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"I'm not an antivaxxer, but...":
Spurious and authentic diversity
among vaccine critical activists

Florian Cafiero, Paul Guille-Escuret, Jeremy K. Ward

Abstract

The most common explanation for the current surge of Vaccine Hesitancy is that the Internet helps vaccine science deniers reach a wide audience. This explanation is challenged by the growing success of critics who present themselves as different from antivaccinationists, using phrases such as “I’m not antivaccine but. . . ” and promoting so-called “alternative vaccination schedules”. This could mean that antivaccinationists strive to appear more moderate than they are. But it could also mean that vaccines are being taken on by less radical activists. We compare these two explanations using the contents of a large sample of French-speaking websites. We qualitatively coded the contents of these websites, analysed their citation patterns and assessed their presence in mainstream media. We found that this milieu is fragmented. The most prominent activists only criticise some vaccines and disassociate themselves from the tightly-knit community of radical antivaccinationists. We also found that some appear as moderate while being deeply embedded in the community of radicals, indicating that their “moderate” stance is a communication strategy. These results suggest both explanations are simultaneously true. They apply to

different activists, highlighting the importance of exploring the diversity of contemporary vaccine criticism to understand vaccine hesitancy.

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1 Introduction

In the past two decades, doubts toward vaccines add- such as the belief that vaccines cause autism - have become an increasingly important global public health issue, putting the public at risk of epidemics of diseases such as measles (1). Nowhere has this trend been as spectacular as in France. In the past ten years, France has become one of the most vaccine hesitant countries in the world, with up to 40% of the population doubting the safety of at least some vaccines (1, 2). This rather sudden phenomenon has been all the more surprising that France does not have a long history of resistance towards vaccines, contrary to countries such as Great Britain or the United States of America (3). The first major vaccine scare only emerged at the end of the 1990s, targeting the Hepatitis B vaccine. However, doubts have really become widespread since 2009 with the multiplication of vaccine-related controversies around the safety of vaccines against the pandemic flu, human papillomaviruses, and the use of aluminum-based adjuvants (4). Because of the relative suddenness of the rise of doubts and their widespread nature, the French context sheds a unique light on the different pieces of the vaccine hesitancy puzzle. The spread of vaccine hesitancy always has multiple causes (5–7). But one explanation dominates the literature on vaccine hesitancy in France and in the other developed countries. Researchers have presented this trend as the effect of a resurgence of the antivaccine movement. This explanation boils down to the following argument. From their inception, vaccination campaigns have generated activists add - people who devote time and resources to convince other

people and/or obtain policy changes often as part of collectives - who reject the science behind vaccines add(i.e. antivaccinationist) (8, 9). In the past decade, the Internet has made it easier for them to unite, organize, and spread their arguments. The Internet has therefore given new weapons to the enemy in what is still the “age-old struggle against antivaccinationists” (8). This would explain the diffusion of doubts in the population (10–12). However, this explanation is challenged by reports coming from the United States of America, Great Britain and France. Specialists of vaccination have noted the growing success of critics who present themselves as different from antivaccinationists, using slogans such as “green our vaccines”, phrases such as “I am not antivaccine but...” and promoting so-called “alternative vaccination schedules” (13–17). It is possible to account for these public stances without abandoning the “age-old struggle against antivaccinationists” theory. These more moderate forms of criticism could reflect a shift in antivaccinationist activists’ communication strategies. Indeed, it has been shown that in more public settings, some antivaccinationists tend to favor arguments centered on additives and the alleged risks of specific vaccines, keeping their radical critique for more private settings such as activist assemblies or the less immediately visible pages of their websites (14–16). These less radical arguments would therefore merely be rhetorical tools, used by some activists as a gateway to the age-old ideology common to all vaccine critics: radical rejection of vaccination and modern science. However, qualitative studies have suggested that some vaccine critical groups never criticize the principle of vaccination, publicly praising most existing vaccines and actively distancing themselves from proponents of alternative medicines and conspiracy theories (14, 17, 18). A competing explanation of these public stances would therefore be that vaccines are being taken on by new activists, fighting for less radical ideologies such as consumer rights or environmental health (14, 19, 20). Their public stance of distancing themselves from antivaccinationists would therefore be genuine, making them all the more dangerous that their arguments can be perceived as more credible.

It is important to determine whether vaccine critics compose a united front of radicals or a fragmented landscape comprising mainstream social actors. Activists' arguments on vaccines and which political or cultural discourses they are anchored in determine a) whether activists work together and use their limited resources effectively, b) whether their arguments are deemed credible enough by journalists to warrant large exposure, and c) which sections of the public will be convinced by them (7, 21, 22).

In this paper, we confront these two explanations by mapping the network of French-speaking vaccine-critical activists. We approach these activists via the contents of their websites (text and hyperlinks). We analyze a sample of 254 websites built via a snowballing technique (for details, see materials and methods). We qualitatively coded these websites using a typology of vaccine critics inspired by existing studies (14, 17). This typology is based on two sets of distinctions (table 1) :

- between actors who reject any form of vaccination (radicals) and those who only criticize some (reformists);
- between actors for whom vaccination is only one among many subjects of interest and those who focus on vaccination.

The latter distinction draws on a classical dichotomy in sociology of social movements between single and multi-issue organizations, the latter being able to push forward specific issues by bundling them together and integrating them to a broader ideology (23). The public endorsement of Andrew Wakefield's false claims by prominent politicians such as Donald Trump is a typical example of the connection between single and multi-issue activisms. We also identified the websites promoting alternative medicines and conspiracy theories - two cultural traits commonly associated with antivaccinationism - and those created by doctors and elected officials because the former tend to be seen as more trustworthy and the latter are able to touch a

	Criticize all vaccines	Criticize some vaccines
Vaccine-focused	Single-issue radicals (SIRA)	Single-issue reformists (SIRE)
Not vaccine-focused	Multi-issue radicals (MIRA)	Multi-issue reformists (MIRE)

Table 1: Typology of vaccine critics

wide public (7, 15). By combining this qualitative coding, the analysis of the citation patterns between our websites and a measure of their mentions in most French-speaking mainstream media (see materials and methods), we tested three hypotheses deriving from the two explanations presented above. H1: Our first hypothesis was that there are actors who only criticize a limited number of vaccines and not vaccination in general (“reformists”). H2: Our second hypothesis was that reformists keep themselves at a distance from antivaccinationists (“radicals”) and do not interact with them. H3: Our third hypothesis relates to the importance of these various actors in the rise of controversies in the media. We hypothesized that reformists were the only ones to be highly visible in the media. H1 and H3 were fully corroborated and H2 only partially. We found that some reformists, including the most visible activists in the media, do maintain a rift between them and radicals. But we also found that some reformists are deeply embedded in the network of radicals, suggesting that their position reflects a choice of communication strategy rather than a real ideological difference with radicals.

2 The diversity of vaccine critics

As early as the beginning of the 19th century, antivaccine movements across the global North coalesced a wide variety of actors. They were brought together either because vaccination was incompatible with their medical philosophies or because they were against the idea of the state intervening in the public’s health. The principle of vaccination was discovered in 1796 by Edward Jenner. From then on, this public health practice has regularly met with resistance.

During most of the 19th century, vaccination mainly consisted in creating a small wound on someone's arm and applying on it some lymph extracted from a cow or a human infected with a weaker form of smallpox (24). This practice ran counter to some deeply entrenched conceptions of health held not only by the public, but also by some of the most prominent doctors of the time. Let us not forget that the science behind the principle of vaccination was only settled around the end of the 19th century with decisive advances in microbiology. The nature and efficiency of vaccination was therefore not only a subject of debate outside of the scientific world but also inside of it - even if more and more marginally as the decades passed. A wide variety of medical practitioners and proponents of medical philosophies were found among the antivaccination movements of the 19th century and early 20th century. They comprised doctors who abided with the medical theories evicted from mainstream science such as various forms of vitalism and interpretations of the theory of humours (3, 18, 24–26). But they also included many defenders of alternative medicines such as homeopathy, chiropraxy and naturopaths (18, 25, 26). Arguments against the scientific principle of vaccination also came from members of other social movements centred on health and medicine such as Christian Science and antivivisectionism (18, 25–27). According to these activists' medical philosophies, vaccination is dangerous because either a) viruses play a minor role in the person's health and pharmaceutical interventions interfere with the natural balance of the body; b) this intervention interferes with God's plans for each one of us; or c) it violates each person's purity by introducing fluid from other persons or species. Proponents of alternative medicine are still found among the most prominent contemporary deniers of the science of vaccines. For instance, studies performed on English-speaking websites, on participants to debates around the 2009 pandemic flu vaccination campaign in France, to debates around the link between autism and measles vaccination in England and the United States of America have showed a strong presence of defenders of radical forms of homeopathy and naturotherapy, of crystal healing and of new age medicine – to name

just a few (13–17). The study of contemporary forms of vaccine criticism in the English and French speaking world has also shown that many activists who reject vaccination come to this issue via their interest for politically radical ideologies such as extreme forms of libertarianism and environmentalism, fascism and conspiracy theories (14, 15, 18, 26, 28, 29). This is not new either. Historians working on the British antivaccine movement of the second half of the 19th century and on the American movements of the first half of the 20th century have also found this connection with political movements who deny any legitimacy to the State and its institutions (25, 30, 31).

But to understand the rise of vaccine-related controversies and of vaccine hesitancy, it would be a mistake to focus solely on these radical critiques of vaccination in general. Indeed, this tendency in the public health literature to concentrate on the most exotic types of discourses (see for instance (8)) diverts attention from the many instances when criticism of vaccines has dovetailed with legitimate ethical and political concerns (27, 32). The British antivaccine mobilisations of the 19th century were largely embedded in a wider movement against the Victorian State's government of poverty (25, 33). The great anti-vaccine riots of the 1900s in Brazil were also a response to the unfair treatment of the poor and minority groups (34, 35). In both cases, the connection with more mainstream political issues of the time came from the integration of these issues in vaccine critics' discourses but also to relationships built between the central actors of the vaccine critical movement on the one hand, and, on the other, political activists and politicians. This connection helped vaccine critics gain a wider audience and led to vaccination becoming a central issue in the political discussions of the time. This was also the case in vaccine critical mobilisations in the United States between the 1970s and 1980s. Vaccine critical activists created connections with feminist movements and the consumer rights movement. They adopted new types of arguments as well as new forms of collective action which led to public debates over the safety of the Diphtheria Tetanus and Pertussis vaccine in the early

1980s (20). In most of these cases, the implementation of mandatory vaccination has facilitated this connection between activism centred on vaccination and wider and more mainstream political movements. Next to these less radical political arguments, recent scholarship has also underlined the importance of investigating the diverse forms of medical arguments used by vaccine critics that go beyond the simple rejection of the principle of vaccination. Elena Conis insists on the evolution of the definition of “nature” by vaccine critical activists after the Second World War (20). She shows that early vaccine critics saw vaccines as un-natural simply because they were man-made and elicited an “artificial” form of immunity. But recent critics tend to focus more on the various chemicals contained in vaccines in a context where the environmental movement has sensitised a large part of the public to the risks of chemicals in domains such as food and agriculture (see also (13, 36). In her book on current rejection of vaccines in the United States, Jennifer Reich describes the emergence of a “slow vax movement” pushing forward the idea that children get too many vaccines too soon in their life and rallying behind an “alternative vaccination schedule” (13). These forms of critique do not imply a rejection of the principle of vaccination and other studies of contemporary vaccine-critical movements have described the existence of such actors who only criticise some vaccines, some products contained in vaccines or some aspects of vaccination policies (14, 17, 36).

This less radical positioning is understandable given the evolution of vaccination in the past century. Vaccines have increasingly become the symbol of scientific progress and rejecting vaccines as a whole leads to being publicly labelled as anti-science (19, 27, 32). The terms “antivaccinationist” or “antivaxxer” have become a stigmatising label all critics grapple with in their quest to gain new followers and resources, obtain the abrogation of legal mandates or benefit from compensation schemes for purported side effects caused by vaccines (37, 38). Work on groups of purported victims of vaccines formed in the past 30 years in the US, in France and in Great Britain has shown that because their main goal is to obtain financial compensation, they

have to appear credible in court. This entails avoiding being labeled as vaccine science deniers and therefore focusing on arguments that only target a specific vaccine or product contained in vaccines (16, 17, 39). Such a positioning is also necessary for these groups of purported victims in order to form alliances with actors from mainstream political parties or social movements. In his study of French mobilisations against the 2009 pandemic flu vaccine and the use of aluminium-based adjuvants, Jeremy K. Ward shows that the ability of a group of purported victims of adjuvants to organise acts of protest with prominent members of the environmental health movements and the French Green party helped them feature regularly in France's main news outlets in the past 10 years (4, 14). To better understand their ability to bear on public debate and policies, Ward proposes a framework classifying the various types of vaccine-critical actors. Following Pru Hobson-West (Hobson-West, 2007), he proposes to distinguish between actors who reject all vaccines ("radicals", members of "antivaccine movements") and those who only criticise some ("reformists", members of "vaccine critical movements"). He also proposes to distinguish between actors whose main focus is vaccines ("single-issue" vaccine critics such as groups of purported victims of vaccines) and those for whom vaccines are only one element in their repertoire of issues ("multi-issue" vaccine critics). This labelling of actors allows to map out the variety of social movements commonly lumped together in studies "of antivaccine movements". Drawing on the existing literature on moderate forms of vaccine-critical activism and vaccine hesitancy, he then makes explicit the hypothesis that "reformist" vaccine critics rather than "radicals" are at the inception of the large-scale vaccine scares of the past decades in the global North (40). This hypothesis is not the only one that needs testing. Social scientists seem to disagree on the genuineness of these "reformist" stances. Are cries of "I'm not an antivaxxer but" just a rhetorical strategy destined to hide a more radical agenda (15, 16), or are they genuine and accompanied by a refusal to participate in common actions and to be seen together (36, 39) ?

3 Material and methods

We studied a corpus of 254 French-speaking websites, selected based on a close-reading of their vaccine-related contents. We collected our database in the following way. During a period of approximately six years, we analysed the controversies pertaining to vaccines in French-speaking countries via both qualitative and quantitative methods drawing on media contents, Google keywords searches and qualitative interviews (ANONYMOUS). This allowed the identification of 69 vaccine-critical websites, including those of all the prominent actors of these controversies. Using the Web crawler Hyphe (41), we analysed the external links of these websites, to see which sites were cited by this group. We obtained a list of 4485 websites. Following the standard methodology for the study of vaccine criticism on the internet, we excluded, non-French language websites, commercial websites, academic pages, libraries as well as media or media-related pages (15). For the remaining websites, we examined the pages containing vaccine-related keywords to determine whether they criticized at least one recommended vaccine. This crawling allowed to expand our initial sample to 254 French-speaking websites. We thus created a corpus of 27292 HTML pages and their external links collected between March, 23rd and March, 30th 2017.

3.1 Annotation of the pages

In a previous study (ANONYMOUS), we observed that machine learning could separate pro-vaccine texts from vaccine-critical texts, but was unfortunately insufficiently reliable to distinguish reformist criticism from radical criticism. Here, we annotated the websites based on close reading of their pages dedicated to vaccines or vaccine-preventable diseases. Each website criticizing the very principle of vaccination, or 10 vaccines or more, was labeled "radical". Other websites were labeled "reformists". We read all the pages of each website until we found evi-

dence of this radical stance. This means that reformist websites were read entirely while radical websites have sometimes been read only partially. Each website which had vaccines for main topic was labeled "single-issue". Websites for which vaccines were one issue among others were labeled "multi-issue". A sample of 70 websites were coded by two of the authors (A2 and A3) to assess intercoder reliability (very satisfying: Krippendorff's α : 0.88 for the radical vs reformist annotation, 0.82 for the four-value typology). A2 and A3 each coded half of the remaining sample. Single issue websites were crawled entirely while we only crawled the pages dedicated to vaccination on multi-issue websites. This choice was made to avoid generating too many false positives to allow for our qualitative sampling procedure.

3.2 Addressing the commentary sections

Commentary sections allow anyone to publish material on another individual or groups' website, and in particular, to share hyperlinks. Yet, it does not mean in any way that the site's owner(s) agrees to these contents. In the case of a controversial topic such as vaccines, finding comments actually opposing the content of the page is very likely, which can bias our analyses.

Unfortunately, web crawlers are unable to distinguish the "commentary" sections from the rest of the page, as they can be coded in numerous and sometimes unpredictable ways. We therefore had to systematically read the HTML code of the 157 websites allowing comments on their pages. We identified the tags demarcating the beginning and ending of each website's "commentary" section, then systematically removed the comments and the associated links from our database.

3.3 Activists' visibility in the media

To assess our actors' visibility in the media, we drew on Europresse, a reference when it comes to studying not only the French press, but more globally the French-speaking press ((42)). This database archives 1562 French speaking sources, including many print or online media from France, Belgium, Canada and Switzerland. We systematically looked for mentions of their names during a period ranging from January 1st, 1990 to April 1st, 2017 (after the end of our data collection) in French-Speaking print media. The year 1990 was a turning point in the history of vaccine critical movements in France. Following internal dissensions and a decade of decline, the main vaccine-critical organization (the National League for Vaccination Freedom), split in two, leading to a new era for vaccine-critical mobilisations (43). We also drew on the INAthèque database which collects all television and radio sources in France and labels the sections with the names of the people appearing or being mentioned (Annex B).

3.4 Exponential Random Graph Models (ERGM)

We used Exponential Random Graph Models (ERGMs) (44) to model the citation network between vaccine critical activists. In these models, the dependent variable is the structure of the network we study. To understand if a specific local pattern is a statistically significant phenomenon or not, the structure of the network studied is compared to a large series of simulated networks sharing the same basic properties. If the prevalence of the structure in the simulated networks is, on average, sufficiently different from the structure of the observed network, the phenomenon is deemed significant. The parameter estimates (*Estimate* in table 2) indicates whether a particular mechanism occurs more or less frequently than expected at random.

Two structural terms were included in all our models. The propensity to post hyperlinks towards other vaccine critical websites was captured by the term *edges*, evaluating the number

of ties, and thus, the relative density of the network. To evaluate the tendency of actors to cite a website that is citing them, i. e., the reciprocity of links in the network, we included the term *mutual*. Because of the particular form of this network, and notably because of its low density, we were unable to add other structural parameters such as triadic closure without inducing degeneracy (45).

Beyond structural patterns, our models helped us assess the importance of the specific attributes we defined. The first attribute was mostly a control attribute. In our corpus, the type of website observed could influence the citation behaviors. For instance, do individual bloggers cite indifferently other blogs and official websites of an association or political party ? To capture this effect, we computed the propensity to form a link with a site of the same type (*homophily according to website type*" in all our models. We then tested three ways of grouping our actors together. The first model (Model 1) estimated the tendency of actors to post a hyperlink pointing towards a website of the same category in our typology of actors, without differentiating according to types (*Homophily according to website positioning*). In Model 2, we replicated the former model, but distinguish between radical actors and reformist actors (*homophily between: radicals ; reformists*). Model 3 proposed to refine even further, computing homophily for each sub-category of website (single-issue radicals / multi-issue radicals / single-issue reformists / multi-issue reformists).

4 Results

We found that radical websites compose a larger share of our sample (57.5% of websites) than reformists. Single-issue websites are significantly less frequent (6.3 % of single-issue radicals' websites, 5.5% of single-issue reformists' websites) than multi-issue websites.

Among our reformist websites, 20 were set up by doctors, four by purported victims of

	Individual	Organization
Single-Issue Radical (SIRA)	10 (10.20)	6 (5.80)
Single-Issue Reformist (SIRE)	8 (8.93)	6 (5.07)
Multi-Issue Radical (MIRA)	96 (82.91)	34 (47.09)
Multi-Issue Reformist (MIRE)	48 (59.95)	46 (34.05)
Pearson’s chi-squared test	p-value= 0.0057	

Table 2: Counts table of the various websites and Pearson’s chi-squared test, divided between individuals and organizations, and according to our typology of vaccine-critical activists. The theoretical counts under H_0 are shown in brackets.

vaccines and 12 were the official pages of elected politicians and their political parties. Among the radical websites of our sample, we found no official website of elected politicians and only four were created by doctors. Proponents of alternative medicine and conspiracy theories could mostly be found among radicals (48 radicals vs 16 reformists for the former, 58 vs 7 for the latter).

4.1 An apparently cohesive community

The graph displaying all the links between those websites (fig. 2) does not seem to indicate a clear separation between radicals and reformists. The clustering index is rather low (0.25). Using the Louvain method for community detection (46) with standard resolution (1), we observed a rather small modularity (0.26), and 9 hardly homogeneous clusters. To get smaller and more interpretable clusters, we run the same Louvain algorithm with resolution 0.5 and detected 14 communities (new modularity: 0.2). (fig. 1)

The relatively high edgewise reciprocity (18%, compared to 3.5% in average for simulated networks with the same density and number of edges – S.I.2) could also lead us to think that all

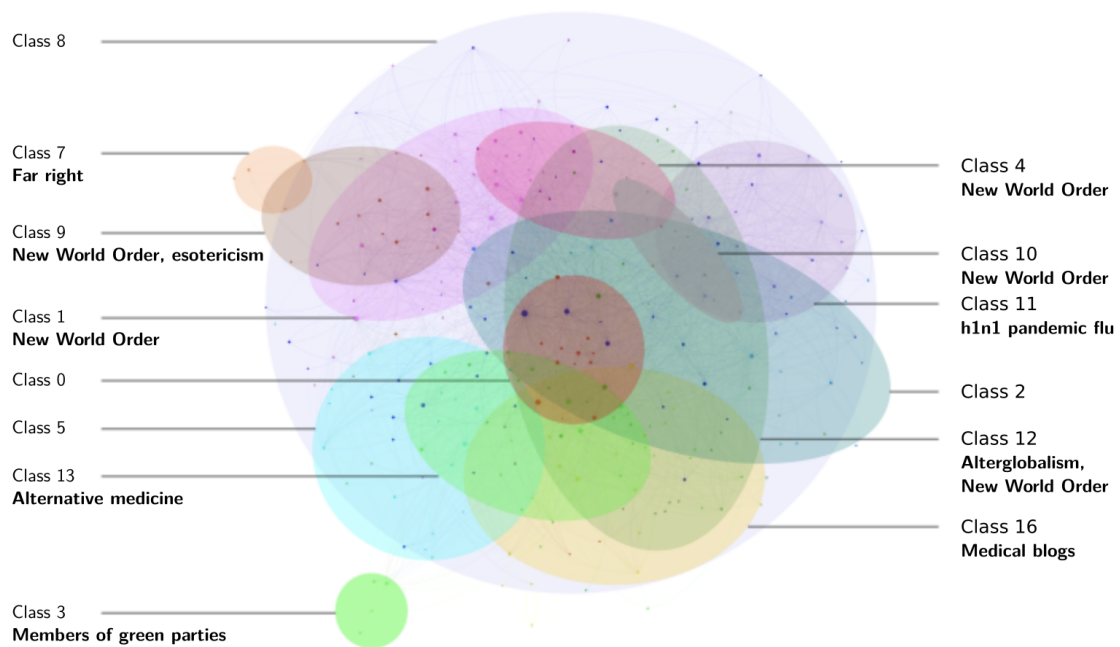


Figure 1: Interpretation of the communities detected through a Louvain modularity algorithm. Communities are labeled with the most frequent "cultural attributes" when they represent a majority of the cluster's nodes, and not labeled otherwise

vaccine critics are part of a rather cohesive group.

The organization of this seemingly cohesive community is not random. First, its most central nodes are mostly radical websites (fig. 2). We computed a rank prestige of all the edges, by weighting their indegree by the indegree of the sites citing them (Annex A). Its values show an unequivocal overrepresentation of radical websites, which constitute more than two thirds of the first decile for rank prestige. Among them, Single-Issue Radicals are particularly influent, representing 5 out of the top 10 websites for prestige, while they only represent 5.5% of the sample. (S.I.3 and fig. 2). The connections observed between websites also seem to follow a particular pattern. Exponential-Random Graph (ERGM) models show that, for a network with those properties, websites sharing the same type of position towards vaccines are excessively likely to be linked through at least one hyperlink (table 3). This effect is differentiated, and driven by the most radical members of our sample. Radical websites seem to be more likely to have links between one another. On the contrary, reformist websites are linked to more diverse contents. At first glance, we could thus think that vaccine critics form a coherent social movement: a sphere with a core of radical activists, drawn to conspiracy theories and supporting alternative medicines, spreading their ideas to less and less radical and invested actors.

4.2 The gap between Radicals and Reformists

However, this intuitive image of the antivaccine movement is misleading, and driven by the citing behaviour of single-issue radical websites. ERGM models show (table 2) that radical activists are indeed significantly and largely more active in citing compared to reformists. By creating numerous links, towards sites sharing their extreme views, but also towards reformist websites, they artificially aggregate the network around them.

When looking more closely at the citation patterns (fig. 3), we observe that reformist websites preferentially cite other sites of their own category. Most of their connections with radical

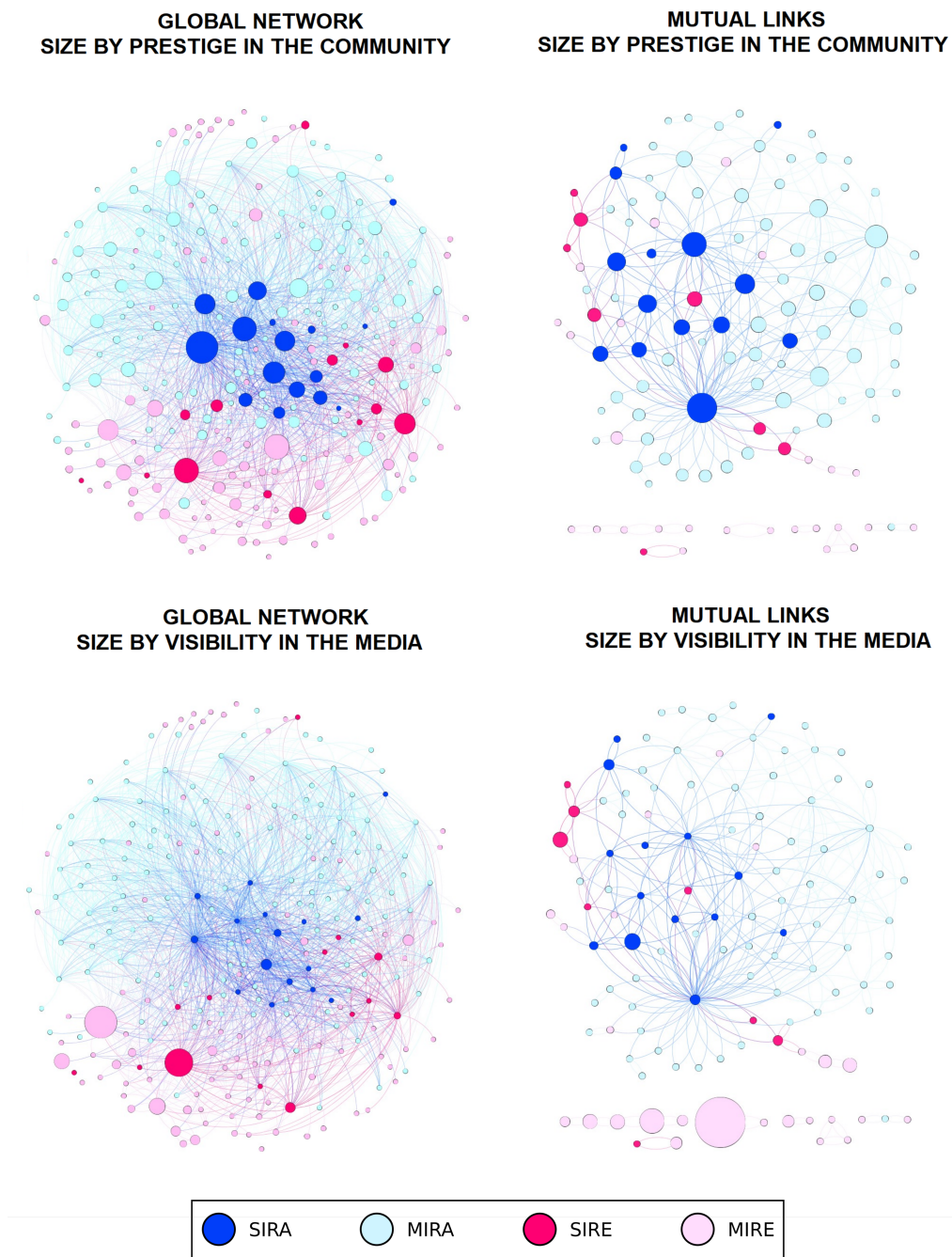


Figure 2: On the left, graphs of the network of all the links between the 254 websites. On the right, graphs of the mutual links between those websites. At the top, nodes are sized according to the rank prestige in the community. At the bottom, nodes are sized according to the frequency of appearance in the media. Graphs are spatialized thanks to a force-based algorithm, Force Atlas 2 (47)

websites are incoming links, not outgoing. Being cited by somebody does not mean that you are actually ideologically close to them.

This lack of reciprocity between reformists and radicals is particularly apparent when we focus on reciprocal citations. Citing back someone who cites you means that you at least acknowledge the existence of someone, and in general, that you share some common views. When looking into this phenomenon of mutual linking, we observe that, while radicals form a rather coherent group, most multi-issue reformist websites are completely separated from radical websites (fig. 2). For instance, 74 of the 108 reformist websites never cite radicals. They cannot be qualified as a community either. They are weakly connected to each other, grouped in isolates of two to five websites.

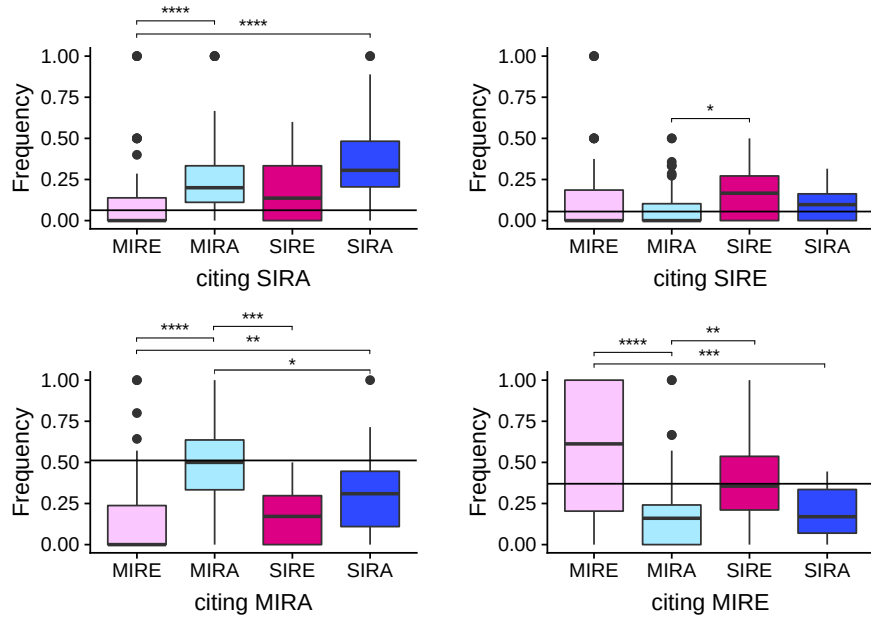


Figure 3: Citation patterns across the various types of vaccine critical addwebsites: boxplots and Wilcoxon-Mann-Whitney tests. P values: *: $p \leq 0.05$ **: $p \leq 0.01$ ***: ≤ 0.001 ****: ≤ 0.0001 . Reading: in the first graph (top left corner), the distribution of the frequency of citation of MIRA websites by MIRE websites is drawn in light pink.

4.3 Prestige in the community, anonymity outside: reasons for a disguise strategy?

There seems to be an almost inverse relationship between popularity in the media and prestige inside the vaccine critical community. Most of the actors associated with websites in our cited in the press are Reformists, while prestigious Radical actors are barely or never cited (fig. 2). Reformists constitute for instance ca. 85% of the top 10% most cited actors (FIG S.I.4).

This discrepancy could explain why Multi-Issue Reformist websites are split into two groups. For a vast majority of them, it is striking that no mutual link was ever formed between a radical website and their own website. (fig. 2). Yet, a significant number of them are actually strongly involved in the radical community. The difference between these sites's reformist discourse and their radical friendships could be the sign of disguise strategies: to avoid being labeled as "anti-vaxxers", some radical vaccine-critical actors would censor their speech on their websites, while still being strongly connected to their community.

5 Discussion

Drawing on the contents of a large sample of websites, we found that the milieu of French-speaking vaccine critics is fragmented. On one side, radical antivaccinationists constitute a tightly-knit community where antivaccine non-profits, conspiracy theorists and proponents of alternative medicines exchange any type of argument as long as it is critical of one or more vaccines. On the other side, some reformist activists – including doctors and prominent politicians - strive to disassociate themselves from this community. They do this by focusing their arguments on a limited number of vaccines and substances present in vaccines and by only connecting with other “moderate” critics or by avoiding connecting with anyone – what sociologists call “boundary work” (48). This group comprises the most visible activists in the media. We

	Model 1	Model 2	Model 3
Density	-3.644*** (0.0369)	-3.619*** (0.041)	-3.628*** (0.038)
Reciprocity	2.088*** (0.090)	2.069*** (0.087)	2.058*** (0.092)
Nature of the website - homophily	-0.067 (0.045)	-0.080 (0.044)	-0.088* (0.044)
Type of vaccine-critical activist - uniform homophily	0.177*** (0.044)		
Radicals (SIRA + MIRA) - homophily		0.277*** (0.046)	
Reformists (SIRE + MIRE) - homophily		-0.271*** (0.073)	
Single-issue radicals (SIRA) - homophily			-0.107 (0.410)
Multi-issue radicals (MIRA) - homophily			0.359*** (0.048)
Single-issue reformists (SIRE) - homophily			0.08342 (0.414)
Multi-issue reformists (SIRE) - homophily			-0.292*** (0.078)
Akaike Information Criterion (AIC)	17042	16984	16968
Bayesian Information Criterion (BIC)	17078	17020	17031

Table 3: Exponential Random Graph Models: network properties and homophily according to the type of vaccine-critical website. Standard errors are shown in brackets. ***: $p < .001$; **: $p < .01$; *: $p < .05$. Goodness of fit diagnostics and sample statistics are provided in fig. S.I.5, S.I.6, S.I.7.

also found that not all reformists maintain this distance with radical antivaccinationists. Only half of reformist websites never cite radical websites. These results suggest both explanations of the emergence of slogans such as “green our vaccines” and “I am not an antivaxxer but...” are simultaneously true: they reflect both a communication strategy chosen by some radical activists who try to present themselves as more moderate than they actually are, and the choice to distance themselves from radicals made by other activists who genuinely only have issues with some vaccines. Each account applies to different activists, highlighting the importance of exploring the diversity of contemporary vaccine criticism.

Our findings have important implications for current debates on the upsurge of doubts toward vaccines and on the ways to restore trust in them. Recent research on vaccination behaviors shows that, in most cases, negative attitudes do not consist in radical rejection of vaccination in general (“antivaccinationism”) but rather in diffuse suspicion, schedule delays or rejection of a limited number of vaccines perceived as controversial (“vaccine hesitancy”) (5, 6). Our findings suggest that this is likely to be the effect of the behaviour of vaccine critical activists who rarely put forward arguments rejecting vaccination in general. It is therefore important, when analysing vaccine-critical arguments, to move beyond the current focus on their erroneous nature and conspiratorial tendencies. Instead, we should pay closer attention to the various ways vaccine critics build their arguments and how they anchor these arguments on vaccines in wider cultural and political discourses. These choices of political and cultural anchoring determine who is likely to be convinced by their arguments (7, 49, 50) but also, in an era of filter bubbles and polarization, in which social groups they are likely to circulate (51, 52). Also, for almost a decade now, specialists of attitudes to vaccines have underlined the limitations of communication strategies that mistake Vaccine Hesitancy with Antivaccinationism (7, 53, 54). Turning hesitants into antivaccinationists can be one form of backfiring effect (49, 53). Indeed, when some parents feel they are not taken seriously by mainstream healthcare providers, or when

their position is likened to anti-science or conspiracy theories, they turn closer to sources who reinforce their beliefs (55, 56). This has become a widely accepted fact (7, 55, 57). But its implications for public discourses on vaccine-critical activists have not been widely recognized. Indeed, in a context where many vaccine critics present themselves as “not antivaccine” the tendency of public health officials and experts to call all reformist activists “antivaxxers” can paradoxically make them appear more credible to part of the public by suggesting their arguments have not been examined carefully (58). Researchers working on Vaccine Hesitancy promote a tailored approach to the various types of reluctant patients. It is also crucial to devise a tailored approach to the various types of activists to win public debates (58) rather than abandon the stage to vaccine critics as some experts suggest (7).

This study has several limitations. Because there is no available tool to our knowledge that extracts time stamps for each webpage and its outgoing links, our analysis does not account for temporal transformations of this network. Coalitions build and dissolve across time (21, 23). However, this limitation does not affect our main finding that the landscape of vaccine-critical activism is fragmented. Many reformists never cited any radicals across the whole life-span of their websites. The sampling procedure could also introduce biases. Our initial sample contained a majority of French websites. This could entail an over-representation of French activists in our final sample, to the detriment of Belgian, Swiss or Canadian activists for instance. However, this over-representation also reflects both differences in overall population and the recent dynamism of vaccine-critical mobilisations in France (59). The generalizability of this finding constitutes a third issue. Our study focuses on French-speaking countries such as France, Belgium or Quebec. Future studies will tell whether this fragmentation exists addother countries where reformist mobilizations have emerged in past years.addWhile the precise characteristics of social movements are very context-specific, we expect these findings would be replicated in other countries since vaccination seems to have become a symbol of science and

progress at the global level. We also approached the relationships between reformist activists via the contents of their websites and their citation patterns. While the internet is an increasingly important platform for activists, their contacts take place in a variety of settings such as street protests, symposiums, or informal gatherings (21). Activists and organizations can carefully select what they publish on their websites to polish their image (60). It cannot be excluded that some activists effectively managed to not signal, at any time and on any page of their website, their proximity with more radical actors.

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A Prestige measures

To measure the prestige of an actor in a directed network, a simple measure is the *Indegree prestige* - simply counting the number of edges pointing to a specific node.

Being cited by a much cited actor is however different from being cited by a very isolated actor. To correct for this bias, we compute a simple *Rank Prestige*, weighting our Indegree Prestige by the Indegree Prestige of the actors citing a specific node.

B Media exposure measurement

To monitor the media exposure of actors related to our websites, we looked for references to them in French-speaking press through the Europress database (www.europresse.com/). We also drew on the INAthèque database which collects all television and radio sources in France and labels the sections with the names of the people appearing or being mentioned . We systematically looked for the appearance of the website's name in the body or metadata of French-speaking press releases, published from January 1st, 1990 to April 12th, 2017, containing at least once the radical "vaccin-". When known, we looked for the main contributors' names or aliases. We checked the results for false positives - as homonyms who would also talk about vaccines are rare, yet not nonexistent. Database S1 gathers all the queries we ran, and the associated results. Database S2 indexes all the media we queried.

Websites appearing in the media at least once are displayed in figure S2.

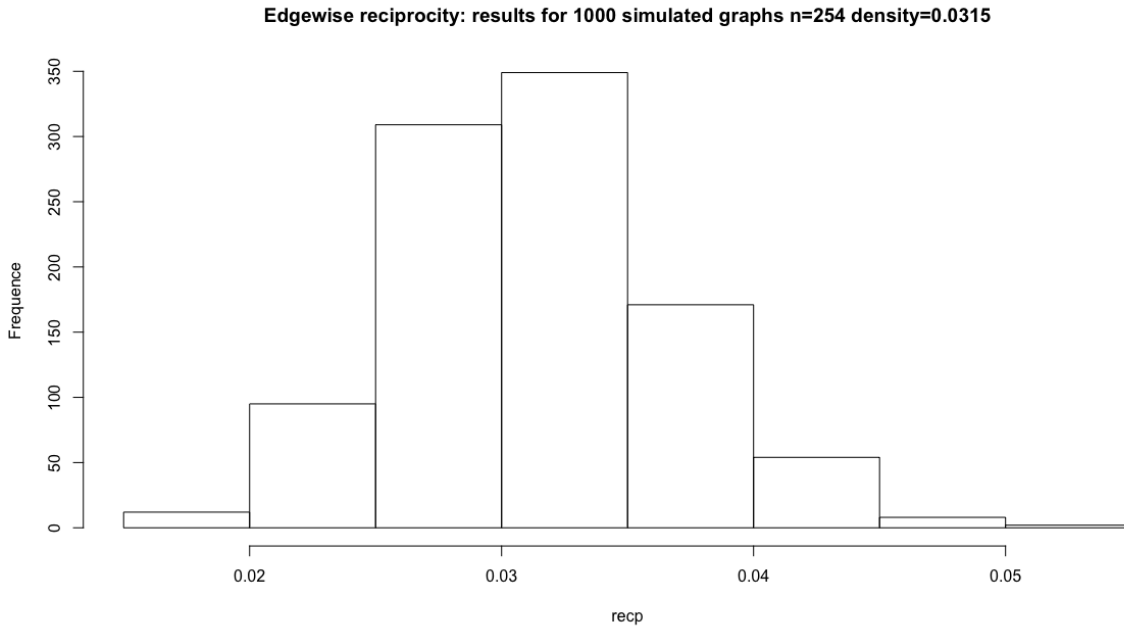


Figure S.I. 2: Simulated reciprocity for 1000 graphs with similar density and number of nodes as our network.

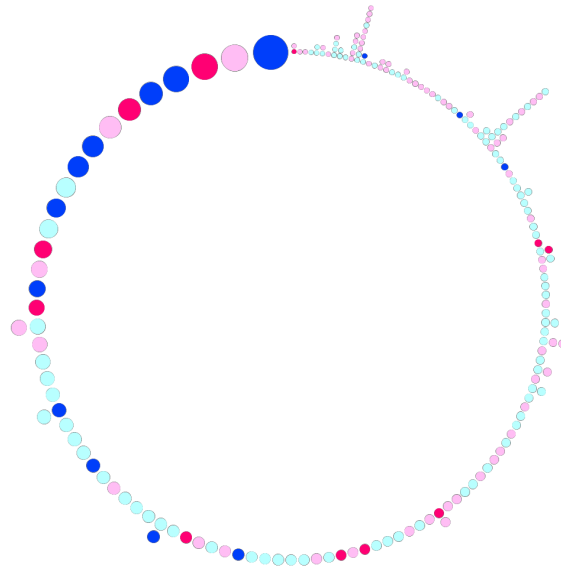


Figure S.I.3: Websites ranked according to their rank prestige in this network. Nodes' size is proportional to the number of citations. In dark blue, single-issue radicals ; in light blue, multi-issue radicals ; in red, single-issue reformists ; in pink, multi-issue reformists.

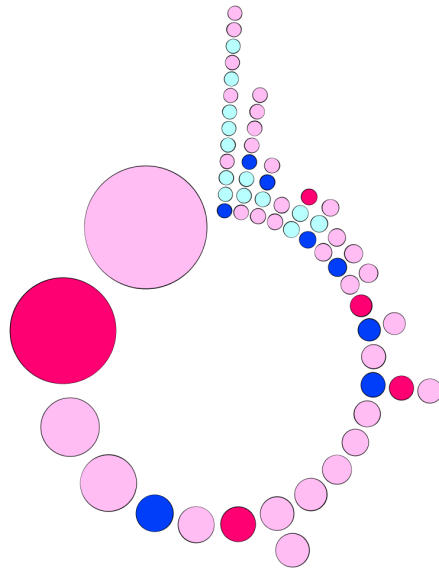


Figure S.I.4 - Websites appearing in the French-Speaking press at least once. Nodes' size is proportional to the number of citations. In dark blue, single-issue radicals ; in light blue, multi-issue radicals ; in red, single-issue reformists ; in pink, multi-issue reformists.

C Datasets

- `Europresse_citations.csv`: Appearances of anti-vaccine actors in French-Speaking press: keywords used in Europresse and INATHèque, number of confirmed appearances
- `Europresse_sources.csv`: Appearances of anti-vaccine actors in French-Speaking press: sources chosen in the Europresse and INATHèque databases

D ERGMs - Goodness of fit and sample statistics

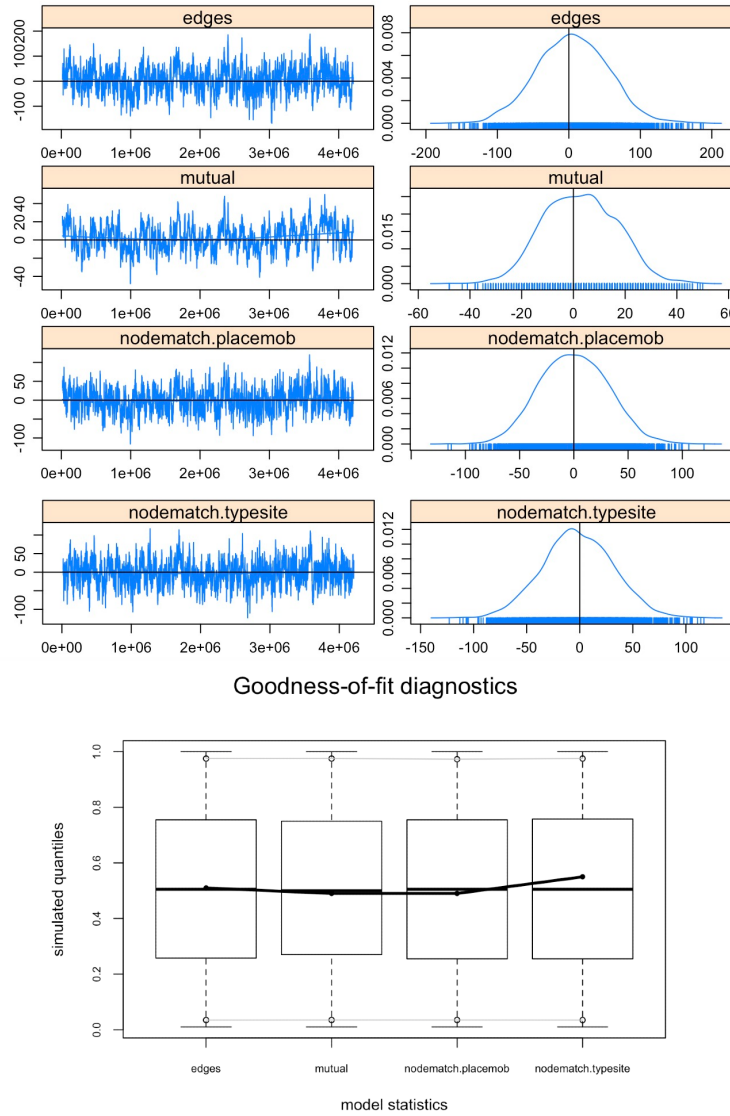


Figure S.I.5 - Goodness of fit and sample statistics for ERGM model 1

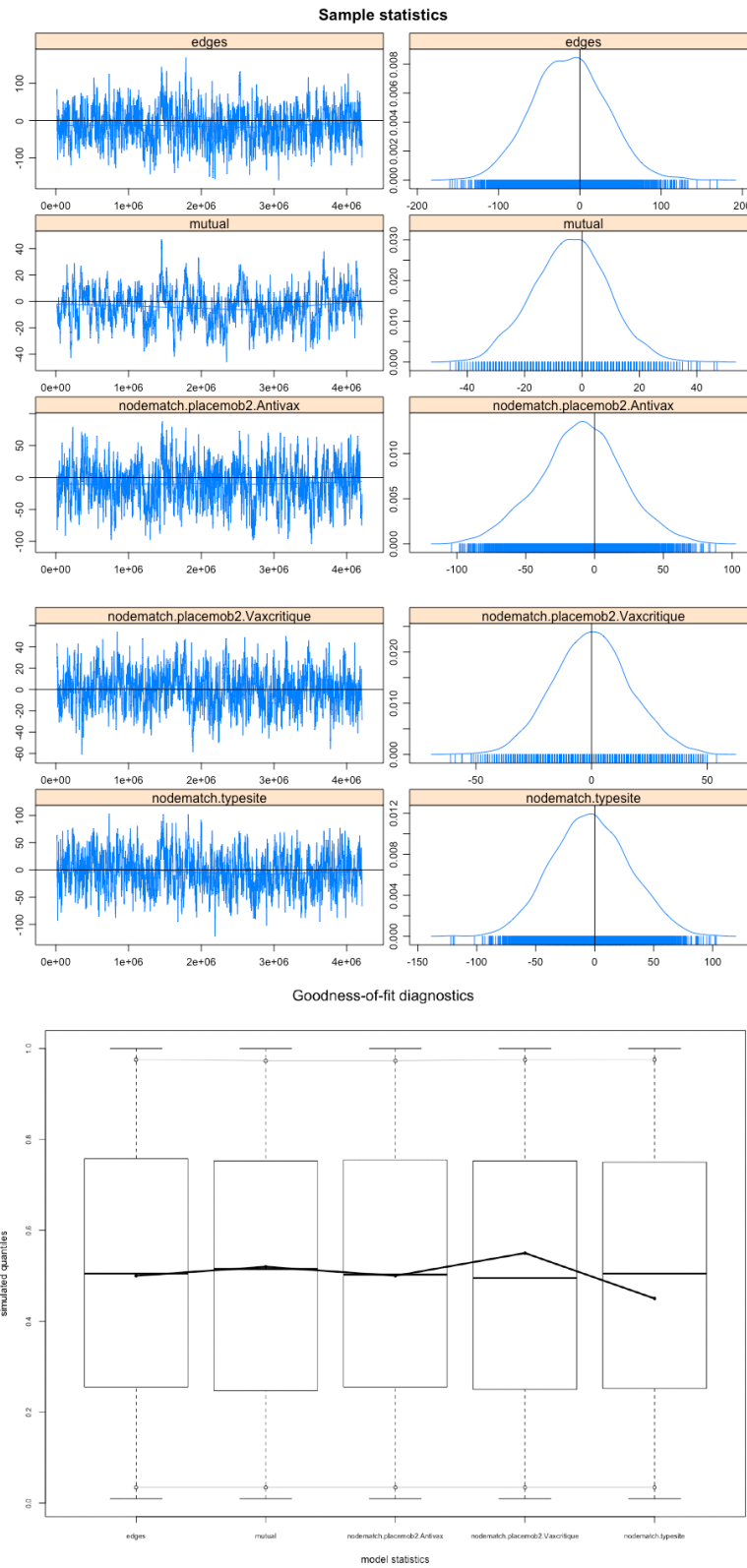


Figure S.I.6 - Goodness of fit and sample statistics for ERGM model 2

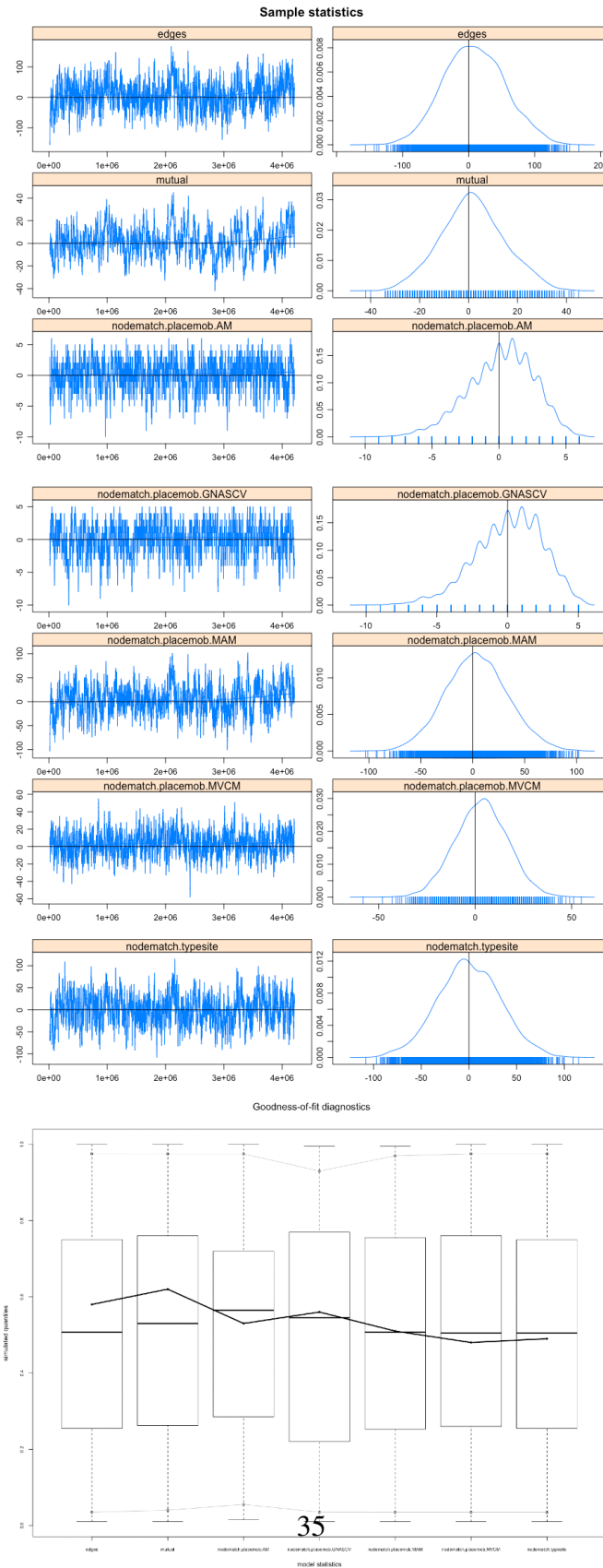
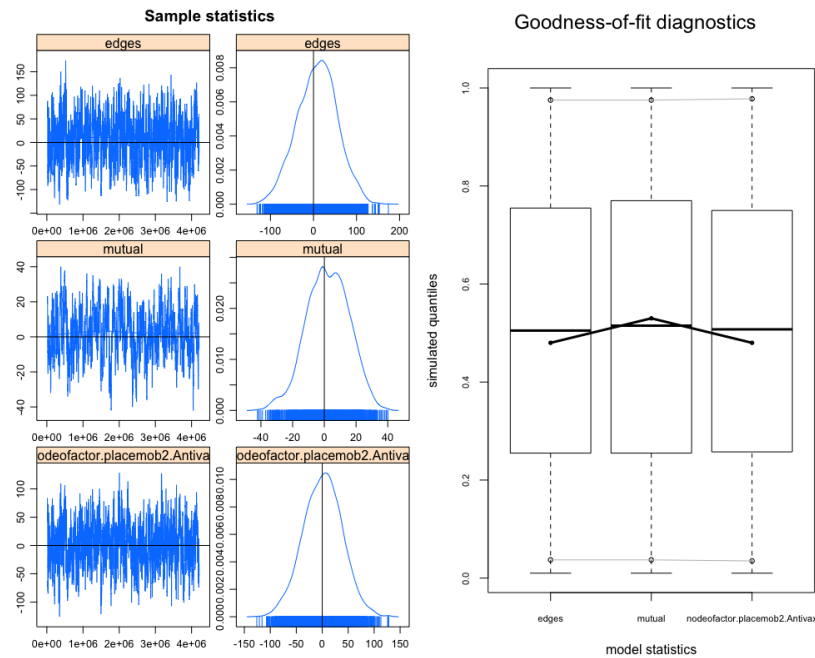


Figure S.I.7- Goodness of fit and sample statistics for ERGM model 3



Summary of model fit

Formula: $\text{nonrec} \sim \text{edges} + \text{mutual} + \text{nodeofactor}(\text{"placemob2"}, \text{base} = 2)$

Iterations: 2 out of 20

Monte Carlo MLE Results:

	Estimate	Std. Error	MCMC %	z value	Pr(> z)
edges	-3.80846	0.04199	0	-90.705	<1e-04 ***
mutual	2.10875	0.09050	0	23.300	<1e-04 ***
nodeofactor.placemob2.Antivax	0.33883	0.04967	0	6.822	<1e-04 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Null Deviance: 86297 on 62250 degrees of freedom

Residual Deviance: 16999 on 62247 degrees of freedom

AIC: 17005 BIC: 17032 (Smaller is better.)

Figure S.I.8 - Results, goodness of fit and sample statistics for ERGM model analysis of outdegree