

## Case Report



# Mental health impact on a humidifier disinfectant disaster victim: a case report

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## ABSTRACT

In Korea, the cause of lung disease of unknown origin was identified as humidifier disinfectants in November 2011. In February 2017, the ‘Special Act on Remedy for Damage Caused by Humidifier Disinfectants’ was promulgated. Even though emotional and mental injuries caused by humidifier disinfectants have been reported, the focus of the special act has been on physical injury only, and criteria for recognizing mental health impact have not been considered. This case considers emotional and mental injury caused by humidifier disinfectants. After a humidifier disinfectant was used from January 2005 to April 2006, the patient's son aged 20 months was hospitalized with respiratory symptoms, and he died within two weeks. Also, the patient was hospitalized for a month with the same symptoms, and then she led a normal life with no symptoms. After both mother and son were diagnosed with definite (level 1) humidifier disinfectant lung injury (HDLI) in 2017, she took to drinking alcohol because of extreme guilt over her son's death. In March 2018 she died from acute liver failure due to alcohol use disorder. The patient's death was caused by continuous alcoholism, due to emotional and mental trauma caused by her son's death after HDLI was revealed as the cause. The government did not acknowledge her death was due to humidifier disinfectants, but the company that sold the humidifier disinfectants recognized her as a victim and compensated the family of the victim. There are still lots of psychological responses among humidifier disinfectant disaster victims. Mental health impact on humidifier disinfectant victims should be considered more carefully, and institutional improvements should be made into establish psychological interventions and measures.

**Keywords:** Humidifier disinfectant disaster; Humidifier disinfectant lung injury (HDLI); Mental health impact; Alcohol use disorder; Victim

## BACKGROUND

In November 2011, the cause of lung disease of unknown origin in Korea, was identified as humidifier disinfectants; this remained unknown to the public until prosecutors expanded their investigations and released information to the media in January 2016. In February 2017, the ‘Special Act on Remedy for Damage Caused by Humidifier Disinfectants’ was

### Abbreviations

FEV<sub>1</sub>: forced expiratory volume in 1 second; FVC: forced vital capacity; HDLI: humidifier disinfectant lung injury; MIT: methylisothiazolinone; PHMG: polyhexamethylene guanidine phosphate; PTED: posttraumatic embitterment disorder; PTSD: post-traumatic stress disorder.

### Competing interests

The authors declare that they have no competing interests.

### Authors contributions

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promulgated. The government recognized cases where the cause of physical injury—lung injury, injury to fetal health, and asthma—was clearly established. The Enforcement Decree of the Special Act was revised in July 2018 and victims with bronchiectasis, interstitial lung diseases, pneumonia, and asthma, that did not meet the criteria for asthma injury were selected for the Special Remedy Account [1,2]. In July 2019, the Committee on Remedy for Damage caused by humidifier disinfectants added toxic hepatitis to the list of diseases recognized as physical injuries caused by humidifier disinfectants [1].

Despite the fact that not only physical injury has been linked to humidifier disinfectants, but also emotional and mental injuries—such as post-traumatic stress disorder (PTSD), depression, and suicide attempts due to the death of family members—the recognition criteria have not been reviewed [3,4]. Researchers and the government have focused on identifying causality of physical injury related to humidifier disinfectants; however, physical injury in these cases also leads to unintentional abusers and victims in the family. The government provides little support for emotional and mental injury, such as the guilt that results from causing unintentional injury to a family member by using humidifier disinfectants.

With this case report of a death judged to be the result of emotional and mental injury caused by humidifier disinfectants, we claim that there are problems with the current narrow criteria for recognition of humidifier disinfectant lung injury (HDLI) that focus only on physical injury. Additionally, this research was conducted to provide fundamental evidence for establishing a mental support system for victims of humidifier disinfectants.

This case was linked to a claim for remedial benefit adjustments and funeral expenses pursuant upon the death of a female and her son. She died due to hepatic failure after being diagnosed with definite HDLI (level 1) in March 2018, and her son (who died in May 2006) was also diagnosed with HDLI. The mother's cause of death was recorded as sepsis after liver transplantation due to alcoholic cirrhosis. We carefully reviewed her medical records to determine whether humidifier disinfectants were related to her death.

## CASE PRESENTATION

A Korean female aged 39 years at time of death had used a humidifier disinfectant containing polyhexamethylene guanidine phosphate (PHMG) from January 2005 to April 2006, during which time her son had also been exposed to it.

### Progression of pulmonary disease in the patient's son after exposure to humidifier disinfectants

When the patient's son was 20 months old, cough, sputum, and dyspnea had appeared intermittently since April 2006. During treatment at the local clinic the dyspnea and cough became worse, and he was admitted to a general hospital due to anorexia. No improvement was observed, and he was diagnosed with idiopathic interstitial lung disease and acute respiratory distress syndrome, and died 2 weeks after admission.

### Progression of pulmonary disease in the patient after humidifier disinfectant exposure

A few days after the death of her son, the patient started showing a mild cough and dyspnea, in the same pattern as her son had. From June 2006 whitish sputum and dyspnea worsened, and

she was admitted to the respiratory department of a tertiary hospital on June 30, 2006. Multiple ground-glass opacities were observed in both lungs on chest X-rays, and computed tomography of the chest showed interlobular septal thickening, with centrilobular nodules distributed symmetrically in both lungs. Pulmonary function tests showed reduction of forced expiratory volume in 1 second (FEV<sub>1</sub>) (31%), forced vital capacity (FVC) (36%), FEV<sub>1</sub>/FVC (68%), and diffusing capacity of the lungs for carbon monoxide (55%). Mild interstitial inflammation was observed on transbronchial lung biopsy, so she was suspected to have interstitial pneumonia and viral pneumonia. Symptoms improved after one month of hospitalization, but after discharge she still had a mild cough, especially during winter and spring.

### Psychological injury after exposure to humidifier disinfectants

After her 20-month-old son died, the patient was hospitalized for lung disease. While her symptoms improved, her son's death shocked her deeply, resulting in decreased appetite, weight loss, insomnia, and suicide attempts with sleeping pills due to extreme feelings of guilt. In June 2006, a psychiatrist diagnosed her mental symptoms as a normal mourning response to her son's death, but stated that there was a risk of developing depression, so antidepressant treatment was recommended. However, she refused antidepressant treatment during the month of inpatient treatment for interstitial pulmonary disease. After discharge she still felt depressed and guilty for her son's death, sometimes not eating for one to two months. She drank every day and developed alcoholic liver disease.

In April 2008, her depression improved after she gave birth to a daughter; while breastfeeding for 30 months she stopped drinking and resumed work as an acupuncturist nursing assistant, leading a normal life with no symptoms. Every year in May she cried and drank occasionally, but her daily life was not affected.

The media reported the health impact of humidifier disinfectants in 2011, and the patient's husband then suspected that his son and wife's diseases were caused by them. However, he did not mention the issue around humidifier disinfectants because he did not want to bring up painful memories. In May 2016, the press began to report widely on humidifier disinfectants, and he became certain that his wife and son's pneumonia was caused by them. He recommended that his wife apply to the health injury recognition program, so that her health status could be accepted as caused by humidifier disinfectants. The wife previously had no knowledge of the connection between disease and the humidifier disinfectants and began to feel depressed and struggled emotionally while reviewing medical records and preparing documents.

### Determination of HDLI

After applying for recognition of health damage caused by humidifier disinfectants in May 2016, both the patient and her son were diagnosed as having definite HDLI (level 1) in August 2017.

### Death after diagnosis with HDLI

In August 2017, after it was discovered that her son had also suffered from the lung disease, her self-blame and guilt became more severe, and she restarted drinking every day. In January 2018, she had extreme jaundice, dizziness, and general weakness, and was admitted to hospital. Even after transplantation with part of her husband's liver in January 2018, symptoms did not improve, and intraperitoneal bleeding, sepsis, and disseminated intravascular coagulation developed. Treatment was not stopped, but there was no improvement, and she died on March 15, 2018. Cause of death was reported as sepsis after liver transplantation required because of alcoholic cirrhosis.

### Medical and social history

In the early 2000s, the patient had 2 miscarriages and one ectopic pregnancy. After that, symptoms of mild depression were observed, and she drank about one bottle of soju twice a week. In October 2002, she was admitted to the emergency room for taking 12 tablets of analgesics after drinking. She was diagnosed with major depressive disorder, and it was recommended that she be hospitalized, but she refused. No special problems or symptoms were observed or reported until she lost her son in 2006. After then, she drank two bottles of soju every day. In 2008, she stopped drinking alcohol for 40 months after the birth of her daughter, but after being diagnosed as having definite HDLI she drank three bottles of soju every day. There was no history of smoking.

### Ethics statement

This study was approved by the Kangbuk Samsung Hospital Institutional Review Board (IRB No. 2019-07-050-001). Consent forms were signed by the legal representative of the victim.

## DISCUSSION AND CONCLUSION

After exposure to a humidifier disinfectant, the patient's 20-month-old son died of unknown pulmonary disease; the mother had the same symptoms but was successfully treated. The patient was depressed after losing her son and had alcohol use disorder. She stopped drinking after giving birth to her daughter, but when it was revealed that her son's death was due to humidifier disinfectant, her self-blame and depression became severe, and she died from acute liver failure caused by alcohol use disorder.

Considering that her death was caused by a humidifier disinfectant, the legal representative applied for coverage of funeral expenses. However, the current law only pays for deaths due to physical health injury from humidifier disinfectants, which meet the recognized criteria, such as lung injury, injury to fetal health, and asthma. This patient was recognized as the primary victim of humidifier disinfectant and lung disease, but there was no abnormal lung function until death. The government concluded that her death was not related to humidifier disinfectants, because she died from liver failure caused by liver transplantation due to alcoholic cirrhosis. Therefore, the government denied the request for payment of funeral expenses.

However, although this patient did not have abnormal pulmonary function at the time of death, her demise should be considered as resulting from emotional and mental injury caused by humidifier disinfectants, because these caused her son's death, which resulted in her feelings of extreme guilt and ultimately led to her excessive drinking. The company that sold the humidifier disinfectants compensated the family of the victims in this case, unlike the government. In the current government-level compensation policy, funeral expenses are paid only if research shows that cause of death was due to physical injury and none of their emotional and mental injuries were approved for compensation.

To evaluate the injuries caused by humidifier disinfectants, the Korean Environmental Health Association collected health injury reports from September 2011 to April 2012. A total of 174 cases were filed, and 69 people (40%) from 28 families reported injury to the health of other family members [5]. Unlike other disasters, the characteristic of victims exposed to humidifier disinfectants is that there may be unintentional potential offenders in victim's family [5-7]. Humidifier disinfectants can cause family-wide damage; therefore, mental

interventions and countermeasures for the humidifier disinfectant victims are urgent. Even though the government expanded the eligibility criteria, but there is still no government action on mental support of humidifier disinfectant victims, such as supporting mental health at family level. Since mental and emotional injury can occur within family members, the risk of the collapse of the entire family remains. Therefore, it is desirable to provide mental health services for humidifier disinfectant victims at family level even if they have not been physically exposed to humidifier disinfectants.

There must be more victims suffering not only from physical injury but also from emotional and mental injury caused by humidifier disinfectants, as reported here. However, studies have not been conducted on the emotional and mental injuries, and the current law does not recognize these nor compensate the victims, because there is not enough evidence to support the link between emotional and mental injury and humidifier disinfectants. Therefore, it is important to revise the current recognition criteria to include emotional and mental injury. Surveillance for emotional and mental injury has been conducted [5,8], but it has not received much attention until now. If the family of the patient in this case report had been compensated for funeral expenses, this would have helped to establish the basis for including emotional and mental injury in the recognition criteria.

In 2012, the Korean Society of Environmental Health contacted victims who had reported injuries, and 76 households participated. Of 67 participants, 56 cases (83.6%) were at high risk of PTSD, and 28 cases whose family member died due to humidifier disinfectants showed statistically significantly higher odds of having impulsive suicide attempts (odds ratio: 4.97, 95% confidence interval: 1.43–17.27) [5]. Research that surveyed 44 high-risk victims of humidifier disinfectants in 2016 found 19 cases of depression (43.2%), 10 cases of anxiety disorder (22.7%), and 9 cases of PTSD (20.5%) [8]. Also, a study that conducted a maladaptive cognitive emotion regulation survey of 40 victims of humidifier disinfectants in 2018 concluded that those with insomnia, depression, and PTSD were more likely to engage in self-blame, repetitive rumination on the past, and catastrophizing of the government's late response [6]. A survey of 26 victims at the National Mental Health Center in 2018 also revealed anxiety disorders (10 cases, 38.5%) and depression (10 cases, 38.5%) [4].

According to the survey on injury to the family and households by humidifier disinfectants, of 127 adult victims more than half had depression and were less motivated (73 cases, 57.5%), had guilt and self-blame (70 cases, 55.1%), anger (69 cases, 54.3%), and anxiety and nervousness (69 cases, 54.5%). The results for suicidal thoughts (35 cases, 27.6%) and suicide attempts (14 cases, 11.0%) were significantly higher than in the Korea National Health and Nutrition Examination Survey of 2015 (5.1% suicidal thoughts and 0.6% suicide attempts). Additionally, after being exposed to humidifier disinfectants, newly diagnosed mental disorders included sleep disorders (24 cases, 18.9%), depression (17 cases, 13.4%), and anxiety disorders (10 cases, 7.9%), indicating that these people were much more vulnerable to mental disorders than those who were not exposed [7]. Moreover, 43 (33.3%) of the 129 respondents were found to have posttraumatic embitterment disorder (PTED), a chronic reaction to stressful, negative life events which develops the tendency of a person to constantly think that he/she is a victim of this unfair event; eventually the victim becomes mentally unstable and is unable to participate in society [9,10]. In previous studies conducted on the general public, the proportion of PTED was 13–14%, so it was 2.27 times higher in victims of exposure to humidifier disinfectants. In addition, statistically significant differences were found among the victims in suicidal thought experiences between the PTED

group (27 out of 43 cases, 62.8%) and non-PTED group (15 out of 86 cases, 17.4%). This indicates that the mental pain of perceived unfairness makes the victim mentally vulnerable, as self-control becomes difficult [7,11].

According to the household survey to the humidifier disinfectant victims in 2019 which included 207 children and adolescents, there were higher rates of ADHD (46 cases, 21.4%) and developmental disorders such as autism (15 cases, 7.6%) than the general population [12]. Several studies suggested that long-term exposure to organophosphate pesticides causes mental disorders such as depression and anxiety disorder and increases suicidal thoughts [13,14]. It also has been reported to increase the risk of ADHD and autism in children [15,16]. Animal studies have shown that prolonged exposure to low levels of methylisothiazolinone (MIT), one of the components of humidifier disinfectants, may have damaging consequences to the developing central nervous system [17-19]. Considering the neurotoxicological effects of organophosphate pesticides and MIT, one of the biocides, the possibility of mental health effects due to the neurotoxicity of humidifier disinfectants should also be considered.

The Mental Health Counseling Center was established for victims with humidifier disinfectant-related emotional and mental injury, but mental health counselors refer patients to psychiatrists only if a high risk of mental disorder is observed [7]. However, the victims are less likely to participate in counseling, with less than 10% doing so due, to shyness, indifference, self-blame, and lack of information. Furthermore, whether the patients are referred to psychiatrists depends on mental health counselors, and there are difficulties in monitoring the overall condition of victims or delivering proper treatment or active countermeasures. Lack of active support for victims can lead to emotional and mental injury not only to themselves but also to their family. It is therefore important to evaluate the mental health of victims regularly, to identify patients with a high risk of humidifier disinfectant-related mental disorders and provide psychiatric treatment services for them.

The prevalence of PTSD in about 20% of adults who experienced the 9/11 World Trade Centre attacks in the United States of America is a rate four times higher than in the general prevalence [20]. Other studies have also shown that victims of 9/11 had a higher prevalence of PTSD, higher alcohol consumption, and were more vulnerable to substance abuse [21,22]. Previous studies found that adolescents have more symptoms of PTSD and are mentally more prone to shock when experiencing human-made disasters compared to natural disasters [23,24]. The medical services provided to victims of 9/11 could be applied to formulate plans to support the mental health of the victims of humidifier disinfectants. The Zadroga Act enacted in 2011 established the World Trade Center Health Program to provide medical assistance to local emergency medical technicians, volunteers, and residents who experienced 9/11. The health services, that have been continuously provided through health programs, would be a good example of establishing programs to provide health monitoring for humidifier disinfectant victims.

In Korea, a mental health trauma center was established to cope with the mental disorders of victims after the Sewol ferry disaster. Recently, the services have been expanded to include the victims of other disasters, and particularly families of victims of the Sewol ferry incident, and they have assigned managers to provide a variety of welfare services [25]. However, such care still does not apply to the victims of humidifier disinfectants, and unlike other disasters, these victims first have to be recognized for their health damage, because the recognition



criteria have not been clearly defined. Despite the damages and injuries, the recognition process, including lawsuits for claims, is too strict to allow victims to receive compensation. Therefore, in addition to criteria for the recognition of physical injury in victims of humidifier disinfectants, improvements are needed to provide proper support for mental health at institutional level for cases where exposure to humidifier disinfectants is demonstrated.

The patient in this case suffered grief and guilt related to unintentionally causing her son's death after he was exposed to humidifier disinfectants, and she lived without any symptoms for 11 years after his death. However, once she and her son were diagnosed as having had definite HDLI (level 1), she started to experience severe mental disorders due to the guilt she felt for the death of her son, leading her to drink alcohol to excess, and her eventual death at the age of 39.

Notwithstanding approval of physical injuries as criteria, there has been limited attention to humidifier disinfectant-related mental and emotional injury. This case emphasizes that after recognition of their physical injuries, we should pay attention to the emotional and mental injuries of the victims and improve interventions at an institutional level to support them.

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