

Supplemental Tables and Materials - Contents

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Table S1a. Max level of personal protective equipment (PPE) worn by all responders.

	Firefighter (n=61)	EMS (n=20)	Law Enforcement (n=11)	Other (n=13)	Overall (n=105)
PPE Ensemble Worn					
Level C *	1 (1.6%)	0 (0%)	0 (0%)	0 (0%)	1 (1%)
Level D †	0 (0%)	1 (5.0%)	1 (9%)	3 (23.1%)	5 (5%)
Firefighter turn-out gear [¶] <u>with</u> respiratory protection.	8 (13.1%)	0 (0%)	0 (0%)	0 (0%)	8 (8%)
Firefighter turn-out gear [¶] <u>without</u> respiratory protection.	36 (59.0%)	1 (5.0%)	0 (0%)	0 (0%)	37 (35%)
Partial PPE ensemble [§]	3 (4.9%)	2 (10.0%)	0 (0%)	2 (15.4%)	7 (7%)
None	12 (19.7%)	16 (80.0%)	10 (91%)	8 (61.5%)	46 (44%)
Missing	1 (1.6%)	0 (0%)	0 (0%)	0 (0%)	1 (1%)

* Level C ensemble includes full-face air purifying respirators, chemical-resistant gloves, proper footwear including Safety steel-toe boots with shanks on the outside, and two-way radio as well as a hard hat.

† Level D ensemble includes coveralls, proper footwear including Safety steel-toe boots with shanks on the outside, goggles/glasses, and gloves. Level D suits don't require much protection and can be found as firefighter turnout gear, for example.

¶ Firefighter turn-out gear (also known as "bunker gear") is standard personal protective equipment used by firefighters. This ensemble includes fire-resistant pants, boots, coat, and gloves. Similar to Level D ensembles.

§ Responder wore some PPE, but not all elements required to meet one of the classified ensemble levels; for example, a responder that reported wearing just boots would be considered wearing a partial ensemble.

Table S1b. Reason stated for not wearing personal protective equipment (PPE) (n=46).

	Firefighter (n=12)	EMS (n=16)	Law Enforcement (n=10)	Other (n=8)	Overall (n=46)
Reason for not wearing PPE					
PPE was not available at the time	3 (24%)	4 (25%)	7 (70%)	1 (13%)	15 (33%)
Felt did not need PPE/ was not instructed to wear	7 (58%)	5 (31%)	2 (20%)	6 (75%)	20 (43%)
Unknown/Unclear/Unsure	2 (17%)	7 (44%)	1 (10%)	1 (13%)	11 (24%)

Table S2a. Proportion of responders experiencing any new or worsening symptom stratified by symptom category and responder type.

	Firefighter (n=61)	EMS (n=20)	Law Enforcement (n=11)	Other (n=13)	Overall (n=105)
Headache					
No	51 (83.6%)	17 (85.0%)	9 (81.8%)	9 (69.2%)	86 (81.9%)
Yes	10 (16.4%)	3 (15.0%)	2 (18.2%)	4 (30.8%)	19 (18.1%)
Eye Irritation*					
No	53 (86.9%)	17 (85.0%)	8 (72.7%)	9 (69.2%)	87 (82.9%)
Yes	8 (13.1%)	3 (15.0%)	3 (27.3%)	4 (30.8%)	18 (17.1%)
Ear/Hearing†					
No	59 (96.7%)	19 (95.0%)	10 (90.9%)	13 (100%)	101 (96.2%)
Yes	2 (3.3%)	1 (5.0%)	1 (9.1%)	0 (0%)	4 (3.8%)
Upper Respiratory§					
No	35 (57.4%)	14 (70.0%)	8 (72.7%)	7 (53.8%)	64 (61.0%)
Yes	26 (42.6%)	6 (30.0%)	3 (27.3%)	6 (46.2%)	41 (39.0%)
Lower Respiratory¶					
No	52 (85.2%)	15 (75.0%)	9 (81.8%)	12 (92.3%)	88 (83.8%)
Yes	9 (14.8%)	5 (25.0%)	2 (18.2%)	1 (7.7%)	17 (16.2%)
Any Respiratory**					
No	35 (57.4%)	13 (65.0%)	8 (72.7%)	7 (53.8%)	63 (60.0%)
Yes	26 (42.6%)	7 (35.0%)	3 (27.3%)	6 (46.2%)	42 (40.0%)
Cardiac††					
No	56 (91.8%)	18 (90.0%)	10 (90.9%)	12 (92.3%)	96 (91.4%)
Yes	5 (8.2%)	2 (10.0%)	1 (9.1%)	1 (7.7%)	9 (8.6%)
Skin Irritation or Injury§§					
No	57 (93.4%)	19 (95.0%)	10 (90.9%)	12 (92.3%)	98 (93.3%)
Yes	4 (6.6%)	1 (5.0%)	1 (9.1%)	1 (7.7%)	7 (6.7%)
Any New/Worsening Symptom					
No	27 (44.3%)	11 (55.0%)	6 (54.5%)	5 (38.5%)	49 (46.7%)
Yes	34 (55.7%)	9 (45.0%)	5 (45.5%)	8 (61.5%)	56 (53.3%)

* Eye irritation include eye irritation, and increased tearing (i.e., watery eyes).

† Ear or hearing symptoms include tinnitus, and hearing loss.

§ Upper respiratory symptoms include runny nose, congestion, anosmia, burning nose or throat, cough, and sore throat.

¶ Lower respiratory symptoms include difficulty breathing, wheezing, and burning lungs.

** Any respiratory symptoms include both upper and lower respiratory symptoms.

†† Cardiac symptoms include fast heart rate/pulse, chest tightness, and chest pain (i.e., angina).

§§ Skin irritation or injuries include skin irritation, rash, blisters, burns and lacerations.

Table S2b. Individual symptoms categorized as “Headache”

	Firefighter (n=61)	EMS (n=20)	Law Enforcement (n=11)	Other (n=13)	Overall (n=105)
Headache					
No	51 (83.6%)	17 (85.0%)	9 (81.8%)	9 (69.2%)	86 (81.9%)
Yes	10 (16.4%)	3 (15.0%)	2 (18.2%)	4 (30.8%)	19 (18.1%)

Table S2c. Individual symptoms categorized as “Eye Irritation”

	Firefighter (n=61)	EMS (n=20)	Law Enforcement (n=11)	Other (n=13)	Overall (n=105)
Eye Irritation					
No	54 (88.5%)	18 (90.0%)	8 (72.7%)	9 (69.2%)	89 (84.8%)
Yes	7 (11.5%)	2 (10.0%)	3 (27.3%)	4 (30.8%)	16 (15.2%)
Increased Tearing					
No	58 (95.1%)	19 (95.0%)	9 (81.8%)	12 (92.3%)	98 (93.3%)
Yes	3 (4.9%)	1 (5.0%)	2 (18.2%)	1 (7.7%)	7 (6.7%)
Eye Irritation					
No	53 (86.9%)	17 (85.0%)	8 (72.7%)	9 (69.2%)	87 (82.9%)
Yes	8 (13.1%)	3 (15.0%)	3 (27.3%)	4 (30.8%)	18 (17.1%)

Table S2d. Individual symptoms categorized as “Ear/Hearing”

	Firefighter (n=61)	EMS (n=20)	Law Enforcement (n=11)	Other (n=13)	Overall (n=105)
Ringling in Ears					
No	60 (98.4%)	19 (95.0%)	10 (90.9%)	13 (100%)	102 (97.1%)
Yes	1 (1.6%)	1 (5.0%)	1 (9.1%)	0 (0%)	3 (2.9%)
Hearing Loss					
No	60 (98.4%)	20 (100%)	11 (100%)	13 (100%)	104 (99.0%)
Yes	1 (1.6%)	0 (0%)	0 (0%)	0 (0%)	1 (1.0%)
Ear/Hearing					
No	59 (96.7%)	19 (95.0%)	10 (90.9%)	13 (100%)	101 (96.2%)
Yes	2 (3.3%)	1 (5.0%)	1 (9.1%)	0 (0%)	4 (3.8%)

Table S2e. Individual symptoms categorized as “Upper Respiratory”

	Firefighter (n=61)	EMS (n=20)	Law Enforcement (n=11)	Other (n=13)	Overall (n=105)
Runny nose/congestion					
No	48 (78.7%)	18 (90.0%)	8 (72.7%)	11 (84.6%)	85 (81.0%)
Yes	13 (21.3%)	2 (10.0%)	3 (27.3%)	2 (15.4%)	20 (19.0%)
Loss of sense of smell					
No	60 (98.4%)	20 (100%)	11 (100%)	12 (92.3%)	103 (98.1%)
Yes	1 (1.6%)	0 (0%)	0 (0%)	1 (7.7%)	2 (1.9%)
Burning nose or throat					
No	58 (95.1%)	19 (95.0%)	8 (72.7%)	11 (84.6%)	96 (91.4%)
Yes	3 (4.9%)	1 (5.0%)	3 (27.3%)	2 (15.4%)	9 (8.6%)
Coughing					
No	41 (67.2%)	15 (75.0%)	8 (72.7%)	8 (61.5%)	72 (68.6%)
Yes	20 (32.8%)	5 (25.0%)	3 (27.3%)	5 (38.5%)	33 (31.4%)
Sore throat					
No	53 (86.9%)	18 (90.0%)	9 (81.8%)	9 (69.2%)	89 (84.8%)
Yes	8 (13.1%)	2 (10.0%)	2 (18.2%)	4 (30.8%)	16 (15.2%)
Any Upper Respiratory					
No	35 (57.4%)	14 (70.0%)	8 (72.7%)	7 (53.8%)	64 (61.0%)
Yes	26 (42.6%)	6 (30.0%)	3 (27.3%)	6 (46.2%)	41 (39.0%)

Table S2f. Individual symptoms categorized as “Lower Respiratory”

	Firefighter/Hazmat (n=61)	EMS (n=20)	Law Enforcement (n=11)	Other (n=13)	Overall (n=105)
Difficulty Breathing					
No	56 (91.8%)	16 (80.0%)	9 (81.8%)	12 (92.3%)	93 (88.6%)
Yes	5 (8.2%)	4 (20.0%)	2 (18.2%)	1 (7.7%)	12 (11.4%)
Wheeze					
No	59 (96.7%)	19 (95.0%)	10 (90.9%)	12 (92.3%)	100 (95.2%)
Yes	2 (3.3%)	1 (5.0%)	1 (9.1%)	1 (7.7%)	5 (4.8%)
Burning in Lungs					
No	55 (90.2%)	18 (90.0%)	11 (100%)	12 (92.3%)	96 (91.4%)
Yes	6 (9.8%)	2 (10.0%)	0 (0%)	1 (7.7%)	9 (8.6%)
Any Lower Respiratory					
No	52 (85.2%)	15 (75.0%)	9 (81.8%)	12 (92.3%)	88 (83.8%)
Yes	9 (14.8%)	5 (25.0%)	2 (18.2%)	1 (7.7%)	17 (16.2%)

Table S2g. Individual symptoms categorized as “Cardiac”

	Firefighter/Hazmat (n=61)	EMS (n=20)	Law Enforcement (n=11)	Other (n=13)	Overall (n=105)
Fast Heart Rate					
No	60 (98.4%)	19 (95.0%)	10 (90.9%)	13 (100%)	102 (97.1%)
Yes	1 (1.6%)	1 (5.0%)	1 (9.1%)	0 (0%)	3 (2.9%)
Chest Pain/Angina					
No	57 (93.4%)	19 (95.0%)	11 (100%)	12 (92.3%)	99 (94.3%)
Yes	4 (6.6%)	1 (5.0%)	0 (0%)	1 (7.7%)	6 (5.7%)
Any Cardiac					
No	56 (91.8%)	18 (90.0%)	10 (90.9%)	12 (92.3%)	96 (91.4%)
Yes	5 (8.2%)	2 (10.0%)	1 (9.1%)	1 (7.7%)	9 (8.6%)

Table S2h. Individual symptoms categorized as “Skin Irritation or Injury”

	Firefighter (n=61)	EMS (n=20)	Law Enforcement (n=11)	Other (n=13)	Overall (n=105)
Irritation, pain, or burning of skin					
No	59 (96.7%)	19 (95.0%)	10 (90.9%)	12 (92.3%)	100 (95.2%)
Yes	2 (3.3%)	1 (5.0%)	1 (9.1%)	1 (7.7%)	5 (4.8%)
Laceration					
No	59 (96.7%)	20 (100%)	11 (100%)	13 (100%)	103 (98.1%)
Yes	2 (3.3%)	0 (0%)	0 (0%)	0 (0%)	2 (1.9%)
Broken Bones					
No	61 (100%)	20 (100%)	11 (100%)	13 (100%)	105 (100%)
Yes	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Burns					
No	61 (100%)	20 (100%)	11 (100%)	13 (100%)	105 (100%)
Yes	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Any Skin Irritation or Injury					
No	57 (93.4%)	19 (95.0%)	10 (90.9%)	12 (92.3%)	98 (93.3%)
Yes	4 (6.6%)	1 (5.0%)	1 (9.1%)	1 (7.7%)	7 (6.7%)

Table S3. Adjusted logistic regression results for all exposures/risk factors and symptoms assessed

Predictors	Headache		Eye Irritation		Ear/Hearing		Upper Respiratory		Lower Respiratory		Skin Irritation/Injury		Cardiac	
	Odds Ratios	CI	Odds Ratios	CI	Odds Ratios	CI	Odds Ratios	CI	Odds Ratios	CI	Odds Ratios	CI	Odds Ratios	CI
Exposed to smoke*														
No	Ref		Ref		Ref		Ref		Ref		Ref		Ref	
Yes	---	---	---	---	---	---	2.83	0.81 – 13.31	2.98	0.53 – 56.36	---	---	1.15	0.17 – 23.19
Exposed to ash/debris*														
No	Ref		Ref		Ref		Ref		Ref		Ref		Ref	
Yes	2.09	0.70 – 7.23	4.22	1.19 – 20.53	---	---	3.74	1.52 – 10.04	6.14	1.59 – 40.72	0.47	0.09 – 2.29	6.45	1.06 – 126.49
Rating of Perceived Exertion†														
Light (Borg Rating 6 - 12)	Ref		Ref		Ref		Ref		Ref		Ref		Ref	
Hard (Borg Rating >12 - 20)	3.62	1.15 – 13.10	5.65	1.61 – 23.93	---	---	2.99	1.25 – 7.50	2.82	0.89 – 10.04	1.64	0.32 – 9.38	1.53	0.34 – 7.52
Used PPE During Response*														
Yes	Ref		Ref		Ref		Ref		Ref		Ref		Ref	
No	1.27	0.42 – 3.90	1.21	0.39 – 3.84	0.24	0.01 – 2.16	0.6	0.25 – 1.43	0.84	0.26 – 2.60	3.09	0.57 – 24.31	1.01	0.21 – 4.60

Note: Each exposure/risk factor was assessed separately for each symptom category; CI = 95% confidence interval; Ref = reference category; “—” indicates model did not converge.

* Models include responder age and response hours worked covariates to control for confounding.

† Models include responder age, response hours worked, and responder type to control for confounding.

Table S4. Reasons that symptomatic responders did not seek medical care or evaluation.

Reason cited for not seeking care	Symptomatic Responders Who Did Not Seek Care* (n=44)
Symptoms Not Serious Enough	34 (77%)
Dislike Doctors	3 (7%)
No Time to Go	0 (0%)
Worried About Cost	2 (4%)
Worried About Losing Job	0 (0%)
Unclear/No Response†	7 (16%)

* Responders were allowed to select multiple reasons for not seeking care.

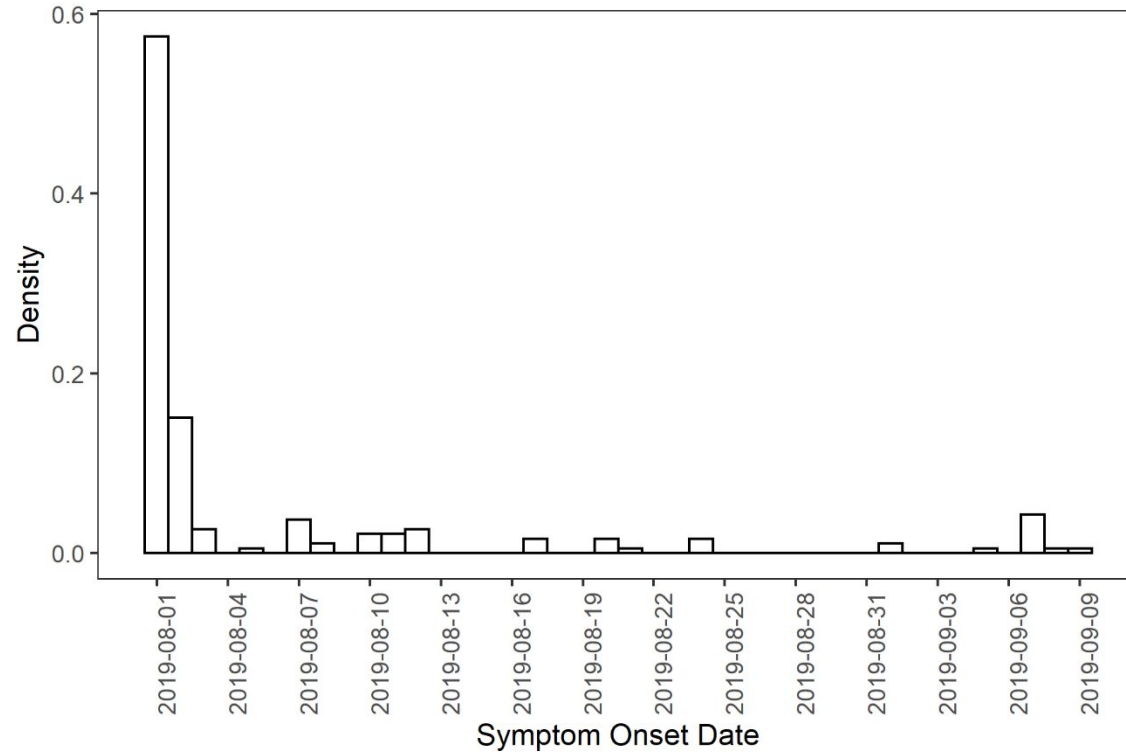
† Did not select reason for not seeking care and did not provide reason.

Table S5. Proportion of symptomatic first responders still experiencing new or worsening symptoms at least one month after responding to the incident, stratified by symptom category and responder type.

Still experiencing...	Firefighter (n=34)*	EMS (n=9)*	Law Enforcement (n=5)*	Other (n=8)*	Overall (n=56)*
Headache					
No	5 (50%)	2 (67%)	1 (50%)	4 (100%)	12 (63%)
Yes	5 (50%)	1 (33%)	1 (50%)	0 (0%)	7 (37%)
Eye Irritation					
No	5 (63%)	2 (67%)	2 (67%)	4 (100%)	13 (72%)
Yes	3 (37%)	1 (33%)	1 (33%)	0 (0%)	5 (28%)
Ear/Hearing					
No	1 (50%)	1 (100%)	1 (100%)	0 (0%)	3 (75%)
Yes	1 (50%)	0 (0%)	0 (0%)	0 (0%)	1 (25%)
Upper Respiratory					
No	16 (61%)	3 (50%)	1 (33%)	5 (83.3%)	25 (61%)
Yes	10 (39%)	3 (50%)	2 (67%)	1 (16.7%)	16 (39%)
Lower Respiratory					
No	3 (33%)	2 (40%)	1 (50%)	0 (0%)	6 (35%)
Yes	6 (67%)	3 (60%)	1 (50%)	1 (100%)	11 (65%)
Cardiac					
No	2 (40%)	1 (50%)	1 (100%)	0 (0%)	4 (44%)
Yes	3 (60%)	1 (50%)	0 (0%)	1 (100%)	5 (56%)
Skin or Injury					
No	3 (75%)	1 (100%)	1 (100%)	0 (0%)	5 (71%)
Yes	1 (25%)	0 (0%)	0 (0%)	1 (100%)	2 (29%)
Any Symptom					
No	19 (55.9%)	4 (50.0%)	3 (60.0%)	6 (75.0%)	33 (59.0%)
Yes	15 (44.1%)	4 (50.0%)	2 (40.0%)	2 (25.0%)	23 (41.0%)

* n indicates total number that reported at least one symptom. Note that denominator for each symptom changes because this is based on the number of responders that reported experiencing the specific symptom.

Figure S1. Histogram of reported symptom onset date for all symptoms.



* The natural gas pipeline explosion occurred on August 1, 2019. All 105 responders working within the evacuation area on August 1, 2019 for some time. Three reported returning and working on August 2, three reported returning and working on August 3, and one returned and worked on August 4.

Personal Protective Equipment (PPE) Questions

- What level of PPE were you wearing when you responded to the incident at this location?
 - None
 - Level "A"
 - Level "B"
 - Level "C"
 - Level "D"
 - Firefighter turn-out gear with respiratory protection.
 - Firefighter turn-out gear without respiratory protection.
 - Other types of protection (such as gloves, eye protection, hardhat, steel-toed shoes)
If selected, ask: Please specify the type of protection:

- What type of protection were you wearing (select all that apply) at this location?
 - None
 - Non-sterile exam gloves
 - Surgical gloves
 - Face mask without protective shield
 - Face mask with protective shield
 - Non-splash resistant disposable gown
 - Splash resistant disposable gown
 - Protective eye glasses/goggles
 - Supplied air respirator
 - Respirator with cartridge/HEPA filters
If selected, ask: Please specify the type of cartridge/filter:

 - Other *If selected, ask:* Please specify the type of protection:

Personal Protective Equipment (PPE) Showcard Level Descriptions*

Level A: The highest level of protection for the skin, eyes and respiratory system that are all at risk when exposed to the dangerous chemicals in any state. Level A suits require: Full face Self Contained Breathing Apparatus (SCBA), two-way radio, proper footwear including safety steel-toe boots with shanks on the outside, and chemical-resistant gloves.

Level B: Very similar to Level A, the Level B suit is extremely protective and the difference is that these suits contain less skin and outer body protection compared the aforementioned level. These are utilized when the wearer may require less skin protection but still a very high level of respiratory protection. Level B suits require: full face Self Contained Breathing Apparatus (SCBA), two-way radio attached either inside or outside the suit to avoid contamination, chemical-resistant gloves, proper footwear including Safety steel-toe boots with shanks on the outside, secured wrist, ankles, and face-piece and waist areas for splash protection

Level C: The most commonly used suit, the Level C, possess similar characteristics as Level B but does not have the same level of respiratory protection. The suit predominately used when the hazardous material is identified, measurable and contained, is utilized when contact with the substance will not cause harm to the skin. Level C suits require: full-face air purifying respirators, chemical-resistant gloves, proper footwear including Safety steel-toe boots with shanks on the outside, and two-way radio as well as a hard hat.

Level D: The least protective of the four suits, the Level D protection suit is mostly used in areas such as a construction site and provides zero protection from chemical exposure. Level D suits require: pair of coveralls, proper footwear including Safety steel-toe boots with shanks on the outside, goggles/glasses, and gloves. Level D suits don't require much protection and can be found as firefighter turnout gear, for example.

* showcard levels based on https://www.osha.gov/SLTC/emergencypreparedness/gettingstarted_ppe.html

Borg Rating of Perceived Exertion Showcard

How you might describe your exertion	Borg rating of your exertion	Examples (for most adults <65 years old)
None	6	Reading a book, watching television
Very, very light	7 to 8	Tying shoes
Very light	9 to 10	Chores like folding clothes that seem to take little effort
Fairly light	11 to 12	Walking through the grocery store or other activities that require some effort but not enough to speed up your breathing
Somewhat hard	13 to 14	Brisk walking or other activities that require moderate effort and speed your heart rate and breathing but don't make you out of breath
Hard	15 to 16	Bicycling, swimming, or other activities that take vigorous effort and get the heart pounding and make breathing very fast
Very hard	17 to 18	The highest level of activity you can sustain
Very, very hard	19 to 20	A finishing kick in a race or other burst of activity that you can't maintain for long

Adapted from Borg GA. Psychophysical bases of perceived exertion. Med Sci Sports Exerc. 1982;14(5):377-81.

List of individual symptoms and mapping to symptom categories

Individual Symptom	Symptom Category
Irritation, pain, or burning of skin	Skin Irritation/Injury
Broken bones	Skin Irritation/Injury
Laceration	Skin Irritation/Injury
Burns	Skin Irritation/Injury
Irritation/pain/burning of eyes	Eye irritation
Increased tearing	Eye irritation
Ringing in ears	Ear/Hearing
Hearing loss	Ear/Hearing
Headache	Headache
Fast heart rate/pulse	Cardiac
Chest tightness or pain/angina	Cardiac
Burning lungs	Lower Respiratory
Difficulty breathing/ feeling out-of-breath	Lower Respiratory
Wheezing in chest	Lower Respiratory
Blurred vision/double vision	Other Neurologic
Loss of consciousness/fainting	Other Neurologic
Inability to urinate or pee	Other Neurologic
Concussion	Other Neurologic
Runny nose/congestion	Upper Respiratory
Loss of sense of smell	Upper Respiratory
Burning nose or throat	Upper Respiratory
Sore throat	Upper Respiratory
Coughing	Upper Respiratory