2013 (upper panel) and 2014 (lower panel) flu vaccination campaigns; the vertical lines (a), (b) and (c) indicate some relevant dates (November 18th , 27th and 29th) in each campaign (see section 3.2). **Sources:** *Il Corriere della Sera*, *La Repubblica*, *La Stampa*, and *SkyTG24* for the news; AHP-Milan for the vaccinations.

We overcome these issues by using data on two subsequent campaigns: the 2014 campaign, which was affected by the adverse cases, and the 2013 campaign, which was unaffected. Our empirical strategy exploits the fact that the 2013 campaign, while being unaffected by the adverse cases, can be considered comparable on all other dimensions to the 2014 campaign. Indeed, Figure 2 shows that the two campaigns, before the adverse case outbreak, are very similar in terms of vaccination take-up. Moreover, the composition of the vaccine did not change from 2013 to 2014 (NMA, 2015). The only difference between the 2014 and the 2013 campaigns is given by the media reporting, as shown by the number of news items on flu vaccination. News related to the campaign *per se*, but not to the adverse cases (e.g., those announcing the beginning of the campaign or giving practical information) are present in both campaigns, and do not differ substantially neither in timing nor in content. Thus, our empirical analysis allows us to estimate the effect of media reporting on vaccination by controlling for

the media and vaccination distributions in a campaign which was not affected by the adverse events.

We estimate the following equation:

$$VC_{tc} = \alpha + \beta News_{tc} + X'_{tc}\delta + \varphi_c + \varphi_m + \varphi_w + \varphi_d + \varphi_t + \varepsilon_{tc} \quad (1)$$

where *t* indicates the campaign day (*t=1* corresponds to the first day of campaign in both years, and so on, and *t=1,…,73*), and *c* the campaign. VC_{tc} is the daily vaccination count, while $News_{tc}$ is the daily measure of news reporting previously defined. We control for month (φ_m), week (φ_w) and day of the week (φ_d) fixed effects, in addition to campaign fixed effects (φ_c), in order to account for any seasonality or temporal trends following the progress of the campaign. We also control for time-varying day-specific weather and public transportation conditions (X'_{tc}) that may affect the decisions to vaccinate. Finally, we add campaign day fixed effects (φ_t), in order to difference out the news and the vaccination behavior occurred in the same day across the two campaigns. In a robustness check, we show that the results do not change if we instead use calendar day fixed effects.

Given the count-data nature of the dependent variable, we estimate Poisson fixed-effects regressions. We test for the presence of over-dispersion in the data following Cameron and Trivedi (2005). The test gives a p-value of 0.091, which suggests that the null of equi-dispersion is not rejected at the 95% confidence level. In addition, all the regressions use heteroskedasticity-robust standard errors, clustered at the campaign day level.

6. Results

6.1 Baseline results

Table 2 reports the baseline results, where we first control for campaign fixed effects, and progressively add month, week and day of the week fixed effects, campaign day fixed effects and control for weather conditions and strikes. The coefficient estimate on our measure of news reporting, in Column (4), implies that one additional news item related to the alleged fatal adverse effects of flu vaccination determines a decrease of about 2.5% in the daily vaccination count, which corresponds to approximately 78 fewer vaccinations per day compared to the average daily vaccination count in the campaign not affected by the adverse cases.

Table 2. Baseline estimates.

	(1)	(2)	(3)	(4)
	Dep. variable: VC			
News	-0.048	-0.020**	-0.019***	-0.025***
	(0.029)	(0.008)	(0.004)	(0.005)
N	146	146	146	146
Campaign FE	Yes	Yes	Yes	Yes
Month, week, day of the week FE		Yes	Yes	Yes
Campaign day FE			Yes	Yes
Weather conditions and strikes				Yes

Notes. Poisson fixed-effects (FE) regressions with SEs heteroskedasticity-robust and clustered at the campaign day level. Significance levels: * p<0.1, ** p<0.05, *** p<0.01. **Sources:** see Table 1.

Table A.1 in the Appendix shows that the results are robust to alternative definitions of the news variable (Columns (1), (2), and (3)), to the exclusion of the weekends and holidays (Columns (4) and (5)), and to the use of calendar day fixed effects instead of campaign day fixed effects (Column (6)). Importantly, Table A.2 in the Appendix shows that the results are not sensitive to the type of media chosen to construct the news variable: in Column (1) we only include the news items retrieved from newspapers; while in Column (2) we use a dummy variable indicating the days in which news about the case were broadcasted by the TV channel *SkyTg24*. In this case, we estimate that in the days when the news related to the suspected deaths were broadcasted by the TV channel *SkyTg24*, the vaccination count decreases by about 37%. Finally, we explore potential heterogeneity in the media reporting effects by age groups (50-64, 65-79, 80 plus). The results are reported in Appendix Table A.3 but do not show significant differences.

Overall, our results indicate a sizable reduction in vaccination counts associated to the media reporting. Given that the vaccine batches linked to the death cases were not distributed in the area to which our data refer, nor any death occurred in this area, the response we observe in vaccination take-up is mainly driven by the media coverage of the case. We discuss the interpretation and implications of our results in Section 5.3. In what follows, we analyze whether the effects persist over time.

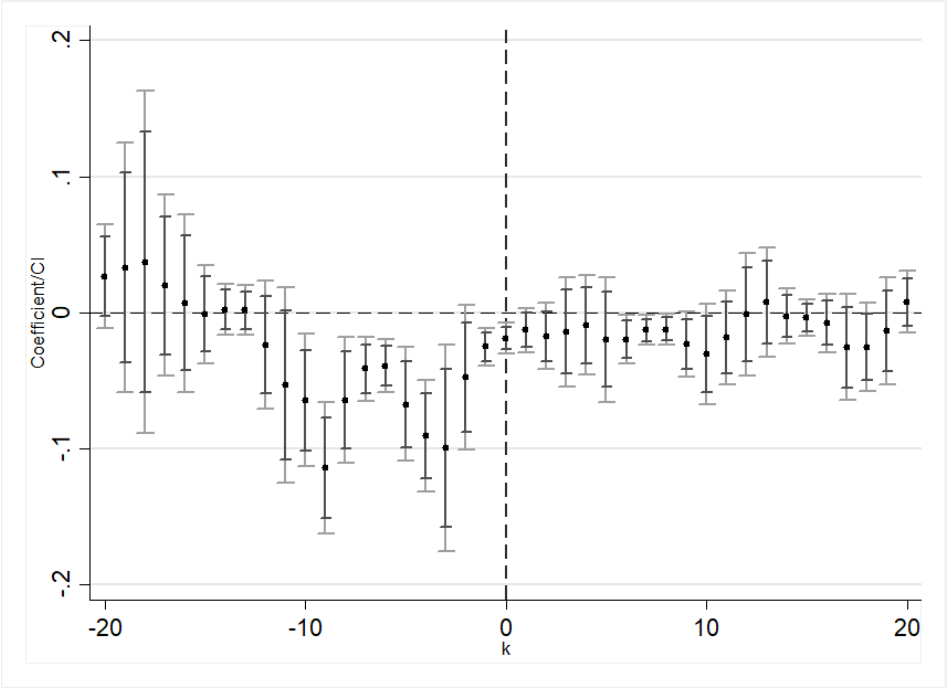
6.2 Persistency

In this section, we analyze the persistency of the vaccination response to the news outbreak. We estimate the following equation:

$$VC_{tc} = \alpha + \beta News_{(t-k)c} + X'_{tc}\delta + \varphi_c + \varphi_m + \varphi_w + \varphi_d + \varphi_t + \varepsilon_{tc} \quad (2)$$

in which we relate the vaccination behavior to the news items ($News_{(t-k)c}$) reported k days before.

Figure 3. Persistency of the media reporting effect.



Notes. The black dots depict the point estimates, the dark (light) grey lines the 99% (95%) confidence intervals, of Poisson fixed-effects (FE) regressions based on equation (2); negative (positive) values of k indicate news appeared k days before (after) the day of vaccination. SEs are heteroskedasticity-robust and clustered at the campaign day level. **Sources:** see Table 1.

The results reported in Figure 3 show that the media effect is short-lived: lagged news variables have a negative and statistically significant effect on vaccination take-up, only up to 10 days after the start of the news outbreak. This implies that media reporting has an immediate effect on individuals' vaccination behavior, explained by the higher perceptions of risks associated with the immunization, the effect however fades away as the news items are 10 or more days distant in time. Figure 3 also reassures us about the validity of our empirical strategy, as the leads of the news variable (i.e., news which appear after the day of vaccination) have no effects. Figure A.1 in the Appendix shows that the results on persistency are unchanged if we exclude weekend days and holidays (Panel A), or if we use the alternative specification with calendar day fixed effects (Panel B).

Given that Health Authorities took approximately 10 days to exclude any association between the adverse cases and the suspended vaccine batches, our results suggest a significant

response of individuals' behavior *vis-à-vis* Health Authorities communication, as confidence in the flu immunization was immediately restored.

6.3 Discussion

Our main findings are very much in line with the existing literature. Similarly to Wang et al. (2016) and Suppli et al. (2017), the reduction in vaccine take-up following the media reporting of adverse cases seems to be triggered by an increase in the perception of risks associated with the immunization, which may have been further exacerbated by the suspension of the vaccine batches. Given that the cases were related to fatal adverse events, the media reporting is likely to have magnified the individuals' risks perceptions, thus contributing further to the negative effect.

As in Anderberg et al. (2011), our results on the persistency of the effect confirm the strict association between media reporting and vaccine take-up behavior. It is worth noting that, similar to the MMR vaccine-autism controversy in the UK analyzed by Anderberg et al. (2011), media coverage can convey both information on adverse events, as well as statements of the Health Authorities, with potentially different effects on individuals' vaccination decisions. In the first case, the news is related to the perceptions of risks associated with the vaccine uptake, in the second case it concerns the warnings about the lack of evidence on the association between the fatal cases and the vaccine, followed later by the official communication about vaccine safety. The fact that we still find an overall negative effect which lasts for several days, should be taken as an indication that media coverage, by raising uncertainty in the public opinion, still induces hesitancy in vaccination behavior. However, differently from Anderberg et al. (2011), we document a very short persistency. This could be partly explained by the immediate response of the Italian Health Authorities, which conducted the proper investigations to restore public's confidence in vaccine safety in approximately 10 days. Also, an important difference with respect to the MMR vaccine-autism controversy is that in our case the flu vaccine per se was not under discussion, as the issue mainly concerned faults in the preparation or conservation process of selected batches. This is also confirmed by the fact that the negative effect of media reporting fades away even before the *Fluad* vaccine batches were re-introduced in the market, suggesting that the vaccination campaign continued with alternative producers' vaccines.

Finally, given that the specific area under investigation (the Metropolitan Area of Milan) is characterized by a lower vaccination rate compared to the rest of the country, we may expect the media reporting effect to be larger in case of a larger share of the population concerned

with the vaccination decisions, and thus, we may interpret our results as a lower bound of the effect in the whole country.

Our analysis is characterized by two main limitations. First, the analysis cannot account for the heterogeneous tone of news articles. As previously discussed, our measure of media reporting is likely to cover news items concerning both suspected death and public authorities recommendations on vaccine safety. Thus our findings should be interpreted as the net effect of a combination of news either in support or against vaccination (as in Andeberg et al. 2011). Nevertheless, the results on the persistency of the effects provides evidence on how the change in the main message of the news might have changed the vaccination take-up: in fact, the negative effect vanishes when media only reported news about the completed investigations which had proved no link between the cases and the vaccine.

Second, in terms of generalizability of the results, our analysis does not consider the effects of news reporting of adverse effects on other age groups (i.e., outside the 50 plus), or other (unrelated) vaccinations. While this is mainly due to data availability, we are convinced that the 50 plus population is the age group most concerned by the case. Official statistics from the National Health Institute show that the largest decline in flu vaccination take-up, between the 2013 and 2014 campaigns, occurred for the age groups 45-64 (2 percentage points) and 65 plus (6.8 percentage points), while the age groups below age 44 appear to be only marginally affected (0.6 percentage points).

Concerning the effects on other vaccinations, official statistics report a decline in all pediatric vaccinations starting from 2014, which, however, can hardly be linked to the case under study here. In fact, Carrieri et al (2019) and Aquino et al (2017) show that the decline is related to the increasing misinformation about the MMR vaccine on the internet. The literature suggests a link between the flu vaccination and other vaccinations for influenza-like diseases, such as pneumococcus or pandemic influenza (see, e.g. Chor et al. 2011, Böhmer et al. 2012). However, Larson et al. (2014) show that concerns about the risks of vaccination are specific to the type of vaccine and to the age group. This would suggest that, given the specificity of the flu vaccination, and the fact that the death cases only referred to old individuals, we could interpret our results as distinctive for the flu vaccination decisions by adults.

7. Conclusions and policy implications

We exploit a case study in which media reported the news of deaths potentially associated to adverse effects of flu vaccine, and show that an additional news item related to the case

induced a reduction in daily vaccinations by about 2.5%. This effect is shown to be short-lived as the vaccination behavior reverted to normality after about 10 days from the news outbreak.

Our results bear important policy implications on the way in which Health Authorities should act in order to reduce vaccine hesitancy, especially in case of adverse effects of vaccination. The first implication relates to the communication strategy that Health Authorities should adopt in case of unexpected events, like the ones considered in this paper. Our results show that beyond the immediate effect on individuals' vaccination behavior, probably due to a higher perceptions of risks associated with the immunization, the overall effect fades away as confidence in vaccine safety is restored. Nevertheless, we find that despite the initial positive statements about the lack of any evidence about the reported deaths and the vaccine by the Health Authorities, higher uncertainty in the public opinion about vaccine safety still induces hesitancy in vaccination behavior.

The second implication refers to the fact that in our case, as well as in the case of Wang et al. (2016) and Suppli et al. (2017), the vaccine batches allegedly linked to the adverse events were suspended by the NMA. The media reporting about the suspension of the batches could well have exacerbated the loss of confidence in the vaccine and contributed to the observed negative effect. Hence, as also pointed out by Signorelli et al (2015), our results highlight that Health Authorities, in case of adverse events of vaccination, should aim at re-establishing as soon as possible confidence in the vaccine, also weighting the benefits and costs of suspending the use of the vaccine.

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Appendix. Additional Tables and Figures

Table A.1. Robustness checks on the baseline results. Alternative specifications.

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. variable: VC						
News	-0.019***	-0.012***	-0.038***	-0.025***	-0.025***	-0.032***
	(0.004)	(0.003)	(0.009)	(0.007)	(0.007)	(0.012)
N	146	146	146	105	103	146
Specifications:						
News in t 0	Yes					
News in t-1		Yes				
News: 3-days MA			Yes			
Excl. weekends				Yes		
Excl. weekends and holidays					Yes	
Calendar day FE						Yes

Notes. Poisson fixed-effects (FE) regressions with SEs heteroskedasticity-robust and clustered at the campaign day level. Specifications in columns (1), (2) and (3) use alternative definitions of the *News* variable (i.e., respectively, news items appeared in the day of vaccination *k=0*, in the day before the vaccination *k=-1* and a 3-days moving average). Specification in column (4) uses calendar day fixed effects instead of campaign day fixed effects, with SEs heteroskedasticity-robust and clustered at the calendar day level. Specifications in columns (4) and (5) exclude, respectively, weekends, and both weekends and holidays (November 2, December 8, and December 7), from the analysis. Significance levels: * p<0.1, ** p<0.05, *** p<0.01. **Sources:** see Table 1.

Table A.2. Robustness checks on the baseline results. Alternative definitions of the *news* variable.

	(1)	(2)
Dep. variable: VC		
News	-0.027***	-0.370***
	(0.006)	(0.084)
N	146	146
Specifications:		
Newspapers only	Yes	
TV channel only		Yes

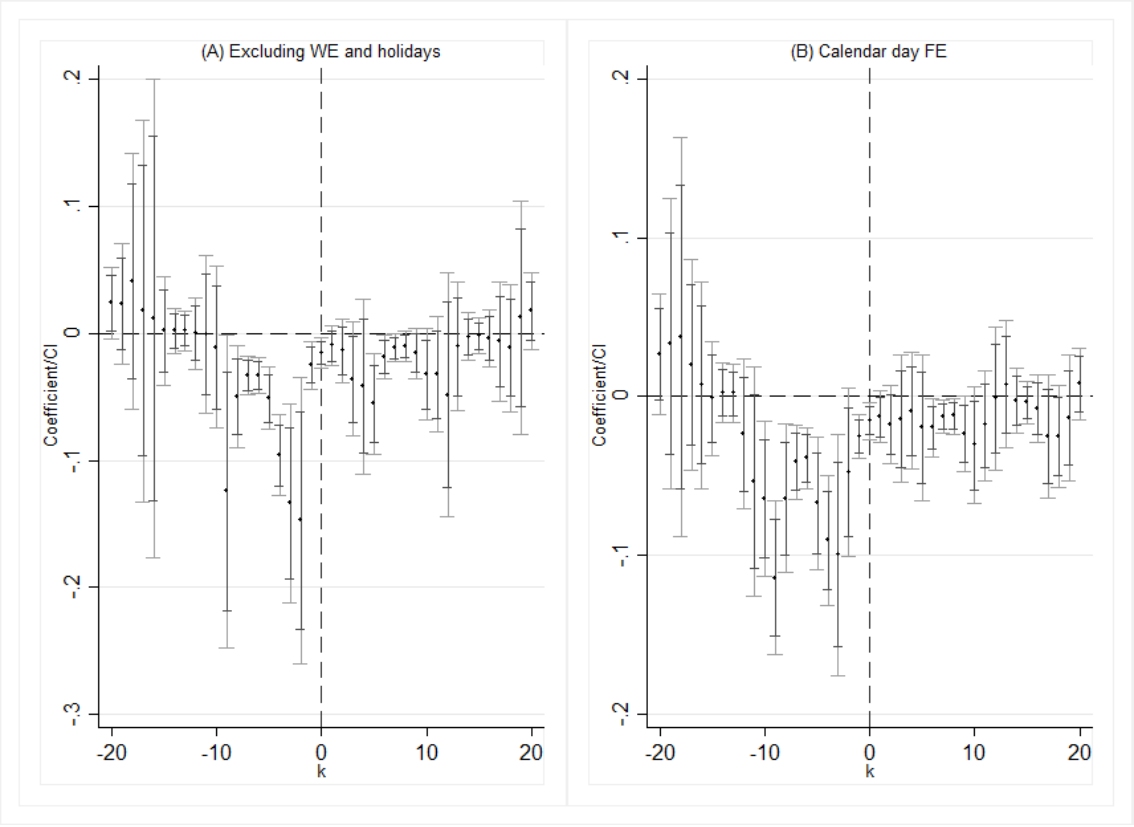
Notes. Poisson fixed-effects (FE) regressions with SEs heteroskedasticity-robust and clustered at the campaign day level. Specification in column (1) uses news only from the three newspapers surveyed; specification in column (2) uses a dummy which takes value 1 if in the day the news about the case were broadcasted in the all-news TV channel *SkyTg24*. Significance levels: * p<0.1, ** p<0.05, *** p<0.01. **Sources:** see Table 1.

Table A.3. Heterogeneous effects of media reporting on flu vaccination by age groups.

	(1)	(2)	(3)	(4)
	Dep. variable: VC			
News	-0.025***	-0.031***	-0.024***	-0.023***
	(0.005)	(0.011)	(0.005)	(0.005)
N	146	146	146	146
All controls and fixed effects	X	X	X	X
Baseline (50 plus)	X			
Age group: 50-64		X		
Age group: 65-79			X	
Age group: 80+				X

Notes. Poisson fixed-effects (FE) regressions with SEs heteroskedasticity-robust and clustered at the campaign day level. Significance levels: * p<0.1, ** p<0.05, *** p<0.01. **Sources:** see Table 1.

Figure A.1. Robustness checks on persistency.



Notes. The black dots depict the point estimates, the dark (light) grey lines the 99% (95%) confidence intervals, of Poisson fixed-effects (FE) regressions based on equation (2); negative (positive) values of *k* indicate news appeared *k* days before (after) the day of vaccination. Specification in the left panel (A) excludes weekend days and holidays; specification in the right panel (B) uses calendar day fixed effects; SEs are heteroskedasticity-robust and clustered at the campaign day level for figure in Panel A, and at the calendar day level for figure in Panel (B). **Sources:** see Table 1.