9.11 World Trade Center Health Program

Evaluation of Scientific Evidence Supporting the Addition of Anti-Glomerular Basement Membrane Disease (Anti-GBM) Glomerulonephritis to the List of WTC-Related Health Conditions

March 11, 2026

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I. EXECUTIVE SUMMARY

At the direction of the Administrator of the World Trade Center (WTC) Health Program, the WTC Health Program Science Team (Science Team) reviewed **Petition 026** requesting the addition of Anti-GBM Disease Glomerulonephritis (Anti-Glomerular Basement Membrane Disease), to the List of WTC-Related Health Conditions (the List). The WTC Health Program's Science Team evaluated the scientific evidence of a causal association between 9/11 exposure and anti-GBM glomerulonephritis in accordance with the *Policy and Procedures for Adding Non-Cancer Health Conditions to the List of WTC-Related Health Conditions (Policy and Procedures)* [NIOSH 2024].

A literature review of peer-reviewed, published, epidemiologic studies published between 2001–2025 did not identify any high-quality studies reporting on the risk of anti-GBM glomerulonephritis in 9/11-exposed populations. As a result, the Science Team was unable to conduct an evaluation of scientific evidence to determine the likelihood of a causal association between 9/11 exposures and the petitioned health condition. The Science Team concludes that there is *inadequate evidence* to determine the likelihood of a causal association between 9/11 exposures and anti-GBM glomerulonephritis (Category V).[1]

II. BACKGROUND

Pursuant to the James Zadroga 9/11 Health and Compensation Act of 2010[2], an interested party may petition the Administrator of the WTC Health Program for the addition of a health condition to the List of conditions eligible for treatment in the Program.[3,4] To petition the Program, petitioners must submit, in writing, their name, contact information, and signature of the interested party requesting the addition of the health condition to the List; a statement of intent to petition for the addition of a health condition to the List; the name or description of the health condition; and reasons for adding the health condition to the List, including the medical basis for the association between the September 11, 2001, terrorist attacks and the condition.[5] These requirements are further explained in the *Policy and Procedures for Handling Submissions and Petitions to Add a Health Condition to the List of WTC-Related Health Conditions (Policy and Procedures for Handling Submissions and Petitions)* [NIOSH 2026]. Submissions that meet all requirements are considered valid petitions.

On March 12, 2020, the Administrator of the WTC Health Program received a submission requesting the addition of "Anti-GBM Disease Glomerulonephritis (Anti-Glomerular Basement Membrane Disease)" to the List. Upon review, the submission was found to be a valid petition and assigned an ordinal as Petition 026. In accordance with the *Policy and Procedures* [NIOSH 2024], the Administrator directed the Science Team to evaluate the scientific evidence of a causal association between 9/11 exposure and anti-GBM glomerulonephritis.

1 *See Policy and Procedures*, Section V. E. [NIOSH 2024].

2 Title 1 of Pub. L. 111-347, as amended by Pub. L. 114-113, Pub. L. 116-59, Pub. L. 117-328, Pub. L. 118-31, and Pub. L. 119-75; codified at 42 U.S.C. §§ 300mm–300mm-64.

3 42 U.S.C. § 300mm-22(a)(6)(B).

4 The current List of WTC-Related Health Conditions is found in WTC Health Program regulations in Title 42 of the Code of Federal Regulations (CFR) Part 88 (42 C.F.R. § 88.15).

5 *See* 42 C.F.R. § 88.16(a)(1).

III. PURPOSE

The purpose of this evaluation is to assess the scientific evidence from peer-reviewed, published, epidemiologic studies of anti-GBM glomerulonephritis among the 9/11-exposed population,[6] to determine whether sufficient evidence of a causal association between 9/11-related exposures, including exposure to 9/11 agents,[7] and anti-GBM glomerulonephritis exists to support adding this condition to the List. This evaluation is being provided to the Administrator of the WTC Health Program to inform the Administrator's decision regarding Petition 026 in accordance with the WTC Health Program's *Policy and Procedures* [NIOSH 2024].

IV. REVIEW OF THE MEDICAL BASIS INFORMATION PROVIDED BY THE PETITIONER

The validity of Petition 026 was previously established by the Program in accordance with Program regulations and the *Policy and Procedures for Handling Submissions and Petitions* [NIOSH 2026]. The Program examined the references provided with the submission to determine whether they included a medical basis for the association between the September 11, 2001, terrorist attacks and the condition to be added. The petitioner referenced two studies providing sparse information on a potential causal association between anti-GBM glomerulonephritis and exposure to "hydrocarbons" [Ravnskov 2000; Pusey 2003], which include various 9/11 agents identified in the *Inventory* [NIOSH 2018]. *See* **Table 1**.

Neither of the studies referenced in the petition discussed specific 9/11 agents, only the general category of "hydrocarbons." Hydrocarbons include organic solvents, fuels, paints, glues and motor exhausts. Several hydrocarbons, including organic solvents and fuels, have been identified as 9/11 agents. Organic solvents include acetone, ethanol, toluene, hexane, benzene, ethers, and esters; these chemicals are all listed as 9/11 agents in the *Inventory*, as are diesel exhaust and other fuels, including pristane, phytane, and benzo(a)pyrene.

A. Ravnskov [2000]

A commentary by Ravnskov [2000] reviewed the literature available prior to 1999 and discussed the role of hydrocarbons in potentially causing glomerulonephritis and end-stage renal failure. The authors concluded that the overall evidence supported a role for hydrocarbon exposure in renal failure. The authors also noted that several questions remained unanswered regarding the mechanisms of a causal association.

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6 9/11-exposed population means those persons who can reasonably [be] assumed to have been exposed to hazards resulting from the September 11, 2001, terrorist attacks, including those 9/11 agents identified in the Program's *Development of the Inventory of 9/11 Agents* (the *Inventory*), within the geographic areas identified in the WTC Health Program's eligibility criteria; such populations may include, but are not limited to, WTC Health Program members. The *Inventory* includes a catalog of chemical, physical, biological, and other hazards that may have been present at the disaster areas. *See* NIOSH [2018]. Development of the Inventory of 9/11 Agents. Cincinnati, OH: National Institute for Occupational Safety and Health, https://www.cdc.gov/wtc/pdfs/research/Development_of_the_Inventory_of_9-11_Agents_20180717.pdf

7 9/11 agents are chemical, physical, biological, or other agents or hazards reported in a peer-reviewed, published, exposure assessment study of responders, recovery workers, or survivors who were present in the New York City disaster area, or at the Pentagon site, or the Shanksville, Pennsylvania site, as those locations are defined in 42 C.F.R. § 88.1, as well as those hazards not identified in a peer-reviewed, published, exposure assessment study, but which are reasonably assumed to have been present at any of the three sites. Known 9/11 agents are established in the *Inventory* [NIOSH 2018].

B. Pusey [2003]

A case-study by Pusey [2003], described a 47-year-old white male who worked as a professional musician and was treated for crescentic glomerulonephritis due to anti-GBM disease. The case-study was supported with a brief overview of potential causes, which introduced the possibility of an association between anti-GBM glomerulonephritis and hydrocarbon exposure citing previous literature. However, the authors made no attempt to discern the specific cause of the disease in this patient.

These two studies are potentially informative on the plausibility of a causal association between 9/11 exposure to hydrocarbons and anti-GBM glomerulonephritis and were deemed sufficient as providing medical basis for initiating this evaluation pursuant to the Program *Policy and Procedures for Handling Submissions and Petitions* [NIOSH 2026]. Since neither Ravnskov [2000] nor Pusey [2003] provided information on exposure-related risk of anti-GBM glomerulonephritis in the 9/11-exposed population as required in Section III.B. of the *Policy and Procedures* [NIOSH 2024], these studies were not considered further in this evaluation.

V. EVALUATED HEALTH CONDITIONS

In accordance with the *Policy and Procedures* [NIOSH 2024], the Science Team reviewed the information provided by the petitioner, including the medical basis, and determined that the health condition of interest for this evaluation is anti-GBM glomerulonephritis (ICD-10 dagger and asterisk codes[8] M31.0† and N08.5*).

The kidney consists of approximately one million filtering units called nephrons [George and Neilson 2022]. Each nephron consists of a glomerulus and a tubule. Blood flowing into the kidney first meets the glomerulus, where the blood is filtered. A healthy glomerulus allows passage of fluid and small molecules from the blood into the urinary space and prevents passage of blood cells and proteins [George and Neilson 2022]. This filtration occurs at the glomerular filtration barrier, which consists of three layers, one of which is the glomerular basement membrane [Daehn and Duffield 2021].

There are many different types of glomerular diseases, also known collectively as glomerulonephritis [Chadban and Atkins 2005]. They encompass a wide range of conditions with etiologies that span autoimmune disease, malignancy-associated conditions, sequelae of infection, genetic mutations, medication-induced, and other toxic exposures. Many cases of glomerulonephritis result in mild, asymptomatic illness that goes unrecognized by the patient and remain undiagnosed. As such, the magnitude of such mild glomerulonephritis is unknown but could be substantial [Chadban and Atkins 2005]. Collectively, glomerular diseases are the third leading cause of end-stage renal disease (ESRD) and account for approximately six percent of ESRD cases [United States Renal Data System 2025]. The two leading causes of ESRD are diabetes mellitus and hypertension [United States Renal Data System 2025].

8 The ICD "dagger and asterisk" system permits the classification of a disease according to its etiology (dagger) and manifestation (asterisk).

Anti-GBM disease is a rare autoimmune disorder characterized by the production of autoantibodies targeting antigens in the glomerular and alveolar basement membranes [Reggiani 2023]. In persons with anti-GBM disease, antibodies bind to the glomerular and alveolar basement membranes in the kidney and lungs, and incite an intense inflammatory response, including glomerulonephritis, that can lead to kidney failure and severe pulmonary hemorrhage.

More than half of patients with anti-GBM antibody disease present with *both* glomerulonephritis and pulmonary hemorrhage. Another one third of patients have *only* glomerulonephritis [Pusey 2003]. This evaluation focuses on the health condition affecting that one third of patients that results in damage to the glomerular basement membrane in the kidneys (i.e., anti-GBM glomerulonephritis), and not on damage to the alveolar-capillary basement membrane in the lungs (i.e., anti-alveolar basement membrane disease).

Without treatment, anti-GBM disease typically translates into a fulminant and fatal disease course [Pusey 2003]. Definitive incidence estimates for anti-GBM disease are lacking, but in European populations it is estimated to be less than one case per million per year [McAdoo and Pusey 2017].

VI. RISK FACTORS FOR THE EVALUATED HEALTH CONDITION

A. General Risk Factors

Anti-GBM disease is more common among White persons, although it has been observed in all racial/ethnic groups [Asim and Akhtar 2022]. A bimodal age distribution has been observed with peaks in the third decade characterized by male preponderance and the seventh decade demonstrating no sex preponderance [Asim and Akhtar 2022].

The cause of anti-GBM disease is largely unclear. Factors that have been suggested to initiate the production of anti-GBM antibodies include the drug alemtuzumab, a lymphocyte-depleting agent that is used to treat relapsing multiple sclerosis and chronic lymphocytic leukemia [Clatworthy et al. 2008]; hydrocarbon exposure [Ravnskov 2000]; SARS-CoV-2 infection, the virus that causes coronavirus disease 2019 (COVID-19) [Klomjit et al. 2023]; and COVID-19 vaccines [Ahmed et al. 2022]. Genetic susceptibility may also play a role, with some genetic alleles associated with an increased risk for anti-GBM disease [McAdoo and Pusey 2017].

B. 9/11 Risk Factors

The Science Team did not find any studies that examined the association between 9/11 exposure and anti-GBM glomerulonephritis risk. However, the medical basis provided by the petitioner suggested that anti-GBM disease may be linked to hydrocarbon exposures. Various hydrocarbons are 9/11 agents and would have been present at the 9/11 sites from the dense plume of dust, gases, and smoke caused by the building collapse, burning jet fuel, and building fires, as well as resuspension of contaminants during months of clean-up and recovery.

VII. SCIENTIFIC EVALUATION APPROACH

The Science Team evaluation was carried out in accordance with the *Policy and Procedures* [NIOSH 2024] and includes the following steps: (1) develop a literature search protocol and conduct a search for peer-reviewed, published, epidemiologic studies of the health condition being evaluated among 9/11-exposed populations;[9] (2) review identified studies to determine which studies are high-quality studies for further evaluation;[10] (3) evaluate and integrate the evidence of a causal association between 9/11 exposures and the health condition being evaluated;[11] and (4) synthesize and interpret all findings to categorize the weight of evidence of a causal association between 9/11 exposures and the health condition evaluated.[12] The Science Team then advises the Administrator of its findings.[13]

VIII. REVIEW OF THE LITERATURE

A. Literature Search

The literature search seeks to identify high-quality peer-reviewed, published, epidemiologic studies that provide evidence on the proposed causal association between 9/11 exposure and the health condition under consideration — anti-GBM glomerulonephritis. To identify potentially relevant studies, the Science Team searched abstracts and titles from peer-reviewed English language literature. In addition to search terms used to identify epidemiologic studies of the 9/11-exposed population, keywords used to uncover potentially informative studies included: anti-glomerular basement membrane disease; anti-GBM; Goodpasture; glomerulonephritis; IgA nephropathy; IgA vasculitis; membranous glomerulopathy; membranous nephropathy; minimal change disease; collagen Type IV-related nephropathy; nephritic syndrome; nephrotic syndrome; glomerular disease; glomerulopathy; and glomerulonephritides. The databases searched were APA PsycInfo®, CINAHL (EBSCOhost), Embase Classic+Embase, Health & Safety Science Abstracts (ProQuest), NIOSHTIC-2, Ovid MEDLINE®, Scopus, and Toxicology Abstracts (ProQuest).

Following the baseline search, additional weekly searches were conducted using the WTC Health Program Bibliographic Database, a database of relevant WTC-related research maintained by the Program and updated at least weekly using a standing search of the previously mentioned databases. This two-pronged approach ensures all relevant and up-to-date literature is available for the evaluation. The last follow-up search was conducted in January 2026. The literature search did not identify any published, peer-reviewed, epidemiological studies examining the risk of anti-GBM glomerulonephritis in 9/11-exposed populations.[14]

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9 *See Policy and Procedures*, Section III.B. [NIOSH 2024].

10 *See Policy and Procedures,* Section III.C. [NIOSH 2024].

11 *See Policy and Procedures,* Section IV. [NIOSH 2024].

12 *See Policy and Procedures*, Section V. [NIOSH 2024].

13 *See Policy and Procedures*, Section VI. [NIOSH 2024].

14 The Science Team also previewed the medical basis provided by the petitioner for relevant information but as noted in Section IV, neither of the two studies provided information on exposure-related risk of anti-GBM glomerulonephritis in the 9/11-exposed population, so they were only potentially informative on the plausibility of a causal association between 9/11 exposure to hydrocarbons and anti-GBM glomerulonephritis.

The Science Team also determined that the available peer-reviewed epidemiologic studies examining mortality patterns among groups of the 9/11-exposed population only reported deaths due to the broad category of chronic renal failure; deaths due to anti-GBM glomerulonephritis were not further specified.[15] As previously noted, glomerulonephritis is responsible for an estimated six percent of ESRD cases [United States Renal Data System 2025]. ESRD is the most severe stage of chronic renal failure, and the distribution of causes of ESRD cases likely reflect the causes of all chronic renal failure. In addition, fatal chronic renal failure is likely caused by ESRD. However, given that glomerulonephritis only causes an estimated six percent of ESRD cases (and anti-GBM disease causes a much smaller percentage of ESRD cases than glomerulonephritis), "chronic renal failure" is an imprecise and insufficient surrogate for glomerulonephritis. Therefore, information from mortality studies was considered not informative and was not included in this review.

B. Identified High-Quality Studies

Since no peer-reviewed, published, epidemiologic studies of 9/11-exposed populations examining the risk of anti-GBM glomerulonephritis were identified in the literature search, there were no high-quality studies available for further review.

IX. SYNTHESIS OF EVIDENCE FOR CATEGORIZATION

In accordance with the *Policy and Procedures* [NIOSH 2024], the Science Team evaluates and synthesizes evidence from the high-quality studies identified following the Review of Literature. Synthesis refers to the process by which the Science Team evaluates the evidence presented in scientific studies, individually and together, to characterize the evidence of a causal association between 9/11 exposures and the health condition of interest[16] and to assign findings regarding causal association to one of five categories as described below in Section IX.A.4.[17] This evaluation includes a consideration of the Bradford Hill criteria, limitations, and representativeness of the findings.

A. Introduction

1. Bradford Hill Framework for Weight-of-the-Evidence Determinations

The *Policy and Procedures* [NIOSH 2024] utilizes the Bradford Hill criteria to determine the degree to which the weight of evidence presented by high-quality peer-reviewed, published, epidemiologic studies supports a causal association between 9/11 exposures and the health condition.

15 Deaths in epidemiologic studies are classified according to the NIOSH Life Table Analysis System (LTAS) 119-cause rate file [Robinson et al. 2006; Schubauer-Berigan et al. 2011]. NIOSH LTAS is computer software used to conduct comparisons of cause-specific incidence and mortality rates by age, sex, race, calendar time, and duration or level of exposure. *See* Bertke SJ, Kelly-Reif K [2022]. Introducing LTASR, a new R package based on the NIOSH Life Table Analysis System. Occup Environ Med 79:792, https://doi.org/10.1136/oemed-2022-108462. The NIOSH LTAS uses codes from the 10th revision of the International Classification of Diseases (ICD-10) that pertain to anti-GBM glomerulonephritis used in the LTAS are lumped into a single category that includes all causes of chronic renal failure.

16 *See Policy and Procedures,* Section IV.A. [NIOSH 2024].

17 Since no peer-reviewed, published, epidemiologic studies examining the risk of anti-GBM glomerulonephritis in the 9/11-exposed population were identified in the literature search, there was no evidence to evaluate or synthesize.

The Bradford Hill criteria include: (1) **strength of the association** between 9/11 exposures and the health condition under consideration and precision of the risk estimate; (2) **consistency of associations** across multiple studies; (3) **specificity** that an association is more likely to be causal if one cause (9/11 exposures) and one effect (the health condition being evaluated) is observed; (4) **temporality** of the cause (9/11 exposure) precedes the effect (the health condition being evaluated); (5) **biological gradient** or dose-response relationship where changes in 9/11 exposures are associated with corresponding changes in the magnitude of the health condition being evaluated; (6) **biological plausibility** — whether 9/11 studies are not in conflict with known facts about the biology of the health condition being evaluated ; (7) **coherence** between a causal association and known disease etiology; and (8) **analogy** with an established similar causal relationship [Hill 1965].

Four Bradford Hill criteria — strength of the association, consistency of associations, temporality, and biological gradient — are directly applicable to the evaluation of evidence from high-quality studies identified in the scientific literature review. Each of these four criteria is given significant weight in synthesizing evidence from high-quality studies found after a review of the scientific literature. In contrast, the Bradford Hill criterion of specificity may be given no weight if multiple causes can lead to the health condition under evaluation.

Biological plausibility, coherence, and analogy are related criteria that require reasonable knowledge of the biology of the health condition of interest, including facts about disease etiology and any established direct or analogous causal relationships [NIOSH 2024]. Although previous biological evidence may have motivated the high-quality epidemiologic studies identified for evaluation, these studies themselves may not provide sufficient information to evaluate the criteria of biological plausibility, coherence, and analogy. To address any concerns regarding incomplete information in the identified studies, the Science Team exercises scientific and medical judgment to refer to additional information from biological, toxicologic, and epidemiologic research, usually from references cited in the identified studies or medical basis, or from a limited review of the literature to assess biological plausibility, coherence, and analogy. This approach permits a more complete analysis of these criteria, offsetting the likelihood of reaching a default decision that there is inadequate information to evaluate the likelihood of a causal association.

2. Study Limitations

In synthesizing evidence from high-quality studies, the Science Team considers limitations that may affect the validity of study findings. Limitations may include the potential for residual confounding of effect measures from incomplete information on risk factors and major sources of selection or information biases, such as healthy worker effects, adequacy of the control group, ascertainment errors, exposure misclassification, and conflicts of

interest, among others. Study limitations are integral to assessing aspects of association, such as strength of the association, consistency of associations, temporality, and biological gradient. For example, large effects (i.e., strength of the association) are generally less vulnerable to study biases. Likewise, cross-sectional studies, by design, generally offer little information on temporality compared with longitudinal studies.

3. Study Representativeness

   In synthesizing evidence from high-quality studies, the Science Team considers the representativeness of the evidence to assess whether the high-quality studies, taken together, represent both WTC responder and survivor populations or, if only a subgroup of 9/11-exposed responder or survivor populations is represented. If the 9/11-exposed population is only partially represented, then the Science Team considers whether the results can reasonably be extrapolated to the full 9/11-exposed population. Representativeness is linked to consistency of associations such that similar findings observed in multiple populations are generally weighted more heavily than findings observed in a single population.

   Due to the interrelatedness of certain Bradford Hill criteria, such as strength of the association, consistency of associations, temporality, and biological gradient, and consideration of study limitations and representativeness, those respective aspects may be grouped together for synthesizing evidence from the totality of high-quality studies.

4. Categorization of Evidence

   After evaluation of the totality of the evidence from high-quality studies, the Science Team categorizes the totality of the evidence into one of the following five categories: (1) Category I — the evidence supports the *substantial likelihood* of a causal association; (2) Category II — the evidence supports the *high likelihood* of a causal association; (3) Category III — the evidence supports a *limited likelihood* of a causal association; (4) Category IV — the *evidence does not support* a causal association; or (5) Category V — the evidence is *inadequate* to determine the likelihood of a causal association [NIOSH 2024].

   This categorization of the evidence is used by the Administrator to determine if there is sufficient evidence of a causal association to conclude that 9/11 exposures are *substantially likely* to be causally associated with the health condition. If categorization of the evidence demonstrates a high, but not substantial, likelihood of causal association between 9/11 exposures and the health condition (Category II), the Administrator may direct the Science Team to evaluate additional highly-relevant scientific information regarding exposures to known 9/11 agents in *non-9/11 exposure scenarios*. Based on such information, coupled with evidence from the evaluation of high-quality studies of the health condition in 9/11-exposed populations, the Science Team will determine whether the totality of the evidence supports a causal association as either Category I (substantial likelihood) or Category II (high likelihood).

B. Summary of Evaluation and Evidence Synthesis

Since no peer-reviewed, published, epidemiologic studies examining the risk of anti-GBM glomerulonephritis in the 9/11-exposed population were identified in the literature search, there was no evidence to evaluate or synthesize.

X. CONCLUSION

The literature search conducted by the Science Team did not identify any peer-reviewed, published, epidemiologic studies of anti-GBM glomerulonephritis in 9/11-exposed populations. Therefore, pursuant to the WTC Health Program's *Policy and Procedures* [NIOSH 2024], there was no evidence available for synthesis by the Science Team. The Science Team concluded that the available scientific evidence for a causal association between 9/11 exposure and anti-GBM glomerulonephritis was *inadequate* to determine the likelihood of causal association (Category V).[18]

18 *See Policy and Procedures*, Section V.E. [NIOSH 2024].

XI. REFERENCES

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APPENDIX

Table 1. Information Provided by the Petitioner and Medical Basis Determination.

Petition Number	Information Provided in the Petition	Medical Basis[1] (Yes/No)
Petition 026	1. Murphy J, Brackbill RM, Thalji L, et al. [2007]. Measuring and maximizing coverage in the World Trade Center Health Registry. Stat Med 26(8):1688–1701, https://doi.org/10.1002/sim.2806	No
	2. Ravnskov U [2000]. Hydrocarbon exposure may cause glomerulonephritis and worse renal function: evidence based on Hill's criteria for causality. QJM-Int J Med 93(8):551-556, https://doi.org/10.1093/qjmed/93.8.551	Yes
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	4. Lingaraj U, Mallappa SS, Neminah RE, et al. [2017]. A "Mini-Epidemic" of anti-glomerular basement membrane disease: Clinical and epidemiological study. Saudi J Kidney Dis Transpl 28(5):1057–1063, https://journals.lww.com/sjkd/fulltext/2017/28050/a__mini_epidemic__of_anti_glomerular_basement.11.aspx	No

1 Medical basis must be scientific in nature and provide a positive association between the September 11, 2001, terrorist attacks and the condition to be added through published, peer-reviewed literature that has not been previously evaluated by the Program. For more information, please see NIOSH [2026]. *Policy and Procedures for Handling Submissions and Petitions to Add a Health Condition to the List of WTC-Related Health Conditions* at https://www.cdc.gov/wtc/policies.html.