Vaccine Nationalism:

How China's State Media misinform about Western vaccines and highlight the successes of Chinese vaccines to different audiences

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Abstract

What motivates state-sponsored vaccine misinformation campaigns, given clear scientific evidence of vaccines' efficacy? We explore this issue through the lens of state-owned presses published in mainland China and in Hong Kong. We first collect an original database of media reports on both Western and Chinese vaccines from 16 Chinese-language media publications based in mainland China, Hong Kong, and Taiwan. We find that the quantity of coverage of Western vaccines by mainland state-owned media outlets to be much less than their coverage of Chinese vaccines, reflecting the unavailability of Western vaccines in mainland China. However, applying a dictionary-based sentiment analysis, we find that state-owned presses in mainland China still portrayed Western vaccines negatively. In Hong Kong, where there is direct competition between Chinese and Western vaccines, we find that state-owned presses gave high coverage of Western and Chinese vaccines but greater negative coverage of Western vaccines. These findings are consistent with a Chinese producer-oriented "vaccine nationalism" policy designed to nurture the domestic biotechnology sector.

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Introduction

A large literature has explored the origins of vaccine hesitancy among a rising number of patients in advanced economies, where vaccines undergo rigorous safety testing and are readily available (Dubé et al. 2013). The origins of such hesitancy are varied, ranging from individual beliefs and knowledge level to social and economic institutions (Dubé et al. 2013). Among the many causes of vaccine hesitancy, researchers have honed in on misinformation in media since it can heighten the perceived risks of vaccination and intensify initial hesitation to receive an effective vaccine (Dubé et al. 2013; Garett and Young 2021; Hayawi et al. 2022). Since the advent of the Covid-19 pandemic and the rapid development of Covid vaccines in 2020, misinformation on Covid-19 vaccines has flooded the media, especially on online social media (Basch et al. 2021; Garett and Young 2021). Examining macro-level cross-national data, Wilson and Wiysonge (2020) find a strong correlation between users' engagement with social media misinformation and vaccine hesitancy for Covid vaccines.

In this paper, we explore one source of vaccine misinformation– national governments and postulate a producer-oriented vaccine nationalism in which national authorities seek to instill consumer preference for domestically made vaccines and hesitancy for foreign-made vaccines, especially in competitive markets, through messages published by the state media. We test this hypothesis through comparative sentiment analysis of state-media and private media produced content related to foreign and domestic vaccines in both Hong Kong and mainland China. By making sentiment comparisons in these various settings, we find that mainland state-owned media mentioned Western vaccines much less than they did Chinese vaccines, and when they did so, they did so more negatively for Western vaccines and more negatively than private media's portrayal of Western vaccines. In Hong Kong, where there is direct competition between Chinese and Western vaccines, Chinese state media gave high coverage of Western and Chinese vaccines but greater negative coverage of Western vaccines,

compared to private media in Hong Kong. These findings support the notion that state media lent their support to Chinese vaccine producers in their competition against proven Western alternatives in the middle of a pandemic.

state-sponsored vaccine misinformation

Given the apparent benefits of vaccines approved by health authorities, why do media content producers feel compelled to create and disseminate misinformation about vaccines? To be sure, some research suggests that vaccine misinformation, especially on social media, is motivated by a strong belief in the misinformation by online influencers themselves or by their desire to obtain greater followings by propagating popular myths about vaccines (Hoffman et al. 2019). Some research also suggests that vaccine misinformation might be politically motivated, especially in polarized democracies. Sorell and Butler (2022) find that vaccine misinformation is motivated by political parties seeking to increase the salience of vaccination as a wedge issue to increase polarization among voters, presumably to prevent voters' defection to another party. Certainly, privately owned media with a strong partisan slant may engage in vaccine misinformation for this reason. At the national level, there is indeed a connection between the level of populism in politics and vaccine hesitancy (Kennedy 2019). Within the US, analysis of politically active Twitter accounts suggests those with right-wing leanings before the pandemic were more likely to spread vaccine misinformation after 2020 (Muric, Wu, and Ferrara 2021). Unfortunately, such partisan misinformation leads members of certain parties, who may already experience some degree of socio-economic disadvantage, to expose themselves to greater disease risks by refusing vaccines.

Within politically motivated misinformation, national governments sometimes engage in systematic misinformation campaigns on vaccines either domestically or abroad. First, because governments have both the capacity to carry out a concerted information campaign and are generally trusted by citizens, vaccine information campaigns, whether propagating

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accurate or misleading information, can have a meaningful impact on the vaccination rate. Research on public Covid-vaccines campaigns using a randomized design finds that government campaigns targeting specific misconceptions of vaccines increase treatment groups' rejection of misinformation and elevate trust in government organs (Yousuf et al. 2021). With the development and roll-out of effective Covid-19 vaccines, public health authorities worldwide have intensified their effort to carry out information campaigns on vaccines to promote vaccination (Cornwall 2020; Sabahelzain, Hartigan-Go, and Larson 2021). Such campaigns aim to convince the domestic public to receive vaccination for the vaccine that is the most readily available, regardless of national origin. Thus, we first and foremost expect any national government to portray readily available vaccines often and positively in state media. This is our model of how governments should manage an information campaign during a pandemic.

Yet, governments also might sponsor information campaigns to discredit proven vaccines. Even before the advent of Covid-19, researchers have uncovered ample evidence of a misinformation campaign on various kinds of vaccines launched by the Russian government with the general aim of sowing division within Western democracies (Broniatowski et al. 2020). Beyond geopolitical objectives abroad, national governments may also launch a domestic misinformation campaign to portray foreign vaccines negatively. An extant literature has shown that consumers can at times exhibit strong preference for domestically produced vaccines (Barceló et al. 2022). If this consumer-driven "vaccine nationalism" was strong, the desire to appease readers may drive both state-owned and private media to cover domestically produced vaccines in the same tone or more positively than foreign ones (Stockmann 2013). We will empirically assess this possibility in our analysis.

The extant literature on import substitution and Chinese industrial policy, however, suggests a type of "vaccine nationalism" which seeks to favor domestic vaccine producers. In this version of vaccine nationalism, state-owned media portray foreign vaccines negatively in

order to reduce demand for foreign-made vaccines, thus giving domestically-made vaccines greater market shares, especially in markets where there is competition. The import substitution motivation of national governments is a well-explored one in the political economy literature on emerging economies (Amsden 2001; Haggard 1990). Essentially, in order to nurture domestic industries which directly compete with imports, governments either subsidize or impose tariffs on imports to protect domestic infant industries (Haggard 1990; Amsden 2001). Indeed, developing countries, especially those in East Asia, used this strategy to accelerate growth and economic development starting in the 1950s (Haggard 1990; Amsden 2001).

As an emerging literature points out, China has gone well beyond traditional developmental state policies of financial repression and nurturing import substituting firms. In addition to these policies, China also has engaged in systematic technological acquisitions from advanced countries using both legal and illegal means, as well as "sectoral funds" which provide additional financing to priority sectors (Wubbeke et al. 2016). By 2015, Chinese industrial policy has become "fully-fledged" covering some 20 emerging industries, including bio-pharmaceuticals and bio-engineering (Naughton 2021). In addition to help with funding and matching technologists to firms, "everyone has an incentive to create forms of protectionism against foreign companies." (Naughton 2021). Thus, limiting foreign competition in emerging sectors, however accomplished, is still a key component of Chinese industrial policy.

In addition to tariff and non-tariff barriers against competitors, governments today can use their influence in the media to discourage consumers from using "rival" foreign products. The temptation to use media misinformation to protect domestic industry may be especially strong where confusion about the new product is still pervasive and the market competition between domestic and foreign alternatives is especially strong. The case of the Chinese Covid vaccine markets, both in the mainland and in Hong Kong Special Administrative

Region (SAR), present the perfect setting to test whether the state mobilized the media to promote domestic producers relative to foreign producers.

When Covid first emerged in China, the US and China were still in the middle of serious trade disputes triggered by the Trump Administration's wide-ranging tariffs on Chinese goods unveiled in 2018. When the pandemic began to spread in China, the Chinese government soon ordered export restrictions on personal protective equipment, which triggered alarms in some countries as Covid spread around the world (Federation of German Industries 2020). Even as major pharmaceuticals around the world scrambled to develop Covid vaccines, the Chinese government also ordered the Chinese pharmaceutical sector to develop indigenous Covid vaccines, which the sector quickly did by relying on the traditional inactivated virus approach. Coronavac, developed and manufactured by Sinovac Pharmaceutical, began Phase 3 trial abroad by July 2020. Yet, at the same time, Western vaccines, using newer approaches such as mRNA and viral vector, also began to go into trial. Thus, Western vaccines quickly became potential competitors of Chinese vaccines toward the end of 2020.

Within mainland China, the Chinese government opted for non-tariff barriers to prevent Western vaccines from entering the mainland Chinese market. As of late 2022, mainland health authorities still have not authorized any Western vaccine for use within mainland China (Stevenson 2022). Of course, when the Chinese vaccine became available, the Chinese government, like other governments, launched a publicity campaign to encourage vaccination. Despite the general unavailability of Western vaccines in mainland China, strong societal preference for Western vaccines might have created pressure on the Chinese government to approve these outside vaccines, which would have undermined indigenous ones. Thus, the government had some incentive to use misinformation to increase distrust of Western vaccines, even in mainland China.

While state-run media outlets are oftentimes used as vehicles for state policies, especially in one-party states like China, Chinese private media are more responsive to market

incentives (Stockmann 2013). Theoretically, in regimes that seek a great deal of control over society, such as China, the state has incentives to own a large segment of the media since it can exert direct control over them at lower cost while minimizing potential non-compliance (Gehlbach and Sonin 2014). In practice, the Chinese government exerts control over the media in China by both owning major media outlets, such as the People's Daily Group, and by instituting party committees within state-owned media outlets, which answer to higher level party committees (Stockmann 2013). Although censors also moderate the content published in privately owned media in China and in Hong Kong, private media respond much more to market forces. If the consumers of private media are interested in foreign vaccines or if foreign vaccine makers are major advertisers, it is in the media's interest to cover them. This is particularly true for foreign vaccines that have proven themselves more effective than domestic variants. Based on our understanding of the Chinese media environment, we expect state preferences to transmit much more directly into the content of state media compared to that of private media. Given the state's industrial policy, this would lead state media to provide more negative coverage of foreign vaccines, compared to private media, which are under greater influence of their readers and advertisers.

Thus in hypothesis testing, we begin with testing the null hypothesis that state media treated both Western and Chinese vaccines equally in terms of coverage and tone. This can be the result of the lack of vaccine nationalism in China or because other factors were seen as more effective in protecting domestic vaccine producers. For example, even into 2022, COVAX, the international consortium to distribute vaccines, struggled with providing enough mainly Western vaccines to the developing world, which meant that Chinese consumers would have found domestic vaccines the most readily available in any event (Cohen 2021). This supply constraint arguably was more effective in limiting Chinese consumption of Western vaccines than misinformation.

H0 In both Hong Kong and mainland China, state-owned presses, as arms of the gov-

ernment's health authorities, covered both Western and Chinese vaccines equally and equally positively.

In an alternative version of the null hypothesis, if there is vaccine nationalism on the consumer side, both state and private media would portray Western vaccines negatively.

H0a In both Hong Kong and mainland China, state-owned presses and private media both covered Western vaccines more negatively than Chinese ones.

If, instead, the coverage of vaccines was driven by the desire to protect the domestic pharmaceutical sector, the state media in mainland China, which are under more direct government control, would cover Western and Chinese vaccines differently in both coverage and tone.

H1 In mainland China, state media covered Chinese vaccines much more so than Western vaccines, compared to even mainland private media.

H1a In order to minimize latent demand for Western vaccines, the state media in mainland China portrayed Western vaccines negatively compared to the portrayal of Chinese vaccines.

In Hong Kong, a special administrative region of China with its own health regulatory authorities, the government decided to treat Western and Chinese vaccines on equal footing and set up an independent Expert Committee on Clinical Events Assessment to evaluate all vaccine candidates (Siu, Cao, and Shum 2022). The Hong Kong health authorities approved both the Sinovac and the Pfizer vaccines for use roughly around the same time in February 2021. With the competition of a Western vaccine, as well as initial Hong Kong residents' distrust of Chinese vaccines (Barceló et al. 2022), the Chinese government, if driven by industrial policy, had a strong incentive to create mistrust of Western vaccines in order to

ensure a high reception rate for the Chinese vaccine. Although the market in Hong Kong is a modest one (7 million or so in population), a substantially higher reception for Pfizer, compared to the Sinovac vaccine, would be highly embarrassing to the Chinese government. At the same time, because competition between the Western and Chinese vaccines was fierce, the state media in Hong Kong needed to cover both types of vaccines well, but the Western ones more negatively. Thus, we expected the following in Hong Kong:

H2 In Hong Kong, Chinese state-owned media covered both Western and Chinese vaccines to the same degree.

H2a In Hong Kong, Chinese state-owned media covered Western vaccines more negatively than Chinese ones, while the private media in Hong Kong covered Western vaccines the same or more positively compared to their coverage of Chinese vaccines.

In terms of the instruments of negative coverage, this study focuses on major media outlets which publish their content on websites. Although some of them have social media accounts, we focus on the content they publish on their websites. In both mainland China and in Hong Kong, the Chinese government has operated media outlets for decades. Although these outlets are under some degree of market pressure, state-owned media outlets like Xinhua in mainland China and Wen Hui Pao in Hong Kong ultimately must publish content approved by the Chinese government (Stockmann 2013). Meanwhile, in both mainland China and in Hong Kong, some media outlets are majority owned by private individuals or corporations, and they have greater editorial control, although in the case of mainland media and increasingly in Hong Kong, they are subjected to government censorship (Stockmann 2013).

In order to test these hypotheses, we first collect an original database of media reports on both Western and Chinese vaccines from 16 Chinese-language media publications. This database includes publications targeting different audiences, including mainland China, Hong

Kong, and Taiwan, as well as publications owned by the Chinese state and private publications. We then apply dictionary-based sentiment analysis to examine how Chinese state media's coverage of Western and Chinese vaccines differs from comparable publications. Given our hypothesis, we expect that Chinese state-owned media will associate far more negative sentiment with Western vaccines than with Chinese vaccines. In contrast, we expect that private media to assign more positive sentiment to Western vaccines, reflecting their higher average efficacy in preventing severe outcomes from Covid-19.

Data

Collecting large-scale data from Chinese media has been a perennial challenge for Chinese scholars. Proprietary databases can be costly and restrict access to the complete text of the archives they advertise. To address this challenge, the authors created a new news archive in which the RSS feeds of 16 Chinese-language news publications are scraped daily. The archive includes articles that were written in the period between September 2020 and January 2023. These articles were collected using the `newspaper3k` python package.

From this archive, we extracted articles that mention the names of one or more of the five vaccines included in our analysis: three Western vaccines – AstraZeneca, Pfizer, and Moderna — and two vaccines produced in China — Sinovac and Sinopharm.[1] This sample of vaccines was selected to represent both of China's commonly used vaccines and non-Chinese vaccines that have been widely used by the international community. We further limited our analysis to articles that mentioned the word "vaccine" at least once. We included this step to ensure that the article discussed details of the vaccine and not the corporation involved in their production.

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[1]We also considered adding Johnson and Johnson as an additional Western vaccine. However, the Chinese characters for J&J, 强生, are identical to those used to represent the name "Johnson." Mentions of these characters in the corpus typically were made in reference to major world leaders, like Boris Johnson, not the vaccine. Due to concerns about potential bias from these misclassifications, we decided to exclude this vaccine from our analysis.

Table 1: Chinese-language News Publications by Location and Ownership Status

	Ownership	
	Private	*State-owned*
Location		
China	Caijing, Caixin, Sina	China Daily, Guangming Daily, Global Times, Chutian Metropolis Daily, The People's Daily, Xinhua, Xinmin, Yangcheng Evening News
Hong Kong	Sing Tao Daily	Hong Kong Commercial Daily, Ta Kung Pao, Wenweipo
Taiwan	The News Lens	None

After identifying articles that mention vaccines and excluding duplicates, we are left with 8,675 news articles from the 16 news publications shown in Table 1. Our sample includes a large representation of major Chinese state-run news publications, such as Xinhua news and the Global Times, as well as the three largest private Chinese news publications, Caijing, Caixin, and Sina. From the Hong Kong media market, we include a privately owned news publication, the Sing Tao Daily, and three publications that are owned by the Chinese Communist Party, Hong Kong Commercial Daily, Ta Kung Pao, and Wenweipo. Finally, Taiwan's media market is represented by The News Lens, a for-profit publication. These publications were selected to represent both some of the largest and most influential publications in each media market.

Methods

Through this analysis, we hope to understand both in the Mainland and in the Hong Kong markets 1) whether the Chinese state has shown preferential levels of coverage towards their vaccines and against Western vaccines and 2) whether the Chinese government has tried to shift the narrative to portray domestically-produced vaccines in a positive light and alternatives negatively. Additionally, we are interested in seeing whether private publications

on the Mainland have been coopted into pushing the Chinese state's narrative on vaccines. To examine these hypotheses, we use descriptive and OLS regression methods to analyze our corpus of Chinese vaccine news.

We parameterize coverage levels as the number of articles covering a given vaccine by a publication in a given month. We expect that Chinese state media will prioritize coverage of domestic vaccines and downplay coverage of alternatives relative to publications that are not influenced by the CCP, namely private publications in Taiwan and Hong Kong. We perform both descriptive and regression analysis to determine whether there is a difference in coverage of vaccines depending on the media publications' ownership status and location. For the latter, we perform OLS regression with time and publication fixed effects. The fixed effects allow us to control for any publications that may be extreme outliers regarding their coverage behavior. To ensure that periods without vaccine coverage are properly accounted for, we aggregate to the level of the publication-month and assign periods in which a publication produced no vaccine-related news a default value of 0. We then estimate the following OLS regression equation:

$$Y_{itj} \sim \beta_0 + (\beta_1 \gamma_i + \beta_2 \omega_i) \times \lambda_j + \beta_3 \gamma_i + \beta_4 \omega_i + \lambda_j + \theta_{it} + X_{itj} + \epsilon_{itj} \tag{1}$$

In equation 1, the outcome variable, Y_{itj}, is the logged count of the number of news articles written by a given publication in a particular month. Our independent variables are indicators for *media ownership status*, γ_i, *mainland*, ω_i, and *vaccine type*, λ_j. *Media ownership status* is a binary variable where a value of 1 indicates that the Chinese government owns the publication and 0 indicates that the publication is privately owned. *Mainland* is firm-level data that we assigned based on the news publication's ownership structure; it takes the value of 1 when the media outlet is located in mainland China and "0" when the media outlet is located in Hong Kong or Taiwan.[2] According to our vaccine nationalism hypotheses,

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[2]A news publication was determined to be owned by the Chinese government if the Chinese government

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β_1 and β_2 will be statistically significant and positive, indicating that both the Chinese media market and ownership by the CCP increase coverage of Chinese-produced vaccines relative to its coverage of foreign-owned vaccines. The parameter θ represents time and publication fixed effects, which we include to account for confounding variables associated with specific publications and time periods.

In addition to our analysis of the quantity of vaccine coverage, we examine how tone differs across news publications. To measure the tone of a news article, t_i, we sum the sentiment of words in a given article, s, where s can have a value of -1 for negative sentiment, 0 for neutral sentiment, and 1 for positive sentiment. We then divide this sum by the number of tokens in a given article and multiply the result by 100. The result produces a measure of tone that can be interpreted as the percentage of net positive words in a given article:

$$t_i = \sum_{m=1}^{M} \frac{s_m W_{im}}{N_i} \times 100 \tag{2}$$

We use the HowNet Chinese-language sentiment dictionary provided by Dong, Dong, and Hao (2010) to parameterize sentiment. They created this dictionary using human evaluations of the dictionary definitions of 50,000 Chinese words to ensure that the sentiment evaluations would apply to various subject domains. One modification we make to the HowNet sentiment dictionary is to exclude single-character sentiment words. This was done out of concern that single characters would double count some sentiment words while also counting false positive sentiment words. For example, on its own, the character yi, 义, carries the meaning of justice, righteousness, and morality; however, it is frequently included in larger words that carry no sentiment, such as zhuyi, 主义, ideology. As single characters like 义 rarely occur alone and are frequently included as components of larger words with no clear sentiment, we believe it best to limit our sentiment analysis to Chinese words of length two or more.

Dictionary analysis can run into pitfalls when a dictionary designed for one domain is

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or a subsidiary of it had a majority stake in the ownership of the news publication.

applied in another (Quinn et al. 2010; Grimmer and Stewart 2013). To validate our findings, compare our results to those produced by the ANTUSD dictionary provided by Wang and Ku (2016). We expect that our findings are not dependent on the specific dictionary used.

In order to conduct sentiment analysis, it is necessary to map a relationship between vaccines and sentiment. To do so, we first create a frequency count of the number of times a vaccine is mentioned in a given article using our vaccine name dictionary. Second, we assign a vaccine label to an article if that vaccine is mentioned more times than any other vaccine, i.e., using a plurality rule. Accordingly, for our analysis, we assume that given that an article discusses a vaccine, the sentiment of that article indicates how the vaccine was portrayed in the text.

We also anticipate that China's state-run publications will produce articles that have a more positive tone for Chinese vaccines compared to Western vaccines and private publications. To test this hypothesis, we will estimate a regression similar to that described in Equation 1. The key differences are that, in this case, the unit of analysis will be the article, not the publication-month, and the dependent variable will be defined as the tone of a given article. Tone will be defined as described in Equation 2. As before, fixed effects for publication and time will be included to account for potential confounding variables.

For our regression analysis, we group Taiwan and Hong Kong's private media into a single category. This is due to two factors: 1) they are both the only members of their respective categories; 2) we expect them to behave according to similar incentive structures. Unlike private media in Mainland China, Taiwan, and Hong Kong's private outlets are not directly regulated by Chinese government censors. Accordingly, market forces are the primary incentives shaping the tone and quantity of the content they produce.

Analysis

Quantity

Does China's state media produce more coverage favoring its domestically produced vaccines? We perform both visual and regression analyses to assess whether they do so. In Figure 1, we examine the logged number of articles produced over time by media ownership status and location, normalized by the number of publications producing content. We also include Figure 2 to highlight the total number of articles produced by publication and the percentage of content dedicated to Western and Chinese vaccines. We can see that there is a large discrepancy in both the total amount of coverage and the relative amount of coverage of vaccines across groups and over time. In particular, State-owned media in mainland China favor domestically produced vaccines in aggregate and across almost every time period, as postulated by H1. Similarly, state-owned media based in Hong Kong dedicate approximately 58% of its vaccine coverage to Chinese-produced vaccines, which is consistent with H2. In contrast, private media, in the mainland and elsewhere, dedicate a smaller share of their vaccine news coverage to Chinese-produced vaccines. This is particularly pronounced for private media outlets in Hong Kong and Taiwan, where coverage of Chinese-made vaccines declines to nearly zero after September 2021.

One notable observation based on this data is that across all media types, vaccine coverage has a general declining trend over time. Another fact of note is that Chinese state media based in the mainland produces much more news coverage of vaccines per publication than other types. This may correlate to a lower demand for information on vaccines as the population becomes more vaccinated. We hope to explore this in a future paper.

We turn to OLS regression to test whether hypotheses 1 and 2 have statistical support. This methodology enables us to disentangle the extent to which media ownership and location impact the quantity of media content dedicated to vaccines. We fit the two-way fixed effects

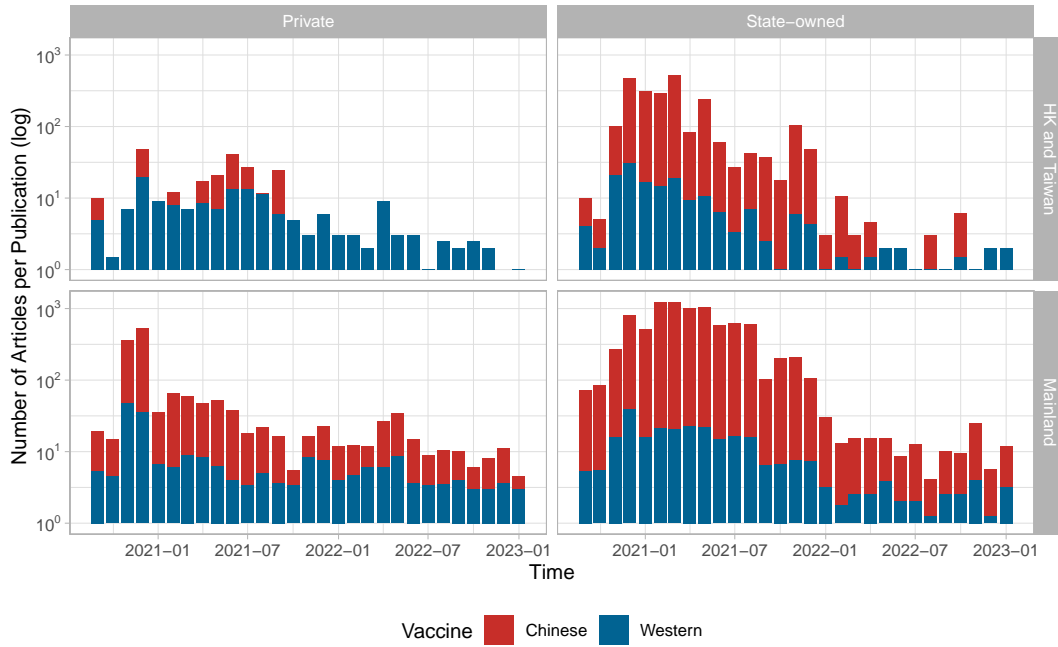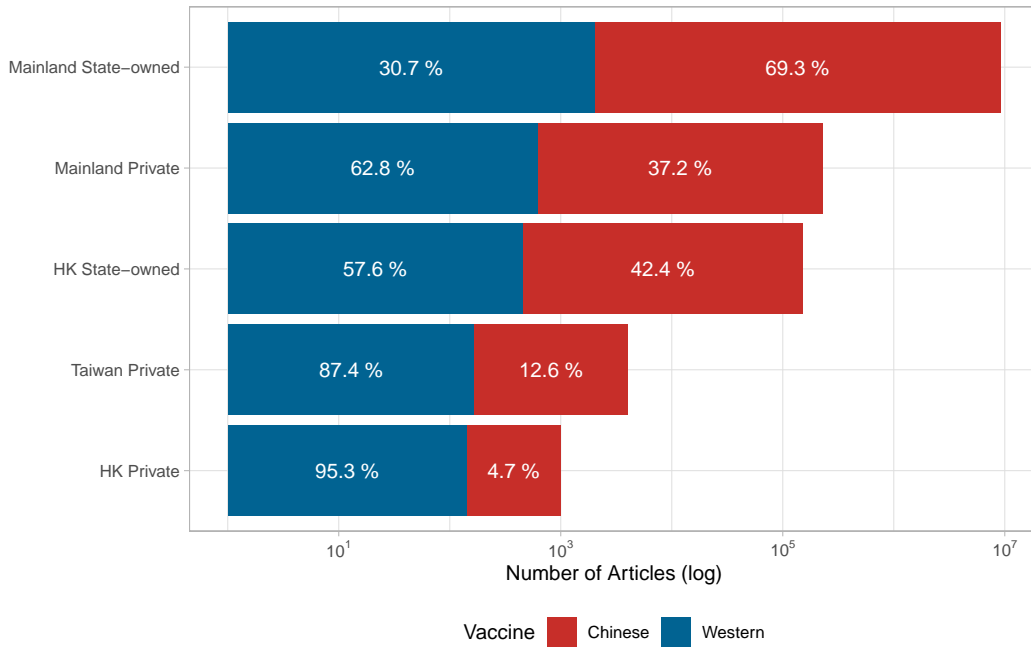**Figure 1:** Vaccine Article Count over Time by Ownership and Location

Figure 2: Quantity of Articles Written by Media Type

regression model described in 1 to account for potential time and publication-level fixed effects. The full results can be seen in Appendix Table 2. Figure 3 summarizes our findings by showing the predicted number of articles for each combination of ownership status, vaccine type, and media location, given our model.

Figure 3: Predicted Effects of Ownership, Location, and Vaccine Type on Article Count (log)
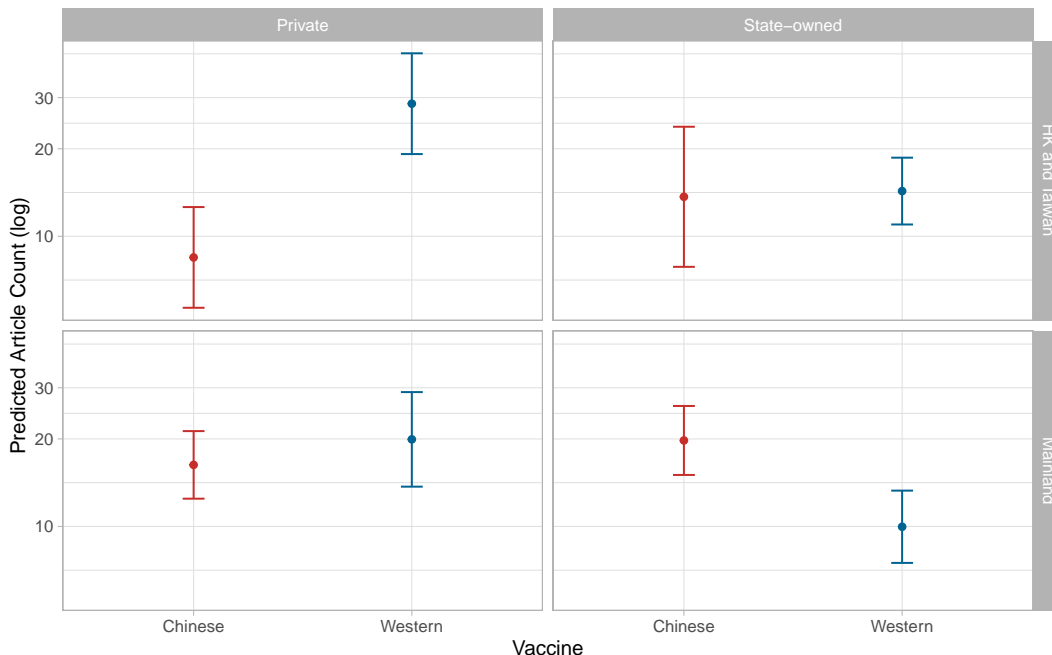
Our theory led us to expect that China's state-owned media would produce high levels of coverage for Chinese-produced vaccines, while we would see less coverage favoritism in Hong Kong due to the more competitive nature of the Hong Kong media and vaccine market. For Hypothesis 1, we see that China's state-run media based in the Mainland do indeed dedicate more of their vaccine coverage to domestically-produced vaccines. Specifically, we see that for a given month mainland Chinese-state media outlets produce an average of 20 articles discussing Chinese vaccines while only producing 10 articles discussing foreign alternatives. This effect is statistically significant at a $p < 0.01$ level. Conversely, for private media outlets based in Mainland China, we see no statistically significant preference for

domestically-produced vaccines. This indicates that pro-Chinese vaccine coverage is not purely a byproduct of demands by Chinese consumers for information; if it were, we would expect private media to cater to those preferences. This finding also leads us to reject the null hypothesis that the state media covered the Chinese and Western vaccines equally.

Looking at state-run media behavior in Hong Kong, we see evidence consistent with Hypothesis 2. We expected as a consequence of Hong Kong's choice to allow both Chinese and Western vaccines to be used by Hong Kong residents that Hong Kong's state-run media would face pressure to dedicate roughly equivalent levels of content to them. Consistent with those expectations, we do not see a statistically significant difference in the absolute levels of coverage of Western and Chinese vaccines by Chinese-owned media in Hong Kong. However, we do see significantly higher coverage of non-Chinese vaccines relative to Chinese vaccines by Hong Kong and Taiwanese private media sources. This observation is consistent with our examination of the raw data presented in Figures 1 and 2. One possible explanation is that readers of those media outlets demanded information about non-Chinese vaccines. Further survey data would be necessary to confirm that this is the case.

Tone

In addition to examining how content differs across media agency types, we examine how they differ in sentiment tone. According to Hypotheses 2a, state media based in Hong Kong should favor domestic vaccines in an effort to push consumers away from alternatives. Despite the absence of competition in mainland China, perhaps the state-owned media still felt compelled to reduce latent demand for Western vaccines by portraying them negatively (Hypothesis 1a). In this section, we start by examining the raw tone produced by publications in our sample, and we conclude by formally testing our hypotheses using OLS regression.

Figure 4 shows average tone levels by media and vaccine type with 95% confidence intervals, while Figure 5 shows how tone changes over time by media ownership and location.

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Figure 4: Tone Associated with Vaccines by Media Type
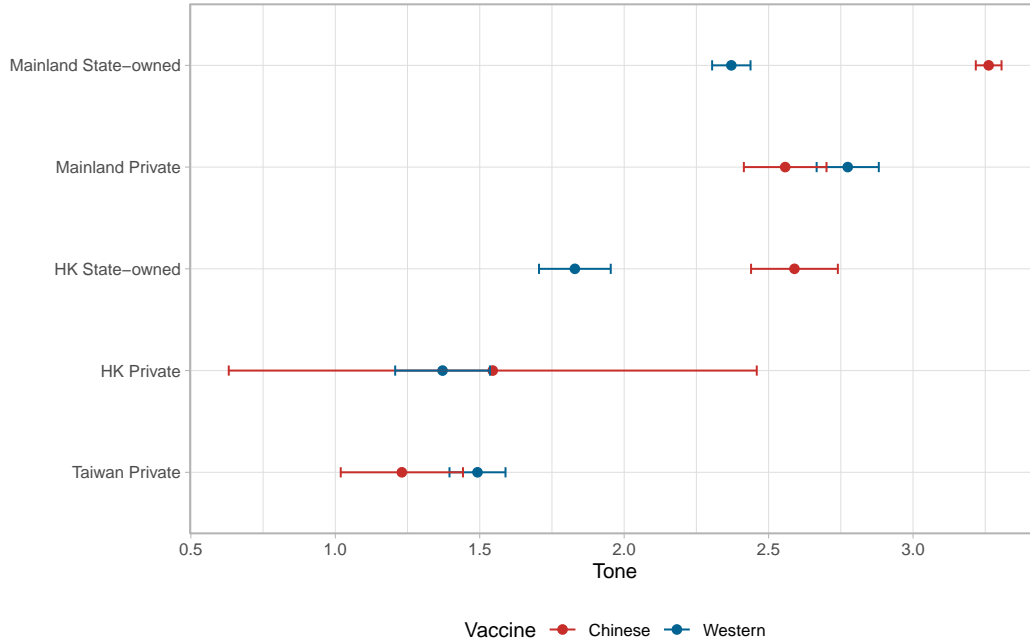
We can see that there appear to be some meaningful differences in how outlets portray vaccines. In particular, Figure 4 indicates that Mainland state-owned media outlets strongly favor Chinese-produced vaccines with positive sentiment relative to the sentiment used for Western vaccines. We see a similar pattern for state-owned media based in Hong Kong, as they likewise show higher average positive sentiment for Chinese-produced vaccines relative to non-Chinese vaccines. It is less obvious whether sentiment levels differ across other media types. The 95% confidence intervals for Mainland private media's coverage of Chinese and Western vaccines overlap, indicating that there is no significant difference in the sentiment of their vaccine coverage. The same is true for Hong Kong and Taiwan's private media outlets, though those groups use a lower average tone compared to state-owned and mainland media when covering vaccines.

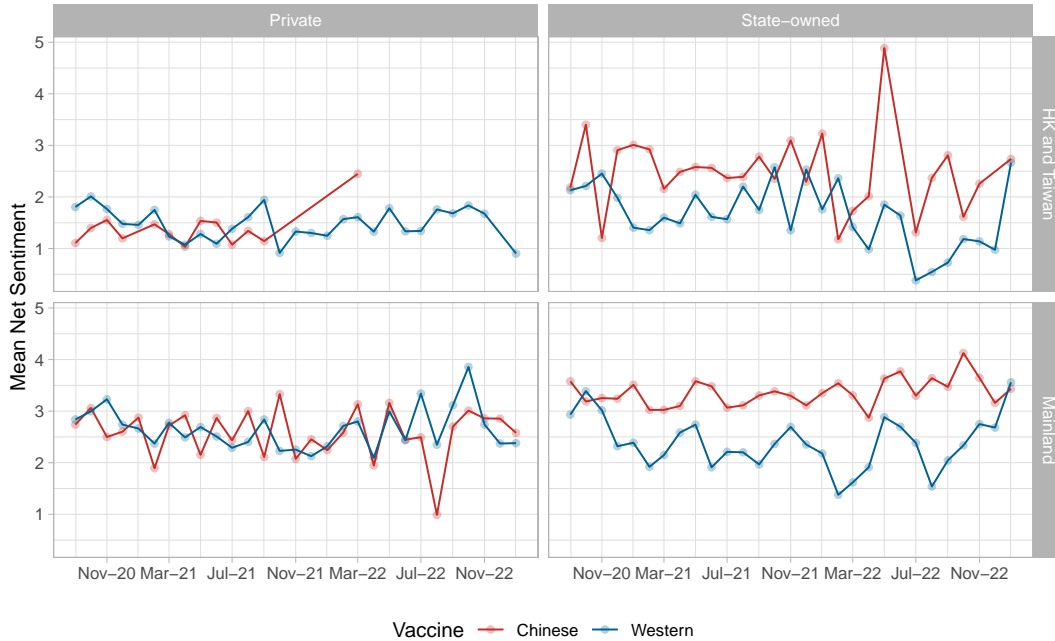**Figure 5:** Tone over Time by Ownership, Location, and Vaccine

Figure 5 tells a similar story, with a higher average tone observed for Mainland state-owned media's coverage of Chinese vaccines relative to Western ones for all but one period in our sample. As before, we see a similar pattern in Hong Kong, with state-owned media favoring Chinese vaccines in most periods. In contrast, we see private media outlets both in the mainland and outside of it using remarkably similar tones to describe Chinese and non-Chinese vaccines over time.[3] Overall, these results suggest that China's state-owned media shows a strong preference in tone towards Chinese-produced vaccines relative to both alternative vaccines and alternative media outlets. This is consistent with our expectations for state-owned media in both Hong Kong and mainland China. This is consistent with our argument that the mainland government was concerned about potential demand for Western vaccines. While these observations are suggestive, it is not a given that these associations are

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[3]It is noteworthy that for state-owned media there is a pronounced increase in positive sentiment associated with foreign vaccines in the final period of our data, January 2023. There is currently not enough data to confirm whether this represents a lasting change in how foreign vaccines are framed, though this is a development that is worth tracking and exploring with future research.

robust to control variables. To address this concern we turn again to fixed-effects regression analysis to ensure that these patterns hold up when covariates are controlled.

Figure 6: Predicted Effects of Ownership, Location, and Vaccine Type on Tone
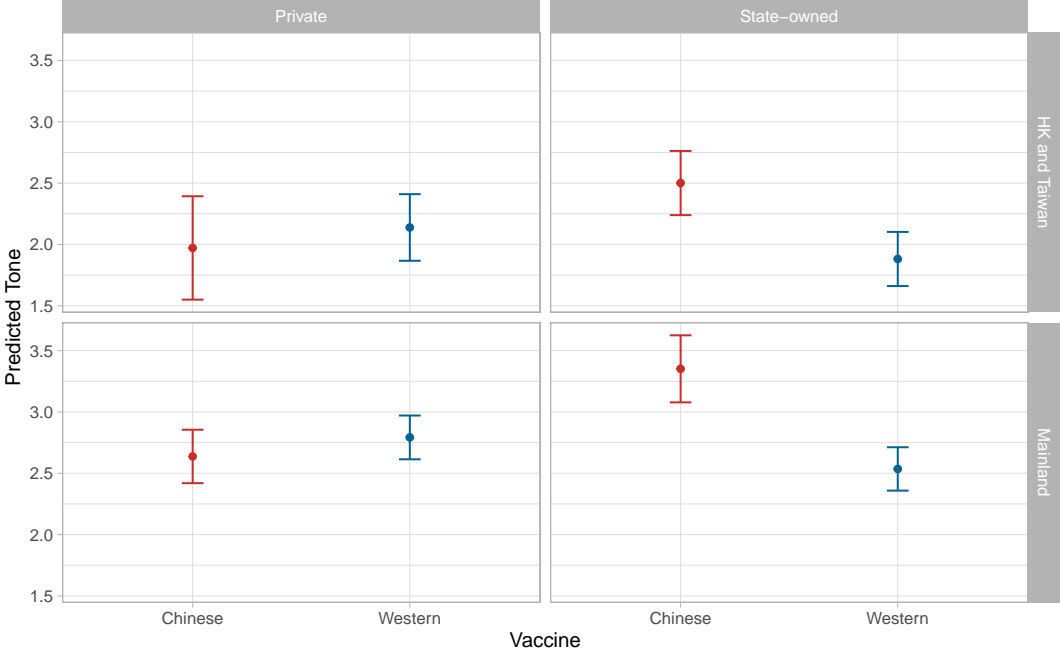
For our regression analysis of tone, we again control for both time and publication fixed effects. The coefficient estimates are available in Table 3, while present the predicted values of our model in Figure 6. We can see that our regression results are largely consistent with our descriptive analysis and hypotheses 1a and 2a: in both the mainland and Hong Kong, we see China's state-owned media producing news that heavily favors domestically-produced vaccines. This effect is statistically significant at a 0.01 level across both localities. In contrast, we do not see a similar pattern in private media outlets: in both Hong Kong and the mainland, private media writes articles that treat Chinese and Western vaccines with similar sentiment.

We run several tests to examine whether our results are robust. In particular, we consider whether changing the dictionary used to measure tone meaningfully changes our findings.

We apply an alternative Chinese dictionary from ANTUSD produced by (Wang and Ku 2016). The results of this analysis can be found in our appendix. This alternative dictionary does not meaningfully change the significance or direction of the results presented in this paper.

Overall, our regression and descriptive analyses find evidence consistent with the expectations presented in hypotheses 1a and 2a. In mainland China, the authorities seemed concerned with latent demand for Western vaccines and tried to forestall it by portraying them negatively. Similarly, state-owned media in Hong Kong attempted to shape their readers' perceptions of vaccines so as to induce higher consumption of domestically produced vaccines. Conversely, private media appeared to show less of a preference for domestic vaccine variants than what was observed in state-run media in both the domestic and Hong Kong markets, which is consistent with our expectation that China has a media environment with non-trivial transaction costs (Gehlbach and Sonin 2014).

Conclusion

The Covid-19 pandemic has revealed that misinformation is one of the greatest threats to public health. A necessary condition to combating misinformation is documenting when it was used, how it was used, who used it, and why they felt compelled to do so. With this study, we hope to shed light on what may have been one of the most consequential state-sponsored misinformation campaigns of the pandemic, one that is still shaping public behavior and policy decisions in China and abroad.

Scraping a large corpus of news articles from Chinese language media in mainland China, Hong Kong, and Taiwan, both state-owned and privately owned, we find that state-owned media covered domestic vaccines much more so than Western vaccines in mainland China. In Hong Kong, where there is intense competition between the Chinese and Western vaccines, the state media covered both types roughly equally. In both mainland China and in Hong

Kong, however, state-owned media portrayed Western vaccines more negatively than Chinese vaccines and more negatively than how private media outlets would portray Western vaccines. This negative portrayal of Western vaccines might have intensified common vaccine hesitance against foreign-made vaccines, especially among older, more patriotic Chinese residents of Hong Kong (Barceló et al. 2022). The effect of negatively portraying Western vaccines might have been felt in diaspora communities around the world, where older overseas Chinese are more likely to read Hong Kong-based state-owned presses. We hope that future research can explore the impact of this state-sponsored campaign on Covid vaccination rates in China and abroad.

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Appendix

Table 2: Effect of Media Ownership and Location on Vaccine Coverage Levels

	Articles (log)			
	(1)	(2)	(3)	(4)
Intercept	1.64 (0.13)***	2.26 (0.08)***	1.48 (0.17)***	2.03 (0.17)***
Chinese Vaccine	−0.70 (0.19)***	−0.75 (0.19)***	−0.93 (0.27)***	−1.22 (0.09)***
Mainland	0.16 (0.16)	−0.54 (0.07)***	0.22 (0.19)	−0.36 (0.11)***
State-owned	0.14 (0.20)	−0.52 (0.10)***	0.05 (0.22)	−0.69 (0.12)***
Chinese Vaccine x Mainland	0.49 (0.22)**	0.59 (0.22)***	0.64 (0.28)**	1.02 (0.20)***
Chinese Vaccine x State-owned	0.75 (0.17)***	0.74 (0.19)***	0.93 (0.18)***	1.17 (0.35)***
Fixed effects				
Publication	No	Yes	No	Yes
Time	No	No	Yes	Yes
Statistics				
R^2	0.13	0.28	0.48	0.67
N	718	718	718	718

Notes: *p<0.1; **p<0.05; ***p<0.01 White robust standard errors clustered by publication in parentheses. Coefficient estimates are at the month-year and publication level.

Table 3: Effect of Media Ownership and Location on Tone

	Average Tone			
	(1)	(2)	(3)	(4)
Intercept	0.21 (0.64)	0.40 (0.62)	0.49 (0.66)	0.75 (0.64)
Chinese Vaccine	0.03 (0.15)	−0.37 (0.15)**	0.06 (0.14)	−0.17 (0.15)
Mainland	0.81 (0.21)***	0.70 (0.13)***	0.79 (0.19)***	0.65 (0.10)***
State-owned	−0.10 (0.17)	−0.25 (0.09)***	−0.06 (0.14)	−0.26 (0.09)***
Chinese Vaccine x Mainland	−0.12 (0.15)	0.20 (0.12)*	−0.11 (0.14)	0.01 (0.19)
Chinese Vaccine x State-owned	0.88 (0.17)***	0.95 (0.16)***	0.88 (0.16)***	0.79 (0.16)***
Tokens (log)	0.24 (0.10)**	0.24 (0.10)**	0.23 (0.10)**	0.23 (0.10)**
Fixed effects				
Publication	No	Yes	No	Yes
Time	No	No	Yes	Yes
Statistics				
R^2	0.13	0.15	0.15	0.16
N	8675	8675	8675	8675

Notes: *p<0.1; **p<0.05; ***p<0.01 White robust standard errors clustered by publication in parentheses. Coefficient estimates are at the article level.

Table 4: Effect of Media Ownership and Location on Tone

	Average Tone	
	(1) HowNet	(2) ANTUSD
Intercept	0.75 (0.64)	3.10 (1.29)**
Chinese Vaccine	−0.17 (0.15)	−1.21 (0.43)***
Mainland	0.65 (0.10)***	4.15 (0.17)***
State-owned	−0.26 (0.09)***	−1.59 (0.29)***
Chinese Vaccine x Mainland	0.01 (0.19)	1.36 (0.56)**
Chinese Vaccine x State-owned	0.79 (0.16)***	3.40 (0.51)***
Tokens (log)	0.23 (0.10)**	0.35 (0.20)*
Fixed effects		
Publication	Yes	Yes
Time	Yes	Yes
Statistics		
R^2	0.16	0.23
N	8675	8675

Notes: *p<0.1; **p<0.05; ***p<0.01 White robust standard errors clustered by publication in parentheses. Coefficient estimates are at the article level.