

DR MARIA THERESE AHLEN (Orcid ID : 0000-0002-3104-3818)

Article type : Brief Report

## An observational study to identify the prevalence of thrombocytopenia and anti-PF4/polyanion antibodies in Norwegian health care workers after COVID-19 vaccination

Running title: Anti-PF4/polyanion antibodies after vaccination

Ingvild Hausberg Sørvoll\*<sup>1</sup>, Kjersti Daae Horvei\*<sup>1</sup>, Siw Leiknes Ernstsens<sup>1</sup>, Ingvild Jenssen Lægreid<sup>1</sup>, Svetlana Lund<sup>1</sup>, Renathe Henriksen Grønli<sup>1</sup>, Magnus Kringstad Olsen<sup>2</sup>, Hege Karine Jacobsen<sup>2</sup>, Anna Eriksson<sup>2</sup>, Anne Marie Halstensen<sup>2</sup>, Eirik Tjønnfjord<sup>3</sup>, Waleed Ghanima<sup>4,5</sup> and Maria Therese Ahlen<sup>1</sup>

\* dual first authorship

<sup>1</sup>Norwegian National Unit for platelet immunology, Department of laboratory medicine, University Hospital of North Norway, Tromsø, Norway

<sup>2</sup>Østfold Hospital, Department of research, Grålum, Norway

<sup>3</sup>Østfold Hospital, Department of emergency medicine, Grålum, Norway

<sup>4</sup>Østfold Hospital, Department of medicine, hematology and research, Grålum, Norway

This article has been accepted for publication and undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the [Version of Record](#). Please cite this article as [doi: 10.1111/JTH.15352](https://doi.org/10.1111/JTH.15352)

This article is protected by copyright. All rights reserved

<sup>5</sup>University of Oslo, Institute for clinical medicine, Department of haematology, Oslo, Norway

Corresponding Author: Maria Therese Ahlen, Sykehusveien 38, 9019 Tromsø, Norway,  
maria.therese.ahlen@unn.no

Word count: 1 840

## Essentials

- PF4/polyanion antibodies are associated with vaccine-induced thrombotic thrombocytopenia (VITT)
- 492 vaccinated individuals were screened for thrombocytopenia and anti-PF4/polyanion antibodies
- We found low prevalence of thrombocytopenia in the vaccinated individuals
- There was a low prevalence of anti-PF4/polyanion antibodies 11-35 days post vaccination

## Key words

Thrombocytopenia, COVID-19 Vaccines, Platelet Factor 4, Drug related Side Effects and Adverse Reactions, COVID-19 Vaccines/adverse effects

## Abstract

Background: The COVID-19 Vaccine from AstraZeneca (AZD1222) is one of several vaccines introduced to provide immunity against SARS-CoV-2. Recently, more than 50 cases have been reported presenting a combination of thrombosis, thrombocytopenia and remarkably high levels of anti-PF4/polyanion antibodies post-AZD1222 vaccination. Now linked to the vaccine, the condition is referred to as vaccine-induced thrombotic thrombocytopenia (VITT). The European Medicines Agency still recommends vaccination with AZD1222, but several European countries have temporally paused and/or restricted its use because of the perceived risk of this severe side effect. As there is no description of PF4/polyanion antibody testing in the clinical trials, knowledge about the prevalence of such antibodies in a vaccinated cohort is needed.

Objectives: To investigate prevalence of thrombocytopenia and anti-PF4/polyanion antibodies in a population recently vaccinated with AZD1222.

Patients/Methods: 492 health care workers recently vaccinated with the first dose of AZD1222 were recruited from two hospitals in Norway. Study individuals were screened for thrombocytopenia and the presence of anti-PF4/polyanion antibodies with a PF4/PVS IgG ELISA immunoassay. Side effects after vaccination were registered.

Results: The majority of study participants had normal platelet counts and negative immunoassay. Anti-PF4/polyanion antibodies without platelet activating properties were only detected in 6 individuals ( $OD \geq 0.4$ , range 0.58-1.16), all with normal platelet counts. No subjects had severe thrombocytopenia.

Conclusions: We found low prevalence of both thrombocytopenia and antibodies to PF4/polyanion-complexes among Norwegian health care workers after vaccination with AZD1222.

## Introduction

Massive vaccination campaigns using various anti-covid vaccines have started around the world to bring Covid-19 pandemic to a halt. Among these, the AZD1222 (ChAdOx nCoV-19) vaccine from AstraZeneca has been shown to be effective and safe in preventing COVID-19.[1] This vaccine was widely administered to health care workers under the age of 65 years in Norway. Recently, a link between the AZD1222 and a rare thrombotic disorder has been reported by The European Medicines Agency (EMA)[2] with more than 50 cases reported in Europe.[3-5] The disorder has a resemblance to heparin-induced thrombocytopenia, however it does not require heparin as a trigger, thus mimicking spontaneous autoimmune heparin-induced thrombocytopenia (aHIT).[6]

We recently reported this condition in five Norwegian health care workers presenting with venous thrombosis at unusual sites, and thrombocytopenia 7-10 days after receiving AZD1222.[4] At the Norwegian National Unit for Platelet Immunology, we revealed remarkably high levels of anti-platelet factor 4 (PF4)/polyanion antibodies in enzyme-linked immunosorbent assay (ELISA) in all the five cases. Four of these cases also demonstrated platelet activating properties in functional testing assay. This tentative vaccine-induced condition has been referred to as vaccine-induced thrombotic thrombocytopenia (VITT). Other groups have also reported several cases with very similar clinical presentation after AZD1222 vaccination. [3, 5] The pathogenesis of VITT is still unknown.

Across Europe, millions of people aged 18 years or older have been vaccinated with AZD1222. Systemic adverse reactions are common, but rarely severe,[7] in contrast to the devastating VITT development which often has a fatal outcome.

Several countries have put the vaccine on hold after the emergence of cases of these rare thrombotic events. The safety committee of EMA concluded after evaluation in March 2021 that the benefits of the vaccine in combating COVID-19 still outweigh the risk of side effects. Further, according to EMA there is no evidence of product quality issues related to specific vaccine batches or manufacturing sites.[2] The safety studies report fewer cases of thrombosis than in unvaccinated controls.[7]

In Norway, approximately 135,000 individuals have received AZD1222 since February 2021.[8]

The VITT cases have raised concern that vaccinated individuals have a higher risk of development or boosting of anti-PF4/polyanion reactive antibodies. Platelet antibody testing has not been

previously described in the intervention group or control group in the clinical phase I/II/III studies.[1, 9, 10]

The aim of this study was to investigate the prevalence of thrombocytopenia and anti-PF4/polyanion antibodies in a population recently vaccinated with AZD1222, both to identify individuals that may be at risk of developing VITT, and to investigate the prevalence of apparently subclinical anti-PF4/polyanion antibodies. ELISA has been shown to reliably detect anti-PF4-antibodies associated with VITT,[3-5] and was thus used for antibody screening in this study.

## **Materials and methods**

### **Subjects and materials**

Health care workers were in an open invitation recruited from the University Hospital of North Norway (UNN) and Østfold Hospital Trust during 22<sup>th</sup> – 29<sup>th</sup> of March 2021 into two identical studies, here reported together. Study participants who had received first dose of AZD1222 vaccine within 10-35 days were included. All participants gave written informed consent. The number of recruited participants was selected to ensure detection of PF4/polyanion antibodies in the event this is a common occurrence post-vaccination. The studies were approved by the two Ethics Committees (REK 257384 and REK 255184). In addition, we included non-vaccinated healthy blood donors with no history of COVID-19 from the blood donation service (UNN) as a control group. Plasma and serum were also biobanked for further analysis related to the safety of this vaccine.

### **Questionnaire and blood sampling**

Side effect data were reported on a questionnaire grading experienced symptoms, as fever, headache, vomiting, fatigue, cutaneous bleeding, malaise, muscle- and joint ache on a scale from 0-6. Demographic data was registered. Also, the participants reported use of medication such as paracetamol or ibuprofen in relation to vaccination. Whole blood was collected and processed by standard procedures for hematology and platelet immunology testing.

### **Laboratory analyses**

Platelet counts were measured on Sysmex (UNN) and ADVIA (Østfold) hematology analyzers. Severe thrombocytopenia was defined as a platelet count  $<50 \times 10^9/L$ , and moderate

thrombocytopenia as  $50-150 \times 10^9/L$ . Antibodies to PF4/PVS (polyanionic polyvinyl sulfonate) were screened for by LIFECODES PF4 IgG ELISA immunoassay (Immucor, Waukesha, WI), according to manufacturer's instructions, dilution 1:50, and an optical density (OD) cut-of value  $\geq 0.4$ . Positive samples in ELISA were tested by heparin-induced multiple electrode aggregometry (HIMEA) on the Multiplate analyzer (Dynabyte Medical, Germany). In the HIMEA assay[11], normal blood group O donor platelets were incubated with PF4/PVS positive sera in the presence of low dose heparin (UFH 0.96 IU/ml), high dose heparin (UFH 96 IU/ml) and saline buffer. A previously confirmed HIT serum was used as a positive control, and normal pooled plasma as negative control. The test was performed according to in-house validated protocol.

### **Statistics**

Proportions and confidence intervals (CI) for descriptive data and side effects were calculated in SPSS Statistics 26 with 95% significance level (bootstrap method). GraphPad Prism 8.12 was used to create figures for platelet counts and ELISA OD values. Line represents median value, and whiskers 95% CI.

### **Results and Discussion**

Anti-PF4/polyanion reactive antibodies in high levels seem to be a defining feature of VITT, the devastating clinical picture recently described after AZD1222 vaccination.[4] The link between vaccination and antibody formation or boosting is unknown and determining the frequency of PF4/PVS-antibodies in a vaccinated group compared to unvaccinated is an important contribution to investigate such an association.

A total of 502 vaccinated health care workers were included in the study. Due to missing data, 10 individuals were excluded. The remaining 492 study participants were included in final data analysis. In the control group, 110 blood donors were included (Table 1).

The vast majority of study participants had normal platelet counts and low OD values in anti-PF4/PVS IgG ELISA (Figure 1). In the same cohort, 8 subjects had reduced platelet counts, all above  $100 \times 10^9/L$  (1.6%, 95% CI: 0.6-2.8). Anti-PF4/polyanion antibodies with OD values over cut-off  $\geq 0.4$  were detected in 6 subjects (1.2%, 95% CI: 0.4-2.2) in the vaccine cohort, all having

platelet count above  $150 \times 10^9/L$  (Figure 2). None of the PF4/PVS positive sera induced platelet aggregation in the HIMEA assay. In the control group there were no ELISA positive sera.

Noteworthy, the cut-off value  $\geq 0.4$  in the PF4 IgG ELISA is set to achieve a specificity appropriate for the detection of clinically relevant antibodies in typical HIT investigations. VITT patients have presented remarkably high OD values in ELISA, however the antibody level in vaccinated individuals with no clinical signs of VITT is not known. Given this, we note that about 6% (n=28) of the vaccinated cohort had OD values in the range of 0.2-0.4, as opposed to none in the control group. Gender distribution and mean platelet count in this group was not different from individuals with OD values  $< 0.2$  (mean 274 vs  $270 \times 10^9/L$ ). These individuals may not be at risk for disease, but they might have mounted an immune response weakly detectable in the ELISA and could in theory trigger a clinically relevant stronger response with a second vaccination or booster in the future.

Whether or not the established cut-off  $\geq 0.4$  is suitable in a screening setting to determine the prevalence of low levels of antibodies after COVID-19 vaccination, remains to be discussed, preferably supported by studies including a pre-vaccination baseline sample.

Interestingly, the prevalence of anti-PF4/polyanion antibodies in our study were lower in the vaccinated cohort (1.2%,  $OD \geq 0.4$ ), than reported previously for blood donors. Hursting et al found low levels of non-pathogenic PF4/polyanion antibodies (IgG/IgM/IgA) detectable in ELISA in 5-7% of blood donors, of which 50% had IgG isotype.[12] This discrepancy in reported seroprevalence and our results may be explained by differences between the study populations and/or the immunoassays.

Our narrow inclusion window of 10-35 days post vaccination was selected to be able to detect both an immunological boosting of preformed antibodies, as well as a de novo anti-PF4/polyanion IgG response. There is limited data regarding the time range for antibody detection for autoimmune HIT, but for typical HIT the detection window is relatively short, as these antibodies tend to disappear within 50-85 days.[13]

Most participants reported fever, headache, fatigue, malaise and muscle/joint ache (table 2). 65% used medication to relieve symptoms in relation to vaccination. In order to detect potential VITT-development at the time of the study, participants were asked whether they experienced recent malaise. 94% denied malaise the last days prior to blood sampling.

It has been suggested that an inflammatory response to the vaccine triggers the antibody production tentatively causing VITT.[3, 4] Therefore, Norwegian health authorities have instructed vaccinated individuals to be aware of persisting symptoms, skin bleedings or neurological symptoms post-vaccination. The side effects in our vaccinated cohort are similar to the reports from the clinical safety study for this vaccine.[7] In summary, more than 60% of the subjects reported side effects as fever, headache, fatigue, malaise and muscle/joint ache, out of which >40% reporting symptoms as moderate or severe. A few individuals reported persisting symptoms, and 10% reported skin bleedings/bruising. The individuals with anti-PF4/ polyanion antibodies did not report higher rates of malaise prior to blood sampling, and three out of six reported fever and muscle/joint ache the days following vaccination, a frequency not differing from subjects without anti-PF4 antibodies. Taken together, our data indicates that inflammatory symptoms show low pretest probability for anti-PF4/PVS antibody detection and the development of VITT.

Based on reported VITT cases in Norway, the incidence can be estimated to 1 in 25,000 vaccinated individuals.[4] This seems to be higher than in other European countries, possibly because of a more robust national reporting system and short lines of communication within the health care community in a low population country. Also, the demographic group receiving this vaccine, might differ from other European countries as it was given to health care workers.

Importantly, the study population of vaccinated health care workers reflects a similar cohort as the Norwegian VITT-cases. However, since the entity emerged very recently with only a few cases reported world-wide, the condition may be underreported, and its true incidence is yet unknown.

Perceived risk of severe side effects can lead to vaccine hesitancy in the general population, which may delay vaccine coverage. Vaccination is of utter importance in combating the COVID-19 pandemic. To earn public trust, gathering knowledge about serious adverse effects from vaccination is important to be able to make well-informed decisions regarding vaccine strategy.

In conclusion, this is the first study to screen for anti-PF4/polyanion antibodies in a population vaccinated with AZD1222. We did not find anti-PF4/polyanion platelet activating antibodies, nor severe thrombocytopenia in approximately 500 vaccinated participants. This suggests that both the natural occurrence and post-vaccine de novo generation or boosting of such antibodies are rare. If the incidence of high-level anti-PF4/polyanion antibodies tentatively causing VITT is closer to the

observed incidence of VITT, the number of individuals included in our observational study is clearly too low. Determining a low incidence would require a larger study, preferably with more high-throughput methods for antibody testing.

## **Acknowledgments**

We are grateful to all involved personnel at the Department of Laboratory Medicine, University Hospital of North Norway (UNN), the Departments of Research and Laboratory Medicine, and the Research and laboratory departments, and Thrombosis and Hemostasis Research Group, Østfold Hospital. We also thank the blood donors and health care workers for their taking part in the study.

## **Authorship**

IHS, KDH, SLE, IJL, ET, WG and MTA designed the study. RHG and SL performed antibody analysis. IHS, KDH and MTA drafted the manuscript. ET, WG, AE, MKO, HKJ, AMH collected and discussed data. IHS, KDH, SLE, IJL, WG, and MTA collected, analyzed and discussed data.

All authors revised the manuscript and approved the final version for publication.

Conflict-of-interest disclosure: WG reports grant from Bayer and BMS/Pfizer, and fees for lectures and consultancy from Novartis, Amgen, Principia, Bayer, Pfizer, Sobi and Sanofi. MTA reports shares in the biotech/pharmaceutical companies Vaccibody, Photocure, ArcticZymes Technologies, Exact Therapies and Viramabs Inc. IHS reports that her spouse is the CFO in ArcticZymes Technologies. The other authors declare no competing financial interests.

Funding: We have received external funding from the Northern Norway Regional Health Authority (Helse Nord).

## References

1. Ramasamy MN, Minassian AM, Ewer KJ et al. Safety and immunogenicity of ChAdOx1 nCoV-19 vaccine administered in a prime-boost regimen in young and old adults (COV002): a single-blind, randomised, controlled, phase 2/3 trial. *Lancet*. 2020;396:1979-93.
2. Signal assessment report on embolic and thrombotic events (SMQ) with COVID-19 Vaccine (ChAdOx1-S [recombinant]) – COVID-19 Vaccine AstraZeneca (Other viral vaccines) EMA/PRAC/157045/2021. Available from: [https://www.ema.europa.eu/en/documents/prac-recommendation/signal-assessment-report-embolic-thrombotic-events-smq-covid-19-vaccine-chadox1-s-recombinant-covid\\_en.pdf](https://www.ema.europa.eu/en/documents/prac-recommendation/signal-assessment-report-embolic-thrombotic-events-smq-covid-19-vaccine-chadox1-s-recombinant-covid_en.pdf).
3. Greinacher A, Thiele T, Warkentin TE, Weisser K, Kyrle PA, Eichinger S. Thrombotic Thrombocytopenia after ChAdOx1 nCov-19 Vaccination. *N Engl J Med*. 2021:DOI: 10.1056/NEJMoa2104840.
4. Schultz NH, Sørvoll IH, Michelsen AE, Munthe LA, Lund-Johansen F, Ahlen MT, Wiedmann M, Aamodt A-H, Skattør TH, Tjønnfjord GE, Holme PA. Thrombosis and Thrombocytopenia after ChAdOx1 nCoV-19 Vaccination. *N Engl J Med*. 2021:DOI: 10.1056/NEJMoa2104882.
5. Scully M, Singh D, Lown R, Poles A, Solomon T, Levi M, Goldblatt D, Kotoucek P, Thomas W, Lester W. Pathologic Antibodies to Platelet Factor 4 after ChAdOx1 nCoV-19 Vaccination. *N Engl J Med*. 2021:DOI: 10.1056/NEJMoa2105385.
6. Greinacher A, Selleng K, Warkentin TE. Autoimmune heparin-induced thrombocytopenia. *J Thromb Haemost*. 2017;15:2099-114.
7. Folegatti PM, Ewer KJ, Aley PK et al. Safety and immunogenicity of the ChAdOx1 nCoV-19 vaccine against SARS-CoV-2: a preliminary report of a phase 1/2, single-blind, randomised controlled trial. *Lancet*. 2020;396:467-78.
8. Norwegian Institute of Public Health. COVID-19 Ukerapport - Uke 15 Available from: <https://www.fhi.no/contentassets/8a971e7b0a3c4a06bdbf381ab52e6157/vedlegg/2021/ukerapport-uke-15-12.04---18.04.21.pdf>.
9. Voysey M, Clemens SAC, Madhi SA et al. Safety and efficacy of the ChAdOx1 nCoV-19 vaccine (AZD1222) against SARS-CoV-2: an interim analysis of four randomised controlled trials in Brazil, South Africa, and the UK. *Lancet*. 2021;397:99-111.

10. Voysey M, Costa Clemens SA, Madhi SA et al. Single-dose administration and the influence of the timing of the booster dose on immunogenicity and efficacy of ChAdOx1 nCoV-19 (AZD1222) vaccine: a pooled analysis of four randomised trials. *Lancet*. 2021;397:881-91.
11. Galea V, Khaterchi A, Robert F, Gerotziafas G, Hatmi M, Elalamy I. Heparin-induced multiple electrode aggregometry is a promising and useful functional tool for heparin-induced thrombocytopenia diagnosis: confirmation in a prospective study. *Platelets*. 2013;24:441-7.
12. Hursting MJ, Pai PJ, McCracken JE, Hwang F, Suvarna S, Lokhnygina Y, Bandarenko N, Arepally GM. Platelet factor 4/heparin antibodies in blood bank donors. *Am J Clin Pathol*. 2010;134:774-80.
13. Warkentin TE, Kelton JG. Temporal Aspects of Heparin-Induced Thrombocytopenia. *N Engl J Med*. 2001;344:1286-92.

**Table 1. Demographic of the study population**

	Vaccinated cohort ( <i>n</i> = 492)	Control group ( <i>n</i> = 110)
Age ( <i>years</i> )*	44 (21-69)	43 (21-66)
Female Sex ( <i>n</i> , %)	373, 76%	56, 51%
Time since vaccination ( <i>days</i> )*	20 (11-35)	-

\*medians (range)

**Table 2. Self-reported side effects after vaccination.**

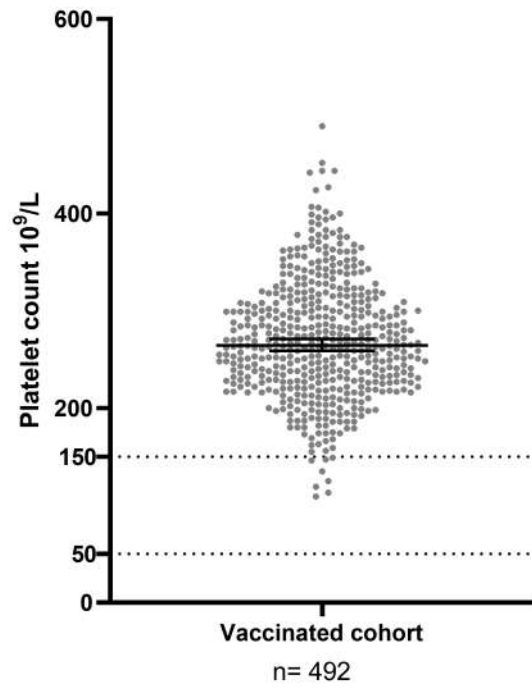
Symptom ( <i>n</i> =492)	None <i>N</i> , % (95% <i>CI</i> )	Mild	Moderate	Severe	Any
Fever	193, 39% (35%-44%)	90, 18% (15%-22%)	111, 23% (19%-26%)	98, 20% (17-24%)	299, 61% (57%-65%)
Headache	140, 28% (24%-32%)	100, 20% (17%-24%)	169, 34% (30%-38%)	83, 17% (14%-20%)	352, 72% (68%-76%)
Vomiting	471, 96% (94%-98%)	15, 3.0% (1.6%-4.7%)	5, 1.0% (0.2%-1.8%)	1, 0.2% (0.0%-0.6%)	21, 4.3% (2.4%-6.1%)
Fatigue	188, 38% (34%-43%)	78, 16% (13%-19%)	144, 29% (25%-34%)	82, 17% (14%-20%)	304, 62% (58%-66%)
Cutaneous bleeding	443, 90% (87%-93%)	32, 6.5% (4.3%-8.7%)	13, 2.6% (1.2%-4.3%)	4, 0.8% (0.2%-1.6%)	49, 10% (7.3%-13%)
Malaise	190, 39% (34%-43%)	56, 11% (8.5%-14%)	139, 28% (24%-32%)	107, 22% (18%-25%)	302, 61% (57%-66%)
Muscle/joint ache	170, 35% (30%-39%)	75, 15% (12%-19%)	142, 29% (25%-33%)	105, 21% (18%-25%)	322, 65% (61%-70%)

Categories of symptoms in questionnaire 0-6: None (0), Mild (1-2), Moderate (3-4), Severe (5-6), Any (1-6).

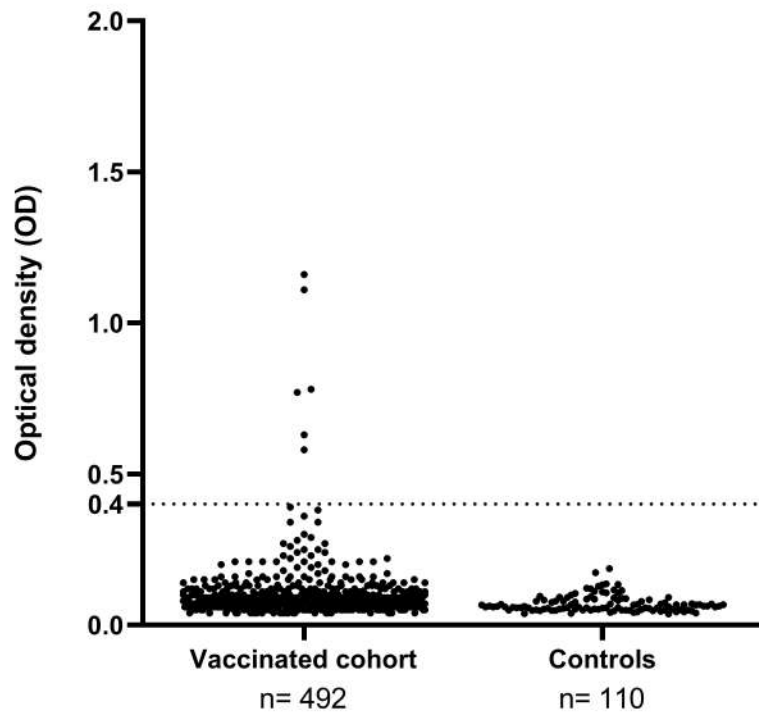
## Figure Legends

Figure 1. In total, only 8 out of the 492 vaccinated individuals (1.6%) had thrombocytopenia, with platelet count above  $100 \times 10^9/L$ . Line represents median, error bars 95% CI.

Figure 2. Anti-PF4/PVS reactive antibodies were detectable in 6 individuals (1.2%) in the vaccine cohort by ELISA. The highest OD value was 1.16,  $OD \geq 0,4$  indicate presence of antibodies. OD: Optical density



jth\_15352\_f1.tif



jth\_15352\_f2.tif