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Sudden Unexpected Death in the Pfizer BNT162b2 Trial: A Pharmacovigilance Failure

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ABSTRACT

OPEN ACCESS

Objective: To characterize the Sudden Unexpected Death (SUD) signal in the Pfizer/BioNTech BNT162b2 mRNA vaccine clinical trial (C4591001) and evaluate factors that may have obscured its detection.

Methods: We conducted a forensic analysis of original trial documents released through litigation and public transparency efforts. All-cause mortality within the first six months was reviewed, with sudden unexpected death defined as death occurring suddenly and unexpectedly in an apparently stable individual.

Results: Of 38 all-cause deaths reported in the six-month interim report, 15 met criteria for sudden unexpected death: 10 in the vaccinated group and 5 in the placebo group. This represents a two-fold increase in sudden unexpected death incidence in the vaccinated group compared to placebo. Autopsy data were unavailable for the majority of cases; only four of the 15 sudden unexpected deaths underwent autopsy, with original reports not provided. The reported cause of death for eight cases was "cardiac arrest" or "cardiopulmonary arrest," descriptions that do not elucidate underlying etiology. One death was attributed to "sudden cardiac death" and another to "aortic rupture," suggesting autopsy findings were summarized but not detailed in the case report forms. Age-stratified analysis indicated a shift toward younger age at death among vaccinated males with sudden unexpected death compared to placebo.

Conclusions: The sudden unexpected death signal in the BNT162b2 trial was obscured by three methodological factors: (1) exclusion of sudden death from the predefined list of adverse events requiring special monitoring, (2) inconsistent reporting of dates of death, and (3) absence of standardized autopsy data. These limitations impeded comprehensive safety-signal detection. Future trials of novel vaccine platforms should include sudden death as a predefined outcome requiring special monitoring and mandate autopsy for unexpected deaths to enable accurate causality assessment.

Key words: Sudden Unexpected Death, Sudden Cardiac Death, Autopsy, Pfizer/BioNTech Protocol C4591001.

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Introduction

Sudden unexpected death (SUD) and sudden cardiac death (SCD) constitute a major public health burden, accounting for up to 20% of mortality in industrialized nations, with most events occurring out-of-hospital[1–10]. Despite this substantial impact, SCD remains underrecognized in both clinical practice and safety surveillance frameworks. The incidence of SCD varies considerably based on methodology and definition, ranging from 30–60 per 100,000 person-years in middle-aged adults to over 1,000 per 100,000 in those over 85 years[3,9,11]. Given that cardiovascular disease predominates as the underlying cause, sudden death represents a critical safety signal in clinical trials involving interventions with potential cardiovascular effects[5–7,12].

For clinical trials enrolling tens of thousands of participants, a baseline incidence of SUD is expected based on population epidemiology. In a trial of approximately 44,000 adults with diverse age and comorbidity profiles followed for six months, one would anticipate approximately 40–50 sudden cardiac deaths as background incidence alone[5]. This predictable background incidence makes systematic detection and investigation of unexpected deaths essential for accurate safety profiling. For surviving family members, thorough investigation provides closure; for public health, it distinguishes signal from noise.

Pharmacovigilance—the science and activities relating to the detection, assessment, understanding, and prevention of adverse effects—relies on predefined safety endpoints and standardized reporting to identify potential harms. Standardized case definitions for sudden unexpected death have been established to facilitate *vaccine safety surveillance*[13].

However, the COVID-19 pandemic created unprecedented pressure for rapid vaccine development, with novel mRNA-LNP (lipid nanoparticle) platforms receiving Emergency Use Authorization based on abbreviated safety data[14]. Human trials of this technology had previously progressed no further than Phase 1, involving fewer than 250 adults and demonstrating only antibody production rather than clinical protection[15–17].

The Pfizer/BioNTech BNT162b2 mRNA vaccine clinical trial (Protocol C4591001) exemplifies these tensions. Michels et al.[18] conducted a forensic analysis of the 38 subject deaths reported in the 6-Month Interim Report, identifying a sudden-death adverse event signal that had not been disclosed to regulators or in published trial results. Of these 38 deaths, 15 occurred suddenly or involved subjects found dead—10 in the vaccinated arm and 5 in placebo, representing a 2-fold increase in SUD incidence among vaccine recipients.

Here, we provide a detailed forensic analysis of these 15 sudden unexpected deaths. We examine the circumstances of each subject's death, evaluate the proposed causes, and identify systemic factors that obscured this safety signal.

The original Pfizer/BioNTech documentation and data files from Protocol C4591001 remained shielded from public scrutiny well after Emergency Use Authorization (EUA)[19] and Biologics License Application (BLA) approval[20]. Following a Freedom of Information Act lawsuit (Pub. Health & Med. Pros. for Transparency v. FDA, No. 4:21-CV-1058-P), these files were incrementally released beginning June 2022 through the Public Health and Medical Professionals for Transparency website (https://phmpt.org/pfizers-documents/). The analysis presented here represents an independent evaluation of primary evidence underlying the BNT162b2 trial, conducted by investigators unaffiliated with the manufacturer or clinical trial sites.

Methods

Source documents.

The document files listed below can be found on the Public Health and Medical Professionals for Transparency (PHMPT) website (https://phmpt.org/pfizers-documents/).

Documents were downloaded from the PHMPT website, and, for data files, the information was converted into Excel files. The accuracy of the conversion was confirmed. The Excel files listed below were merged into a single Excel Pivot Table file.

- 6-Month Interim Report of Adverse Events C4591001 (16.2.7.4.1 Listing of Adverse Events – All Subjects ≥16Years of Age) (https://pdata0916.s3.us-east-2.amazonaws.com/pdocs/070122/125742_S1_M5_5351_c4591001-interim-mth6-adverse-events.zip#page=3646)
- Randomization Scheme and Actual Vaccine Received (16.1.7.1 Listing of Randomization Scheme and Actual Vaccine Received – All Subjects ≥16 Years of Age) (https://phmpt.org/wp-content/uploads/2022/05/125742_S1_M5_5351_c4591001-interim-mth6-randomization-sensitive.pdf#page=4377)
- Listing of Discontinued Subjects (16.2.1.1 Listing of Subjects Discontinued From Vaccination and/or From the Study – All Subjects ≥16 Years of Age) (https://phmpt.org/wp-content/uploads/2022/07/125742_S1_M5_5351_c4591001-interim-mth6-discontinued-patients.pdf)
- 6-Month Summary of Clinical Safety (2.7.4 STN Summary of Clinical Safety) (https://phmpt.org/wp-content/uploads/2021/12/STN-125742_0_0-Section-2.7.4-summary-clin-safety.pdf#page=345)
- 5.3.6 Cumulative Analysis of Post-authorization Adverse Event Reports (*Post-marketing Report on BNT162b2*) (https://phmpt.org/wp-content/uploads/2021/11/5.3.6-postmarketing-experience.pdf)
- Narrative Reports on Subject Deaths from Emergency Use Application – generated 20November 2020 (https://pdata0916.s3.us-east-2.amazonaws.com/pdocs/070122/125742_S1_M5_5351_c4591001-fa-interim-narrative-sensitive.pdf
- Narrative Reports on Subject Deaths from 6-Month Interim Report – generated 26March 2021 (125742_S1_M5_5351_c4591001-interim-mth6-narrative-sensitive) (https://phmpt.org/wp-content/uploads/2023/09/125742_S1_M5_5351_c4591001-interim-mth6-narrative-sensitive.pdf)
- Case Report Forms (ordered by Subject number)

  - Subject 10071101 (https://phmpt.org/wp-content/uploads/2022/06/125742_S1_M5_CRF_c4591001-1007-10071101.pdf)
  - Subject 10361140 (https://phmpt.org/wp-content/uploads/2023/05/125742_S1_M5_CRF_c4591001-1036-10361140.pdf)
  - Subject 10391010 (https://phmpt.org/wp-content/uploads/2023/07/125742_S1_M5_CRF_c4591001-1039-10391010.pdf)
  - Subject 10661350 (https://phmpt.org/wp-content/uploads/2023/05/125742_S1_M5_CRF_c4591001-1066-10661350.pdf)
  - Subject 10811194 (https://phmpt.org/wp-content/uploads/2022/06/125742_S1_M5_CRF_c4591001-1081-10811194-reissue.pdf)
  - Subject 10881126 (https://phmpt.org/wp-content/uploads/2023/08/125742_S1_M5_CRF_c4591001-1088-10881126.pdf)
  - Subject 11141050 (https://phmpt.org/wp-content/uploads/2023/05/125742_S1_M5_CRF_c4591001-1114-11141050.pdf)
  - Subject 11201050 (https://phmpt.org/wp-content/uploads/2023/05/125742_S1_M5_CRF_c4591001-1120-11201050.pdf)
  - Subject 11271112 (https://phmpt.org/wp-content/uploads/2023/08/125742_S1_M5_CRF_c4591001-1127-11271112.pdf)
  - Subject 11311204 (https://phmpt.org/wp-content/uploads/2023/07/125742_S1_M5_CRF_c4591001-1131-11311204.pdf)
  - Subject 11361102 (https://phmpt.org/wp-content/uploads/2023/08/125742_S1_M5_CRF_c4591001-1136-11361102.pdf)
  - Subject 11401117 (https://phmpt.org/wp-content/uploads/2023/08/125742_S1_M5_CRF_c4591001-1140-11401117.pdf)

- Subject 11521085 (https://phmpt.org/wp-content/uploads/2023/07/125742_S1_M5_CRF_c4591001-1152-11521085.pdf)
- Subject 11621327 (https://phmpt.org/wp-content/uploads/2023/06/125742_S1_M5_CRF_c4591001-1162-11621327.pdf)
- Subject 11681083 (https://phmpt.org/wp-content/uploads/2023/05/125742_S1_M5_CRF_c4591001-1168-11681083.pdf)
- Subject 11291166 (https://phmpt.org/wp-content/uploads/2023/05/125742_S1_M5_CRF_c4591001-1129-11291166.pdf)

Determination of All-cause Death and Sudden Cardiac Death incidence.
The annual incidence of death (per 100,000 PY) is based on data from 2018 CDC National Center for Health Statistics (NCHS), National Vital Statistics Systems Mortality database (https://cdc.gov/nchs/data/databriefs/db395-H.pdf). The incidence of Sudden Cardiac Death (SCD) was determined by a survey of the available literature[1–3,6–12,21,22] and data from the CDC NCHS National Vital Statistics Systems Mortality database (https://cdc.gov/nchs/data/databriefs/db395-H.pdf).

Result

The following definition was used in this study. Sudden death (SD) or sudden unexpected death (SUD) refers to a natural death that is not preceded by a significant symptom. Many SUDs are witnessed but some occur during sleep or when the individual is alone and are thus unwitnessed. The timeline of unwitnessed SUD is a matter of debate and often determined by individual circumstances, statements of relatives and neighbors, or coroner reports. If the individual was last seen to be in good health, the death is considered an unwitnessed SUD. Obviously, this definition excludes violent or accidental deaths.

Protocol C4591001 overview.
The Pfizer/BioNTech mRNA COVID-19 vaccine clinical trial Protocol C4591001 was intended to be a randomized, placebo-controlled, double-blinded trial. Subject health outcomes were to be observed over a 2-year period, with major reports submitted to the FDA after 6 months, one year, and 2 years[23].

Subjects were enrolled into Phase 2/3 of the Pfizer/BioNTech clinical trial on a rolling basis starting on 27 July 2020 at 153 trial sites in 6 countries, with 131 U.S. sites. The first 4 digits of the Subject ID number indicate the clinical trial site in which the subject was enrolled. United States trial site numbers were 1002 to 1270. The largest cohort of subjects were in the 131 US trial sites (33,594 subjects), with Argentina's 2 trial sites (5,771 subjects) having the next largest number of subjects in the Pfizer/BioNTech clinical trial.

Subjects underwent an extensive array of medical testing and pre-trial screening to determine eligibility to be accepted into the trial. These test results included complete blood counts, metabolic tests, pregnancy tests, COVID-19 tests, a comprehensive list of active medications, and more.

The trial was limited to "generally healthy" participants defined as, "Healthy participants who are determined by medical history, physical examination (if required), and clinical judgment of the investigator [are] eligible for inclusion in the study." Healthy participants were "participants with preexisting stable disease, defined as disease not requiring significant change in therapy or hospitalization for worsening disease during the 6 weeks before enrollment". The available information on subject comorbidities is limited but using the information available to us, we did not observe major differences between the arms of the trial. We did note a significant (up to 2-fold) greater representation in the trial of participants in the 45-54, 55-64, and 65-74 age groups compared to the US 2020 census data.

On their enrollment date, Day 1, subjects were assigned a subject ID number, and a digital medical record form on the subject was submitted to a centralized computer system for randomization. The system considered characteristics such as age, sex, race, and comorbidities such as diabetes, known heart and kidney disease, and respiratory problems. The computer system then randomized the subject to either the vaccine or placebo arm of the trial. Dose 1 was administered on that subject's Day 1. Dose 1 was either 0.3

ml of BNT162b2 for vaccinated subjects or 0.3 ml of normal saline for placebo subjects, depending on their randomized assignment.

This was a double-blinded trial. Neither the trial site nor the subject was to know whether they had received the vaccine or the placebo. Each subject received two doses 21 days apart (later amended to 19–42 days), Dose 1 at Visit 1, Dose 2 at Visit 2. These visits were followed by scheduled follow-up visits. Protocol C4591001 used Medical Dictionary for Regulatory Activities (MedDRA) version 23.1 for safety monitoring. Records of these visits were maintained in the subject's Case Report Form. Serious adverse events (SAE) as defined in the study protocol as an untoward medical occurrence that at any dose resulted in death, is life threatening, requires in patient hospitalization or prolongation of hospitalization or results in a permanent disability, had a dedicated reporting channel via Vaccine SAE Report Form to Pfizer Safety within 24 hours of awareness. The Vaccine SAE Reports are not part of the publicly available documentation.

Enrollment proceeded rapidly until the Pfizer/BioNTech BNT162b2 vaccine received Emergency Use Approval (EUA)[19] but the last person was enrolled on 8 January 2021. On 14 November 2020, the data closing date for the EUA application, 43,414 subjects were registered. On 12 December 2020, this number had reached 44,008. On 13 March 2021, the date of the 6-month interim report, 44,426 subjects had been enrolled. The total number of active subject participants varied slightly due to discontinuation and return of some subjects for various reasons. Our calculations are based on enrollment numbers.

The FDA granted an EUA for Pfizer/BioNTech's B162b2 mRNA COVID-19 vaccine on 11 December 2020. After this date, all subjects were "unblinded", that is, they were told whether they had received the vaccine or the placebo and were offered the vaccine at their next scheduled visit. Over the course of the next months, about 19,685 of the placebo subjects opted to be BNT162b2 vaccinated. This "unblinding" ended the placebo-controlled trial and essentially the clinical trial.

Sudden unexplained deaths (SUD) in the Pfizer/BioNTech clinical trial.

Pfizer/BioNTech reported 38 all-cause subject deaths in the 6-Month Interim Report[24]. The report was submitted to the FDA on 01 April 2021 and included data up to 13 March 2021. The report is a 3645-page document listing all adverse events (AE) and serious adverse events (SAE) that occurred to subjects up to that point of the clinical trial. Subject Deaths for all subjects 16 years of age and older were listed separately on pages 3640 – 3642.

Figure 1 shows page 3640 of the 6-Month Interim Report. It lists 15 of the 38 subjects who died between 27 July 2020 and 13 March 2021. Pages 3641-3642 list the remaining 23 subject deaths. A look at the first subject ID listed in Figure 1 provides the following information: the trial number, C4591001, followed by the trial site number, 1021 (US site), and the specific subject's number, 1127. Of the 38 deaths, 33 occurred in the United States, 3 in Argentina, 1 in Turkey, and 1 in South Africa.

16.2.7.7 Listing of Deaths – All Subjects ≥16 Years of Age

Age Group (Years)	Subject	Dose No.	Rel Day*	Sex	Date of Death	Age at Death (Years)	Primary Cause of Death	Secondary Cause(s) of Death
16-55	C4591001 1021 10211127∞	2	88	M	19DEC2020	54	Cardiac failure congestive	
	C4591001 1081 10811194	2	37	F	04NOV2020	51	Myocardial infarction	
	C4591001 1120 11201266∞	2	113	M	19JAN2021	51	Lung cancer metastatic	
	C4591001 1127 11271112∞	2	86	M	04DEC2020	53	Cardio-respiratory arrest	
	C4591001 1152 11521085	1	8	F	26AUG2020	42	Death	
	C4591001 1156 11561124	2	32	M	02NOV2020	53	Overdose	
	C4591001 1229 12291083†	2	76	F	05JAN2021	56	COVID-19 pneumonia	
	C4591001 1231 12314987	2	82	M	06DEC2020	47	Cardio-respiratory arrest	
>55	C4591001 1007 10071101∞	2	63	F	21OCT2020	56	Cardiac arrest	
	C4591001 1019 10191146	2	87	M	17DEC2020	67	Metastases to liver	Biliary cancer metastatic
	C4591001 1027 10271191#	2	135	F	13FEB2021	68	Respiratory failure	COVID-19
	C4591001 1036 10361140∞#	2	91	M	10FEB2021	64	Road traffic accident	
	C4591001 1039 10391010∞	2	71	M	18NOV2020	85	Arteriosclerosis	Hypertensive heart disease
	C4591001 1066 10661350	1	16	M	03NOV2020	58	Myocardial infarction	
	C4591001 1084 10841266∞	2	121	M	12JAN2021	77	Sepsis	Emphysematous cholecystitis

Figure 1. Sample page from the Pfizer/BioNTech 6-Month Interim Report

The table illustrated in Figure 1 lists the subject's age and sex, the date of death and the number of days the death occurred relative to the last Dose received by the subject. Also indicated is Pfizer's decision on the "Primary Cause of Death" and, for a few, "Secondary Cause(s) of Death". Missing, is (1) whether the subject was in the placebo or vaccinated arm of the trial, and (2) the evidentiary basis for determining the cause of death, which requires an autopsy or medical reports from a hospital attending physician.

To obtain more information on the circumstances surrounding the deaths of these subjects, Michels et al.[18] reviewed the Case Report Forms and Narratives for all 38 deaths. In so doing, it was discovered that 15 of the all-cause deaths had died suddenly or were found dead. This report focuses on these 15 subjects who died suddenly.

CRFs were available for all 15 SUD subjects plus one subject who died in a road traffic accident (PDFs listed in Methods section). Two Narrative Reports documents were also available for review for this study (listed in Methods section). The Narrative Sensitive Reports on Subject Deaths from Emergency Use Application was generated on 20 November 2020 for submission to the FDA with Pfizer/BioNTech's EUA application. The Report on Subject Deaths from 6-Month Interim Report was generated on 26 March 2021 for submission to the FDA with Pfizer/BioNTech's 6-Month Interim Report. These documents were invaluable when generating the summary reports on each SUD subject. They alone reported that the circumstances of each subject's death, whether it was a witnessed sudden death or unwitnessed and found dead.

A summary of the circumstances of each subject's death and additional information gleaned from the Narrative Reports, their Case Report File, and other available information is presented below. Each summary states whether the deceased subject was given an autopsy and if the results of that autopsy were made available for public review by Pfizer/BioNTech. Autopsy is the only sure way to determine the cause of death for individuals who do not die while under a physician's care, which is the case for these subjects[5]. As far as we can tell, only 4 of the 15 subjects who died suddenly or were found dead were autopsied. For 2 of these, their CRF or Narrative comment on the autopsy result. One, 11681083, specifically states "aortic rupture". Another, 11141050, is less informative and simply states "Sudden Cardiac Death". Nonetheless, all report a cause of death despite the critical evidence of an autopsy is not presented.

Please note that, for each deceased subject, whether autopsied or not, the subject's Narrative contained some variation of the following statement. "In the opinion of the investigator, there was no reasonable possibility that the sudden cardiac death was related to the study intervention, concomitant medications, or clinical trial procedures. Pfizer concurred with the investigator's causality assessment." This will be elaborated further in the Discussion.

Subjects from the vaccinated arm of the trial.

Subject 10071101, a 56-year-old female subject from the vaccinated arm of the study, suffered cardiac arrest 59 days after receiving Dose 2 of BNT162b2. She was obese (BMI 46.2), had hypothyroidism (since November 2007), depression (since 2008), asthma (since 2009), sleep apnea syndrome (since 2013), and supraventricular tachycardia (since October 2019). Her medications included levothyroxine for hypothyroidism (since November 2007), albuterol for asthma (since 2016), citalopram for depression (since May 2017), metoprolol succinate for supraventricular tachycardia (since October 2019), and pantoprazole for gastroesophageal reflux disease (since September 2020). She may have been a resident at a nursing facility and was brought in intubated. Her urine toxicology screening showed elevated ethanol at 109mg/dL (upper limit of normal: 9.9mg/dL) and was positive for amphetamines. She showed signs of anoxic brain injury, and treatment was aimed at improving neurological outcomes. This proved futile, and she died three days later. It is unknown if an autopsy was performed. In the opinion of the investigator, "…there was no reasonable possibility that the cardiac arrest was related to the study intervention, concomitant medications, or clinical trial procedures, as the death occurred 2 months after receiving Dose 2."

Subject 10391010, an 84-year-old male subject from the vaccinated arm of the study, had a witnessed loss of consciousness 70 days after Dose 2 of BNT162b2. His family attempted resuscitation, but it was

unsuccessful, and he died. He was not taken to the hospital or the physician's office. No autopsy was performed. His comorbidities included hypertension, hyperlipidemia, carotid artery stenosis, and coronary artery disease. He was on aspirin, multivitamin, lovastatin, cernitin GBX, and cernitin T60 (both since 2018), vitamin D and hydrochlorothiazide/olmesartan medoxomil (since 10 September 2020) for hypertension He had a right carotid stent placed in 2016. He had regular follow-ups with his primary care physician and had no reported events or complications prior to his death. The trial investigators ascribed cause of death to arteriosclerosis and hypertensive heart disease. In the opinion of the investigator, "…there was no reasonable possibility that the arteriosclerosis and hypertensive heart disease was [sic] related to the study intervention, concomitant medications, or clinical trial procedures, but rather they were related to cardiovascular disease."

Subject 11141050, a 63-year-old female subject from the vaccinated arm of the study died unexpectedly on the 19 October 2020, 41 days after receiving Dose 2 of BNT162b2. She was postmenopausal, had depression, hypertension, osteoporosis, rheumatoid arthritis and sleep apnoea. Her medications included trazodone (since 01January 2005) for depression, pregabalin (since 01 January 2005) for degenerative disc disease, amlodipine (since 01 January 2010) for hypertension, baclofen (since 01 January 2018) for degenerative disc disease, hydralazine (since 01 February 2020) for hypertension, and sertraline (since 01 July 2020) for depression. The subject appears to have had an autopsy, based on comments in her Case Report Form. On December 9th, there was a query from an investigator whether indeed her cause of death was unknown, as the specific diagnosis of "sudden cardiac death" had been given a serious adverse event number in this subject's CRF, whilst cause of death was still retained as unknown in other listings. This death was not disclosed publicly in the 10 December 2020 VRBPAC meeting nor in the Polack et al.[8] publication, though it occurred well before the data cutoff date of 14 November 2020. As such, the autopsy result, which concluded the cause of death was "sudden cardiac death", was not disclosed during this meeting. The trial investigator expressed, "…there was no reasonable possibility that the sudden cardiac death was related to the study intervention, concomitant medications, or clinical trial procedures". The trial investigators noted that the subject had risk factors of hypertension and obesity, which put her "at high risk for cardiovascular/acute myocardial infarction death". This subject weighed 74 kg (with a BMI of 27 – overweight) and had no blood pressure readings noted in her clinical records. Her autopsy report is not publicly available to this day.

Subject 11201050, a 58-year-old female from the vaccinated arm of the study, was found dead on 7 November 2020, in her sleep by her husband 72 days after receiving Dose 2 of BNT162b2. He informed the clinical trial site of her death on November 7th itself. Her comorbidities included chronic back pain (since 2015), hypertension (since 2017), anxiety (since 2018), and type 2 diabetes mellitus (since 2018). Concomitant medications included metformin (since 2017) for type 2 diabetes mellitus; lisinopril (since 2017) and clonidine (since 2018) both for hypertension; and lorazepam (since 2018) for anxiety. She had no preceding symptoms or illnesses, so the death was unexpected. She was not seen in hospital, and no autopsy was performed. The death certificate listed cardiac arrest as the cause of death. In the opinion of the investigator, "…there was no reasonable possibility that the cardiac arrest was related to the study intervention, concomitant medications, or clinical trial procedures." This death was also not disclosed publicly even though it happened before the data cutoff date of 14 November 2020.

Subject 11271112, a 53-year-old male subject from the vaccinated arm of the trial, was found sitting, slumped forward and dead by his mother in the laundry 85 days after receiving Dose 2 of BNT162b2. An autopsy was performed, but results were not available at the time the trial investigator examined his case. His comorbidities included hypoglycemia, chronic obstructive pulmonary disease, and a myocardial infarction in 2008. No concomitant medication was documented. The preliminary cause of death was cardiopulmonary arrest. Despite a pending autopsy result, in the opinion of the investigator, "…there was no reasonable possibility that the cardiopulmonary arrest was related to the study intervention, concomitant medications, or clinical trial procedures, but rather to underlying cardiac disease."

Subject 11291166, a 78-year-old female from the vaccinated arm of the study, was found dead in her apartment by her neighbors because of the odor, 128 days after receiving Dose 2 of BNT162b2. Her son, who had been alerted by the neighbors, found a large amount of blood and fluids pooled on the floor around her body. Her skin was mottled, bruised, and rigid. Her actual death date is unknown. No autopsy was performed, with the medical examiner reporting her cause of death as myocardial infarction. Her comorbidities were hypercholesterolemia, peripheral vascular disease, and hypertension, Grade 1 diastolic dysfunction, depression, esophageal stricture, and a hiatus hernia. Her medications were Atorvastatin (since 2017), Omeprazole, Citalopram hydrobromide, Denosumab. In the opinion of the investigator, "…there was no reasonable possibility that the myocardial infarction was related to the study intervention, concomitant medications, or clinical trial procedures, but related to hyperlipidemia".

Subject 11311204, an 84-year-old male, was initially in the placebo arm of the trial. When the trial was unblinded, he went on to receive BNT162b2. He died of cardiopulmonary arrest 25 days after receiving Dose 1 of BNT162b2. His comorbidities included aortic stenosis (since 2010), memory impairment (since 2015), cerebrovascular accident (in 2018), atrial fibrillation (since 2018), and cardiac murmur (since 2019). His medication included apixaban, a blood thinner, (since April 2018) for a previous stroke. There was documentation of worsening aortic stenosis 10 days prior to his death, and he required hospitalization. He had an angiogram, and a stent was recommended; but the cardiologist did not feel it was urgently needed. He was discharged home three days prior to his death. However, at home, he took a nap and was found dead by his wife. No autopsy was done. The death certificate stated the cause of death to be cardiopulmonary arrest secondary to a cerebrovascular event. In the opinion of the investigator, "…there was no reasonable possibility that the worsening aortic stenosis and cardiopulmonary arrest were related to BNT162b2, concomitant medications, or clinical trial procedures". This subject had gone through the trial uneventfully in the placebo arm, had a sudden deterioration 15 days after receiving Dose 1 of BNT162b2, and died 25 days after receiving his first dose of the vaccine.

Subject 11361102, a 76-year-old male subject from the vaccinated arm of the study, died of cardiac arrest 30 days after receiving Dose 2 of BNT162b2. He had a history of Patent Ductus Arteriosus, which was repaired in 1947 and 1949. He was also deaf. He was on no prescription drugs and only took multivitamins. He had collapsed whilst on a walk. An ambulance was called, and the emergency medical services found the subject to have ventricular tachycardia (heart rate not reported) followed by ventricular fibrillation. Two rounds of defibrillation with 3 rounds of epinephrine were done. Chest compressions and epinephrine, calcium, sodium bicarbonate, and amiodarone were administered. An echocardiogram performed at bedside revealed cardiac standstill. Resuscitation efforts were terminated and he died. It is not known if an autopsy was done. In the opinion of the investigator, "…there was no reasonable possibility that the cardiac arrest was related to the study intervention, concomitant medications, or clinical trial procedures".

Subject 11401117, a 58-year-old male subject from the vaccinated arm of the study, suffered cardiac arrest 116 days after receiving Dose 2 of BNT162b2. He was severely obese (BMI 38.1). His comorbidities included coronary artery disease, hyperlipidemia, hyperglycemia, and hypertension. His medications included meloxicam (since 1 August 2010), vitamin D3 (since 01August 2015) for general health, hydrochlorothiazide and losartan (both since 01August 2018) for hypertension, sertraline (since 01 October 2018) for depression, acetylsalicylic acid (since 01 June 2020) for coronary artery disease, pravastatin (since 01 June 2020) for hyperlipidemia, and dulaglutide (since 07 December 2020) for hyperglycemia. His was a witnessed cardiac arrest, and he experienced seizure-like activity, collapsed, and received bystander and emergency services cardiopulmonary resuscitation. Despite extensive resuscitation efforts by the bystander and the emergency department in which he received 5 rounds of epinephrine, 1 ampoule of sodium bicarbonate, 1 gm calcium chloride, 1 mg atropine, and 300 mg amiodarone, and defibrillation, he died that day. No autopsy was done. In the opinion of the investigator, "…there was no reasonable possibility that the cardiac arrest was related to the study intervention, concomitant medications, or clinical trial procedures, but rather it was related to underlying comorbidities."

Subject 11621327, a 60-year-old male subject from the vaccinated arm of the trial, was found dead in his house by the police three days after Dose 1 of BNT162b2. He was obese (BMI 32.6), had autoimmune thyroiditis, depression, and craniocerebral injury since 2011. His medications included aripiprazole (from 2011 to an unspecified date) and venlafaxine hydrochloride (from 2015 to an unspecified date), both for depression. The police went to his house to perform a welfare check and found his body cold with visible lividity. It is unknown whether an autopsy was done. According to the medical examiner, the probable cause of death was "progression of atherosclerotic disease". The trial investigator's opinion was, "…there was no reasonable possibility that the arteriosclerosis was related to the study intervention, concomitant medications, or clinical trial procedures". There was confusion amongst trial investigators indicated in the patient's medical records as to whether atherosclerosis could be a cause of death as the subject did not have any documented history of it.

Subjects from the placebo arm of the trial.

Subject 10661350, a 58-year-old male from the placebo arm, died 16 days after receiving Dose 1 of the placebo on 03 November 2020. He had a history of hypertension, gastroesophageal reflux disease, insomnia, hyponatremia, seizures, alcohol abuse (from 2010 to 2018), and myocardial infarction (in March 2018), with cardiomyopathy. Concomitant medications included omeprazole (Protonix) for gastroesophageal reflux disease, trazodone (since 2015) for insomnia, Depade and acamprosate calcium (Campral) (since 2018) both for alcohol dependence, and levetiracetam (Keppra) (since 2018) for seizures. When the subject did not return for Visit 2 on 09 November 2020 (Day 22), the subject's wife was contacted on the same day, and she stated that the subject suffered a heart attack and died in his sleep on 03 November 2020 (Day 16). An autopsy was not performed. In the opinion of the investigator, there was no reasonable possibility that the myocardial infarction was related to the study intervention, concomitant medications, or clinical trial procedures, but rather it was related to disease progression.

Subject 10811194, a 51-year-old female from the placebo arm of the trial was found dead on 4 November 2020, 56 days after receiving Dose 1 of the placebo and 36 days after receiving Dose 2 of the placebo. She had a background history of hypertension, hypothyroidism, chronic obstructive airways disease (COPD), attention deficit hypersensitivity disorder, osteoarthritis and was postmenopausal. Her medications included levothyroxine sodium (since 2015) for hypothyroidism; atomoxetine hydrochloride (since 2017) and bupropion hydrochloride (since 2018) for attention deficit disorder; salbutamol sulfate (since 2018) for COPD; diclofenac (since 2018) for osteoarthritis; and hydrochlorothiazide/lisinopril (since 01Aug 2020) for hypertension. She had cough and sore throat on 12 October 2020, saw her primary care physician who arranged for appropriate swabs and lab tests done in the emergency department, which were presumably COVID-negative. This was followed up via a telephone consult as an unscheduled COVID visit by the clinical trial site. She did not require hospitalization. She was scheduled for a follow-up visit on 11 November 2020. When she did not turn up for the visit, a follow-up phone call revealed that the patient was found deceased in her home on 04 November 2020. They believe she likely died three days earlier when she had told her family member she had "stomach pains ". The death certificate and toxicology report were received on 24 November 2020, and the date of death was 04 November 2020 per state regulations; the cause of death was reported as myocardial infarction due to hypertensive cardiovascular disease and disease progression. The toxicology report was negative. No autopsy was performed. In the opinion of the investigator, there was no reasonable possibility that the myocardial infarction was related to the study intervention, concomitant medications, or clinical trial procedures, but rather it was related to hypertensive cardiovascular disease.

Subject 10881126, a 66-year-old male from the placebo arm of the trial died on 01December 2020, 93 days after receiving Dose 1 of the placebo, and 69 days after receiving Dose 2 of the placebo. He had a background history of coronary artery disease (since 1983); hypercholesterolemia and hypertension (both since 2010); and dyspepsia (since 2012). He was on lisinopril (since 2010) for hypertension, atorvastatin (since 2010) for hypercholesterolemia, omeprazole (since 2010) for heartburn, apixaban (since 2015) for coronary artery disease, and folic acid (since 2015). He had developed COVID-19 on 29 November and presented to

the clinical trial site for an unscheduled COVID-19 visit on 30 November 2020. The swab returned a positive result. Whilst the clinical site was trying to contact him on 01 December, they discovered he had died. On 01 December, he had visited his primary care physician with cough, fatigue, muscle/body aches, diarrhea, nasal congestion, and a runny nose. The subject was advised to self-isolate, increase fluids and rest, take acetaminophen as needed, and consider taking vitamin D and vitamin C to boost his immune system. The subject was reported to have experienced cardiac arrest, and it was unknown if cardiopulmonary resuscitation was attempted. The death certificate indicated the cause of death as cardiac arrest due to progression of coronary artery disease, hypertension, and COVID-19. An autopsy was not performed. It was also reported that the coronary artery disease and hypertension did not worsen after receiving study intervention. In the opinion of the investigator, there was no reasonable possibility that the cardiac arrest that resulted from coronary artery disease and COVID-19 were related to the study intervention, concomitant medications, or clinical trial procedures.

Subject 11521085, a 42-year-old female from the placebo arm of the trial was found dead 8 days after receiving Dose 1 of the placebo on 26 August 2020. She had a background of recurrent breast cancer (in 2001 and 2017) and lumpectomy 2001 and 2017. Notably in 2017, she had been implanted with an Essure permanent birth control device. As noted by the trial investigators, the Essure implant for permanent birth control was taken off the market in the United States by the Food and Drug Administration (FDA) in 2018. The Essure implant was still place at the time of her death. She had an autopsy done, and results are still pending. In the opinion of the trial investigator, there was no reasonable possibility that the death was related to the study intervention. The medical examiner had informed the subjects husband that the subject died from sudden cardiac failure brought on by 2 rounds of radiation for recurring breast cancer, which weakened her heart. Trial investigators postulated that she had had a thromboembolic event related to a history of breast cancer, or suffered potential toxicity related to the Essure permanent birth control device. The investigator further stated that whilst the full autopsy report was pending, determining cause of death at this time was essentially an educated guess.

Subject 11681083, a 65-year-old male from the placebo arm of the trial, was found dead, unresponsive at his workplace 86 days after receiving Dose 1 of the placebo and 65 after receiving Dose 2 of the placebo. He had a background history of basal cell carcinoma and spinal osteoarthritis. His medications included ibuprofen (from 2010) for general pain, multivitamin (from 2015) as a nutritional supplement, gabapentin (from 2019) for cervical neck pain, glucosamine (from 2019) for full spine joint pain, and hydrocodone bitartrate/paracetamol (from 2020) for full spine joint pain. An autopsy was performed and on 20 November 2020, the medical examiner verbally confirmed the cause of death to be aortic rupture. In the opinion of the investigator, there was no reasonable possibility that the aortic rupture was related to the study intervention, concomitant medications, or clinical trial procedures.

Road traffic death.
Included below is the summary on subject 10361140 who died as the result of a road traffic accident in which he was the driver. His possible sudden death at the wheel might have caused the accident. Such events do occur in older individuals at a frequency that cannot be ignored. Nevertheless, an autopsy was not performed making it impossible to determine if the subject died because of the accident or while driving prior to the accident. For this reason, we did not include subject 10361140 in further analyses.

Subject 10361140, a 64-year-old male from the vaccinated arm of the study died on 10 February 2021 in a road traffic accident. He was the driver. No autopsy was performed and no accident report was available. This happened 112 days after receiving Dose 1 of BNT162b2, and 91 days after receiving Dose 2. He had a background history of tinnitus, scoliosis, insomnia, hypertension, hypercholesterolemia, and Barett's esophagus.

Table 1 summarizes the important information on the 15 subjects who died suddenly detailed in the summaries above. Subjects are listed separately by trial arm, placebo control or BNT162b2 vaccinated. Most important, Table 1 indicates whether there was an autopsy followed the subject's death.

Table 1. Summary of relevant findings from our review of Narrative and CRF for each SUD subject.

Subject ID	Age	Sex	BNT or Placebo	Comorbidities	Cause of Death	Autopsy	Autopsy result	Days Post Inoculation
10071101	56	F	BNT	BMI 46, hypothyroid-ism, SVT, depression, asthma	Cardiac Arrest	UNK		59 (Dose 2)
10391010	84	M	BNT	High BP, cardio-vascular disease	Seizure	N		70 (Dose 2)
11141050	63	F	BNT	BMI 27	Sudden Cardiac Death	Y	Full report not Available	41 (Dose 2)
11201050	58	F	BNT	High BP and Type 2 diabetes	Cardiac Arrest	N		72 (Dose 2)
11271112	53	M	BNT	Diabetes, COPD, MI	Cardio-pulmonary Arrest	Y	Not Available	85 (Dose 2)
11291166	78	F	BNT	Cardio-vascular disease and hyperlipidemia	Myo-cardial Infarction	N		128 (Dose 2)
11311204	84	M	Placebo Then Dose 3	Aortic Stenosis	Cardio-pulmonary Arrest	N		25 (Dose 1)
11361102	76	M	BNT	Repaired Patent Ductus Arteriosus (as a child)	Cardiac Arrest	UNK		30 (Dose 2)
11401117	58	M	BNT	BMI 38, coronary artery disease, hyperlipidemia and diabetes	Cardiac Arrest	N		116 (Dose 2)
11621327	60	M	BNT	BMI 32.6, autoimmune thyroiditis, depression	Arterio-sclerosis	N		3 (Dose 1)
10661350	58	M	Placebo	Hypertension and MI	Cardiac Arrest	N		9 (Dose 2)
10811194	51	F	Placebo	Hypertension, heart failure, and hypothyroid- ism	Myo-cardial Infarction	N		36 (Dose 2)
10881126	66	M	Placebo	Cardio-vascular disease and hypercholesterolem ia	Cardiac Arrest	N		69 (Dose 2)
11521085	42	F	Placebo	Breast cancer (Recurrent)	Thrombo-embolic event	Y	Not Available	8 (Dose 1)
11681083	65	M	Placebo	Arthritis	Aortic rupture	Y	Not Available	65 (Dose 2)

Note: Days Post Inoculation: days since last dose of the vaccine, with the number in parentheses

Sudden Unexpected Death (SUD) signal is exhibited by subjects in the vaccinated arm.

Fifteen (15) subjects in the Pfizer/BioNTech mRNA vaccine clinical trial died suddenly. Of these, 10 were in the vaccinated arm of the trial (6 males and 4 females) and 5 in the placebo arm (3 males and 2 females). The data set is small. Nonetheless, it represents a 2-fold increase in SUD in vaccinated subjects, a safety signal worthy of deeper exploration.

A total of 38 all-cause subject deaths were reported in the 6-Month Interim Report, 17 in the placebo arm and 21 in the vaccinated arm. Based on these numbers, SUD represented 29% and 48%, respectively, of the placebo versus vaccinated deaths. While 29% is higher than the 18.5% rate for Sudden Cardiac Death

reported in the literature[20], this higher rate might result from the small sample size or increased noncardiac problems in the control group. Either way, 48% Sudden Deaths in the treatment arm of the trial is a strong signal.

The most frequent cause of death listed in Table 1 is "cardiac arrest". Death is always accompanied by stoppage of the heart. Statements such as "cardiac arrest" or "cardio-pulmonary arrest" are descriptors of death, not causes of death. Except for subject 11141050, there is no indication that the subject died suddenly. Moreover, "Sudden Cardiac Death" and "Sudden Death", which are listed in MedDRA 23.1, did not appear to be followed by Pfizer/BioNTech during safety surveillance of trial subjects[23]. Additionally, the FDA provided a list of Adverse Events of Special Interest (AESI) to COVID-19 vaccine sponsors specifically developed based on past safety monitoring of subjects in vaccine clinical trials (see Table 1 of Markowitz et al.[14]). This list does not include the word "sudden" although terms such as death, acute myocardial infarction, and stroke are listed.

Table 1 indicates that only 4 of the 15 subjects who died suddenly were autopsied. According to Protocol C4591001[23], "In the case of a participant death, a summary of available autopsy findings must be submitted as soon as possible to Pfizer Safety." If these autopsy reports exist, none have been released to the public by Pfizer/BioNTech. Thus, apart from subjects 11681083 and 11141050, the trial site investigator and Pfizer Safety had no evidence upon which to accurately determine the cause of death for a subject who died suddenly or was found dead.

Estimate of the expected number of SUD.

According to Michels et al.[18], the 38 subject deaths reported by Pfizer/BioNTech represented only 17% of the 222 deaths estimated to have occurred in the 44,060 subjects during this initial 6-months of the trial, based on the U.S. National Center for Health Statistics data. Michels et al.[18] suggested that the missing subjects could be among the 395 subjects classified as "Lost to Follow Up".

We explored the possibility that the 15 SUD listed in Table 1 might also be an underestimate, particularly given the rather lax efforts used by the trial sites to contact subjects who did not show up for scheduled visits. Table 2 provides the distribution of subjects by age and sex as of 13 March 2021. This was determined using the document files entitled Randomization Scheme and Actual Vaccine Received[25] and includes subjects 16+ years of age who received the intervention.

Table 2. Distribution of subjects by age, sex, and trial arm in Pfizer/BioNTech clinical trial Protocol C4591001.

Age Group (years)	MALE BNT	MALE Placebo	FEMALE BNT	FEMALE Placebo	Total
16-24	800	762	836	900	3,298
25-34	1,438	1,403	1,367	1,477	5,685
35-44	1,985	1,951	1,854	1,958	7,748
45-54	2,181	2,046	2,135	2,133	8,495
55-64	2,463	2,430	2,404	2,408	9,705
65-74	1,928	1,945	1,697	1,706	7,276
75-84	640	642	467	428	2,177
85+	12	14	11	5	42
Total	11,447	11,193	10,771	11,015	44,426

The numbers shown in Table 2 are based on data from the Randomization Scheme and Actual Vaccine Received[25]. Enrollment numbers included all subjects enrolled in Phase 2/3 of the clinical trial through to 13 March 2021, the end date of the 6-Month Interim Report[24]. Phase 2/3 included those subjects who received 30mg Doses of BNT162b2 in Phase 1. Subjects in the vaccinated arm received the BNT162b2 vaccine. Those in the Placebo arm received normal saline.

The number of subjects in the specific age groups in Table 2 was used to estimate the total number of subject deaths expected in each age category over the 33 weeks of the Pfizer/BioNTech clinical trial in Table

3. As described in the Methods section, age-specific annual incidence of death (per 100,000 PY) was based on data from the 2018 CDC National Center for Health Statistics (NCHS), National Vital Statistics Systems Mortality database. The age-specific annual incidence of sudden death was based on a survey of the available literature and the reports by the CDC NCHS National Vital Statistics Systems Mortality database (see Methods). The wide range of incidence rates results from differing definitions of terminology, low rate of autopsy (about 10% in the U.S.), inaccurate reporting on death certificates, *et cetera*. The expected number of Sudden Deaths in each age group was calculated using the highest number for the age group rounded to the nearest whole number.

Table 3. Estimation of the expected number of Sudden Unexplained Deaths in the Pfizer/BioNTech mRNA COVID-19 clinical trial.

Age Group (Years)	Number of Subjects	Annual Incidence of Death*	Expected Number of Sudden Deaths**	Annual Incidence of Sudden Cardiac Death*	Expected Number of Sudden Unexplained Deaths**	Actual Number of Sudden Unexplained Deaths
16-24	3,298	70.2	1.5			0
25-34	5,685	128.8	4.6	**1–3**	0	0
35-44	7,748	194.7	9.5	**10–20**	1	1
45-54	8,495	395.9	21.3	**30–60**	3	2
55-64	9,705	886.7	54.4	**80–150**	9	6
65-74	7,276	1,783.3	82.0	**200–350**	16	2
75-84	2,177	4,386.1	60.4	**500–900**	12	3
85+	42	13,450.7	3.6	**1,000–2,000**	1	1
Total	44,426		237.3		42	15

Note: *Incidence per 100,000 persons per year. **Expected based on the number of subjects in age group in the 33-week trial period (27 July 2020 to 13 March 2021).

Table 3 used the annual incidence of Sudden Cardiac Death as a surrogate for Sudden Death. Sudden Death, or Sudden Unexpected Death, are terms not commonly used in the literature[3]. Most often, Sudden Cardiac Death (SCD) or Sudden Cardiac Arrest (SCA) are reported but these terms are not synonymous with Sudden Death[5]. SCA indicates that the heart stopped beating but not why. SCD is a more specific term. Up to 90% of SUD result from cardiovascular diseases and are often termed Sudden Cardiac Deaths, defined as complete collapse of the circulatory system[3–7,11,12,26–28]. The underlying causes of SCD are coronary artery disease (57-80%), aortic rupture, heart arrhythmias, coronary artery thrombosis, myocardial infarction and fibrosis, and coronary artery stenosis. The remaining 10% non-cardiac causes of SUD include acute pulmonary embolism, and stroke due to cerebral hemorrhage or cerebral embolism. We used the highest percentage value of the range shown in Table 3 to adjust for the fact that SCD is a portion of SD and is not clearly defined clinically.

The results in Table estimate 237 all-cause deaths should have been expected in the Pfizer/BioNTech vaccine clinical trial by 13 March 2021. These findings confirm those of Michels et al.[18] concluding that 38 total all-cause subject deaths was a significant underestimate of the expected number of deaths in a typical year prior to 2020. The 38 subject deaths reported in the 6-Month Interim Report and Thomas et al.[29] represent less than one-fifth the expected number of all-cause deaths (38 divided by 237 equals 16%).

The data in Table 3 reveal a substantial discrepancy between expected and reported sudden deaths, supporting our hypothesis of underreporting by Pfizer/BioNTech. Our model's expected 42 SCDs (17.7% of 237 total deaths) aligns closely with established literature rates of 18.5%, lending credibility to our incidence assumptions[3,5,7,11]. Given this alignment, we infer that the 15 SDs reported by Pfizer/BioNTech likely represent

only a fraction of actual occurrences. If these 15 cases constitute approximately 20% of the true SD count, the actual number of sudden deaths in the trial may have been up to five times the reported figure.

Sudden Death is clearly a serious public health issue[4,6]. Considering the importance of subject deaths to the trial's data, it was the responsibility of the trial site to fully investigate each time a subject missed a scheduled visit. Phone calls and letters were not sufficient. An official welfare check should have been required and, for the most part, would not have been onerous. We found 395 unique subjects listed as "Lost to Follow Up" up in the Discontinued Subjects report[30], 178 in the BNT162b2 arm and 217 in the placebo arm. Of the 153 trial sites, 96 trial sites reported 0 to 1 Lost to Follow Up subjects. Thirty-four (34) reported 2 to 5 subjects Lost to Follow Up. Only 4 sites each reported over 20 subjects Lost to Follow Up for a total of 105. None were sanctioned for negligence. It is likely that additional SUD subjects would have been revealed had a more aggressive effort been made to find those Lost to Follow Up subjects.

Taken together, the SUD signal would have been impossible to obscure had Pfizer/BioNTech accurately reported Sudden Death in the subject population of 44,426.

Impact of receipt of BNT162b2 and subject age and sex.

The data in Table 3 also show that, based on pre-2020 information, the **expected** number of SUD peaks in the oldest age groups, between 65-74 and 75-84 years. Two thirds, 16 plus 12, respectively, of the 42 expected SCD were in these older age groups. In contrast, in the actual clinical trial numbers, 40% of the SUD observed, 6 of 15, were in the 55-64 years age group. The results suggest that SUD subjects in the Pfizer/BioNTech trial were younger than pre-2020 expectations by at least by a decade.

Despite the small size of the data set, we felt a more detailed look at sudden deaths in the trial was warranted. If the increase in the numbers of SD is related to the B162b2 vaccine, we should be able to detect this in vaccinated subjects.

Table 4 compares the number of all-cause deaths observed in Pfizer/BioNTech's 6-Month Interim Report[4] to the number of subjects we found to have died suddenly. The subjects are listed separately by trial arm, age group, and sex.

Table 4. Sudden Death *versus* All-cause Deaths in the Pfizer/BioNTech clinical trial.

	Total Number of Deaths of Men		Number of Sudden Deaths of Men		Total Number of Deaths of Women		Number of Sudden Deaths of Women	
Age Group	Placebo	BNT	Placebo	BNT	Placebo	BNT	Placebo	BNT162
35-44	0	0	0	0	1	0	1	0
45-54	2	3	0	1	1	0	1	0
55-64	1	3	1	2	4	5	0	3
65-74	6	2	2	0	1	0	0	0
75-84	0	5	0	3	1	1	0	1
85+	0	1	0	0	0	1	0	0
Trial Arm	9	14	3	6	8	7	2	4
Total	23		9		15		6	

Again, given the small data set, only limited conclusions can be drawn. Overall, more men died but the percentage of both men and women who died suddenly was about the same. This contrasts with reports in the literature indicating that Sudden Death is at least twice as common in men as women[1,3–5,9–11].

While the largest number of all cause deaths occurred among men in the 65-74 age group, surprisingly, this age group included none of the men in the vaccinated arm who died suddenly and only 2 from the placebo arm. Half of the men in the vaccinated arm who died suddenly, 3 of 6, were 45-54 and 55-64 years of age. This suggests a shift to younger ages, about a decade, for SUD in vaccinated men.

Only 6 women, 2 placebo and 4 vaccinated, died suddenly. These numbers are consistent with the number of all-cause deaths of women in the different age groups. A similar shift to younger ages is not supported by this data.

Explored the temporal relationship between dose and SAD/FD.
Figure 2 plots the temporal relationship between the date of receiving Dose 1 (Figure 2A) or Dose 2 (Figure 2B) and the date of the subject's sudden death.

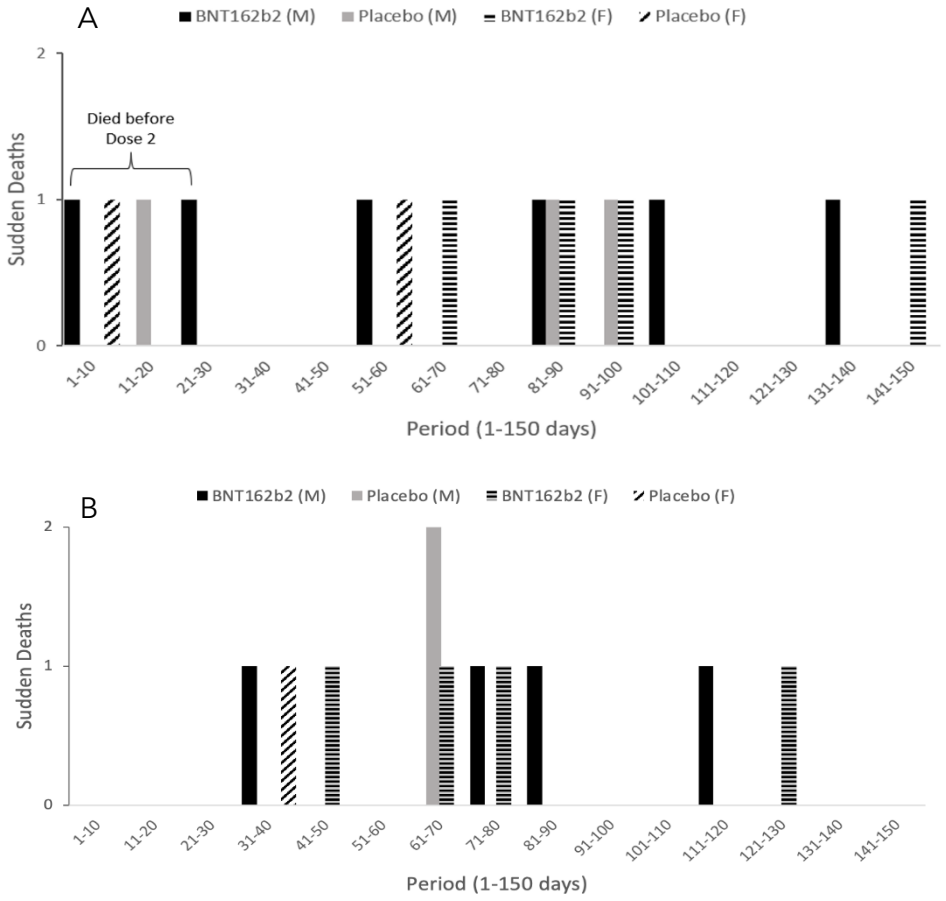

Figure 2. Temporal relationship between receipt of Dose 1 and Dose 2 and subject's date of Sudden Death

Four subjects died soon after receiving Dose 1, 2 vaccinated males and 2 placebo subjects, 1 male and 1 female. One male subject in the vaccinated arm, 11621327, was found dead only 3 days after receiving the vaccine. These are the 4 subjects seen in Figure 2A but missing from Figure 2B.

Other than this noteworthy change, there appears to be a random temporal distribution of Sudden Deaths in men and women in both arms of the trial, including those who died soon after receiving Dose 1. Subjects from both arms of the trial died soon after receiving Dose 1 as well at different times throughout the later weeks.

Of those subjects who died after receiving Dose 2 (Figure 2B), their distribution does not change significantly suggesting that Sudden Death was not potentiated by the second dose of the vaccine.

The data do not support a difference in the temporal pattern between BNT162b2 vaccination and sudden death in this small data set.

Discussion

Sudden death (SD) and sudden unexpected death (SUD) account for up to 20% of mortality in industrialized nations, with most events occurring out-of-hospital[2–5,8–10,12,26,31,32]. Cardiovascular disease is the predominant underlying cause. Given the established relationship between sudden death and cardiovascular pathology, sudden death and related terms should be considered critical safety signals, particularly in clinical trials

involving interventions with potential cardiovascular effects. The fact that sudden death is not a rare event makes it more likely that even small increases in frequency in the treatment arm of a trial will be easily detected. Accordingly, their inclusion as Adverse Events of Special Interest (AESI) should be recognized as a component of pharmacovigilance best practice[33].

This study extends the analysis of the Sudden Death signal first identified by Michels et al.[18] in their forensic analysis of the initial 6-Month Interim Report of the Pfizer/BioNTech mRNA COVID vaccine. In the vaccinated arm, 10 of the 21 all-cause deaths (48%) met criteria for SUD, representing 2.5-fold the expected rate based on pre-2020 U.S. epidemiological data. This proportional excess suggests a potential association with the vaccine, though the small number of events limits definitive inference.

As was found for all-cause deaths, the number of SUD was significantly under reported in the 6-Month Interim Report, as was the total number of all-cause deaths. Under reporting of deaths, not only SUD, was one of the more significant flaws in the Pfizer/BioNTech mRNA vaccine trial that has not received much attention, but which potentially obscured a very important adverse event signal. The number of SUD in the trial is small because the total number of all-cause deaths was small. This limited our ability to estimate accurately.

The largest number of all cause deaths occurred among vaccinated men in the 65-74 and 75-84 age groups, 7, but only 2 men in the vaccinated arm who died suddenly. Half of the men in the vaccinated arm who died suddenly were 45 to 64 years old suggesting a shift to younger ages for SUD in vaccinated men.

No temporal pattern was observed in the relationship between the date that a subject received Dose 1 or Dose 2 and the date of death, regardless of the trial arm of the subject.

Why did this clear SAE signal get missed and go unreported?

Two factors may explain why the SUD signal was not readily apparent in regulatory submissions and published reports. First, sudden death and related terms were not included as predefined AESI in Protocol C4591001, nor were they systematically captured in the trial's data structure[23]. Consequently, deaths that occurred suddenly were only identifiable through narrative review of individual Case Report Forms (CRFs), which were not aggregated in safety summaries. Second, discrepancies in the reporting of dates of death resulted in delayed attribution of mortality events, particularly for vaccinated subjects who died prior to the EUA data cutoff (14 November 2020)[18]. These reporting delays averaged 18.5 days for vaccinated subjects versus 5.9 days for other subjects, potentially affecting the risk-benefit assessment presented to regulators.

Given the known relationship of Sudden Death and cardiovascular disease, related terms such as sudden cardiac death or sudden cardiac arrest, should be included in a list of AESI in a clinical trial designed to evaluate any vaccine. Ultimately, this would result in the inclusion of comments like "the subject died suddenly and unexpectedly" or "was unexpectedly found dead" in safety summary reports such as Pfizer/BioNTech's Emergency Use Authorization application[19], the 6-Month Interim Report[24], or the Summary Clinical Report[34], all of which are easily searchable. Combing through CRF and Narratives for unknown tidbits of information is not for the faint of heart. A CRF for one of the 38 subjects who died in the Pfizer/BioNTech trial was 924 pages long! Not highlighting sudden deaths in safety summary reports had the effect of obscuring this very important information from regulators.

The second reason SUD signal was missed requires a more complex explanation. An unexpected discovery by Michels et al.[18] revealed that Pfizer/BioNTech had mismanaged records regarding the true date a subjected died. Based on the actual subject death dates, the EUA should have reported that 11 subjects died by 14 November 2020, 6 in the vaccinated arm and 5 in the placebo arm. Hence, at the point of the EUA submission, there was only a 33% (2 out of 6) reporting rate of deaths in the vaccinated arm compared to 80% (4 out of 5) in the placebo arm, because of the delay in recording deaths.

It should be noted that the delays allowed Pfizer/BioNTech to omit the deaths of 2 vaccinated subjects, subjects 11141050 and 11201050, from their EUA application. In these subjects' documents, there is evidence that their emergency contacts promptly notified the clinical trial sites of their deaths on the day

their deaths occurred, 19 October 2020 and 7 November 2020. According to the trial protocol, Pfizer Safety was to be notified of these deaths within 24 hours. However, these deaths were only followed up by the clinical trial sites 37 and 26 days later, which went past the data cutoff date. These "hidden deaths" are described in Kunadhasan and Michels[35]. Had this data been available to regulators, there would have been an equal number of deaths in both arms of the trial and no evidence that the Pfizer/BioNTech vaccine saved lives, possibly disrupting approval of Pfizer/BioNTech's EUA application.

Delayed reporting of subject deaths also obscured the SUD signal. All 4 of the vaccinated subjects who should have been reported in the EUA application are listed in Table 1 as Sudden Unexplained Deaths – subjects 10071101, 11141050, 11201050, 11621327 – while only 2 of the 4 placebo subject deaths reported were SUD – subjects 10661350 and 11521085. Thus, by inaccurately reporting subjects' dates of death, Pfizer/BioNTech obscured a potential SUD signal even at the time of their EUA application. The reporting error was corrected in the 6-Month Interim Report but, in their summary of the 6-Month Report, Thomas et al.[29] only further obscured the error. SUD is never mentioned. Michels et al.[18] revealed details of these data discrepancies, errors, misrepresentations, and obfuscations in Pfizer/BioNTech safety reports and publications.

Absence of autopsy of subjects in the Pfizer/BioNTech clinical trial.

A systematic review of the CRFs for all 38 deaths revealed that autopsy data were absent for all cases of SUD. The documented causes of death were derived from investigator assessments based on clinical narratives rather than postmortem examination. This limitation is particularly relevant for SUD, where autopsy is the gold standard for determining etiology[5]. In the U.S., where all SUD cases in the trial occurred, autopsy rates for out-of-hospital deaths range from 8.5% to 11% depending on age[36], but COVID-19 trial protocols did not mandate autopsies for unexpected deaths. Consequently, the assigned causes of death (e.g., cardiac arrest) may reflect terminal events rather than underlying pathology, obscuring potential vaccine-related mechanisms.

The C4591001 protocol[23] clearly indicated that the trial site investigators were responsible for investigating the causes of an Adverse Event (AE) or Serious Adverse Event (SAE). "The investigator is obligated to perform or arrange for the conduct of supplemental measurements and/or evaluations as medically indicated or requested by the sponsor to elucidate the nature and/or causality of the AE or SAE as fully as possible." Additionally, "If a participant dies during participation in the study or during a recognized follow-up period, the investigator will provide Pfizer Safety with a copy of any postmortem findings including histopathology." Autopsy is essential to accurately determine causality in cases of Sudden Death[5].

At this time, it is unclear whether the trial site investigators fulfilled this obligation or if the autopsy reports have not yet been released to the PHMPT.org website by Pfizer/BioNTech. All the subjects who died suddenly in the Pfizer/BioNTech clinical trial were in U.S. trial sites. Requirements for autopsy vary based on hospital accreditation standards, state laws and regulations about which deaths should be investigated, and sudden and unexplained infant death protocols[36]. Additionally, this low autopsy rate in the U.S. is declining[12,36].

Autopsy Requirements in U.S. Jurisdictions Reporting Sudden Deaths in the BNT162b2 Trial

The United States employs a decentralized approach to medicolegal death investigation, with no federal standard for autopsy requirements. Instead, authority rests with state or local systems, which may be administered by a medical examiner (physician-led) or a coroner (an elected official who is not necessarily a physician). All seven U.S. states that reported Sudden Unexpected Deaths (SUD) in the Pfizer/BioNTech clinical trial mandate the reporting and review of such cases. However, the subsequent requirement for a full autopsy is not uniform and is often at the discretion of the overseeing office.

The data in Table 5 illustrate that even in jurisdictions with robust medical examiner systems, such as New York and Texas, a full autopsy is not guaranteed for every SUD case. In states with coroner systems or mixed systems, like California and Georgia, the requirement is even more discretionary. This fragmented regulatory landscape, where the necessity of an autopsy is determined on a case-by-case basis, provides a clear

explanation for why none of the 15 SUD deaths in the C4591001 trial underwent a complete, standardized postmortem examination whose findings were available for independent review.

Table 5. Autopsy Discretion in U.S. States with Sudden Deaths in the BNT162b2 Trial.

State	System Type	Reporting Requirement for SUD	Autopsy Requirement
California	Medical Examiner/Coroner mix	Yes	Highly discretionary; autopsy if needed to establish cause
Florida	Medical Examiner	Yes	Highly discretionary; autopsy if needed to establish cause
Georgia	Medical Examiner/Coroner mix	Yes	Highly discretionary; autopsy if needed to establish cause
Kansas	Coroner	Yes	Highly discretionary; autopsy if needed to establish cause
Nevada	Coroner	Yes	Highly discretionary; autopsy if needed to establish cause
New York	Medical Examiner	Yes	Discretionary; autopsy depends on findings after review
Texas	Medical Examiner	Yes	Discretionary; autopsy depends on findings after review

Table notes: SUD = Sudden Unexpected Death. Discretionary systems typically allow for external examination or toxicology without a full dissection.

Regulators can ask a trial sponsor to provide a causality assessment[23]. It is further stated, "If the investigator does not know whether or not the study intervention caused the event, then the event will be handled as "related to study intervention" for reporting purposes, as defined by the sponsor." Determination of causality of an Adverse Event or Serious Adverse Event, such as death, in a clinical trial requires statistical comparison of the treatment and placebo arms of the trial as well as evidence-based determination of the cause of the event. Our review of the critical trial documents – Pfizer/BioNTech's EUA application[19], Pfizer/BioNTech's presentation to the 10 December 2020 VRAPAC meeting[37], and the 6-Month Interim Report[24] – found no reference to such a statistical analysis of subject deaths or subject Sudden Deaths. Nor has Pfizer/BioNTech released any official autopsy reports for public review.

Given the above, we believe regulators should have made clear in the EUA approval documentation for the Pfizer/BioNTech mRNA vaccine, that the results of the trial do not exclude the possibility that the subject's death was related to the study intervention, concomitant medications, or clinical trial procedures. In the absence of such statements, individuals considering being vaccinated might easily misinterpret FDA approval. They could assume that, other than the "reactogenicity adverse events" that occurred within a few days after injection, more serious adverse events, like death, were known to be unrelated to the vaccine when this was not accurate.

The Pfizer/BioNTech modified mRNA COVID-19 vaccine was an entirely new technology[15–17]. Human clinical trials for this mRNA-LNP (lipid nanoparticle) technology had never progressed beyond Phase 1. As Phase 1 trials, they involved fewer than a total of 250 adults. Most significantly, these trials demonstrated ONLY IgG antibody production, not immunity to the disease. Given the clear understanding of the experimental nature of the modRNA-LNP technology, the FDA and all international regulatory agencies should have held the Pfizer/BioNTech C4591001 trial to a very high safety standard.

In summary, the SUD signal in the BNT162b2 trial was obscured by the exclusion of sudden death from the predefined AESI list, inconsistent reporting of dates of death, and the absence of autopsy data. These limitations highlight the need for: (1) standardized inclusion of sudden death and related terms as AESI in trials of novel platforms; (2) real-time verification of critical events such as dates of death in regulatory submissions; and (3) protocol-mandated autopsies for unexpected deaths in high-risk pharmacovigilance studies. Implementing these measures would enhance the detection and evaluation of safety signals in future trials.

Pfizer/BioNTech post-marketing report.

The omission of sudden death as an AESI in the trial protocol is consistent with its absence from Pfizer's post-authorization safety report (document 5.3.6)[38]. This safety report, which analyzed 42,086 cases with 1,223 fatalities, did not include sudden death as a search term or safety category, nor did it aggregate deaths by clinical presentation. The cardiovascular AESI analysis excluded "cardiac arrest" and "cardio-respiratory arrest" despite their presence on the AESI list, further limiting the ability to detect a sudden-death signal. This methodological continuity between the trial and post-marketing phases underscores a systematic blind spot in the safety surveillance framework for BNT162b2.

Notably, neither "sudden death" nor "sudden cardiac death" appears anywhere in the document as a reported event, search term, or safety category, and "sudden cardiac death" is absent from the company's AESI inventory entirely, despite that inventory comprising approximately 1,000 preferred terms. The sole sudden-death descriptor in the document – "Sudden unexplained death in epilepsy" – appears only as an unused line item in the AESI appendix, with no associated cases.

This omission is compounded by the construction of the cardiovascular AESI search strategy, which was limited to ten preferred terms (e.g., acute myocardial infarction, arrhythmia, cardiac failure, and tachycardia) and excluded "cardiac arrest" and "cardio-respiratory arrest," even though both terms were present on the AESI list. Consequently, a death presenting as cardiac arrest would not have been captured under the cardiovascular signal review.

Taken together, the structure of this post-authorization report – like the trial documentation analyzed by Michels et al.[18] – was not configured to detect or reveal a sudden unexpected death signal, even where the underlying reports may have contained one.

Sudden Death reports following world-wide distribution.

Post-marketing surveillance data from 2021, following the widespread administration of COVID-19 vaccines, offer valuable context for the Sudden Unexpected Death (SUD) signal identified in the BNT162b2 clinical trial. One of the most concerning signals emerged from Israel, where a 25% increase in emergency calls for cardiac arrest (CA) and acute coronary syndrome (ACS) was observed in individuals aged 16–39 during the vaccine rollout (January–May 2021) compared with the equivalent period in 2019 and 2020[39]. This age-specific elevation is notable because it mirrors our trial's finding of a potential shift toward younger age at SUD occurrence among vaccinated males. The Israeli data suggest that the cardiovascular safety signal observed in the 'controlled trial' environment may have manifested in real-world settings, particularly in younger adults who were not the primary focus of the initial trial efficacy analyses.

Verma et al.[40], Pillay et al.[41], and Gil et al.[42] published case studies of deaths due to vaccine-associated myocarditis and pericarditis. Faksova et al.[43] found a statistically significant cardiovascular safety signal with BNT162b2 vaccination across 8 countries. These safety signals were foreshadowed in Michels et al.[18] who identified a 3.7-fold increase in fatal cardiac events in the Pfizer/BioNTech clinical trial vaccinated arm compared to the placebo. Potential mechanisms for the increased cardiovascular-related deaths came to light with the work of the late German pathologist Arne Burkhard, who was interviewed shortly before his death in 2024[44]. Professor Burkhard describes autopsies of individuals who died after vaccination in which he was able to demonstrate expression of the specific vaccine-encoded PP-Spike protein histologically with inflammation in blood vessels and in all major organs, including areas of myocarditis in the heart.

The possible relationship between increases in Sudden Unexpected Deaths and the mRNA COVID-19 vaccines has become seemingly undeniable with multiple published reports from a number of countries[28,43,45–47]. We urge the inclusion of Sudden Unexpected Death and Sudden Cardiac Death as Adverse Events of Special Interest in pharmacovigilance surveillance of clinical trials and reporting structures.

Conclusion

Despite the small data set of subjects who died suddenly and unexpectedly in the Pfizer/BioNTech mRNA COVID-19 vaccine clinical trial, we draw the following conclusions.

- Of 38 all-cause deaths reported in the 6-Month Interim Report, 15 were Sudden Unexpected Deaths – 10 in the vaccinated arm and 5 in the placebo arm.
- SUD represents 48% of all-cause deaths in the vaccinated arm of the trial.
- SUD were a 2-fold higher in subjects who received the vaccine compared to the placebo control group.
- Pfizer/BioNTech underreported the number of SUD and all-cause deaths that would have been expected based on pre-2020 U.S. federal records.
- Only 4 of the 15 SUD subjects were autopsied and none of the original autopsy reports were available for review.
- The reported cause of death for 8 of the SUD was "cardiac arrest" or "cardiopulmonary arrest", which provides no insight as to the causal basis of the SUD.
- The cause of death for 2 SUD subjects was listed as "sudden cardiac death" and "aortic rupture" based only on brief comments found in the subjects' Case Report Forms.
- Comparison of the number of all-cause deaths in the Pfizer/BioNTech clinical trial to the number of subjects who died suddenly by age, sex, and trial arm suggested a decrease of about decade in the age of SUD ONLY in vaccinated men.
- No relationship between the dates of inoculation and the dates of SUD was revealed in BNT162b2 vaccinated or placebo subjects of either sex.
- Our analysis suggests that the SUD signal in the Pfizer/BioNTech mRNA COVID-19 vaccine trial was obscured by the exclusion of sudden death from the predefined AESI list, inconsistent reporting of dates of death, and the absence of autopsy data.

Limitations

The main limitation of this study is the small number of Sudden Deaths reported for subject in the trial. Pfizer/BioNTech has yet to release about 1 million pages of documents. Autopsy reports may be among those documents. The lack of this documentation, and possibly other critical data, is a serious limitation for this analysis. Data acquisition relied heavily on analysis of subjects' Case Report Forms and review of Narrative reports, which might introduce subjectivity both on the part of the author of the reports and the reader. Calculations of the number of expected deaths and Sudden Deaths were extrapolated from U.S. rates when the trial population was international, from 6 countries and 4 continents.

Conflicts of interest

The authors have no conflicts of interest to declare.

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References:

1. Zipes DP, Wellens HJJ. Sudden Cardiac Death. *Circulation*. 1998;98(21):2334-2351. doi:10.1161/01.CIR.98.21.2334

2. Skjelbred T, Warming PE, Krøll J, et al. Sudden Cardiac Death as First Manifestation of Cardiovascular Disease. *JACC: Clinical Electrophysiology*. 2025;11(5):881-890. doi:10.1016/j.jacep.2024.12.012

3. Kong MH, Fonarow GC, Peterson ED, et al. Systematic Review of the Incidence of Sudden Cardiac Death in the United States. *Journal of the American College of Cardiology*. 2011;57(7):794-801. doi:10.1016/j.jacc.2010.09.064

4. Stecker EC, Reinier K, Marijon E, et al. Public Health Burden of Sudden Cardiac Death in the United States. *Circ: Arrhythmia and Electrophysiology*. 2014;7(2):212-217. doi:10.1161/CIRCEP.113.001034

5. Sessa F, Esposito M, Messina G, Di Mizio G, Di Nunno N, Salerno M. Sudden Death in Adults: A Practical Flow Chart for Pathologist Guidance. *Healthcare*. 2021;9(7):870. doi:10.3390/healthcare9070870

6. Myerburg RJ. Cardiac and Noncardiac Causes of Apparent Sudden Arrhythmic Deaths: Shadows in a Spectrum. *Circulation*. 2018;137(25):2701-2704. doi:10.1161/CIRCULATIONAHA.118.034594

7. Fabre A, Sheppard MN. Sudden adult death syndrome and other non-ischemic causes of sudden cardiac death. *Heart*. 2006;92(3):316-320. doi:10.1136/hrt.2004.045518

8. Bhagwan R, Nabi R, Rath S, et al. Trends in Sudden Cardiac Death Related Mortality in Adults in the United States: A CDC WONDER Database Analysis, 1999–2020. *Clinical Cardiology*. 2025;48(7):e70180. doi:10.1002/clc.70180

9. Chugh SS, Reinier K, Teodorescu C, et al. Epidemiology of Sudden Cardiac Death: Clinical and Research Implications. *Progress in Cardiovascular Diseases*. 2008;51(3):213-228. doi:10.1016/j.pcad.2008.06.003

10. Paratz ED, Rowsell L, Zentner D, et al. Cardiac arrest and sudden cardiac death registries: a systematic review of global coverage. *Open Heart*. 2020;7(1):e001195. doi:10.1136/openhrt-2019-001195

11. Naneix AL, Perier MC, Beganton F, Jouven X, Lorin G. Sudden adult death: An autopsy series of 534 cases with gender and control comparison. *Journal of Forensic and Legal Medicine*. 2015;32:10-15. doi: http://dx.doi.org/10.1016/j.j m.2015.02.005

12. Tseng ZH, Olgin JE, Vittinghoff E, et al. Prospective Countywide Surveillance and Autopsy Characterization of Sudden Cardiac Death: POST SCD Study. *Circulation*. 2018;137(25):2689-2700. doi:10.1161/CIRCULATIONAHA.117.033427

13. Jorch G, Tapiainen T, Bonhoeffer J, et al. Unexplained sudden death, including sudden infant death syndrome (SIDS), in the first and second years of life: case definition and guidelines for collection, analysis, and presentation of immunization safety data. *Vaccine*. 2007;25(31):5707-5716. doi:10.1016/j.vaccine.2007.02.068

14. Markowitz LE, Hopkins RH, Broder KR, et al. COVID-19 Vaccine Safety Technical (VaST) Work Group: Enhancing vaccine safety monitoring during the pandemic. *Vaccine*. 2024;42:125549. doi:10.1016/j.vaccine.2023.12.059

15. Bahl K, Senn JJ, Yuzhakov O, et al. Preclinical and Clinical Demonstration of Immunogenicity by mRNA Vaccines against H10N8 and H7N9 Influenza Viruses. *Molecular Therapy*. 2017;25(6):1316-1327. doi:10.1016/j.ymthe.2017.03.035

16. Aldrich C, Leroux–Roels I, Huang KB, et al. Proof-of-concept of a low-dose unmodified mRNA-based rabies vaccine formulated with lipid nanoparticles in human volunteers: A phase 1 trial. *Vaccine*. 2021; 39(8):1310-1318. doi:10.1016/j.vaccine.2020.12.070

17. Alberer M, Gnad-Vogt U, Hong HS, et al. Safety and immunogenicity of a mRNA rabies vaccine in healthy adults: an open-label, non-randomized, prospective, first-in-human phase 1 clinical trial. *The Lancet*. 2017;390(10101):1511-1520. doi:10.1016/S0140-6736(17)31665-3

18. Michels C, Perrier D, Kunadhasan J, et al. Forensic analysis of the 38 subject deaths in the 6-Month Interim Report of the Pfizer/BioNTech BNT162b2 mRNA Vaccine Clinical Trial. *Vaccine Theory Prac & Res*. 2023;3(1):973-1008. doi:10.56098/ijvtpr.v3i1.85

19. Emergency Use Authorization (EUA) for an Unapproved Product Review Memorandum https://archive.org/details/emergency-use-authorization-eua-for-an-unapproved-product-review-memorandum. https://archive.org/details/emergency-use-authorization-eua-for-an-unapproved-product-review-memorandum

20. Analysis Data Reviewer Guide BLA Analysis for Participants ≥16 Years of Age BioNTech SE and PFIZER INC. Study C4591001. https://phmpt.org/wp-content/uploads/2022/03/125742_S1_M5_c4591001-A-adrg.pdf#page=85

21. Stiles MK, Wilde AAM, Abrams DJ, et al. 2020 APHRS/HRS expert consensus statement on the investigation of decedents with sudden unexplained death and patients with sudden cardiac arrest, and of their families. *Heart Rhythm*. 2021;18(1):e1-e50. doi:10.1016/j.hrthm.2020.10.010

22. Mattiuzzi C, Lippi G. Recent epidemiology of sudden cardiac death. *Resuscitation*. 2024;201:110315. doi:10.1016/j.resuscitation.2024.110315

23. Pfizer/BioNTech Clinical Trial C4591001 – A Phase 1/2/3, Placebo-Controlled, Randomized, Observer-blind, Dose-finding Study to Evaluate the Safety, Tolerability, Immunogenicity, and Efficacy of SARS-COV-2 RNA Vaccine Candidates Against COVID- 19 in Healthy Individuals. https://www.academia.edu/55465858/C4591001_Clinical_Protocol_Nov2020_Pfizer_BioNTech

24. 6-Month Interim Report of Adverse Events CA4591001. https://pdata0916.s3.us-east-2.amazonaws.com/pdocs/070122/125742_S1_M5_5351_c4591001-interim-mth6-adverse-events.zip#page=3646

25. Randomization Scheme BioNTech C4591001. https://clinicaltrials.biontech.com/trials/C4591001

26. Mäntyniemi L, Pakanen L, Tikkanen J, et al. Incidence and autopsy rates for sudden cardiac death in Northern Finland. *Heart Rhythm*. 2024;21(5):682-683. doi:10.1016/j.hrthm.2023.12.026

27. Sanchez O, Campuzano O, Fernández-Falgueras A, et al. Natural and Undetermined Sudden Death: Value of Post-Mortem Genetic Investigation. Song C, ed. *PLoS ONE*. 2016;11(12):e0167358. doi:10.1371/journal.pone.0167358

28. Potluri S, Chittiprol N, Varaganti V, et al. The Association of SARS-CoV-2 Infection and COVID-19 Vaccination With Sudden Death: An Explorative Review. *Cureus*. Published online August 7, 2025. doi:10.7759/cureus.89527

29. Thomas SJ, Moreira ED, Kitchin N, et al. Safety and Efficacy of the BNT162b2 mRNA Covid-19 Vaccine through 6 Months. *N Engl J Med*. 2021;385(19):1761-1773. doi:10.1056/NEJMoa2110345

30. *16.2.1.1 Listing of Subjects Discontinued From Vaccination and/or From the Study – All Subjects ≥16 Years of Age*. https://phmpt.org/wp-content/uploads/2022/07/125742_S1_M5_5351_c4591001-interim-mth6-discontinued-patients.pdf

31. Jaramillo AP, Yasir M, Iyer N, Hussein S, Sn VP. Sudden Cardiac Death: A Systematic Review. *Cureus*. Published online August 2, 2023. doi:10.7759/cureus.42859

32. Faheem MSB, Asghar T, Feroze F, et al. Trends in Mortalities due to Sudden Cardiac Arrest in the United States Population. *Journal of Arrhythmia*. 2025;41(6):e70240. doi:10.1002/joa3.70240

33. Wittes J, Lakatos E, Probstfield J. Surrogate endpoints in clinical trials: cardiovascular diseases. *Stat Med*. 1989;8(4):415-425. doi:10.1002/sim.4780080405

34. 2.7.4 STN Summary Clinical Safety. https://phmpt.org/wp-content/uploads/2021/12/STN-125742_0_0-Section-2.7.4-summary-clin-safety.pdf#page=345

35. Kunadhasan J, Michels CA. Undisclosed Deaths in the Pfizer mRNA COVID-19 Vaccine Trial: Will There Be Accountability? *Journal of American Physicians and Surgeons*. 30(4):118-121.

36. Donna L. Hoyert. *The Changing Profile of Autopsied Deaths in the United States, 1972–2007*. 2011. https://www.cdc.gov/nchs/data/databriefs/db67.pdf

37. Vaccines and Related Biological Products Advisory Committee Meeting December 10, 2020. Accessed October 8, 2025. https://vbook.pub/download/vrbpac-121020-meeting-briefing-document-fda-e2xzp85nynw0

38. *5.3.6 CUMULATIVE ANALYSIS OF POST-AUTHORIZATION ADVERSE EVENT REPORTS OF PF-07302048 (BNT162B2) RECEIVED THROUGH 28-FEB-2021*.

https://phmpt.org/wp-content/uploads/2021/11/5.3.6-postmarketing-experience.pdf

39. Sun CLF, Jaffe E, Levi R. Increased emergency cardiovascular events among under-40 population in Israel during vaccine rollout and third COVID-19 wave. *Sci Rep*. 2022;12(1):6978. doi:10.1038/s41598-022-10928-z

40. Verma AK, Lavine KJ, Lin CY. Myocarditis after Covid-19 mRNA Vaccination. *N Engl J Med*. 2021;385 (14):1332-1334. doi:10.1056/NEJMc2109975

41. Pillay J, Gaudet L, Wingert A, et al. Incidence, risk factors, natural history, and hypothesised mechanisms of myocarditis and pericarditis following covid-19 vaccination: living evidence syntheses and review. *BMJ*. Published online July 13, 2022:e069445. doi:10.1136/bmj-2021-069445

42. Gill JR, Tashjian R, Duncanson E. Autopsy Histopathologic Cardiac Findings in 2 Adolescents Following the Second COVID-19 Vaccine Dose. *Archives of Pathology & Laboratory Medicine*. 2022;146(8):925-929. doi:10.5858/arpa.2021-0435-SA

43. Faksova K, Walsh D, Jiang Y, et al. COVID-19 vaccines and adverse events of special interest: A multinational Global Vaccine Data Network (GVDN) cohort study of 99 million vaccinated individuals. *Vaccine*. 2024;42(9):2200-2211. doi:10.1016/j.vaccine.2024.01.100

44. Hudak T. Pathologist Arne Burkhardt Final Interview: Revealing the Grave Dangers of mRNA vaccines. Published online January 24, 2024. https://childrenshealthdefense.eu/vaccine-safety/pathologist-arne-burkhardt-final-interview-revealing-the-grave-dangers-of-mrna-vaccines/

45. Sadiq W, Waleed MS, Suen P, Chalhoub MN. Cardiopulmonary Arrest After COVID-19 Vaccination: A Case Report. *Cureus*. Published online January 12, 2022. doi:10.7759/cureus.21141

46. Krauson AJ, Casimero FVC, Siddiquee Z, Stone JR. Duration of SARS-CoV-2 mRNA vaccine persistence and factors associated with cardiac involvement in recently vaccinated patients. *npj Vaccines*. 2023;8(1):141. doi:10.1038/s41541-023-00742-7

47. Maruyama T, Uesako H. Lessons Learnt from Case Series of Out-of-hospital Cardiac Arrest and Unexpected Death after COVID-19 Vaccination. *Intern Med*. 2023;62(22):3267-3275. doi:10.2169/internalmedicine.2298-23