Vaccine effectiveness against SARS-CoV-2 transmission to household contacts during dominance of Delta variant (B.1.617.2), August-September 2021, the Netherlands

Brechje de Gier ¹, Stijn Andeweg ¹, Jantien A. Backer ¹, RIVM COVID-19 surveillance and epidemiology team, Susan J.M. Hahné ¹, Susan van den Hof ¹, Hester E. de Melker ¹, Mirjam J. Knol ¹

Author affiliations:

1. Center for Infectious Disease Control, National Institute for Public Health and the Environment (RIVM), Bilthoven, the Netherlands

Abstract

We estimated vaccine effectiveness against onward transmission by comparing secondary attack rates among household members between vaccinated and unvaccinated index cases, based on source and contact tracing data collected when Delta variant was dominant. Effectiveness of full vaccination of the index against transmission to fully vaccinated household contacts was 40% (95% confidence interval (CI) 20-54%), which is in addition to the direct protection of vaccination of contacts against infection. Effectiveness of full vaccination of the index against transmission to unvaccinated household contacts was 63% (95%CI 46-75%). We previously reported effectiveness of 73% (95%CI 65-79%) against transmission to unvaccinated household contacts for the Alpha variant.

Keywords: SARS-CoV-2, transmission, household study, COVID-19, vaccine effectiveness

Early August 2021 we reported vaccine effectiveness against SARS-CoV-2 transmission and infections among household and other close contacts of confirmed cases [1]. This study was based on source and contact tracing data collected in February- May 2021, during which time the wildtype and Alpha variant of SARS-CoV-2 were dominating. From May 29 to July 4, a transition took place where the Delta variant took over from Alpha and became dominant, with over 85% of sequenced isolates from week of July 5- July 11 pertaining the Delta variant. At the end of June, several non-pharmaceutical measures were relaxed in the Netherlands [2]. This relaxation, combined with the co-occurring emergence of Delta, was followed by a large increase of SARS-CoV-2 infections (Figure 1). This increase was mainly driven by infections in young unvaccinated people.

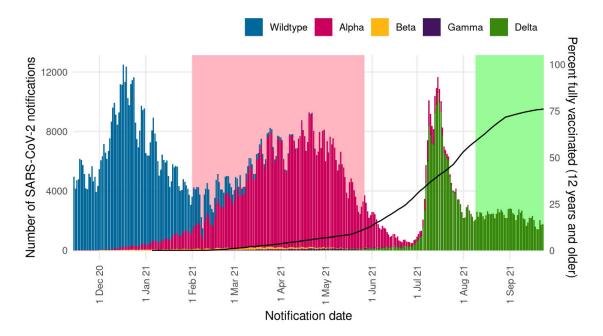


Fig. 1 Number of cases per day in the Netherlands by symptom onset, colored by SARS-CoV-2 variant, and percent of the Dutch population fully vaccinated (defined as 14 or more days post-second-dose or 28 or more days post-single dose (Janssen), black line). The light green area indicates the study period of the study presented here. The pink area indicates the study period of our previous report. The share of SARS-CoV-2 variant results from fitting exponential growth curves to weekly surveillance data of sequenced samples [3].

A result of this large and fast increase in the number of cases was that Municipal Health Services (MHS) lacked capacity to perform full source and contact tracing in July and the beginning of August. Full-scale source and contact tracing has been resumed by all MHS since August 9, 2021. Therefore, our analysis of vaccine effectiveness against transmission (VET) of the Delta variant is only possible for data collected since August 9, 2021. We end our study period at September 24, 2021, as since September 25 unvaccinated people require a negative test or proof of recovery to enter bars, restaurants and events, which will impact testing behavior differentially by vaccination status [4]. During the study period, over 97% of sequenced isolates pertained Delta [3].

Until July 2021, all household contacts of confirmed cases had to quarantine for 10 days, and were urged to get tested on day 1 and day 5 after exposure and in case of symptoms. If a contact was tested negative on day 5, they could end the quarantine. On July 8, 2021, a policy change was implemented, and fully vaccinated household contacts of confirmed cases no longer had to quarantine. These fully vaccinated contacts were still strongly advised to get tested on day 5 and to practice social distancing until day 10.

A full description of the data and methods used can be found in our previous report [1]. In short, the VE against transmission (VET) was estimated by comparing the secondary attack rate (SAR) among household contacts of confirmed index cases by vaccination status of the index case: 1 – (SAR vaccinated index / SAR unvaccinated index) * 100%. An index case is a person with a positive SARS-CoV-2 test, who according to the source tracing interview, was most likely not infected at home. Index cases and household contacts aged 12 years or older are included in the analysis, as all Dutch inhabitants above the age of 12 years are eligible for vaccination since July 2021. Partly vaccinated was defined as having received the first dose of a 2-dose schedule with a time since vaccination of at least 14 days. Fully vaccinated was defined as having completed a 2-dose schedule with a time since vaccination of at least 14 days, or the 1-dose Janssen schedule with a time since vaccination of at least 28 days.

VET was estimated using a binomial generalized linear model. For parameter fitting we used the generalized estimating equations (GEE) approach with exchangeable correlation structure to account for clustering of contacts belonging to the same index case. All models included age group of the index and contact (12-17, 18-29, 30-49, 50-74 and 75+ years), vaccination status of the contact (not, partly or fully vaccinated) and week of notification date of the index case as covariates.

The final dataset contained 7,771 contacts of 4,921 index cases. Of the index cases, 2,602 (33.5%) were fully vaccinated and 912 (11.7%) were partly vaccinated. Of contacts, 4,189 (53.9%) were fully vaccinated and 641 were partly vaccinated (8.2%). The predominance of unvaccinated index cases is the result of vaccine effectiveness against infection, as 71% of all adults was fully vaccinated at the start of the study period [5]. Characteristics of indexes and contacts are shown in Table 1. Vaccination status by age reflects the roll-out of vaccination from old to young. Table 2 shows the vaccination status of contacts by vaccination status of index cases. Of unvaccinated index cases, 59.1% of household contacts were unvaccinated as well, while only 11.6% of household contacts of vaccinated index cases were unvaccinated.

Table 1. Characteristics of index cases, by vaccination status of the index and characteristics of contacts, by vaccination status of the contact. NA = not applicable.

	Index cases			Household contacts			
	Unvaccinated	Partly vaccinated	Fully vaccinated	Unvaccinated	Partly vaccinated	Fully vaccinated	
	(column %)	(column %)	(column %)	(column %)	(column %)	(column %)	
Total	2641	540	1740	2941	641	4189	
Gender							
Female	1480 (56%)	280 (52%)	871 (50%)	1517 (52%)	313 (49%)	2106 (50%)	
Male	1161 (44%)	260 (48%)	869 (50%)	1379 (47%)	320 (50%)	2026 (48%)	
Unknown/ other	0 (0%)	0 (0%)	0 (0%)	45 (2%)	8 (1%)	57 (1%)	
Age group	•					<u> </u>	
12-17	1005 (38%)	174 (32%)	45 (3%)	903 (31%)	172 (27%)	127 (3%)	
18-29	823 (31%)	229 (42%)	549 (32%)	718 (24%)	216 (34%)	673 (16%)	
30-49	616 (23%)	101 (19%)	438 (25%)	910 (31%)	176 (27%)	1460 (35%)	
50-74	183 (7%)	33 (6%)	631 (36%)	383 (13%)	77 (12%)	1841 (44%)	
75+	14 (1%)	3 (1%)	77 (4%)	27 (1%)	0 (0%)	88 (2%)	
Vaccine received	1	-	-	- 1	-	•	
Comirnaty	NA	483 (89%)	963 (55%)	NA	505 (79%)	2544 (61%)	
Spikevax	NA	43 (8%)	87 (5%)	NA	53 (8%)	389 (9%)	
Vaxzevria	NA	14 (3%)	273 (16%)	NA	4 (1%)	350 (8%)	
Janssen	NA	NA	417 (24%)	NA	NA	420 (10%)	
Unknown	NA	0 (0%)	0 (0%)	NA	78 (12%)	486 (12%)	
Household composition	on					•	
Two adults without children	825 (31%)	165 (31%)	977 (56%)	634 (22%)	160 (25%)	1173 (28%)	
Two adults with child(ren)	723 (27%)	153 (28%)	273 (16%)	900 (31%)	184 (29%)	1041 (25%)	
Single adult with child(ren)	573 (22%)	78 (14%)	83 (5%)	496 (17%)	79 (12%)	309 (7%)	
Other	520 (20%)	144 (27%)	407 (23%)	911 (31%)	218 (34%)	1666 (40%)	

aug	1410 (53%)	429 (79%)	916 (53%)	1542 (52%)	486 (76%)	2178 (52%)
sep	1231 (47%)	111 (21%)	824 (47%)	1399 (48%)	155 (24%)	2011 (48%)

Table 2. Vaccination status of contacts relative to vaccination status of index cases

Vaccination status contact	Unvaccinated index, (column %)	Partly vaccinated index, (column %)	Fully vaccinated index, (column %)
Unvaccinated	2517 (59.1)	121 (13.3)	303 (11.6)
Partly vaccinated	235 (5.5)	177 (19.4)	229 (8.8)
Fully vaccinated	1505 (35.4)	614 (67.3)	2070 (79.6)

Table 3. Secondary attack rate of SARS-CoV-2 infection by vaccination status of the index case (≥ 12 years), crude vaccine effectiveness against transmission (VET) and VET adjusted for age group of the index case and contact and week of notification date of the index case.

Analysis	Unvaccinated index - infected contacts / all contacts (SAR)	Partly vaccinated index - infected contacts / all contacts (SAR)	Partly vaccinated index - crude VET (%)(95% CI)	Partly vaccinated index - adjusted VET (%)(95% CI)	Fully vaccinated index - infected contacts / all contacts (SAR)	Fully vaccinated index - crude VET (%)(95% CI)	Fully vaccinated index - adjusted VET (%)(95% CI)
Unvaccinate d household contacts	547/2517 (22%)	21/121 (17%)	28 (-18;56)	38 (-2;62)	38/303 (13%)	50 (28;65)	63 (46;75)
Fully vaccinated household contacts	164/1505 (11%)	37/614 (6%)	46 (22;63)	46 (20;63)	256/2070 (12%)	-16 (-44;6)	40 (20;54)

Table 3 shows a lower crude SAR among unvaccinated household contacts for vaccinated index cases compared to unvaccinated index cases (13% vs. 22%) and a corresponding adjusted vaccine effectiveness of 63% (95%CI 46-75%) against transmission. Among fully vaccinated household contacts, the crude SAR was similar for fully vaccinated index cases compared to unvaccinated index cases (11% vs. 12%), but this was confounded by age of the index – both SAR and proportion of vaccinated index cases are higher in the oldest age groups (Supplementary Table S1). After adjustment, the effectiveness of full vaccination of the index case was 40% (95%CI 20-54%).

We previously found a higher VET to unvaccinated household contacts during the Alpha period (73% (95%CI 65-79))[1]. The secondary attack rate among unvaccinated contacts (22%) is also lower compared to the Alpha period (31%). Possibly, this is a result of increased prevalence of infectioninduced immunity. In the beginning of August, around 20% of Dutch blood donors had infectioninduced immunity [6]. Also, a larger share of index cases were of a younger age (below 30) compared to our Alpha period analysis, and SARs were lower for younger index cases (Supplementary Table S1). Our data does not contain information about negative tests. Therefore it is uncertain whether contacts tested negative or did not test at all. Even though both vaccinated and unvaccinated household contacts are advised to test at day 5 and in case of symptoms, we cannot preclude the possibility that testing rates among household contacts became lower, leading to an underestimation of the SAR. Differences in testing behavior between contacts of vaccinated and unvaccinated index cases could bias our VET estimates. During the study period, most Dutch adults had had the opportunity to receive vaccination, the coverage for 12 to 17-year-olds was still increasing during this period. The current vaccinated and unvaccinated populations are likely different in multiple aspects, such as risk behavior, willingness to test and adherence to quarantine. These aspects might bias out VET estimates in both directions: while the perceived risk of infection might be lower in vaccinated people due to their vaccination status, the perceived risk of infection among current unvaccinated populations could also be low due to personal beliefs. A lower risk perception for both groups may have resulted in decreased testing rates. Daily testing numbers averaged around 60,000 in spring 2021 whilst in August and September this averaged around 20,000, which is also likely influenced by the increasing use of at-home rapid antigen tests [7]. Further, as Table 2 shows, vaccinated and unvaccinated people are highly clustered within households. This reduces the power of our analysis.

It is known from literature that the Delta variant is more transmissible than Alpha, therefore a reduced VET for Delta compared to Alpha is not unexpected [8]. A recent study from the United Kingdom reported reduced transmission for vaccinated index cases, with aOR estimates in line with our VET estimates for both Alpha and Delta [9]. This study found that VET waned over time since vaccination of the index case. We explored whether such waning is also visible in our data (Supplementary Table S2). VET estimates are indeed lower when the index reached full vaccination status 60 or more days ago. However, our data does not allow detailed analysis of VET waning due to small numbers and strong correlation with age and time since vaccination of the household contacts. If VET indeed wanes over time, the lower VET for Delta compared to Alpha might be (partly) due to longer time since vaccination rather than the variant itself.

Our results indicate that vaccination confers protection against onward transmission from vaccinated index cases, albeit somewhat less for Delta than for Alpha. Vaccine effectiveness against transmission to unvaccinated household contacts is stronger than to vaccinated household contacts, with the latter already largely protected from infection, and especially from severe disease, by their own vaccine-induced immunity, but differences in risk behavior may also play a role. Possible waning of vaccine effectiveness against infection and against onward transmission could result in increases

in SARS-CoV-2 circulation among populations with high vaccine coverage. As full vaccination remains highly effective in preventing severe disease, also for Delta, a high vaccination coverage remains the key to control the COVID-19 pandemic [10].

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