1000 FREDERICK LANE, MORGANTOWN, WV 26508 • 304.285.5916

27-Year-old Firefighter has Seizure then Dies of Cardiac Arrest while Responding to Residential Fire – Kansas

Executive Summary

On August 1, 2024, a 27-year-old male career firefighter (FF1) with no known medical conditions participated in a mutual aid response to a residential structure fire. FF1 was inside the building with an active fire for approximately 4 minutes before exiting the front door. Shortly after exiting, the firefighter appeared to have a seizure and collapse to the ground. Nearby firefighters who witnessed the seizure and collapse rushed to assist FF1. FF1's gear and self-contained breathing apparatus (SCBA) were quickly removed, and an initial medical assessment found FF1 to be pulseless and apneic. Cardiopulmonary resuscitation (CPR) was initiated. The initial firefighters tending to FF1 were all basic emergency medical technicians (EMT-B). The first due engine, which was the initial interior fire attack crew, was advanced life support (ALS) equipped and had a firefighter paramedic (FFP) assigned to the crew but no ambulance for patient transport was immediately available. The FFP initiated and continued advanced cardiac care of FF1 until arrival of the ALS ambulance. While en-route, the cyanide antidote hydroxocobalamin was administered. FF1 regained a pulse enroute to the hospital but lost it as he was being taken into the emergency department (ED). The ED staff worked FF1's resuscitation for approximately 15 minutes before he was pronounced dead. The Medical Examiners report listed FF1's cause of death as "unspecified cardiac arrest sustained while fighting a fire". Of note, FF1 had a syncopal event approximately 2 months prior but the cause was not identified, and no further medical evaluation was done. At the approximate time of arrival at the residential fire, the outdoor temperature was 96°F with 44% humidity resulting in a heat index of 103.4°F. However, it is unknown if either the syncopal event or heat stroke was a factor in this death.

Key Recommendations

NIOSH offers the following recommendations to reduce the risk of sudden cardiac arrest among firefighters at this and other fire departments across the country.

- *Key Recommendation #1: Fire departments should consider implementing annual medical examinations as per National Fire Protection Association (NFPA) 1582 recommendations.*
- *Key Recommendation #2: Fire departments should encourage members to reduce and if possible, eliminate intake of/exposure to known risk factors for adverse cardiovascular events and rhabdomyolysis.*

27-Year-old Firefighter has Seizure then Dies of Cardiac Arrest while Responding to Residential Fire – Kansas

- *Key Recommendation #3: Fire departments should increase awareness of conditions that increase risk of heat-related illness (HRI) and implement heat stress management policies to reduce those risks.*
- *Key Recommendation #4: Ensure emergency medical service (EMS) with transport capability is on-scene at any fire or special operation location in the event emergency medical care and transport is needed.*
- *Key Recommendation #5: Fire officers should ensure crew integrity when entering, operating in, and exiting from an environment immediately dangerous to life or health (IDLH).*
- *Key Recommendation #6: Fire departments should provide physicians tasked with pre-employment and return to work medical evaluations, descriptions of the essential tasks and duties and not rely on the cadet/incumbent to relay this information.*
- *Key Recommendation #7: Fire departments should ensure that a physician signs off on pre-employment and return to work evaluations.*

For further information, visit the program Web site at www.cdc.gov/niosh/firefighters/fffipp/about.html or call toll free 1-800-CDC-INFO (1-800-232-4636).

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Introduction

On August 1, 2024, a 27-year-old male career firefighter (FF1) with no known medical conditions participated in a mutual aid response to a residential structure fire. FF1 belonged to Fire Department A (FD-A) which has multiple stations. FF1 was moved from his normally assigned FD-A station 1 to FD-A station 2 for that day due to staffing alignment. This was the first time FF1 worked from FD-A station 2. The structural fire was located in Fire Department B (FD-B)'s service area and FF1's crew responded as part of a mutual aid agreement. The incident command for the fire was FD-B.

FF1 was inside the building with an active fire for approximately 4 minutes before exiting through the front door. Shortly after exiting, the firefighter appeared to have a seizure and collapsed to the ground.

During the investigation, the National Institute for Occupational Safety and Health (NIOSH) investigators interviewed the following people:

- *Chiefs of fire departments involved in the incident*
- *Fire department staff and emergency medical service (EMS) personnel involved in the incident*
- *County Medical Director*
- *Fire Marshal*
- *Medical Examiner*

The NIOSH investigator reviewed the following documents:

- *Standard operating procedures from FD-A and FD-B*
- *Mutual aid agreements between involved departments*
- *Narratives and incident reports from all departments involved*
- *Incident location photos and schematics*
- *Radio communication audio files from incident*
- *Cyanokit training, assignment, and use protocols*
- *FF1 Training Records*

- *FF1 helmet cam during August 1, 2024, residential fire response*
- *Medical examiner's report*
- *Pre-hospital care reports and data from LifePak used by EMS staff in FF1's resuscitation*
- *Emergency Department (ED) records from 5/16/24 and 8/1/24 visits*
- *Pre-employment medical evaluation*
- *Incident/injury reports involving FF1 during his employment with FD-A*

Fire Departments

FD-A is a career municipal fire department with approximately 500 members. FD-A has 22 stations, covering 168 square miles, and serving a population of over 490,000. FD-A responded to this incident under an automatic aid agreement.

There were 3 fire departments involved in this incident. FD-B is a career department serving the county jurisdiction around the municipality of FD-A. The structure fire occurred in FD-B's jurisdiction. FD-B had multiple apparatus respond to this incident. The Battalion Chief that assumed Incident Command (IC) is a member of FD-B.

Fire Department C (FD-C) is a small city department within the same county as FD-A and FD-B. FD-C is a career department that also responded to this incident under an automatic aid agreement. Engine 1 (E1) from FD-C was the first engine company to arrive on-scene. E1 was ALS capable with equipment and a staffed firefighter/paramedic. The initial primary Incident Safety Officer was a Captain from FD-B. The interior Safety Officer was from FD-C.

Membership and Training

FD-A hiring process components consists of a two-part aptitude/interview process:

- Phase 1 consists of a physical abilities evaluation in a group setting where candidates are individually scored and may qualify for phase 2
- Phase 2 is an individually tested and scored, multi-station obstacle course, modeled after the Candidate Physical Abilities Test (CPAT), and a panel interview

In addition, applicants must submit to a background investigation and undergo a physical examination and lab screening. The physical examination is National Fire Protection Association (NFPA) 1582 compliant (Standard on Comprehensive Occupational Medical Program for Fire Departments) and is conducted by a city appointed physician.

Once accepted, the recruit training academy is 22 weeks in length. Eight weeks are dedicated to Emergency Medical Technician training and certification. Fourteen weeks are dedicated to basic training in firefighting, special rescue, and hazardous materials. Recruits participate in ride-outs with operations companies during the academy.

27-Year-old Firefighter has Seizure then Dies of Cardiac Arrest while Responding to Residential Fire – Kansas

Preplacement/Periodic/Return to Work Medical Evaluations

At the time of FF1's hire in 2019, FD-A required the pre-employment medical evaluation to include a physical exam, pulmonary function testing, blood tests (standard chemistry panel and complete blood count), urine drug screen, urinalysis, chest x-ray, lumbosacral spine x-ray, audiogram, functional capacity evaluation (FCE), cardiac treadmill stress test and completion of the Occupational Safety and Health Administration (OSHA) Respirator Clearance form. At the time of FF1's hire through the period of his employment, there were no department requirements for annual medical examinations.

The majority of FF1's pre-employment evaluation was completed on February 19, 2019. The physical exam, blood tests, pulmonary function testing, x-rays, and cardiac treadmill test were all unremarkable. His urinalysis was positive for ketones but was otherwise normal. He was noted to have "good exercise tolerance" on his treadmill test and his functional capacity evaluation was reported in 2 components; The physical classification of the worker was designated as "very heavy", and the physical demand classification of job was designated as "medium heavy". These classifications were defined according to the table below (Table 1). The final determination of the FCE dated February 22, 2019, was that FF1 was "able to meet functional requirements of job based on tests completed".

	Light	Light/Medium	Medium	Medium/Heavy	Heavy	Very Heavy
Occasional (1%–33%)	20 lbs.	35 lbs.	50 lbs.	75 lbs.	90 lbs.	>100 lbs.
Frequent (34%–66%)	10 lbs.	15 lbs.	25 lbs.	35 lbs.	50 lbs.	>50 lbs.
Constant (67%–100%)	Negligible	5 lbs.	10 lbs.	15 lbs.	20 lbs.	>20 lbs.

It was noted on the Respirator Clearance form under job description that "a respirator job description was not provided by the Company and this recommendation is based solely upon history/physical information gained today". The FD's policy manual states that the "description of essential job tasks is included in position classifications associated with specific titles, or ranks, for each commissioned Fire Department position" It is unclear why these were not provided to the physician conducting FF1's pre-placement medical evaluation. The final determination was that FF1 was cleared with "no restrictions of respirator use".

FF1 had 2 illness/injury incidents during his tenure at FD-A. The first incident occurred on July 15, 2020, during participation in a structure fire response when FF1 tripped over a hoseline and fell to the ground. During his fall, his bunker pants were pushed up above his knees, exposing his skin resulting in "slight burns to both shins" when he contacted the heated floor. He was treated at the local ED and discharged to return to work without restrictions. A return-to-work form dated the same day of the incident was completed confirming he was released back to full duty without restriction. The required work release form included a list of essential tasks and functional capabilities required for those tasks. The second incident was dated November 18, 2020, and was described as an inhalational exposure to COVID-19 occurring while engaged in CPR despite wearing proper personal protective equipment (PPE). The form does not list what PPE was worn, only that all personnel on 2 engine crews and EMS

crew were exposed/involved in this incident and "all engine 20 members were wearing proper PPE". No treatment was documented. The form indicated FF1 was not admitted to a hospital and was not seen in the Occupational Medicine Facility. It is unknown if FF1 was subsequently tested for COVID-19 to determine if an infection resulted from that possible exposure. The form asked if work restrictions were prescribed by a clinician. The response to this question was "no" but the form was not signed by any physician, so it is unclear if a physician reviewed this incident report or if there was a reviewing physician and they did not sign the report.

Wellness/Fitness Programs

FD-A has no formal on-going wellness and fitness programs. The only mandated physical occurs at pre-employment. The department's physical fitness training policy allows for one hour of physical training per 24-hour shift. Exercise equipment is furnished by the department.

Investigation

On August 1, 2024, at 07:00 hours, FF1 began his tour of duty on his regularly assigned shift and apparatus at FD-A station 1 on Engine 10 (E10). Soon after arrival at the firehouse, FF1 was reassigned to station 2 as Engine 2 (E2) driver in another part of the city. During the morning at station 2, FF1 checked out his equipment and apparatus, performed physical training which included an upper body weight workout of shoulder press and lateral pull-downs, and took two EMS calls on E2. After completing the second EMS call, FF1 went to lunch then picked up drinks and snacks at a store. During interviews, firefighters from both E10 and E2 stated that FF1 was his typical self, having no complaints and doing nothing out of the ordinary. The E2 crew was less familiar with FF1's routines, but there was nothing that raised any suspicion to any physical or medical concerns. FF1 was in good physical condition, did regular cardiovascular and strength training workouts, and he was an avid hunter.

To understand the brevity of the events in the early stages of this incident, a basic timeline follows. The timeline is derived from 4 sources: the dispatch log of the incident, FF1's self-contained breathing apparatus (SCBA) data log, helmet camera footage from FF1, and eyewitness interviews. There is an approximate 30–60 second margin of error in times associated with the SCBA data log. This includes entry and exit from the structure. The SCBA internal timekeeper was off 4–5 minutes, commonly referred to as time drift. Time drift is not uncommon with SCBA's internal timekeeping mechanisms and is usually rectified at the time of regular equipment service and software updates.

Time	Action
07:00	Shift start
14:56	Dispatch to structure fire
15:02	Battalion Chief (BC1) on -scene
15:03	First engine company (Engine 1 from Fire Department C) on-scene
15:06	Engine 2 marks on-scene (FF1's engine company)
15:11	FF1 goes on air, breathing from his SCBA

27-Year-old Firefighter has Seizure then Dies of Cardiac Arrest while Responding to Residential Fire – Kansas

15:12 FF1 makes entry into the structure

15:13 Primary search marked "all clear"

15:16 SCBA regulator disengaged. It is reasonable to conclude that he exits the structure at this time.

15:22 Multiple eyewitness accounts of FF1's seizure activity and collapse

15:22 Care is initiated immediately following witnessed collapse of FF1

At 14:56, E2 was dispatched to a residence fire as part of a mutual aid response. BC1 arrived first and E2 would be the second engine on scene. BC1 reported smoke and flames coming from the residence. E2 marked on scene at 15:06 and was assigned to pull a 2nd hoseline for fire attack. The E2 crew pulls and sets up a line from the first due engine, Engine 1 (E1). E1 was assigned as the initial attack crew, and they already had their primary attack line inside the structure. The second hoseline was charged and the E2 crew made entry into the residence. FF1 helmet cam video shows FF1 pulling at the exterior roofline when his crew enters the structure, which allows another crew to enter the structure ahead of FF1. This provided an approximate 1-minute delay of FF1 meeting up with his crew inside the residence. Upon entering the structure, FF1 catches up with his crew quickly and assists with moving small piles of burning material with his hook to be extinguished by his crew's hoseline.

At approximately 15:14, FF1 shuts off his helmet camera. In the next 1–2 minutes, FF1 tells one of his engine crew members that he must exit the structure. The firefighter crew member asks FF1 if he's ok and FF1 responds with a "yes". FF1 exits the structure at approximately 15:16. During this same period an Incident Safety Officer reports to the IC that a small amount of fire needed some attention under the front porch. The IC tasked E2 crew with this assignment. Interviews with witnesses believe that FF1, being already outside the structure, heard the redirected assignment for E2 and made his way to this part of the porch in front of the structure. Firefighters at different locations on the fireground reported something did not appear right as FF1 came down the 3–4 steps off the wooden porch and made his way to the area underneath the porch that had some fire. These firefighters could not specify what about FF1 caught their attention as he exited the structure, only that he did. FF1 then began to do some work with his hook at a spot fire under the porch.

At 15:22, FF1 was witnessed to have collapsed from standing position and then had seizure activity at which time a medical emergency was called. Nearby crew members responded to FF1 and by the time they arrived at his position, the seizure activity had stopped, and he was noted to be in cardiac arrest. On-scene FF/EMTs responders were basic life support (BLS) certified so they removed his gear and started chest compressions immediately while the Firefighter Paramedic (FFP) working the interior was directed to FF1. At this time a call was placed for an ALS transport unit.

Resuscitation followed standard BLS protocol with placement of an I-Gel Airway®. A Lucas® device was placed by the FFP to assist with compressions at 15:43. Although FF1 displayed asystole for the majority of the resuscitation during which multiple doses of epinephrine were administered, the Lifepak-15 did advise and delivered one shock of 360J at 15:31 as per pre-hospital records (this differed from the timestamp on the data output of the device which noted this time to be 15:27). Medical command advised administration of 2 doses of sodium bicarbonate (this offsets metabolic acidosis that occurs with prolonged cardiac arrest). At 15:50, the cyanide antidote, hydroxocobalamin, was administered followed by one dose of calcium chloride. At 16:01, return of spontaneous

circulation was noted but this was transient. Additional doses of epinephrine were administered prior to arrival at ED at 16:08. The Lucas® device was removed at 16:10 for a pulse check which did not find one, and asystole was confirmed on the cardiac monitor. Compressions were resumed and additional doses of epinephrine, calcium chloride, and sodium bicarbonate were administered. FF1 showed ventricular fibrillation at 16:15 and a shock of 300J was provided but this degraded back to asystole by the time compressions were stopped for the next pulse check at 16:19. Additional medications were given but he remained in asystole. Time of death was noted as 16:25.

Medical Findings

On one of his pre-placement medical history forms completed in 2019, FF1 stated he had already been in the fire service for 2 years. As this was a hearing history form, there were questions focused on medical conditions involving hearing/vestibular issues which were all negative but none of the provided forms showed a question that asked for any/all past medical history. The Fire Marshal covering FD-A confirmed that FF1 did not have a primary care provider. This was also noted in the May 2024 ED visit records. ED records from August 1, 2024, admission note a past medical history of chickenpox, hay fever, and allergic rhinitis with no known allergies.

The autopsy was conducted on August 2, 2024, the day after FF1 died, by the Chief Medical Examiner (CME) of the district in which the fatality occurred. The cause of death was determined to be "unspecified cardiac arrest while fighting a fire". The manner of death was listed as accident. The CME noted evidence of the medical interventions engaged as part of the resuscitation efforts as well as contusions and a tongue hematoma likely related to his seizure. FF1's height was 70 inches and weight was 185 lbs. There were no structural or vascular abnormalities in the brain. The heart weight was within normal parameters at 440 grams. There were no structural abnormalities of the heart, and the coronary arteries only showed mild atherosclerosis. No evidence of ischemia or infarction were noted. Histological examination of sections from the brain, heart, liver, and kidneys were all normal. Two slides of lung tissue showed congestion, pulmonary edema, and interalveolar (inside the small end airways where gas exchange occurs) hemorrhage. Intracardiac blood was collected and tested negative for ethanol, carbon monoxide, acetone, and a panel of 17 common drugs of abuse including prescription medications and illicit substances.

During the Fire Marshal's inventory of FF1's personal effects, he found a receipt from a local supermarket dated August 1, 2024, and time stamped at 14:38, approximately fifteen minutes before FF1 responded to the residential fire at 14:56. FF1 purchased several caffeinated drinks and snack foods. These purchases caused the Fire Marshal to be concerned regarding FF1's use of caffeinated products. These concerns were relayed to the medical examiner who decided to collect a femoral blood sample to test for a caffeine level. This sample resulted a caffeine level of 4.6 micrograms per milliliter (µg/ml). As per the laboratory that conducted the analysis, caffeine levels in the range 3–15 µg/ml are reflective of "usual stimulant levels" in adults [NMS 2022].

Discussion

Operations/Tactics

This incident exhibits many of the best elements of automatic agreements. The closest apparatus and personnel respond to an emergency incident regardless of the "patch" on the sleeve and the "shield" on

the apparatus door. Within the first few minutes, the IC from FD-B worked with companies from multiple agencies to get an aggressive fire attack in motion, and the primary search was cleared within 10 minutes of the first engine's arrival. NIOSH investigators found the initial operations to be adequate. The IC and his assignments effectively mitigated the fire.

However, good practice and NFPA consensus standards dictates that no firefighter should be entering or leaving the fire structure alone [NFPA 2024]. FF1's helmet camera footage showed he entered the structure following firefighters that were not part of the E2 crew, and quickly caught up with the E2 crew. FF1 spent approximately 4 minutes inside and probably was never more than about 10 feet inside the front door before notifying a member of his crew he was going to exit the structure. His E2 officer was unaware that FF1was exiting the structure until after incident command reassigned the crew to the side A porch for a small fire under the porch. FF1 was not with his crew when he disengaged his SCBA at 15:16 through his collapse at 15:22. If his collapse had not been seen by other nearby responders who began to render aid, there could have been a significant delay in others being aware he was experiencing a medical emergency and initiating medical care. Even when all tactics are accomplishing the objectives of an incident action plan (IAP), it is important to ensure that basic safety tenets are followed.

On scene EMS and related transport service are issues that must be addressed in all emergency response plans. In this incident an operational ALS engine company was part of the initial response increasing FF1's chances of survival. As per NFPA 1550, *Standard for Emergency Responder Health and Safety* states in Paragraphs 10.6.9 – 10.6.11 and A.10.6.9 that basic life support or advanced life support (preferred) with transportation capabilities should be available on scene when members are operating at a structure fire or performing special operations, and for medical monitoring at HAZMAT incidents, and considered based on risk management at other emergency operations [NFPA 2024].

If resources are challenged, efforts should be made to assign EMS transporting units once an incident is confirmed to be a working incident by first arriving crews so that any responding personnel who experience a medical emergency can be immediately transported to a higher level of care. NIOSH investigators identified delays in obtaining EMS transport as this resource was not assigned as part of the original working incident and it was just by happenstance that an ALS level provider was on-scene as part of the responding staff to provide care until an appropriate transport unit arrived.

In these jurisdictions, agencies place paramedics and ALS equipment on apparatus but those apparatus are not part of formal EMS response. In this incident, E1 was ALS staffed and equipped giving FF1 the best chance of survival. Many similar responses could occur in other parts of these jurisdictions and there would be no ALS staffed and equipped apparatus. Knowing where those apparatus are and their availability for response would be helpful when transporting units are unavailable. Fire departments should consider creating a notation on their dispatch records to denote whether staff assigned to apparatus have ALS provider capacity with the associated equipment.

Medical

FF1's cause of death was "unspecified cardiac arrest sustained while fighting a fire". FF1 did not have any known prior medical history. NIOSH investigators cannot make any determinations beyond what the medical examiner stated as to what caused the seizure and cardiac arrest that occurred to FF1 on August 1, 2024. However, there are some aspects to FF1's fatality that may be helpful to discuss.

27-Year-old Firefighter has Seizure then Dies of Cardiac Arrest while Responding to Residential Fire – Kansas

Syncope

The Fire Marshal noted that FF1's neighbors had witnessed him have a syncopal episode sometime around April-May 2024, but he was unable to confirm ED evaluation. Records obtained by NIOSH investigators from an ED near FF1's home showed that he was seen in that ED on May 16, 2024. FD-A's records show that FF1 had worked May 15, 2024, 07:00 to May 16, 2024, 07:00 and during that shift, he responded to 3 calls with the last call dispatching him from the station at 17:00 for an "unauthorized burning".

ED records show that FF1 stated that he started mowing his lawn around 18:00 on May 16, 2024, and had completed 3 passes with his push mower when he suddenly lost consciousness and woke up on the ground. Neighbors witnessed the collapse and reported that he had aroused by the time they reached him. FF1 stated he felt his speech was initially slurred when he came to on the ground. The neighbors contacted FF1's family and he was transported to the ED in their private vehicle. FF1 reported that he "did not drink very much, had not really had much to eat today" and felt that he "woke up after a minute". His job as a firefighter was noted on the chart along with a denial of any past medical history. He denied any recent illness, fever, chills, headache, chest pain or pressure, or abdominal pain. Vital signs on 18:58 arrival to ED were oral temperature of 98.5°F, heart rate 98 beats per minute (bpm), respiratory rate 18 breaths per minute, blood pressure 142/79 millimeters of mercury (mmHg) and oxygen saturation 96% on room air. His physical examination was unremarkable, and no trauma related to his fall from standing height was noted. Head CT was negative. Orthostatic syncope (also called postural hypotension) is tested by obtaining blood pressures when the patient is supine (lying flat on their back) and then immediately after being asked to stand. A positive test for orthostatic syncope is defined as a drop in systolic blood pressure by at least 20 mmHg and a drop in diastolic blood pressure of at least 10 mmHg within 3 minutes of standing. In FF1's case, his orthostatic blood pressures did not meet both of these conditions going from 142/79 mmHg while supine to 127/74 mmHg while standing but he reported feeling "shaky" on standing. An electrocardiogram (EKG) showed a normal sinus rhythm of 93 bpm with no ST segment depression/elevation indicative of cardiac ischemia/infarction. It is important to note that the aforementioned maneuver and blood pressure testing to check for orthostatic syncope has a sensitivity for hypovolemia/dehydration of only 70% [Probst 2022].

Blood tests ordered by the ED physician included a complete blood count which did not show evidence of anemia and a marker for cardiac injury was negative. Chemistry panels showed a normal blood glucose level, liver function, and a ratio of blood urea nitrogen (BUN) to creatinine of 6. Dehydration may be evidenced by a BUN: creatinine ratio > 20. ED notes state that FF1 felt better after 2 liters of intravenous fluids. Repeat vital signs prior to discharge: blood pressure 134/83 mmHg, heart rate 88 bpm, respiratory rate 12 breaths/min and oxygen saturation 97% on room air. Hypovolemia / dehydration is often accompanied by a heart rate > 100 bpm and/or low blood pressure which normalizes once the fluid/volume deficit is corrected but FF1 did not have those on arrival to the ED and his vital signs did not change significantly after receiving IV fluids.

Although FF1 stated he felt better after receiving IV fluids, which would be subjective evidence of dehydration/hypovolemia, his chemistry panel did not reflect this, he did not meet criteria for orthostatic syncope, and there were no significant changes in his vital signs between ED arrival and after receiving the IV fluids as would be expected after correcting a volume deficit. Therefore, his

discharge diagnosis of "vasovagal syncope or dehydration" included instructions to stay hydrated, and "pursue further outpatient evaluation with the primary care physician or the other designated or consulting physician as outlined in the discharge instructions". Vasovagal syncope (VVS) is purely a clinical diagnosis (i.e., there is no diagnostic test for it). VVS is considered a type of reflex or neurally mediated syncope and it is a separate clinical entity from orthostatic syncope. In VVS, the patient usually experiences symptoms immediately preceding the LOC such as nausea, lightheadedness, sweating, warmth, or chills, and blurred or darkening vision. Triggers for vasovagal syncope may include fear/anxiety, prolonged standing, viewing a traumatic scene, etc. [Probst 2022].

However, it was noted FF1 did not have a primary care physician and there were no specialist referrals on the discharge form. FD-A confirmed that FF1 did not have a primary care provider at the time of his death. A first syncopal episode should have further evaluation to determine the cause especially when the initial evaluation does not clearly identify the cause as in this case [Probst 2022; Shen et al. 2017].

Syncope refers to a transient loss of consciousness (LOC) caused by inadequate blood flow to the brain. The LOC associated with a syncopal episode is characterized by "rapid onset, short duration, and spontaneous complete recovery". Syncope can be a presenting symptom of many conditions ranging from life-threatening to benign. Therefore, it is important for someone experiencing a first syncopal episode to have a thorough medical evaluation. An initial evaluation of a syncopal episode often occurs in an ED that conducts an initial assessment for immediate life-threatening conditions including but not limited to acute myocardial infarction, aortic dissection, arrythmia (ventricular tachycardia/fibrillation, high degree atrioventricular blocks, etc.), hypertrophic cardiomyopathy, pulmonary embolism, intracranial bleed, etc. Other causes of syncope are related to vascular tone such as vasovagal/neurocardiogenic disorder, orthostatic hypotension (body cannot maintain perfusion to brain when going from supine to standing position), disorders of the carotid sinus which contain baroreceptors to monitor mean arterial blood pressure (MAP) and can send signals to the heart and brain to adjust vessel tone, heart rate, cardiac stroke volume, etc. to compensate for drops in the MAP. Syncope can even be caused by "bearing down" when coughing or during defecation. Once immediate life-threatening causes are ruled out, the patient can then be provided outpatient referrals to various specialists (i.e., cardiology, neurology, etc.) to determine the cause of the syncopal episode which will then guide treatment options. Other conditions may mimic syncope such as transient low blood sugar, hypoxia due to symptomatic anemia, and certain types of seizures [Furlan et al. 2024; Grossman and Badireddy 2023; Martone et al. 2024].

As per FD-A's Leave Policy dated August 2019, "An employee who is unable to report for duty due to illness or injury shall notify their regularly assigned supervisor or a supervisor where the employee is assigned for the affected duty shift…..It is the employee's responsibility to keep their supervisor informed of progress of the illness or injury on a monthly basis and an estimated return to duty date. When 48 or more consecutive hours of sick leave are used, the employee must provide a Commissioned Fire Personnel Return to Work Form, prior to or upon returning to work. This form must be signed by a health care provider and include information indicating the employee is able to perform assigned duties". In a later section of that same document under the "Return to Work" section, it states that "a doctor's release is required when returning to duty". FD-A records show FF1 returned to work for his next scheduled shift on May 18, 2024, 0700 to May 19, 2024, 0700. Since his syncopal episode and subsequent ED evaluation occurred during non-duty hours and he was able to resume

work as scheduled, he was not required by FD-A policy to inform his supervisor or undergo a Return To Work evaluation.

FD-A does not require annual medical evaluations of its members as per recommendations in NFPA Standard 1582. In this case, lack of an annual NFPA medical examination may represent a missed opportunity for FF1 to report the syncopal episode to a physician who could have coordinated specialist evaluations to determine if he had an underlying medical condition that could have impacted his ability to perform his job especially since FF1 did not have his own primary care physician to fulfill this role. Recurrent syncope is listed as a cardiovascular condition that could impact the safe performance of essential firefighter job tasks in Section 9.7 of this standard. In Section 7.5 of the standard, it states that the annual medical examination should include a medical history questionnaire to "provide baseline information with which to compare future medical concerns" and this questionnaire should include "changes in health status and known occupational exposures since the previous annual evaluation" so this may have been a way for the syncopal event to have been captured in his FD medical record and sent for further evaluation [NFPA 2022].

Sudden Cardiac Death

Sudden cardiac death (SCD) has been a recognized entity in the U.S. Fire Service for over a decade. Although cardiovascular disease (CVD) events of all types, including heart attack, are the leading cause of non-traumatic death in firefighters, SCD is thought to be mainly due to arrhythmias which usually occur in the setting of pre-existing cardiac conditions involving structural abnormalities such as an enlarged heart (cardiomegaly), atherosclerotic cardiovascular disease (ASCVD), thickening of the heart muscle (hypertrophy), etc. [Smith et al. 2013]. Many schools have instituted pre-participation screening of potential athletes for undiagnosed hypertrophic cardiomyopathies (HCMs), thickening of the portion of the heart muscle that separates the ventricles that can bulge out resulting in blood flow obstruction during physical activity and/or place an individual at higher risk for potentially fatal arrythmias leading to SCD. HCMs are the most common cause of SCD among pediatric/ young adult athletes accounting for about 36% of cases [Horeczko 2022]. Endurance and strength training in athletes can induce remodeling of the heart's structure and conduction system making an evaluation by a cardiologist a prudent action prior to approving participation in sports. The American Heart Association (AHA) has developed a standardized screening tool for this purpose [Lammlein et al. 2018]. HCM was noted as the most common cause of death in US athletes overall under 35 years of age while atherosclerotic coronary artery disease is the most common cause of SCD in athletes over 35 years of age [Maron et al. 2007]. FF1's coronary arteries were clear and there were no structural abnormalities found in the heart. The weight of the heart at 400 grams was within the normal range for adult males [Sens and Hughes 2021].

While HCM, heart valve defects, etc. are associated with anatomical abnormalities, arrythmias may result in SCD without leaving macroscopic or histological evidence to be found at autopsy. Some arrythmias are intermittent and would only be found during prolonged Holter monitoring if not captured on a snapshot EKG [Bragg et al. 2024]. There are a class of cardiac arrythmias involving defects in the protein that forms calcium channels because of genetic mutations. Calcium, sodium, and potassium ion channels in the myocardial cell membranes are the base components of the cardiac conduction system. Molecular pumps use these channels to create the voltage gradients that form the electrical signals sent to the various structures of the heart resulting in coordinated contraction for

efficient pumping. Calcium channel defects include Brugada Syndrome as well as Long and Short QT Syndromes and of these, Long QT Syndrome (LTQS) is the most common. Studies have identified ten different genetic mutations causing the defect in the protein that forms the calcium ion channel in LQTS [Grant 2009; Jouriles 2022]. FF1 had an exercise stress test via treadmill done as part of his preplacement medical evaluation in 2019 and an EKG done during his ED visit for syncope in 2024 and neither noted abnormalities consistent with these or other types of cardiac conduction disorders.

One of the challenges in deaths due to SCD, is that there is often no evidence of the cause to be found during autopsy as in this case. This was reflected in a large study using autopsy data from the U.S. Department of Defense's Cardiovascular Death Registry which analyzed 902 nontraumatic sudden deaths of individuals over 18 years of age. Although 79% of these deaths were determined to be due to cardiac causes, no cause could be identified in 21% of these cases [Eckart et al. 2011]. There have been reports of possible increased risk of SCD following COVID-19 infection; particularly in those who develop long COVID-19 [Karimi et al. 2024; Stimart and Hipkins 2024]. However, since FF1 did not have any documented testing confirming COVID-19 infection following his suspected exposure in November 2019, no further association can be made.

Concerns were also raised if COVID-19 vaccination could have played a role in this fatality. There was no documentation provided that FF1 received a COVID-19 vaccination. However, there is no evidence that COVID-19 vaccinations have resulted in sudden cardiac death [Liko and Cieslak 2024]. Review of data provided through the Vaccine Adverse Event Reporting System (VAERS) did show an association between COVID-19 vaccination and occurrence of myocarditis, an inflammation of the heart muscle, and/or pericarditis, an inflammation of the fluid filled sac around the heart, in children and young adults. These conditions are usually accompanied by severe symptoms of chest pain, heart palpitations, and/or shortness of breath and elevations of blood markers for inflammation (increased white blood cell count, erythrocyte sedimentation rate, etc.) and myocardial damage (troponin I, etc.) [CDC 2023]. A large, retrospective study of data from 4 health plans covering over 100 million U.S. adults found that myocarditis and/or pericarditis following mRNA COVID-19 vaccination was rare with only 411 documented cases among 15 million people receiving approximately 27 million doses of vaccine [Wong et al. 2022]. There were no reports of FF1 having symptoms consistent with myocarditis or pericarditis. His EKG and the blood test during his May 16, 2024, ER visit did not show any evidence of myocardial damage.

Heat Stroke/Rhabdomyolysis

Historical weather data showed that on the date and approximate time of his syncopal episode, the outdoor temperature was 75°F with 60% humidity resulting in a heat index of 75°F. On August 1, 2024, at 1500, the approximate time of arrival at the residential fire, the outdoor temperature was 96°F with 44% humidity resulting in a heat index of 103.4°F. It was noted that the cab of the apparatus FF1 was driving during his August 1, 2024, shift was not air conditioned and that crewmembers had reported FF1 stating that he felt hot inside the cab. Exertional heat stroke can occur even in seemingly "cool" environments such as a 25-year-old firefighter who died of this after 30 minutes of engaging in an indoor maze course whose thermostat was set to 66°F while in full turnout gear and SCBA [NIOSH 2018]. It is vital for fire departments not to underestimate the contribution of exertional heat to the net heat load especially while engaged in firefighter essential tasks in a hot environment as in this case.

27-Year-old Firefighter has Seizure then Dies of Cardiac Arrest while Responding to Residential Fire – Kansas

Rhabdomyolysis is the constellation of signs and symptoms that result when muscle tissue is damaged. This damage can be caused by a variety of insults such as direct mechanical disruption, overheating the muscle, overexertion, direct toxicity from medications, decreased blood flow to muscles due to medical conditions such as sickle cell disease or use of vasoconstrictive substances such as caffeine, etc. [CDC 2024; Cervellin et al. 2017].

Both heat stroke and rhabdomyolysis may result in seizures and death but since there is no documentation of any temperature taken in the ED and no creatine kinase (CK) levels, the blood marker for rhabdomyolysis, it is not possible to determine if either condition played a part in this death. NIOSH has created information sheets for structural firefighters regarding their risk for rhabdomyolysis: What Structural Fire Fighters Need to Know about Rhabdomyolysis along with a wallet card that structural firefighters can show to healthcare providers when they present for treatment of possible signs and symptoms of rhabdomyolysis. There is a companion document for healthcare providers of structural firefighters reminding them of their increased risk for rhabdomyolysis as a result of their job titled, "Rhabdomyolysis in Structural Fire Fighters: A Patient Population at Risk". General guidance regarding heat stress evaluation and mitigation along with information on identification of heat-related illness (HRI) including heat-related rhabdomyolysis, is provided in the most recent edition of the NIOSH heat stress criteria document [NIOSH 2016].

Structural firefighters may be exposed to multiple different sources of heat contributing to their overall heat load. Aside from ambient environmental conditions that can be exacerbated due to relative humidity reflected by the local heat index, other heat sources may include heat generated by the fire they are fighting, and metabolic heat generated by their muscles due to the exertion involved in performing their essential job tasks. The turnout gear worn as part of their PPE, can worsen firefighter heat exposure due to increased exertion induced by the extra weight that the firefighter must carry resulting in the generation of more metabolic heat. In addition, the heavy materials used in turnout gear can trap heat by blocking the body's usual methods of dissipating heat through evaporative heat loss from sweating and direct heat transfer from the body to the environment from dilated blood vessels underneath the skin. NIOSH has conducted Health Hazard Evaluations regarding heat exposure and rhabdomyolysis in structural firefighters during training [NIOSH 2015, 2019].

It was also noted that the bay in FD-A in which the exercise equipment is located was not air conditioned. Fitness centers should be located in areas where HVAC systems can offset the heat and/or humidity (from sweat and exhalation) generated by those utilizing the workout area in order to reduce the possible adverse health effects of heat exposure during physical fitness training. Studies have also shown that the indoor air conditions of fitness centers have impacts on the effectiveness of both aerobic and anaerobic training [Huang et al. 2021]. The American College of Sports Medicine recommends an air temperature 65°F–68°F (18.3°C–20°C) and a relative humidity of 40%–60% for areas in which aerobic exercise, strength training, or Pilates workouts are occurring [ACSM 2012].

Caffeine Toxicity

Caffeine is a stimulant that impacts the cardiovascular system by increasing heart rate directly and increasing blood pressure through its vasoconstrictive properties, both of which place additional strain on the heart which can increase risk for an acute cardiac event especially in the setting of increased physical exertion. Vasoconstriction also results in decreased blood flow to the supplied tissues thereby

increasing the risk for rhabdomyolysis. The products noted by the Fire Marshal on the receipt found in FF1's personal effects included Mio water enhancer, Celsius® Energy Drink, and Liquid I.V.

The Mio product line is made by Kraft Heinz food company and comes in 3 different types: Original, Hydrate, and Energy. The original and hydrate lines are caffeine free while Mio Energy contains 90 mg caffeine per serving and each 1.62 fluid ounce (fl oz) bottle of Mio Energy contains 12 servings for a total caffeine content of 1.08 grams per bottle. Celsius® Energy Drink is produced by a company of the same name, and it comes in 3 different lines: Celsius® original (12 oz cans), Celsius® Essentials (16 oz cans), and Celsius® On-the-Go (0.17–0.20 oz powder packets). These products contain between 200–300 milligrams (mg) caffeine per can/packet. The Liquid IV line has 5 products: Hydration Multiplier®, Hydration Multiplier® sugar-free, Immune Support, Gut Health, and Energy Multiplier. Both versions of the Hydration Multiplier® along with the Immune Support, and Gut Health products do not contain any caffeine. The Energy Multiplier contains 100 mg caffeine per serving. The Fire Marshal's notes did not specify which specific product of each of these product lines were purchased.

Caffeine is a widely used stimulant and it is estimated that 85% of the US population drinks at least one caffeinated beverage per day. Moderate caffeine intake of less than 400 mg/day is considered safe. Caffeine content of common items is 30–60 mg per 12 oz. of soda, 50 mg in 8 oz of black tea, and 80 mg per 8 oz coffee. Caffeine is quickly absorbed through the gastrointestinal tract and crosses the blood-brain barrier to directly affect the central nervous system to cause increased alertness and decreased fatigue. It impacts the autonomic nervous system by increasing heart rate, respiratory rate, and blood pressure. Blood pressure is increased via constriction of the smooth muscle in the walls of blood vessels. Excessive intake can lead to caffeine toxicity resulting in heart attack, cardiac arrest, tachycardia, hypertension, and rhabdomyolysis along with seizures, hallucination, anxiety, nausea/vomiting and abdominal pain. Case reports of deaths due to caffeine toxicity have reported postmortem blood caffeine levels 160–400 µg/ml [Banerjee et al. 2014; Brower and Swatek 2024]. NMS labs who conducted the postmortem caffeine test on FF1 reported that levels > 50 µg/ml are considered toxic.

Therefore, FF1's postmortem caffeine level of 4.6 µg/ml would not be considered high enough to have played a significant role in his death. However, first responders should monitor their caffeine intake due to its potential to exacerbate cardiac demands in a job that is already strenuous. In addition, due to its vasoconstrictive properties, caffeine is a known risk factor for rhabdomyolysis and increases the risk for HRI by opposing the body's dilation of the small blood vessels under the skin for heat dissipation. It is good practice for firefighters to reduce exposures to known risk factors for rhabdomyolysis and HRI due to the risks for the conditions inherent in their job.

Cyanide Toxicity

Cyanide is a known product of combustion for many items found in a residential location. Inhalation of cyanide byproducts in fire and smoke inhalation victims can be a cause of cardiac arrest. Therefore, the actions of the EMS crew in administering the cyanide antidote, hydroxocobalamin, were reasonable. Cyanokit®, the brand name that hydroxocobalamin is marketed under and how it is referred to in the FD-B protocol, was approved by the U.S. Food and Drug Administration in 2006. The manufacturer states that its use is indicated for "known or suspected cyanide poisoning. If clinical suspicion of cyanide poisoning is high, Cyanokit® should be administered without delay" [Serb Pharmaceuticals

2024]. One of the challenges of cyanide toxicity is that blood tests for cyanide often take hours to result. Since cyanide acts by disrupting cellular processes, hypoxia and metabolic acidosis quickly evolve and the latter can be detected by rapid tests for lactate and an anion gap [Huzar et al. 2013]. However, disruption of cellular functions that occur during a cardiac arrest can themselves result in elevated lactate levels and metabolic acidosis, so these conditions are not specific to cyanide toxicity.

Although FF1's postmortem blood sample was not tested for cyanide, it was tested for carbon monoxide, another combustion byproduct that would lend evidence to smoke inhalation, and that was not detected. One study measured combustion byproduct gases in fire smoke including carbon monoxide, hydrogen cyanide, hydrogen sulfide, ammonia, nitrogen dioxide, and sulfur dioxide over a period of 16 months within the Chicago Fire Department found that of all the 6 gases measured, carbon monoxide had the highest maximum exposure and the highest total concentration [Fabian et al. 2014]. Carbon monoxide and cyanide levels in the blood of smoke inhalation victims have also been shown to correlate [Baud et al. 1991].

FF1 was wearing his SCBA when he entered the residence and had disengaged it when he exited the structure. Since he was not breathing supplied air at the time of his collapse, cardiac arrest from cyanide exposure from smoke inhalation was possible. However, it would be unlikely to have a fatality due to smoke inhalation injury without evidence of any exposure to carbon monoxide. Regardless, due to the fast progression of cyanide toxicity and its lethality, presumptively treating a cardiac arrest at a fire scene with the cyanide antidote is appropriate and in line with current FD-B protocol but due to the lack of evidence of CO exposure, it is unlikely that cyanide toxicity played a role in this fatality.

Contributing Factors

Occupational injuries and fatalities are often the result of one or more contributing factors or key events in a larger sequence of events that ultimately result in the injury or fatality. Since the cause of death could not be definitively determined in this case, there is no evidence that the following recommendations would have prevented this fatality, but they are being provided here as a reminder of good practice.

Recommendations

Recommendation #1: Fire departments should consider implementing annual medical examinations as per NFPA 1582 recommendations.

Discussion: In this case and many others, firefighters may not have their own primary care physician and the provider of the annual NFPA medical evaluation may be the only physician they see regularly. Section 9.1.2 of this standard states that "The occupational medical evaluation shall include a medical history, examination, and any medical tests required to assess medical conditions that can affect an individual's ability to safely and effectively perform the essential job tasks." In this case, if an annual medical examination had been conducted between May 16, 2024, and August 1, 2024, it is unknown if FF1 would have disclosed his syncopal event and if so, if a further evaluation of it coordinated by the physician conducting the exam would have prevented his death but it does represent a potential missed opportunity.

27-Year-old Firefighter has Seizure then Dies of Cardiac Arrest while Responding to Residential Fire – Kansas

Recommendation #2: Fire departments should encourage members to reduce and if possible, eliminate intake of/exposure to known risk factors for adverse cardiovascular events and rhabdomyolysis.

Discussion: Firefighters have multiple risk factors for adverse cardiac events and rhabdomyolysis due to various inherent aspects of the essential job tasks including intense, physical exertion while in a hot environment. It would be prudent to avoid or at least reduce intake/exposure to additional known risk factors for both cardiac events and rhabdomyolysis such as caffeine use, poor nutrition leading to formation of cholesterol plaques inside blood vessels decreasing blood flow, etc. Fire departments should also encourage seasonal influenza and COVID-19 vaccinations as both these infections have been associated with increased risk for rhabdomyolysis [Singh and Scheld 1996; Singh et al. 2020]. Ensuring that fitness centers inside fire stations and apparatus cabs are air conditioned, will help reduce risk of HRI, heat-related rhabdomyolysis, and adverse cardiac events while encouraging improved physical fitness.

Recommendation #3: Fire departments should increase awareness of conditions that increase risk of heat-related illness (HRI) and implement heat stress management policies to reduce those risks.

Discussion: Heat stress is the net exposure experienced which can be from multiple sources such as ambient environmental conditions, active heat source such as a fire, and heat generated by muscles through physical exertion. Heat exposure in structural firefighters can be exacerbated by wearing turnout gear that can trap heat due to disruption of the body's usual routes of heat dispersion of evaporative heat loss from sweating or direct conductive heat transfer to the environment. Heat strain is the body's response to heat stress and consists of a spectrum of clinical conditions from heat cramps to the most severe and potentially life-threatening heat stroke. Although many heat sources are unavoidable for structural firefighters, efforts should be made to mitigate those that can be reduced. In this case, on the day FF1 died, the outdoor temperature was 96°F with 44% humidity resulting in a heat index of 103.4°F. The cab of the apparatus FF1 was driving that shift was not air conditioned and crewmembers had reported FF1 stating that he felt hot inside the cab. Fire departments should consider purchasing apparatus with air-conditioned cabs to reduce the heat stress firefighters inside that cab experience due to environmental conditions but also to act as a cooling location if a firefighter should develop heat-related illness on scene before an EMS unit is present. Similarly, fitness centers located in fire stations should also be air conditioned to reduce the risk of HRI in those using those facilities. Lastly, this fatality occurred shortly after the incident response began, otherwise with an event of extended duration, a rehab location would be protocol to provide cooling and rehydration along with a crew rotation as a heat stress mitigation approach.

Recommendation #4: Ensure EMS with transport capability is on-scene at any fire or special operation location in the event emergency medical care and transport is needed.

Discussion: Based on resource availability in this jurisdiction, EMS transporting units were not automatically sent to structure fires on the initial dispatch nor at the report of a working incident by initial on-scene firefighting personnel. Normal operations in this jurisdiction give EMS transport unit requesting authority to the IC. In this incident, the IC requested a transporting unit upon witnessing FF1 collapse. Given normal jurisdictional procedures, this operation appropriately requested an EMS transport unit.

27-Year-old Firefighter has Seizure then Dies of Cardiac Arrest while Responding to Residential Fire – Kansas

Strain on EMS system resources can affect many aspects of emergency response, and that challenge has no doubt impacted agencies across the United States. It is imperative to find ways to get needed resources to an emergency incident. In this case, ALS capability was part of the first due engine company and the efforts of the firefighter paramedic, along with on-scene firefighter EMT-Basics, afforded FF1 the best opportunity for survival. In this incident, the response delay of the transporting unit did not delay advanced care. However, at fire scenes where a FFP is not on a responding apparatus, there would be a delay in initiation of ALS care and transport if an ALS EMS unit is not dispatched as soon as a working fire is identified. The NFPA 1550, *Standard for Emergency Responder Health and Safety* states in Paragraphs 10.6.9 – 10.6.11 and A.10.6.9 that basic life support or advanced life support (preferred) with transportation capabilities should be available on scene when members are operating at a structure fire or performing special operations, and for medical monitoring at HAZMAT incidents, and considered based on risk management at other emergency operations. [NFPA 2024].

Recommendation #5: Fire officers should ensure crew integrity when entering, operating in, and exiting from an environment immediately dangerous to life or health (IDLH).

Discussion: In this incident, the crew was assigned to pull a 2nd 1-3/4-inch hoseline for interior attack. Crew members reported that they went in together. Once inside, it was reported that the crew was split into two teams, with FF1 and the nozzleman in the living room to hit spot fires. Helmet cam video from FF1 provides a few minutes of conditions and actions beginning outside readying to enter the residence and continues inside the residence until the helmet cam is turned off. The video shows: The fire officer entered and was followed by the nozzleman and back up. However, before FF1 enters, several firefighters from other companies were in line at the side A door working their way in. These firefighters pushed the hoseline while FF1 pulled at hot spots along the roofline. FF1 then entered and made his way into the residence before meeting up with his crew. The crew worked on dousing a debris fire from roofing materials collapsed into the residence. In the video, the crew goes out of view as FF1 remains in the same area of the residence with other firefighters passing by. The crew appears again in the video before the video is turned off. The video does not continue to when FF1 tells one of the crew that he's leaving the structure. FF1 reportedly exits on his own. The fire officer was unaware . that FF1 was exiting the structure until after IC reassigned the crew to the side A porch for a small fire under the porch.

NFPA 1550, *Standard for Emergency Responder Health and Safety* states in Paragraph 10.5.6 that company officers shall maintain an ongoing awareness of the location and condition of all company members. Paragraph 10.5.7 states that, where assigned as a company, members shall be responsible to remain under the supervision of their assigned company officer [NFPA 2024].

The International Association of Fire Chiefs' Safety, Health, and Survival Section has redefined the Rules of Engagement for Structural Fire Fighting. One of the objectives is to ensure that firefighters always enter a burning building as a team of two or more members and no firefighter is allowed to be alone at any time while entering, operating in, or exiting a building. A critical element for firefighter survival is crew integrity. Crew integrity means firefighters stay together as a team of two or more. They must enter a structure together and remain together at all times while in the interior, and all members come out together.

27-Year-old Firefighter has Seizure then Dies of Cardiac Arrest while Responding to Residential Fire – Kansas

Crew integrity starts with the company officer ensuring that all members of the company understand their riding assignment, have the proper personal protective equipment, and have the proper tools and equipment. Upon arrival at the incident, the company is given a task to perform by the incident commander. The company officer communicates to the members of the company what their assignment is and how they will accomplish their assignment. Just as the members of a company enter a hazardous environment together, they should leave together to ensure that crew integrity is maintained. If one member has to leave, the whole company leaves together [IAFC 2012]. It is the responsibility of every firefighter and company officer to stay in communication or contact with crew members at all times by visual observation, voice, or touch while operating in the hazard zone.

All firefighters should maintain the unity of command by operating under the direction of the incident commander, division/group supervisor, or their company officer at all times. The ultimate responsibility for crew integrity and ensuring no members get separated or lost rests with the company officer. If crew integrity is lost, firefighters are placed at increased risk. A Mayday should be called if any member cannot be accounted for as described above. Company officers should give an accountability report upon exiting the hazard zone to either Command or their assigned division or group supervisor.

Recommendation #6: Fire departments should provide physicians tasked with pre-employment and return to work medical evaluations, descriptions of the essential tasks and duties and not rely on the cadet/incumbent to relay this information.

Discussion: NFPA 1582 Section 4.1.5 states "The fire department shall provide the fire department physician with a fire service overview, current job descriptions, and the essential job tasks required for all fire department positions and ranks [NFPA 2022]." On FF1's preplacement Respirator Physical – Physician's Recommendations form, there are 2 options under the "Job Description" section, and they are:

- Yes, a specific respirator job description was provided by the Company. This recommendation is based upon this description and history/physical information gained today.
- No, a respirator job description was not provided by the Company and this recommendation is based solely upon history/physical information gained today.

The nurse who signed off on that form on February 19, 2019, selected the "No" option. Fire Departments should consider including in their pre-employment medical evaluation form packets a document containing a description of their essential tasks to ensure all providers involved in these evaluations have access to that information and can affirm their awareness of these tasks upon signing off on their respective components of the candidate's medical condition.

Recommendation #7: Fire departments should ensure that a physician signs off on pre-employment and return to work evaluations.

Discussion: NFPA 1582 states medical evaluations should be conducted by a Fire Department Physician as per Section 7.2.1 "The fire department, the fire department physician, and member organizations where they exist shall be responsible to convey the purposes and importance of the annual occupational medical evaluation to members and to the AHJ". Section 3.3.6 defines a Fire Department Physician as "A licensed doctor of medicine or osteopathy who has been designated by the

fire department to provide professional expertise in the areas of occupational safety and health as they relate to emergency services". Section 4.2.2. states "When medical evaluations are conducted by a physician or medical provider other than the fire department physician, the evaluation shall be reviewed and approved by the fire department physician." In FF1's case, his pre-employment clearance was signed off by an advanced practice registered nurse without clear evidence of physician oversight or documentation of review by the fire department physician.

References

American College of Sports Medicine [2012]. ACSM's Health/Fitness Facility Standards and Guidelines. Fifth Edition. Champaign, Illinois: Human Kinetics.

Banerjee P, Ali Z, Levine B, Fowler DR [2014]. Fatal caffeine intoxication: a series of eight cases from 1999 to 2009. J Forensic Sci *59*(3):865–868.

Baud FJ, Barriot P, Toffis V, Riou B, Vicaut E, Lecarpentier Y, Bourdon R, Astier A, Bismuth C [1991]. Elevated blood cyanide concentrations in victims of smoke inhalation. N Engl J Med *325*(25):1761–1766.

Bragg S, Brown B, DeCastro AO [2024]. Arrhythmias and Sudden Cardiac Death. Prim Care *51*(1):143–154.

Brower JO, Swatek JL [2024]. Beyond the buzz: the fatal consequences of caffeine overconsumption. J Anal Toxicol *48*(8):535–540.

Centers for Disease Control and Prevention [2023]. Clinical considerations: myocarditis after COVID-19 vaccines | CDC. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention.

Centers for Disease Control and Prevention [2024]. Rhabdomyolysis. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention.

Cervellin G, Comelli I, Benatti M, Sanchis-Gomar F, Bassi A, Lippi G [2017]. Non-traumatic rhabdomyolysis: background, laboratory features, and acute clinical management. Clin Biochem *50*(12):656–662.

Eckart RE, Shry EA, Burke AP, McNear JA, Appel DA, Castillo-Rojas LM, Avedissian L, Pearse LA, Potter RN, Tremaine L, Gentlesk PJ, Huffer L, Reich SS, Stevenson WG [2011]. Department of Defense Cardiovascular Death Registry Group. Sudden death in young adults: an autopsy-based series of a population undergoing active surveillance. J Am Coll Cardiol *58*(12):1254–1261.

Fabian TZ, Borgerson JL, Gandhi PD, Baxter CS, Ross CS, Lockey JE, Dalton JM [2014]. Characterization of firefighter smoke exposure. Fire Technol *50*:993–1019.

Furlan L, Jacobitti Esposito G, Gianni F, Solbiati M, Mancusi C, Costantino G [2024]. Syncope in the emergency department: a practical approach. J Clin Med *13*(11):3231

Grant AO [2009]. Cardiac ion channels. Circ Arrhythm Electrophysiol *2*(1):185–194.

Grossman SA, Badireddy M [2024]. Syncope. In: StatPearls [Internet]. Treasure Island, FL: StatPearls Publishing. Available from: https://www.ncbi.nlm.nih.gov/books/NBK442006/.

27-Year-old Firefighter has Seizure then Dies of Cardiac Arrest while Responding to Residential Fire – Kansas

Horeczko T [2022]. Chapter 165: Pediatric Cardiac Disorders. In Rosen's Emergency Medicine 10th Edition. Walls R, Hockberger R, Gausche-Hill M, Erickson TB, and Wilcox SR Editors. Published by Elsevier.

Huang C, Que J, Liu Q, Zhang Y [2021]. On the gym air temperature supporting exercise and comfort. Build Environ *206*:108313.

Huzar TF, George T, Cross JM [2013]. Carbon monoxide and cyanide toxicity: etiology, pathophysiology and treatment in inhalation injury. Expert Rev Respir Med *7*(2):159–170.

IAFC [2012]. Rules of engagement for structural firefighting: increasing firefighter survival. Draft 10 developed by the Safety, Health and Survival Section International Association of Fire Chiefs.

Jouriles NJ [2022]. Chapter 68: Pericardial and myocardial disease. In Rosen's Emergency Medicine 10th Edition. Walls R, Hockberger R, Gausche-Hill M, Erickson TB, and Wilcox SR Editors. Published by Elsevier. Pgs. 1112–1126.

Karimi M, Faal Hamedanchi N, Ansari K, Nahavandi R, Mazdak M, Javaherchian F, Koochaki P, Asadi Anar M, Shirforoush Sattari M, Mohamaditabar M [2024]. Rhabdomyolysis secondary to COVID-19 infection and vaccination: a review of literature. Front Med (Lausanne).

Lammlein KP, Stoddard JM, O'Connor FG [2018]. Preparticipation screening of young athletes: identifying cardiovascular disease. Prim Care *45*(1):95–107.

Liko J, Cieslak PR [2024]. Assessment of risk for sudden cardiac death among adolescents and young adults after receipt of COVID-19 vaccine - Oregon, June 2021-December 2022. MMWR *73*(14):317–320.

Maron BJ, Thompson PD, Ackerman MJ, Balady G, Berger S, Cohen D, Dimeff R, Douglas PS, Glover DW, Hutter AM Jr, Krauss MD, Maron MS, Mitten MJ, Roberts WO, Puffer JC [2007]. American Heart Association Council on Nutrition, Physical Activity, and Metabolism. Recommendations and considerations related to preparticipation screening for cardiovascular abnormalities in competitive athletes: 2007 update: a scientific statement from the American Heart Association Council on Nutrition, Physical Activity, and Metabolism: endorsed by the American College of Cardiology Foundation. Circulation *115*(12):1643–1655.

Martone AM, Parrini I, Ciciarello F, Galluzzo V, Cacciatore S, Massaro C, Giordano R, Giani T, Landi G, Gulizia MM, Colivicchi F, Gabrielli D, Oliva F, Zuccalà G [2024]. Recent advances and future directions in syncope management: a comprehensive narrative review. J Clin Med *13*(3):727.

NFPA [2022]. NFPA 1582. Standard on Comprehensive Occupational Medical Program for Fire Departments. Quincy, MA: National Fire Protection Association.

NFPA [2024]. NFPA 1550. Standard for Emergency Responder Health and Safety. Quincy, MA: National Fire Protection Association.

NIOSH [2015]. Evaluation of heat stress, heat strain, and rhabdomyolysis during structural firefighter training. By Eisenberg J, Methner M, Dowell CH, Mueller C. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, Health Hazard Evaluation Report 2012-0039-3242.

27-Year-old Firefighter has Seizure then Dies of Cardiac Arrest while Responding to Residential Fire – Kansas

NIOSH [2016]. NIOSH criteria for a recommended standard: occupational exposure to heat and hot environments. By Jacklitsch B, Williams WJ, Musolin K, Coca A, Kim J-H, Turner N. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2016-106.

NIOSH [2018]. Cadet dies from hyperthermia and exertional heat stroke during indoor SCBA maze training—Texas. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, F2016-05.

NIOSH [2019]. Evaluation of rhabdomyolysis and heat stroke in structural firefighter cadets. By Eisenberg J, Li JF, Feldmann KD. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, Health Hazard Evaluation Report 2012-0039-3242.

NMS Labs [2022]. Caffeine, Blood-0930B. Horsham, PA: NMS Labs.

Probst M [2022]. Chapter 11: Syncope. In Rosen's Emergency Medicine 10th ed. Walls R, Hockberger R, Gausche-Hill M, Erickson TB, Wilcox SR eds. Published by Elsevier.

Serb Pharaceuticals [2024]. CYANOKIT® (hydroxocobalamin) | Cyanide Poisoning Treatment.

Sens MA, Hughes R [2021]. Diagnostic pathology: forensic autopsy, 1st ed. Internal Examination Cardiovascular System. Philadelphia, PA: Elsevier.

Shen WK, Sheldon RS, Benditt DG, Cohen MI, Forman DE, Goldberger ZD, Grubb BP, Hamdan MH, Krahn AD, Link MS, Olshansky B, Raj SR, Sandhu RK, Sorajja D, Sun BC, Yancy CW [2017]. 2017 ACC/AHA/HRS Guideline for the Evaluation and Management of Patients With Syncope: Executive Summary: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines and the Heart Rhythm Society. Circulation *136*(5):e25–e59.

Singh B, Kaur P, Reid RR [2020]. Case reports: rhabdomyolysis associated with COVID-19. Am Fam Physician *102*(11):645–648.

Singh U, Shceld WM [1996]. Infectious etiologies of rhabdomyolysis: three case reports and review. Clin Infect Dis *22*(4):642–649.

Smith DL, Barr DA, Kales SN [2013]. Extreme sacrifice: sudden cardiac death in the US Fire Service. Extrem Physiol Med *2*(1):6.

Stimart HL, Hipkins B [2024]. The negative effects of long COVID-19 on cardiovascular health and implications for the presurgical examination. J Osteopath Med. Online ahead of print.

Wong HL, Hu M, Zhou CK, Lloyd PC, Amend KL, Beachler DC, Secora A, McMahill-Walraven CN, Lu Y, Wu Y, Ogilvie RP, Reich C, Djibo DA, Wan Z, Seeger JD, Akhtar S, Jiao Y, Chillarige Y, Do R, Hornberger J, Obidi J, Forshee R, Shoaibi A, Anderson SA [2022]. Risk of myocarditis and pericarditis after the COVID-19 mRNA vaccination in the USA: a cohort study in claims databases. Lancet *399*(10342):2191–2199.

27-Year-old Firefighter has Seizure then Dies of Cardiac Arrest while Responding to Residential Fire – Kansas

Investigator Information

This incident was investigated jointly by the NIOSH Fire Fighter Fatality Investigation and Prevention Program (FFFIPP) Medical Team based in the Division of Field Studies and Engineering in Cincinnati, Ohio and the FFFIPP Trauma Team based in the Division of Safety Research in Morgantown, West Virginia. This investigation was conducted and this report was co-authored by Judith Eisenberg MD, MS, and Mr. Rob Saunders of the FFFIPP Medical Team and Tammy Schaeffer of the FFFIPP Trauma Team. Dr. Eisenberg is a board certified Emergency Medicine physician and Rob Saunders is a former NIOSH Technical Information Specialist. Mr. Saunders retired after 31 years with the Pike Township Fire Department, Indianapolis, Indiana. In addition to having served as a firefighter, paramedic, heavy rescue technician, and rescue diver, he has held the positions of company officer, Division Chief of Emergency Medical Services, Deputy Chief of Operations, and Fire Chief. Tammy Schaeffer is a Safety & Occupational Health Specialist. In addition, Mrs. Schaeffer served as a Pennsylvania Paramedic for 20 years and as a U.S. Army Combat Medic for 8 years, with deployment for Operation Iraqi Freedom in 2004

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