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PERSONNEL AND READINESS

SEP 29 2023

The Honorable Mike D. Rogers
Chairman
Committee on Armed Services
U.S. House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

The Department's response to House Report 117–397, page 186, accompanying H.R. 7900, the National Defense Authorization Act for Fiscal Year 2023, "Department of Defense Report on Cardiac and Kidney Issues in Service Members Prior to and Following the COVID Vaccine Requirement," is enclosed.

The report provides a review of the overall annual crude prevalence of three cardiac conditions (myocarditis, pericarditis, and acute myocardial infarction) and two kidney conditions (acute kidney injury and chronic kidney disease) among Active Component members from January 2019 to June 2022. Additionally, the report includes a review of overall annual crude incidence stratified by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) infection and coronavirus disease 2019 (COVID-19) vaccination; a review of adjusted incidence rates; and adjusted rate ratios as a measure of risk. The report shows that, upon review of the Military Health System data from January 2019 to June 2022, there was an overall small increase in the myocarditis prevalence and incidence associated with both COVID-19 vaccine and SARS-CoV-2 infection. The magnitude of impact on myocarditis incidence is significantly higher from those with a recent SARS-CoV-2 infection in comparison to recent COVID-19 vaccination. All other cardiac and kidney outcomes evaluated showed mostly similar trends. The results support similar conclusions drawn by published studies that the risks for cardiac and kidney complications are higher after SARS-CoV-2 infection than they are after COVID-19 vaccine.

Thank you for your continued strong support for the health and well-being of our Service members.

Sincerely,

[redacted]

Ashish S. Vazirani
Acting

Enclosure:
As stated

cc:
The Honorable Adam Smith
Ranking Member

Report to the Committee on Armed Services of the House of Representatives

Department of Defense Report on Cardiac and Kidney Issues in Service Members Prior to and Following the COVID Vaccine Requirement

September 2023

The estimated cost of this report or study for the Department of Defense is approximately $29,000 in Fiscal Years 2021 – 2022. This includes $6,470 in expenses and $23,000 in DoD labor.

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PURPOSE

This report is in response to House Report 117–397, page 186, accompanying H.R. 7900, the National Defense Authorization Act for Fiscal Year 2023, "Department of Defense Report on Cardiac and Kidney Issues in Service Members Prior to and Following the COVID Vaccine Requirement," which requests an analysis of prevalence and incidence of kidney and cardiac complications in Service members in 2019 compared to the same measures in 2021 and 2022. The report analyzes annual incidence of select kidney and cardiac conditions identified as rare adverse outcomes following identified coronavirus disease 2019 (COVID-19) vaccination among Service members in the Active Component between Calendar Years (CY) 2019 and 2022. Incidence rates for each adverse outcome (myocarditis, pericarditis, acute myocardial infarction (AMI), chronic kidney disease (CKD), and acute kidney injury (AKI)) were stratified by receipt of COVID-19 vaccine and history of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection with confounding factors identified and adjusted when possible. As a secondary analysis, the overall annual prevalence of each outcome was described and discussed.

INTRODUCTION

On December 11, 2020, the Food and Drug Administration (FDA) issued an emergency use authorization (EUA) for the Pfizer-BioNTech BNT162b2 vaccine. Immediately thereafter, on December 14, 2020, the Department of Defense (DoD) mobilized to begin voluntarily administering the first doses of Pfizer-BioNTech BNT162b2 vaccine to military communities with priority given to frontline health care workers at highest risk of exposure to SARS-CoV-2 infection. Two dose Moderna mRNA-1273 and single dose Johnson & Johnson JNJ-78436735 vaccines were added to the approved distribution list as they received subsequent EUAs from FDA. A year later in December 2021, over 6.4 million doses of vaccine had been distributed. The Pfizer-BioNTech and Moderna vaccines would both go on to receive full FDA approval in August 2021 and January 2022, respectively.

Eight months after DoD vaccination distribution began, on August 24, 2021, the Secretary of Defense released a memorandum requiring that all members of the Armed Forces under DoD authority on active duty or in the Ready Reserve (including National Guard) receive a COVID-19 vaccination as part of their readiness requirements. Mandatory vaccinations are familiar to all Service members, with as many as 17 different vaccines required for military personnel in the "Joint Instruction on Immunizations and Chemoprophylaxis" as necessary to mitigate risk for various infections. Some vaccines are only required to be administered in certain special, risk-based geographical and occupational circumstances of the individual Service member. Other vaccinations, like the annual influenza vaccine, are required for all Service members regardless of the circumstances, unless the Service member is covered by an administrative (including religious) or medical exemption. All vaccination requirements, including COVID-19 when it was in effect, are in place to keep the Armed Force as a whole healthy and medically ready.

BACKGROUND

COVID-19 Vaccination Associated Cardiac Adverse Events

Severe adverse events following COVID-19 vaccinations remain rare and studies continue to support that the benefit of vaccination outweigh the risk.[1] Although extremely rare, myocarditis and pericarditis are reported following COVID-19 vaccination particularly in adolescents and young males.[2] Myocarditis is the inflammation of cardiac muscle predominantly caused by viruses including SARS-CoV-2 and other infections (e.g., influenza, hepatitis B, staphylococcus), toxins (e.g., alcohol, heavy metals, chemotherapy), and systemic immune-related diseases (e.g., sarcoidosis, celiac disease). Vaccinations such as smallpox vaccine has been causally linked to hypersensitivity myocarditis with numerous studies reporting that more than expected incidence of myocarditis and pericarditis have been found associated with COVID-19 mRNA vaccines (Pfizer-BioNTech BNT162b2 and Moderna mRNA-1273).[3,4]

The classic clinical presentation of COVID-19 vaccine-related myocarditis is acute chest pain with an average time of onset of 3 days (range 1-28 days) after vaccination. Pericarditis, an inflammation of the pericardial sac that lines the outside of the heart, occurs most often in conjunction with myocarditis, but when observed in isolation, the onset of chest pain may be somewhat later, with an average of 5 days (range 1-28 days) after vaccination.[4,5] The incidence of myocarditis as an adverse event following COVID-19 vaccination is highly dependent on the sex and age of the patient, as well as the vaccine dose and type. As a vaccine-related safety signal, myocarditis has been most firmly established in younger (ages 18-29 years) male patients after receiving their second dose of mRNA (Pfizer-BioNTech BNT162b2 and Moderna mRNA-1273) vaccine. A safety signal for myocarditis has not been clearly established after non-mRNA vaccines (e.g., Johnson & Johnson JNJ-78436735), after first dose of vaccine, or in patients over age 40 years.[6] Most of the clinical presentations have been mild for this very rare complication which continues to support the broader Centers for Disease Control (CDC) finding that the benefit of vaccination outweighs the risk.[7]

Myocarditis Incidence in the Vaccine Adverse Event Reporting System (VAERS) and the Military Health System (MHS)

Both the CDC and the FDA monitor for COVID-19 vaccination adverse events using a voluntary reporting system called VAERS. Anyone, including patients, can report any safety concerns related to vaccines in VAERS. A review of the VAERS safety data between December 2020 and August 2021 found a small but increased risk for myocarditis after receipt of mRNA COVID-19 vaccines. In the VAERS data review of myocarditis cases, 87 percent of those hospitalized had initial symptoms resolved by the discharge date and no cases of severe manifestation required transplant or ventricular assist device.[3]

Myocarditis occurring after administration of COVID-19 mRNA vaccines (Pfizer-BioNTech BNT162b2 and Moderna mRNA-1273) was first noted by the U.S. military in early 2021 reporting on a case series of 23 male military members who were diagnosed with myocarditis within 4 days of receipt of COVID-19 vaccine.[8] The MHS-specific case series observed a median age of 25 with all military members who were previously healthy with no prior history of

cardiac disease. Most cases were related to second dose of mRNA vaccine, presenting within 50 hours of receiving the vaccine with no concurrent SARS-CoV-2 infection. All patients have either recovered and or were recovering at the time results were published.

Incidence of Cardiovascular Complications – Comparison between SARS-CoV-2 Infection and COVID-19 Vaccination

COVID-19 vaccination is associated with reduced risk for cardiovascular complications such as AMI after SARS-CoV-2 infection compared to those who have never been vaccinated.[9] CDC continues to recommend COVID-19 vaccination given that many more adverse outcomes related to SARS-CoV-2 infection, including death, can be avoided even among the groups at highest risk for myocarditis as an adverse event from immunization. In the highest risk group of males ages 18-29, 300 hospitalizations, 60 ICU admissions and 3 deaths due to SARS-CoV-2 infection related complications would be prevented if vaccination had been provided compared to instead preventing 22-27 COVID-19 vaccination associated myocarditis incidents should vaccination had not occured.[6]

Furthermore, data from 40 health care systems reviewing over 14 million cases from January 1, 2021 to January 31, 2022, continue to support the benefit of COVID-19 vaccination with a significantly higher cardiac complication incidence associated with SARS-CoV-2 infection than after mRNA COVID-19 vaccination for both males and females in all age groups. Analysis also confirmed the higher incidence of myocarditis or pericarditis after mRNA COVID-19 vaccination in males, with incidence of 0-35.9 per 100,000 in males compared to 0-10.9 for females across age groups. The 12-17 age group had the highest incidence of mRNA COVID-19 vaccine associated cardiac complication, with a 1.8-5.6 times higher risk for cardiac complications after SARS-CoV-2 infection than after vaccination.[10]

Kidney Complications with COVID-19 Vaccination

Serious adverse kidney events following COVID-19 vaccine are extremely rare and vaccinations continue to provide protective benefits that far outweigh the known associated kidney complications related to SARS-CoV-2 infection. Rare cases of new onset kidney disease have been reported in literature since 2020 with early complication rates reported at 0.46 percent of all adverse events in VAERS in January 2021 and most recent analysis showing kidney complication reported at incidence of 0.006 percent based on review of VAERS data.[11,12]

The majority of reported kidney disease developed de novo which would be captured under the major category of AKI, also known as acute kidney failure. There is no specific clinical presentation although edema was reported as the most common symptom in addition to hematuria and proteinuria. Various kidney pathologies have been reported with minimal change disease observed as the most common pathology.[13,14] Pathogenesis of COVID-19 vaccine associated kidney complications is unknown although T-cell mediated immune dysregulation causing podocyte damage is one of the proposed theories.[13,14]

A causal relationship between vaccine and AKI cannot be made given many confounding factors such as advanced age, underlying kidney disease, and concurrent infections that independently

predispose increased risk for AKI regardless of vaccination administration. Review of AKI cases in the self-reported VAERS from December 2020 to June 2021 showed that the majority of AKI cases potentially associated with COVID-19 vaccination was reported among individuals of advanced age (ages ranging from 59.75 to 68.41 years). Additionally, more than half of this group also had existing comorbidities such as diabetes, hypertension and heart disease. The most common cause of VAERS reported AKI was volume depletion and sepsis, which again can independently cause AKI. Most cases of AKI developed within 2 weeks of vaccination primarily related to mRNA vaccine type.[12] Fortunately, in two separate systematic reviews of kidney complications post- COVID-19 vaccination, the majority of kidney dysfunction returned to baseline within 90 days of vaccination.[13,14]

AKI is a well-recognized complication that is commonly associated with SARS-CoV-2 infection, with a wide range of incidence rate among hospitalized patients with some reports as high as 46 percent.[15,16,17] The most common cause of AKI was acute tubular necrosis associated with multi-organ failure and shock. In critically ill adults with SARS-CoV-2 infection, AKI often required renal replacement therapy (e.g., dialysis) with mortality up to 58 percent, with more than one-third having persistent need for renal replacement therapy upon discharge from the hospital.[18] Underlying CKD is also a clearly associated risk factor for severe disease with increased risk for mortality associated with SARS-CoV-2 infection. Mortality is significantly higher in those on renal replacement therapy and in kidney transplant recipients.[19]

METHODS

The primary data source for this analysis is the Defense Medical Surveillance System (DMSS), a continuously expanding relational database of personnel demographic and medical data.[20] The DMSS contains records of ambulatory encounters and hospitalizations of Active Component members of the U.S. Armed Forces when reimbursed through TRICARE. Also included are medical encounter data from the Theater Medical Data Store (TMDS), which includes diagnoses of deployed Service members. In addition, the DMSS contains immunization records for Service members from the MHS Information Platform. Due to a gap in immunization records for Air Force members identified at the time of the analysis, immunization data for Air Force members who were missing immunization records in the DMSS were extracted from the Aeromedical Services Information Management System.

The Armed Forces Health Surveillance Division maintains a list of COVID-19 infections among Service members which is updated daily. The list is comprised of reverse transcription-polymerase chain reaction and antigen test laboratory confirmed SARS-CoV-2 infections, as well as medical event reports of SARS-CoV-2 infection from Disease Reporting System Internet. For the purpose of this analysis, SARS-CoV-2 infections were also identified from the DMSS medical encounter data using the ICD-10 code U07.1. A 90-day incidence rule was applied, such that an individual could qualify as having a repeat SARS-CoV-2 infection if at least 90 days had passed since the last diagnosis or positive laboratory test.[21]

To measure obesity status, height and weight data collected from routine medical appointments were extracted from the MHS Data Repository and MHS GENESIS Vitals table in the Medical Data Repository, as well as height and weight information recorded in the electronic annual

Periodic Health Assessment data in DMSS. Individuals were categorized as obese during a given CY if they had a record Body Mass Index (BMI) greater than or equal to 30 where the height and weight measurement were taken that year.[22] If they only had records indicating a BMI less than 30 then they were classified as not obese for that year. If they had no height and weight records, then they were classified as having an unknown weight status for that year. Height and weight measurements were excluded if they occurred within 280 days of a female Service member's medical encounter that included a diagnosis for pregnancy, childbirth, and the puerperium (ICD-10 codes beginning with "O").

This study assessed three cardiac conditions that were most frequently associated with COVID-19 vaccine complications (myocarditis, pericarditis, and AMI) and two categories of kidney conditions that would broadly capture majority of COVID-19 vaccine complications (AKI and CKD). Some case definitions for each condition were referenced from a Department of Veterans Affairs study[23] comparing safety of two versions of COVID-19 vaccines: cases of myocarditis, pericarditis, AMI, and AKI were defined by having at least two medical encounters (inpatient, outpatient, or TMDS) within 60 days of each other with a qualifying diagnosis in any diagnostic position. The incident date was defined as the first qualifying encounter of which there were two within 60 days. Cases of CKD were defined by having at least two medical encounters within 730 days (2 years) of each other with a qualifying diagnosis in any diagnostic position. The incident date was defined as the date of the first-ever encounter with a diagnosis of CKD. The ICD-9 and ICD-10 codes used to define the cases are included in Appendix A, Tables A1-A5.

For each Service member, the number of days in active military service was ascertained and aggregated for each CY between 2019 and 2021. The resultant annual totals were expressed as person-years of service and used as the denominators for the calculation of annual incidence rates for each of the five outcomes. For each outcome, person time was censored at the date of the incident diagnosis and prevalent cases (i.e., cases identified prior to the start of the surveillance period in 2019) were excluded. "At risk" periods for each of the outcomes was categorized as the 45-day period following SARS-CoV-2 infection, and the 21-day period following receipt of any dose of a COVID-19 vaccine (Appendix A, Table A6). The 45-day period following SARS-CoV-2 infection was chosen to represent a general average of variable time to symptom resolution that are reported in literature. For mild acute illness, symptoms may resolve in a few days to 2 weeks whereas prolonged recovery time for months has been observed in those with severe disease. To ensure optimal inclusion of the most appropriate clinical cases and to avoid potential confounding factors, a 45-day at risk period was chosen. The 21-day at risk period following COVID-19 vaccination was chosen to be aligned with at-risk timelines that are most commonly reported in literature, federal vaccine injury compensation programs (using 0-21 day time window for smallpox vaccine associated myocarditis), and review of data from VAERS. Person time periods considered to be not at risk for the outcome due to either SARS-CoV-2 infection or vaccination with a COVID-19 vaccine were divided into two categories: infection or vaccination occurred greater than 45 days or 21 days ago, respectively, or no previous infection or vaccination. However, for CKD, the "at risk" period following SARS-CoV-2 infection and COVID-19 vaccination was categorized as 180 days instead of 45 days to ensure inclusion of all potential CKD cases. Although CKD is defined as having a decrement in kidney function that lasts for at minimum 3 months (based on references from the Kidney Disease Improving Global Outcomes and Kidney Disease Outcomes Quality Initiative), the at-

risk period for CKD was extended to 180 days to allow adequate time for follow up with a provider and to mitigate risk for exclusion of potential cases. Incidence rates were calculated per 100,000 person-years of Active Component service.

A multivariable Poisson regression model was used to calculate the adjusted incidence rate ratios for each of the five outcomes for CY 2021 by "at risk" status. Similar to the crude (i.e., unadjusted) analysis, the "at risk" periods were defined as the 45-day period following SARS-CoV-2 infection and the 21-day period following receipt of a COVID-19 vaccine dose which aligns with most published literature (except for CKD which used a 180-day period following SARS-CoV-2 infection and vaccination). These models adjusted for age, sex, race and ethnicity, obesity status, and either SARS-CoV-2 infection within the past 45 days (180 days for CKD) or COVID-19 vaccine dose received within the past 21 days (180 days for CKD). Adjusted incidence rates were calculated per 100,000 person-years of Active Component service. Due to the small number of Service members vaccinated against COVID-19 prior to 2021, these adjusted incidence rates could only be calculated in 2021.

Finally, overall crude annual prevalence was calculated for each of the five conditions. An individual was counted as a prevalent case if they had been previously identified as an incident case for that condition and had a medical encounter for that condition during the year of interest. The denominator was calculated using the number of Active Component Service members who were in service during June of that CY. Prevalence rates were calculated as the number of prevalent cases per 100,000 Service members.

RESULTS

General Explanation of Prevalence, Incidence, and Rate Ratio

Crude annual prevalence (the unadjusted rate of new and existing cases) rates were calculated for each condition of interest at the overall population level among Active Component members. It is typically best practice to use a mid-year (June) population count as denominator for this type of rate, given this population's constant fluctuation. However, numerators for this type of measure need to be able to count cases across the same amount of time for all years in order to be comparable. For this reason, a crude annual prevalence rate for CY 2022 is not able to be calculated – its numerator would be inappropriately small leading to an equally inappropriately small prevalence rate that is incomparable and otherwise easy to misinterpret.

Incidence rates (the rate of new cases in each CY) calculated for this report, both crude and adjusted, utilize a person-time (specifically person-years of military service) type of denominator that aims to better handle fluctuations in the amount of time an individual is cared for in the MHS and, thus, is not as subject to the drawbacks of the crude annual prevalence rate. While CY 2022 incidence rates are able to be calculated and compared between previous years, it is still important to practice caution when interpreting incomplete CY 2022 incidence data. Lastly, incidence rates are also likely the most appropriate measure to examine for this report given its focus on examining the likelihood of developing cardiac and kidney adverse events associated with SAR-CoV-2 infection or COVID-19 vaccination and not the general burden of these conditions on the MHS population.

Finally, adjusted incidence rate ratios were calculated for this report. A rate ratio allows for person-time incidence rates of two groups to be compared to each other, differentiated by usually a demographic feature or by exposure to a suspected causative agent and statistical significance to be tested. In this case, the rate ratios reported are differentiated by exposure to SARS-CoV-2 infection and COVID-19 vaccination separately and compared to the "Never" exposure group consistently. Interpretation of a rate ratio is straight-forward: a rate ratio of 1.0 indicates equal rates within the groups compared, a rate ratio greater than 1.0 indicates increased risk, and a rate ratio less than 1.0 indicates decreased risk or a protective effect.

Cardiac Outcomes – Overall Prevalence Data

The overall prevalence data captures the general burden of disease and causality to specific changes related to SARS-CoV-2 infection or COVID-19 vaccine cannot be made. As explained above, incidence rates are likely the most appropriate measure to examine for this report given its focus on examining the likelihood of developing cardiac and kidney adverse events associated with SAR-CoV-2 infection or COVID-19 vaccination.

Table 1. Crude Annual Prevalence Rates of Select Cardiac Conditions within Active Component Service Members

	Calendar Year								
	2019			2020			2021		
	N	Persons	Prevalence*	N	Persons	Prevalence*	N	Persons	Prevalence*
Myocarditis	205	1,313,942	15.6	189	1,320,699	14.3	326	1,339,485	24.3
Pericarditis	363	1,313,942	27.6	334	1,320,699	25.3	351	1,339,485	26.2
AMI	283	1,313,942	21.5	314	1,320,699	23.8	353	1,339,485	26.4

Abbreviations: AMI = acute myocardial infraction;
*****Cases per 100,000 persons

In CY 2019, the crude prevalence (the unadjusted rate of new and existing cases) of myocarditis, pericarditis, and AMI was 15.6 cases per 100,000 persons, 27.6 per 100,000 persons, and 21.5 per 100,000 persons respectively (Table 1). By CY 2021, crude prevalence rates for myocarditis increased more than 50 percent to 24.3 cases per 100,000 persons. However, rates for pericarditis remained mostly unchanged and rates for AMI increased only modestly from 23.8 per 100,000 persons to 26.4 per 100,000 persons. Crude prevalence rates for CY 2022 could not be reported at this time, as explained above.

Cardiac Outcomes – Overall and Infection/Vaccination Exposure Incidence Data

Overall crude incidence rates (the unadjusted rate of new cases in each CY) for pericarditis and AMI remained mostly stable across the observed timespan from CY 2019 to available data in CY 2022 (Table 2). Unlike with AMI, rates for pericarditis did slightly decrease between CY 2021 and the first half of CY 2022. However, crude incidence rates for myocarditis decreased from 10.8 per 100,000 person-years (p-yrs) in CY 2019 to 8.7 in CY 2020 and then increased to 17.9 in CY 2021. While data for CY 2022 is currently only available between January and June 2022, the crude incidence rate for myocarditis during this 6-month period (13.0 cases per 100,000 p-yrs) is still above what was observed in CY 2019 (Table 2). These overall crude incidence rates include all Active Component members who experienced a new case of myocarditis, pericarditis,

or AMI during each year of interest, regardless of if they had a previous SARS-CoV-2 infection or received COVID-19 vaccine.

Table 2. Crude Annual Incidence Rates of Select Cardiac Conditions within Active Component Service Members, Overall and Stratified by SARS-CoV-2 Infection and COVID-19 Vaccine

	Calendar Year							
	2019		2020		2021		2022 (through June)	
	N	Incidence*	N	Incidence*	N	Incidence*	N	Incidence*
Myocarditis	142	10.8	116	8.7	239	17.9	84	13.0
SARS-CoV-2 Infection								
Yes, ≤ 45 days	0	0.0	13	142.8	27	152.1	16	59.1
No, > 45 days	0	0.0	7	56.5	55	41.9	16	11.6
Never	142	10.8	96	7.4	157	13.3	52	10.8
COVID-19 Vaccine								
Yes, ≤ 21 days	0	0.0	0	0.0	63	40.6	3	17.8
No, > 21 days	0	0.0	0	0.0	92	13.4	76	12.4
Never	142	10.8	116	8.8	84	17.1	5	33.9
Pericarditis	266	20.3	242	18.3	244	18.3	91	14.1
SARS-CoV-2 Infection								
Yes, ≤ 45 days	0	0.0	6	66.0	18	101.5	13	48.0
No, > 45 days	0	0.0	5	40.4	41	31.2	27	19.5
Never	266	20.3	231	17.7	185	15.6	51	10.6
COVID-19 Vaccine								
Yes, ≤ 21 days	0	0.0	1	133.9	48	30.9	5	29.7
No, > 21 days	0	0.0	0	0.0	115	16.8	82	13.3
Never	266	20.3	241	18.2	81	16.5	4	27.1
AMI	198	15.1	229	17.3	244	18.3	117	18.1
SARS-CoV-2 Infection								
Yes, ≤ 45 days	0	0.0	9	98.9	8	45.1	16	59.1
No, > 45 days	0	0.0	2	16.1	20	15.2	23	16.6
Never	198	15.1	218	16.7	216	18.2	78	16.2
COVID-19 Vaccine								
Yes, ≤ 21 days	0	0.0	0	0.0	35	22.6	0	0.0
No, > 21 days	0	0.0	0	0.0	120	17.5	115	18.7
Never	198	15.1	229	17.3	89	18.1	2	13.6

Abbreviations: AMI = acute myocardial infarction;
*****Cases per 100,000 person-years of Active Component service

The overall crude incidence rates reported above were then stratified by cases that occurred within 45 days after SARS-CoV-2 (180 days for CKD) infection and cases that occurred within 21 days after COVID-19 vaccination (180 days for CKD). Given that the first laboratory confirmed case of SARS-CoV-2 in the United States occurred in January 2020 and DoD did not begin administering vaccine until December 2020, there are no cases of myocarditis, pericarditis, or AMI with previous infection or vaccine in CY 2019. In CY 2020, there were overall low number of cases related to either SARS-CoV-2 infection or COVID-19 vaccine. Specifically, in

CY 2020, there were 13, 6, and 9 cases of myocarditis, pericarditis, and AMI, respectively, which occurred within 45 days after SARS-CoV-2 infection, and only a single case of pericarditis within 21 days of receiving COVID-19 vaccine (Table 2).

In CY 2021, the crude incidence of myocarditis was 11 times higher in those with a past 45-day SARS-CoV-2 infection (152.1 per 100,000 p-yrs) compared to those with no prior SARS-CoV-2 infection (13.3 per 100,000 p-yrs) (Table 2). In contrast, the crude incidence of myocarditis was 2.4 times higher among those who received a vaccine dose within 21 days prior (40.6 per 100,000 p-yrs) compared to those who did not receive any prior dose of vaccine (17.1 per 100,000 p-yrs). The crude incidence of pericarditis was 6 times higher in those with a previous infection (101.5 per 100,00 p-yrs) compared to those without, and 1.9 times higher in those with a previous vaccination (30.9 per 100,000 p-yrs) compared to those without. Finally, incidence of AMI was 2.5 times higher in those with a recent infection and 1.2 times higher in those with a recent vaccination. For the most part, these trends continue in the 6 months available for CY 2022 at lesser magnitudes.

Cardiac outcome results showed similar patterns after adjusting for age, sex, race/ethnicity, obesity status, and either prior infection or prior vaccination (Table 3). In CY21, those with a recent SARS-CoV-2 infection had a rate ratio that showed incidence of myocarditis and pericarditis was 10.4 and 6.1 (respectively) times higher in this group compared to the incidence rates of those who were never infected. Those who were recently vaccinated had a rate ratio that showed their incidences of myocarditis and pericarditis were 2.6 and 2.0 times higher compared to those who were never vaccinated. These findings were statistically significant ($p<0.001$). In addition, those with a recent infection had a rate ratio that showed incidence for AMI was 2.4 times higher in this group compared to those who were never infected. Unlike with myocarditis and pericarditis rate ratios showing increased risk associated with vaccination, those who were recently vaccinated did not have increased incidence of AMI compared to those who were not vaccinated. The rate ratio for AMI comparing those who were vaccinated to those who were never vaccinated was at 1.1, effectively implying there was no difference between vaccination groups, although the association is not statistically significant.

Table 3: Adjusted Incidence Rates and Rate Ratios of Selected Cardiac Conditions Stratified by SARS-CoV-2 Infection and COVID-19 Vaccine, 2021

	Incidence*		Rate Ratio	
	SARS-CoV-2 Infection	COVID-19 Vaccine	SARS-CoV-2 Infection	COVID-19 Vaccine
Myocarditis				
Yes	98.2	57.2	10.4**	2.6**
No	27.8	20.3	2.9**	0.9
Never	9.5	22.2	Ref	Ref
Pericarditis				
Yes	55.5	30.8	6.1**	2.0**
No	16.3	17.5	1.8**	1.1
Never	9.1	15.3	Ref	Ref
AMI				
Yes	27.1	16.3	2.4**	1.1
No	9.9	12.1	0.9	0.8
Never	11.2	15.2	Ref	Ref

Abbreviations: AMI = acute myocardial infarction;
*****Cases per 100,000 person-years in Active Component service, adjusted for age, sex, race and ethnicity, obesity status, and either COVID-19 infection within the past 45 days (180 days for CKD) or COVID-19 vaccine dose received within the past 21 days
**Statistically significant, p-value at least <0.05

Kidney Outcomes – Overall Prevalence Data

In CY 2019, the crude prevalence rates for AKI and CKD were 110.3 cases per 100,000 persons and 121.3 per 100,000 persons, respectively (Table 4). Both conditions had similar prevalence rates in both CY 2020 and CY 2021. Prevalence data for CY 2022 could not be reported as explained above.

Table 4. Crude Annual Prevalence Rates of Select Kidney Conditions within Active Component Service Members

	Calendar Year								
	2019			2020			2021		
	N	Persons	Prevalence*	N	Persons	Prevalence*	N	Persons	Prevalence*
AKI	1,449	1,313,942	110.3	1,433	1,320,699	108.5	1,533	1,339,485	114.5
CKD	1,594	1,313,942	121.3	1,547	1,320,699	117.1	1,607	1,339,485	120.0

Abbreviations: AKI = acute kidney injury; CKD = chronic kidney disease
*****Cases per 100,000 persons

Kidney Outcomes – Overall and Infection/Vaccination Exposure Incidence Data

Crude annual incidence rates for AKI and CKD showed the same pattern – a slight decrease during CY 2020 followed by a return to roughly the same rate in CY 2021 as in CY 2019 (Table 5). While data for CY 2022 is only partially available at this time, the crude incidence rates for both conditions appear to be on track to end up similar to CY 2019 and CY 2021.

Table 5. Crude Annual Incidence Rates of Select Kidney Conditions within Active Component Service Members, Overall and Stratified by SARS-CoV-2 Infection and COVID-19 Vaccine

	Calendar Year							
	2019		2020		2021		2022 (through June)	
	N	Incidence*	N	Incidence*	N	Incidence*	N	Incidence*
AKI	1340	102.3	1307	98.9	1406	105.8	625	97.0
SARS-CoV-2 Infection								
Yes, ≤ 45 days	0	0.0	74	816.2	136	769.8	55	203.8
No, > 45 days	0	0.0	17	137.8	164	125.4	143	103.8
Never	1340	102.3	1216	93.5	1106	93.7	427	89.0
COVID-19 Vaccine								
Yes, ≤ 21 days	0	0.0	1	134.3	138	89.2	13	77.5
No, > 21 days	0	0.0	0	0.0	663	96.9	588	95.9
Never	1340	102.3	1306	98.8	605	123.5	24	163.2
CKD	724	55.2	648	48.9	680	51.1	230	35.6
SARS-CoV-2 Infection	0	0.0	18.0	88.2	64	88.6	42	44.4
Yes, ≤ 180 days	0	0.0	1.0	95.1	36	47.0	26	36.8
No, > 180 days	724	55.2	629.0	48.3	580	49.1	162	33.7
Never	0	0.0	18.0	88.2	64	88.6	42	44.4
COVID-19 Vaccine								
Yes, ≤ 180 days	0	0.0	1	134.1	339	51.4	85	36.2
No, > 180 days	0	0.0	0	0.0	85	46.4	137	34.2
Never	724	55.2	647	48.9	256	52.4	8	56.8

Abbreviations: AKI = acute kidney injury; CKD = chronic kidney disease
*****Cases per 100,000 person-years of active component service

Once crude incidence rates were stratified by SARS-CoV-2 infection and COVID-19 vaccination, similar low case counts occur in these categories during CY 2020 for kidney conditions as they do for cardiac conditions with the exception of AKI. There was a total of 74 cases of AKI with prior SARS-CoV-2 infection within 45 days, which correlates with initial published reports of AKI complicating SARS-CoV-2 infection in as much as about 46 percent of all cases.[15] In CY 2021, the crude incidence of AKI was 8.2 times higher in those with a past 45-day SARS-CoV-2 infection (769.8 per 100,000 p-yrs) compared to those with no prior SARS-CoV-2 infection (93.7 per 100,000 p-yrs) (Table 5). In contrast, the crude incidence of AKI was reduced 28 percent among those who received a vaccine dose within 21 days prior (89.2 per 100,000 p-yrs) compared to those who did not receive any prior dose of vaccine (123.5 per 100,000 p-yrs). The crude incidence of CKD in CY 2021 was 1.8 times higher in those with an infection in the past 180 days compared to those never infected. Crude incidence rates of CKD between those with previous COVID-19 vaccination in the past 180 days (51.4 per 100,000 p-yrs) was similar to those who never had the vaccine (52.4 per 100,000 p-yrs).

Kidney outcomes again showed similar patterns after adjusting for age, sex, race/ethnicity, obesity status, and either prior infection or vaccination (Table 6). Those with a recent SARS-CoV-2 infection had a rate ratio that showed AKI incidence was 7.6 times higher among this group compared to those who were never infected. Similar for CKD, those with a recent SARS-

CoV-2 infection had a rate ratio that showed their CKD incidence was 1.8 times higher compared to those who were never infected. Those who were recently vaccinated had a rate ratio that showed they had a 20 percent reduced incidence of AKI and 20 percent reduced incidence of CKD compared to those who were never vaccinated.

Table 6: Adjusted Incidence Rates and Rate Ratios of Selected Kidney Conditions Stratified by SARS-CoV-2 Infection and COVID-19 Vaccine, 2021

	Incidence*		Rate Ratio	
	SARS-CoV-2 Infection	COVID-19 Vaccine	SARS-CoV-2 Infection	COVID-19 Vaccine
AKI				
Yes	537.8	132.8	7.6**	0.8**
No	92.5	150.4	1.3**	0.9**
Never	71.0	176.8	Ref	Ref
CKD				
Yes	64.4	44.2	1.8**	0.8**
No	36.8	34.8	1.1	0.6**
Never	35.0	54.0	Ref	Ref

Abbreviations: AKI = acute kidney injury; CKD = chronic kidney disease
*****Cases per 100,000 person-years in Active Component service, adjusted for age, sex, race and ethnicity, obesity status, and either COVID-19 infection within the past 45 days (180 days for CKD) or COVID-19 vaccine dose received within the past 21 days
**Statistically significant, p-value at least <0.05

DISCUSSION

In response to the public health emergency of pandemic level spread of SARS-CoV-2 virus, DoD began administering COVID-19 vaccines in December 2020 with the full 2-dose vaccination against COVID-19 being required for all Active Component (and Ready Reserve) Service members starting in August 2021. Almost 1.5 million Active Component members have received at least one dose of the COVID-19 vaccine and the report findings suggest overall stable incidence and prevalence rates of most cardiac and kidney conditions from 2019 to 2022. Similar to numerous studies reporting an increase in myocarditis incidence as a rare complication of mRNA COVID-19 vaccination, MHS data review from January 2019 to June 2022 showed an overall small increase in myocarditis incidence and prevalence among Active Component Service members.[3-10]

The overall small increase in myocarditis incidence, which was most profound in 2021, is potentially related to the general increased incidence of SARS-CoV-2 infection that was observed nationwide and also within DoD during the surge from the Delta variant spread in summer 2021. After adjusting for confounding factors, there was a 10.4 times increased risk for myocarditis associated with recent SARS-CoV-2 infection compared to 2.6 times increased risk for myocarditis associated with COVID-19 vaccine. MHS data align with published studies acknowledging a small increase in myocarditis incidence potentially related to COVID-19 vaccine but with far worse outcomes that was potentially avoided with SARS-CoV-2 infection.[9,10]

The only other clinical outcome with a trend toward increased overall prevalence, although slight, was in AMI. To reiterate, prevalence data captures the general burden of disease and incidence rates are most appropriate to examine for this report for potential causality to changes related to SARS-CoV-2 infection or COVID-19 vaccination. Specifically, the crude prevalence rates for AMI modestly increased across the 2019-2021 time period. Conversely, the crude incidence rate for AMI started low at 15.1 cases per 100,000 p-yrs in 2019 before increasing to 17.3 in 2020 and remaining relatively stable at this increased level for 2021 and through June 2022. Both prior SARS-CoV-2 infection and receipt of COVID-19 vaccine resulted in higher crude incidence rates of AMI compared to never being infected or never receiving the vaccine. However, SARS-CoV-2 infection associated AMI crude incidence rates were markedly higher than vaccine-associated AMI crude incidence rates. Similarly, after adjusting for confounding factors, there was 2.4 times increased risk for AMI associated with recent SARS-CoV-2 infection compared to 1.1 times increased risk for AMI associated with COVID-19 vaccination. The higher and statistically significant rate ratio of 2.4 suggests that having previous SARS-CoV-2 infection had a more significant impact on AMI incidence rate than COVID-19 vaccine, the rate ratio of which was not statistically significant and nearly 1.0 (implying almost no difference in incidence rates between those who received COVID-19 vaccine and those who never received COVID-19 vaccine). At the very least, this could be a weak signal inferring that SARS-CoV-2 infection did indeed drive the moderate increase in observed AMI prevalence, but a more detailed analysis is likely needed to confirm.

The incidence and prevalence of pericarditis and both kidney outcomes (AKI and CKD) evaluated in this report remained similar or at least mostly similar in 2021 compared to previous years. The association between CKD and COVID-19 vaccine is difficult to make given multiple confounding factors and the prolonged timeline associated with CKD development. However, crude incidence rates between those with previous COVID-19 vaccination (51.4 per 100,000 p-yrs) were similar to those who never had the vaccine (52.4 per 100,000 p-yrs). Overall, our data suggests that there was a trend showing no differences in CKD incidence.

Although the incidence and prevalence of pericarditis remained stable from 2019 to 2021 with a trend toward decrease in 2022, the adjusted rate ratio of 2.0 showed a potential increase in the risk for pericarditis associated with COVID-19 vaccine. However, similar to the myocarditis findings, there was a significantly 6.1 times higher increased risk for pericarditis associated with SARS-CoV-2 infection compared to 2.0 times increased risk for pericarditis associated with the vaccine. To date and based on published clinical case reports and case series, it remains difficult to separate pericarditis from myocarditis (possible myocarditis cases) because features of myocarditis and pericarditis may overlap and commonly present as myopericarditis.[4,7] While diagnostic criteria exist for the diagnosis of pericarditis, without further review of the individual cases to confirm the clinical evaluation and diagnosis of pericarditis, it is difficult to accurately estimate the prevalence and incidence of infection or vaccine associated pericarditis as this condition may present across a spectrum of severity and symptoms that can overlap with myocarditis.

Similar to data reported in literature, the incidence of all cardiac and kidney conditions evaluated in this report were higher in those with a recent SARS-CoV-2 infection compared to without infection (rate ratios ranging from 1.8-10.4, all statistically significant).[9-10] While there was also

increased incidence for myocarditis and pericarditis in the 21 days following COVID-19 vaccination compared to those without vaccination (rate ratios of 2.6 and 2.0 respectively, both statistically significant), this increase was much lesser in magnitude compared to those observed following infection with SARS-CoV-2. Furthermore, there was no observed increase in risk for AMI, AKI, or CKD incidence following COVID-19 vaccination. In fact, rate ratios for these conditions implied either no difference in incidence rates following vaccine (AMI, though not statistically significant) or a reduced effect in incidence rates following vaccine (AKI and CKD, both statistically significant). These observations are consistent with what is reported in literature for the selected cardiac and kidney conditions.

Global studies have shown that COVID-19 vaccines are effective in protecting against SARS-CoV-2 infections and complications of infection. While vaccine effectiveness against mild infection is dependent on viral variants,[24,25] effectiveness calculations against severe disease, hospitalization, and death have been consistently estimated as high as 80-90 percent.[26,27] Vaccine effectiveness has been established in vulnerable populations as well as the relatively healthy military population.[28] The COVID-19 vaccination program in the United States has been estimated as preventing nearly 120 million infections, 18.5 million hospitalizations, and 3.2 million deaths.[29] Prevention of SARS-CoV-2 infections and complications has also been translated into substantial economic value.[29,30] Expanded understanding of post-acute sequelae of SARS-CoV-2 infection, or long-COVID, and recent research demonstrating effectiveness of vaccination in preventing long-COVID,[31] will make future calculations of vaccine value even higher than previous robust estimates. Although all vaccinations carry some risk of rare adverse events, the benefit of COVID-19 vaccination during the current pandemic has been strongly established by all international public health authorities.[32]

The findings in this report are subject to at least three limitations. First, this is a population-level evaluation of administrative data records within the MHS. Time period risk windows were used to associate outcomes with COVID-19 infection or vaccination. However, this does not necessarily mean that a case occurring during the risk window was caused by COVID-19 infection or vaccination. Detailed chart review confirmation would be needed to determine causality of the cardiac and kidney conditions included in this study. The use of administrative data for outcome definition may also result in misclassification of diagnoses due to miscoding in patient records. Furthermore, only individuals who show up for healthcare services billable to military insurance are able to be included for evaluation. While this report did focus on Active Component members, a subgroup of the MHS population that receives the majority of its health care covered by military insurance, it is still possible that cases of SARS-CoV-2 infection, myocarditis, pericarditis, AMI, AKI, and CKD were missed due to the nature of the data source. Second, this report only evaluates vaccinations administered while an Active Component member is in Military Service and may have missed vaccinations completed prior to the first date in military. Third, while the report did observe an increased risk for certain cardiac conditions after SARS-CoV-2 infection and COVID-19 vaccination, these associations are far from causal and too many factors are unable to be controlled for. Rather, the report serves as soft confirmation of trends also observed in the general population: while the COVID-19 vaccine does carry increased risk for certain cardiac conditions, the risk for those same conditions is higher still following SAR-CoV-2 infection, albeit overall a rare event in both cases.

There are no long-term outcome data available for the increased myocarditis incidence associated with both COVID-19 vaccine and SARS-CoV-2 infection globally and also within MHS. Active and continued long-term surveillance of potential incident cases with diagnosis confirmation through detailed case reviews may be pursued to assist in mitigating potential risk factors associated with increased myocarditis risk for Service members.

CONCLUSION

Review of MHS data spanning January 2019 to June 2022 demonstrates that both the prevalence and incidence of myocarditis has increased among Active Component members of the Armed Forces. All other cardiac and kidney outcomes remained mostly stable through the time period. Recent receipt of COVID-19 vaccine was shown to carry increased risk for development of both myocarditis and pericarditis, but without increased risk for AMI and with a slightly reduced risk for AKI and CKD. However, recent SARS-CoV-2 infection was associated with a significantly higher magnitude of increased risk for all observed cardiac and kidney conditions when compared to vaccine administration. While all vaccinations including COVID-19 carry some amount of risk for rare adverse events, the MHS data shows that risks for cardiac and kidney complications are higher after SARS-CoV-2 infection than they are after COVID-19 vaccine, supporting similar conclusions drawn by previous published studies.

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APPENDIX A: ICD-9, ICD-10, and CVX Codes for Case Definitions of Cardiac, Kidney, and COVID-19 Vaccination

Table A1. ICD codes for Myocarditis

ICD-10	ICD-10 Description	ICD-9	ICD-9 Description
I51.4	Myocarditis, unspecified	429.0	Myocarditis, unspecified
I40.9	Acute myocarditis, unspecified	422.90	Acute myocarditis, unspecified
I40.8	Other acute myocarditis	422.93, 422.99	Toxic myocarditis, Other acute myocarditis
I40.1	Isolated myocarditis	422.91	Idiopathic myocarditis
I40.0	Infective myocarditis	422.92	Septic myocarditis
I41	Myocarditis in diseases classified elsewhere	422.0	Acute myocarditis in diseases classified elsewhere
I01.2	Acute rheumatic myocarditis	391.2	Acute rheumatic myocarditis
I09.0	Rheumatic myocarditis	398.0	Rheumatic myocarditis

Table A2. ICD codes for Pericarditis

ICD-10	ICD-10 Description	ICD-9	ICD-9 Description
I32	Pericarditis in diseases classified elsewhere	420.0	Acute pericarditis in diseases classified elsewhere
I30.9	Acute pericarditis, unspecified	420.90	Acute pericarditis, unspecified
I30.8	Other forms of acute pericarditis	420.99	Other acute pericarditis
I30.1	Infective pericarditis	420.90	Acute pericarditis, unspecified
I30.0	Acute nonspecific idiopathic pericarditis	420.91	Acute idiopathic pericarditis
M32.12	Pericarditis in systemic lupus erythematosus	423.9	Unspecified disease of pericardium

Table A3. ICD codes for Acute Myocardial Infarction

ICD-10	ICD-10 Desc	ICD-9	ICD-9 Desc
I21.0*	ST elevation (STEMI) myocardial infarction of anterior wall	410*	Acute myocardial infarction
I21.1*	ST elevation (STEMI) myocardial infarction of inferior wall	As above	
I21.2*	ST elevation (STEMI) myocardial infarction of other sites	As above	
I21.3	ST elevation (STEMI) myocardial infarction of unspecified site	As above	
I21.4	Non-ST elevation (NSTEMI) myocardial infarction	As above	
I21.9	Acute myocardial infarction, unspecified	As above	
I22*	Subsequent ST elevation (STEMI) and non-ST elevation (NSTEMI) myocardial infarction	As above	

*Indicates that all subsequent digits/characters are included

Table A4. ICD codes for Acute Kidney Failure

ICD-10	ICD-10 Desc	ICD-9	ICD-9 Desc
N17.0	Acute kidney failure with tubular necrosis	584.5	Acute kidney failure with lesion of tubular necrosis
N17.1	Acute kidney failure with acute cortical necrosis	584.6	Acute kidney failure with lesion of renal cortical necrosis
N17.2	Acute kidney failure with medullary necrosis	584.7	Acute kidney failure with lesion of renal medullary [papillary] necrosis

N17.8	Other acute kidney failure	584.8	Acute kidney failure with other specified pathological lesion in kidney
N17.9	Acute kidney failure, unspecified	584.9	Acute kidney failure, unspecified

Table A5. ICD codes for Chronic Kidney Disease

ICD-10	ICD-10 Desc	ICD-9	ICD-9 Desc
I12.0	Hypertensive chronic kidney disease with stage 5 chronic kidney disease or end stage renal disease	403.01, 403.11, 403.91	Hypertensive chronic kidney disease, malignant, with chronic kidney disease stage V or end stage renal disease; Hypertensive chronic kidney disease, benign, with chronic kidney disease stage V or end stage renal disease; Hypertensive chronic kidney disease, unspecified, with chronic kidney disease stage V or end stage renal disease
I13.1	Hypertensive heart and chronic kidney disease without heart failure		
I13.10	Hypertensive heart and chronic kidney disease without heart failure, with stage 1 through stage 4 chronic kidney disease, or unspecified chronic kidney disease	404.00, 404.10, 404.90	Hypertensive heart and chronic kidney disease, malignant, without heart failure and with chronic kidney disease stage I through stage IV, or unspecified; Hypertensive heart and chronic kidney disease, benign, without heart failure and with chronic kidney disease stage I through stage IV, or unspecified; Hypertensive heart and chronic kidney disease, unspecified, without heart failure and with chronic kidney disease stage I through stage IV, or unspecified
I13.11	Hypertensive heart and chronic kidney disease without heart failure, with stage 5 chronic kidney disease, or end stage renal disease	404.02, 404.12, 404.92	Hypertensive heart and chronic kidney disease, malignant, without heart failure and with chronic kidney disease stage V or end stage renal disease; Hypertensive heart and chronic kidney disease, benign, without heart failure and with chronic kidney disease stage V or end stage renal disease; Hypertensive heart and chronic kidney disease, unspecified, without heart failure and with chronic kidney disease stage V or end stage renal disease
N03.2	Chronic nephritic syndrome with diffuse membranous glomerulonephritis	582.0	Chronic glomerulonephritis with lesion of proliferative glomerulonephritis
N03.3	Chronic nephritic syndrome with diffuse mesangial proliferative glomerulonephritis	582.1	Chronic glomerulonephritis with lesion of membranous glomerulonephritis
N03.4	Chronic nephritic syndrome with diffuse endocapillary proliferative glomerulonephritis	582.2	Chronic glomerulonephritis with lesion of membranoproliferative glomerulonephritis
N03.5	Chronic nephritic syndrome with diffuse mesangiocapillary glomerulonephritis	As above	
N03.6	Chronic nephritic syndrome with dense deposit disease	As above	
N03.7	Chronic nephritic syndrome with diffuse crescentic glomerulonephritis	As above	
N18*	Chronic kidney disease (CKD)	585*	Chronic kidney disease (CKD)
N19	Unspecified kidney failure	586	Renal failure, unspecified

N05.2	Unspecified nephritic syndrome with diffuse membranous glomerulonephritis	583.1	Nephritis and nephropathy, not specified as acute or chronic, with lesion of membranous glomerulonephritis
N05.3	Unspecified nephritic syndrome with diffuse mesangial proliferative glomerulonephritis	583.2	Nephritis and nephropathy, not specified as acute or chronic, with lesion of membranoproliferative glomerulonephritis
N05.4	Unspecified nephritic syndrome with diffuse endocapillary proliferative glomerulonephritis	As above	
N05.5	Unspecified nephritic syndrome with diffuse mesangiocapillary glomerulonephritis	As above	
N05.6	Unspecified nephritic syndrome with dense deposit disease	583.89	Nephritis and nephropathy, not specified as acute or chronic, with other specified pathological lesion in kidney
N05.7	Unspecified nephritic syndrome with diffuse crescentic glomerulonephritis	As above	
N25.0	Renal osteodystrophy	588.0	Renal osteodystrophy
Z49.01, Z49.02	Encounter for fitting and adjustment of extracorporeal dialysis catheter; Encounter for fitting and adjustment of peritoneal dialysis catheter	V56.1, V56.2	Fitting and adjustment of extracorporeal dialysis catheter; Fitting and adjustment of peritoneal dialysis catheter
Z94.0	Kidney transplant status	V42.0	Kidney replaced by transplant
Z99.2	Dependence on renal dialysis	V45.11	Renal dialysis status

*Indicates that all subsequent digits/characters are included

Table A6. CVX codes for COVID-19 vaccination

Imm_type	Description	Comments
510	SARS-COV-2 COVID-19 Inactivated Virus Non-U.S. Vaccine Product (BIBP, Sinopharm)	WHO authorized pandemic vaccine. Recognized towards immunity in U.S.
511	SARS-COV-2 COVID-19 Inactivated Virus Non-U.S. Vaccine Product (CoronaVac, Sinovac)	WHO authorized pandemic vaccine. Recognized towards immunity in U.S.
502	SARS-COV-2 COVID-19 Inactivated Virus Non-U.S. Vaccine Product (COVAXIN)	Pandemic Non-U.S. Vaccine Authorized by WHO 11-3-2021, recognized toward immunity in U.S., https://extranet.who.int/pqweb/vaccines/who-recommendation-bharat-biotech-international-ltd-covid-19-vaccine-whole-virion.
212	SARS-COV-2 (COVID-19) vaccine, vector non-replicating, recombinant spike protein-Ad26, preservative free, 0.5 mL	FDA EUA 02/27/2021, 1-dose vaccine. Used to record Janssen/J&J vaccines administered in the U.S. and in non-U.S. locations
210	SARS-COV-2 (COVID-19) vaccine, vector non-replicating, recombinant spike protein-ChAdOx1, preservative free, 0.5 mL	Potential FDA EUA, 2-dose vaccine. AstraZeneca vaccine is authorized by the WHO and recognized towards immunity in the U.S. Non-U.S. WHO authorized tradenames/identifiers include VAXZEVRIA, AZD1222, ChAdOx1 nCoV-19, COVISHIELD
207	SARS-COV-2 (COVID-19) vaccine, mRNA, spike protein, LNP, preservative free, 100 mcg/0.5mL dose or 50 mcg/0.25mL dose	FDA EUA 12/18/2020, 2-dose vaccine. Used to record Moderna vaccines administered in the U.S. and in non-U.S. locations (includes tradename Spikevax)
208	SARS-COV-2 (COVID-19) vaccine, mRNA, spike protein, LNP, preservative free, 30 mcg/0.3mL dose	FDA BLA 08/23/2021 for adult dose (16+ years). Still under EUA for adolescent doses and presentations. EUA 12/11/2020, 2-dose vaccine. Used to record Pfizer vaccines administered in the U.S. and in non-U.S. locations (includes tradename Comirnaty)

217	SARS-COV-2 (COVID-19) vaccine, mRNA, spike protein, LNP, preservative free, 30 mcg/0.3mL dose, tris-sucrose formulation	EUA 12+ yrs, BLA 16+ yrs Pfizer tris-sucrose formulation vaccine for ages 12 and older
221	SARS-COV-2 (COVID-19) vaccine, mRNA, spike protein, LNP, preservative free, 50 mcg/0.5 mL dose	FDA EUA 03/29/2022, Moderna booster dose 2.5mL vial presentation only
211	SARS-COV-2 (COVID-19) vaccine, subunit, recombinant spike protein-nanoparticle+Matrix-M1 Adjuvant, preservative free, 0.5mL dose	Pre-EUA Authorization - Novavax Primary Series dose
229	SARS-COV-2 (COVID-19) vaccine, mRNA, spike protein, LNP, bivalent booster, preservative free, 50 mcg/0.5 mL or 25 mcg/0.25 mL dose	Pre-EUA Moderna bivalent booster, ages 6yr+ as authorized, original strain + omicron BA.4/BA.5
300	SARS-COV-2 (COVID-19) vaccine, mRNA, spike protein, LNP, bivalent booster, preservative free, 30 mcg/0.3 mL dose, tris-sucrose formulation	Pre-EUA Pfizer bivalent booster, ages adult 12+, original strain + omicron BA.4/BA.5

Note: CVX codes 207, 208, 217, 221, 229, 300 are categorized as “mRNA”, 212 is “JNJ”, and all others are categorized as “other”