

• **Special Topic**

# Humidifier disinfectant lung injury, how do we approach the issues?

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A large portion of the Korean population has been exposed to toxic humidifier disinfectants (HDs), and considering that the majority of the victims are infants, the magnitude of the damage is expected to be considerably larger than what has currently been revealed. The current victims are voicing problems caused by various diseases, including but not limited to lung, upper respiratory tract, cardiovascular, kidney, musculoskeletal, eye, and skin diseases, etc. However, there has been difficulty in gaining validation for these health problems and identifying causal relationships due to lack of evidence proving that toxic HD is the specific causes of extrapulmonary diseases such as allergic rhinitis. Furthermore, the victims and bereaved families of the HD case have not received any support for psychological distress such as post-traumatic stress disorder, depression, feelings of injustice, and anger caused by the trauma. In addition, because the underlying mechanisms of the toxic materials within the HDs such as polyhexamethylene guanidine phosphate, poly(oxyalkylene guanidine) hydrochloride, chloromethylisothiazolinone /methylisothiazolinone have yet to be determined, the demand for information regarding the HD issue is growing. The victims of the HD cases require support that goes beyond financial aid for medical costs and living expenses. There is a desperate need for government-led integrated support centers that provide individualized support through health screenings; in other words, we need an integrated facility that provides the appropriate social support to allow the victims to recover their physical and mental health, so as to well prepare them to return to a normal life. The implementation of such a plan requires not only the close cooperation between those departments already directly involved such as the Ministry of Environment and the Ministry of Health and Welfare, but also active support on a national scale from pan-governmental consultative bodies.

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## Introduction

### Investigation and the Current Status of Humidifier Disinfectant Lung Injury

The Korea Centers for Disease Control and Prevention

(KCDC) under the Ministry of Health and Welfare declared toxic humidifier disinfectant (HD) as a cause of lung injury and ordered a product recall in November 2011 [1-6]. In December 2012, a Lung Injury Investigation Committee (LIIC) was formed by professionals in the relevant fields and began the offi-

**Table 1.** General evaluation classification and definition for lung injury caused by humidifier disinfectants

Level	Injury classification
1 (definite)	As a confirmed case of humidifier disinfectant exposure, the case can be verified through centrilobular radiologic findings, typical clinical findings on the basis of clinical course of the disease, and/or pathologic findings; The possibility of humidifier disinfectant lung injury (disease of the terminal bronchiole caused by the humidifier disinfectant) is almost certain or highly probably without any other causes for the lung disease
2 (probable)	As a confirmed case of humidifier disinfectant exposure, the case can be verified through centrilobular radiologic findings, typical clinical findings on the basis of clinical course of the disease, and/or pathologic findings; The possibility of humidifier disinfectant lung injury (disease of the terminal bronchiole caused by the humidifier disinfectant) is probable or somewhat likely even though other causes cannot be ruled out completely
3 (possible)	As a confirmed case of humidifier disinfectant exposure, the case can be suspected through findings, typical clinical findings on the basis of clinical course of the disease, and/or pathologic findings but those findings are not compatible with typical humidifier disinfectant lung injury; The possibility of humidifier disinfectant lung injury (disease of the terminal bronchiole caused by the humidifier disinfectant) is probably not because other causes cannot be ruled out
4 (unlikely)	As a confirmed case of humidifier disinfectant exposure, the case is different from the findings, typical clinical findings on the basis of clinical course of the disease, and/or pathologic findings; The possibility of humidifier disinfectant lung injury (disease of the terminal bronchiole caused by the humidifier disinfectant) is almost certainly not because other causes may be suspected
Indeterminate	Lack of data to identify humidifier disinfectant lung injury

cial investigation and damage survey of the HDs starting in July 2013. The first investigation took place from July 2013 to April 2014 and the second investigation took place from July 2014 to April 2015. The first two have concluded, while the third evaluation, which began in September 2015 is still underway with 752 applicants. The fourth investigation began accepting applications in April 2016, but this time the government has shifted to a system with no deadline for applications and will be accepting ongoing victim reports. The investigation committee evaluates the degree of damage by compiling results from individual tests such as environmental exposure, histopathology, radiology, and clinical tests. The final decision regarding the identification of lung disease due to the HD is made after a final review by the Environment and Health Committee (deputy chairman of the Ministry of Environment). The classifications for being identified as a lung disease caused by HD and the definition of the respective categories of judgement are listed in Table 1 [7].

As shown in Table 2, among the total of 530 registered victims (361 and 169 individuals from the first and second investigations, respectively), 168 individuals (46.6%) from the first investigation and 49 individuals (29%) from the second investigation were classified as ‘definite’ or ‘probable’. The rest were classified as ‘possible’, ‘unlikely’, or ‘indeterminate’ due to lack of data [8,9]. A recent finding in the injury verification process of LIIC reveals that although there are fewer patients with severe lung injury in the third investigation when compared to the first and second investigations, we can see that more individuals are being acknowledged as victims even among those with minor injuries or those who were not aware that they had lung injury.

### What Is the Range of Injury From the Humidifier Disinfectants?

The magnitude and the severity of the damage from HD cannot

**Table 2.** Investigation and assessment of humidifier disinfectant victims

Investigation	Registration status (n)	Classification status of assessment
1st investigation (Jul 2013-Apr 2014)	361	Level 1: 127 (35.2) Level 2: 41 (11.4) Level 3: 42 (11.6) Level 4: 144 (39.9) Indeterminate: 7 (1.9)
2nd investigation (Jul 2014-Apr 2015)	169	Level 1: 28 (16.6) Level 2: 21 (12.4) Level 3: 21 (12.4) Level 4: 98 (58.0) Indeterminate: 1 (0.6)

Values are presented as number (%).

be evaluated just from reported cases; these cases can be estimated as only a portion of the total damage caused by HD, and even the epidemiological investigation results show that the victims that have been reported thus far are simply the tip of the iceberg.

In 2011, the KCDC under the Ministry of Health and Welfare reported that from a study conducted on 94 adults in Gwangmyeong City, Gyeonggi Province on the usage of humidifiers and HDs, 37.2% of individuals used a humidifier and 18.1% of individuals used HDs [10]. An epidemiological study conducted on 1144 pregnant women indicated that 28.2% of the subjects used a humidifier [11]. Moreover, a study conducted on 375 atopic dermatitis patients of ages 3-12 showed that 54.3% of these individuals used a humidifier [12], leading to the conclusion that a high percentage of infants suffering from allergic diseases lived in households that use humidifiers. Using the above epidemiological reports as background and considering that 18% of adults have been exposed to HDs, we can estimate that a significant portion of the population has been exposed. Furthermore, considering that a majority of the victims are infants and much of the damage has affected family units, we can

infer that the usage of HDs was more common in families with children, and that the number of victims who have been exposed to the HDs is greater than currently reported. When considering the fact that there are 20 different types of HDs with 600000 units being sold annually, the number of individuals who have used HDs could reach up to millions annually (a maximum of eight million) [7]. If the predictions are correct, then, as stated earlier, the magnitude of the damage may be much greater than what is currently known. Hence, it is necessary to conduct an epidemiological investigation using a nationwide representative sample in order to verify this prediction.

### Questions and Hopes Regarding the Diseases Suffered by the Humidifier Disinfectant Victims

Currently, the victims are voicing many illnesses and issues related to their diseases. Through examining the ongoing investigation and classification results by LIIC, we can analyze the illnesses and their requests for lung injury and non-lung injury respectively, details of which can be seen as follows (Table 3).

Firstly, regarding the lung related illnesses, there is hope that the victims will be compensated for their inability to participate in gainful employment along with their direct and indirect physical and mental suffering. Hence, on June 3, 2014, the Ministry of Environment announced that they will implement a “Plan for Additional Support for HD Victims” that will cover living expenses and caring costs of the victims [13] in addition to the medical and funeral costs that have already been supported since May 2014 [14]) until the end of the litigation.

Secondly, individuals suffering from extrapulmonary diseases or who were classified as level three or four are greatly outraged or felt injustice for not receiving social recognition of their suffering. Level three and four victims are voicing complaints of acute or chronic bronchitis, acute nasopharyngitis, acute laryngitis, asthma, acute tonsillitis, and other non-lung related diseases, primarily involving the upper respiratory tract. Other diseases that have also been reported to the Ministry of Environment include cardiovascular, kidney, musculoskeletal, eye, and skin diseases. However, these diseases have not been medically proven to be directly related to HD and as a result, these individuals are facing difficulties in receiving acknowledgment of the health damage. Also, the chloromethylisothiazolinone/methylisothiazolinone (CMIT/MIT) strand of HDs have yet to show valid evidence in animal testing [8], allowing the manufacturers of these strands to avoid legal responsibility for the damage. Hence, victims are calling for further investigation and more widespread acknowledgement of their diseases.

Finally, the request for an increase in the range of diseases recognized includes cases of fetal exposure. This is because while the main victims of HDs were initially pregnant women, the causal relation between HD and lung injury has not been clearly defined. As a result, in cases of premature birth or miscarriages, there is still a lack of direct evidence that can be utilized as a standard for evaluation, leading to conflicts regarding the lack of information pertaining to the direct causal relationships between health damage and HDs.

**Table 3.** Requests and needs for health-related information made by the humidifier disinfectant victims

Requests & needs	Details
General requests & needs	Acknowledgement of non-lung related diseases (upper and lower respiratory tract, cardiovascular, viscera, immune system, skin, etc.) Inclusion of disregarded level 3 and 4 victims in the prosecutor's investigation Establishment of practical medical support and a damage management plan Investigation and legal punishment through special hearings of relevant government departments and firms responsible for the humidifier disinfectant damage (manufacturer, sales) Establishment of a practical standard for damage compensation and medical support for the victims by passing a humidifier disinfectant special law Address the criticisms raised during the first assessment of the reported victims and hold a second assessment that addresses these complaints Comprehensive reevaluation of the CMIT/MIT damage acknowledgement standards Implementation of different damage standards for infants and adults Epidemiological investigation regarding the diseases that the victims are suffering from Addition of CMIT/MIT toxicity research
Requests & needs for medical support	A need for resolving anxiety regarding the preservation of health for victims, especially those with infants: long-term health care system and sustainable medical support by law Opening a trauma center (mental consultation and treatment for children and adults are desperately needed) Dedicated medical centers for the complete management of recovery from physical and mental diseases Increase in the number of hospitals that examine and monitor the health of victims (on a national scale)
Requests & needs for communication of information	A dedicated center that can address victims' anxiety and answer questions is needed Presentation of future plans regarding the inspection of and expansion for non-lung related diseases Explanation regarding the inspection methods of diseases caused by the humidifier disinfectant

CMIT, chloromethylisothiazolinone; MIT, methylisothiazolinone.

### The Need for Psychological Support for the Victims and Bereaved of Humidifier Disinfectants

The psychological problems suffered by the victims can be grouped as follows: depression or anxiety caused by feelings of injustice and anger from acquiring a new disease or deterioration of the current condition, and the physical symptoms followed by psychological trauma, also known as post-traumatic stress disorder (PTSD).

When examining the 2015 mental health assessment screen-

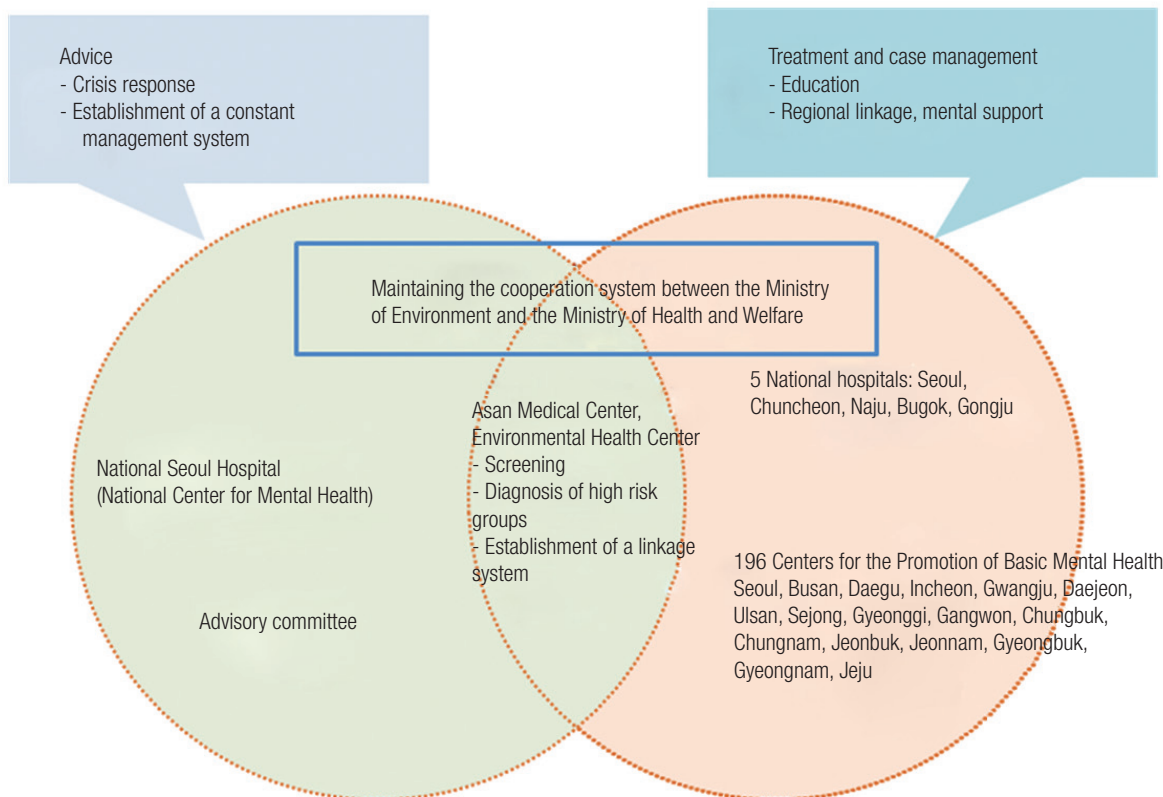
**Table 4.** Diagnosis results from the interviews conducted by neuropsychiatric specialist on high risk humidifier disinfectant patients

Diagnosis	n	%
Depression	19	43.2
Anxiety disorder	10	22.7
PTSD	9	20.5
ADHD	5	11.4
Insomnia	5	11.4
Adjustment disorder	4	9.1
PCRP	2	4.5
Panic: not definite	1	2.3
Obstructive sleep apnea	1	2.3
No specific diagnosis	10	22.7

PTSD, post-traumatic stress disorder; ADHD, attention deficit/hyperactivity disorder; PCRP, parent-child relational problem.

ing results conducted on 135 recognized victims and families of the HD case, 101 out of the 135 individuals (82 adults, 19 children and adolescents) or 74.8% of the victims and families were classified as a high-risk group, scoring extremely high on the incident impact, depression self-evaluation, and PTSD scales. Within this high-risk group, 44 victims who completed a psychiatric consultation with a professional were examined and the most common disorders were depression (43.2%), anxiety disorder (22.7%), and PTSD (20.5%). Furthermore, there were also individuals who have been diagnosed with more than two disorders, indicating a significant amount of psychological and mental suffering (Table 4) [15].

However, victims involved in the HD case have not been able to receive appropriate mental and psychological support because such problems were dismissed as personal problems. It is very concerning since by contrast, during the Sewol Ferry incident, the Gyeonggi-Ansan City Integrated Disaster Psychological Support Group was established on the day of the tragedy (April 16, 2014), and by May 1, 2014, the Ansan Mental Health Trauma Center (36 employees, annual budget of four billion Korean won) was established for the mental and psychological support of the victims and the bereaved [16]. In addition, because the HD incident caused an unprecedented amount of damage and



**Figure 1.** Individualized mental and social support system.

because the harm caused by some of the toxins such as polyhexa-methylene guanidine phosphate, poly(oxyalkylene guanidine) hydrochloride, CMIT/MIT disinfectants have yet to be identified, the anxiety of the victims and even regular civilians with even a minimal amount of exposure is ever increasing. Hence, there is a desperate need not only for a space where accurate information can be communicated, but also for support of living and medical expenses of the victims, physical and mental recovery through individualized mental and social support by means of mental health screenings, and social rehabilitation programs that allow the victims to readapt to society. In order to achieve the aims above, active cooperation between the Ministry of Environment and the Ministry of Health and Welfare, which have experience in establishing mental and psychological support centers from the Sewol Ferry incident, is imperative (Figure 1).

### The Need for a National Integrated Support Center

Under the current circumstances, even if the programs listed above are established, the victims must locate and visit each relevant center one by one for injury registration, diagnosis for evaluation/classification, and for mental and psychological consultation. Hence, in order to quickly and efficiently address the so far overlooked physical, mental, and social pain that the victims have suffered, integrated support centers on a national level that provide a one-stop service and operate with cooperation between the Ministry of Health and Welfare and the Ministry of Environment must be established (Figure 2). Furthermore, currently Asan Medical Center has been the only hospital involved in the diagnosis and evaluation; therefore, there is a dire need to increase the number of regional hospitals involved as well as the establishment of an organization that standardizes the varying

results from the different hospitals. Hence, if a national integrated support center were to be established, it would greatly reduce the confusion of the victims and their families regarding unforeseen situations, provide mental stability from the notion that they are being protected by the government, and provide a positive influence in reducing general anxiety felt by society. Such a system would also help in carrying out studies to quickly understand the mechanism of how HD leads to health damage, while also offering evidence to justify providing treatment support. In addition, such an organization would enable us to predict and prevent problems that may occur as the patients recover. All of the above would help provide ongoing physical and mental health monitoring regarding the diseases the victims and their families may suffer from, and also lend a hand in improving the quality of life of the victims and ensure their safe rehabilitation and reintegration into society.

The damage caused by the HD is not simply a singular, personal, or a family problem, but rather a social and national problem that must be closely observed by every member of society. This is not a matter that a single division such as the Ministry of Environment or the Ministry of Health and Welfare should handle by themselves, but rather a government-wide and nationwide problem that involves legislative, judicial, and executive branches. It isn't just a fleeting problem regarding an event from the past, but rather a problem that is ongoing and will continue into the future. Hence, professionals in a wide range of fields must continue research related to the victims. In particular, as a lot of difficulty was faced in attempting to find a causal relationship between the humidifier disinfectant and the diseases, CMIT/MIT mechanism study and epidemiological research should be carried out in all facets in order to find certain evi-

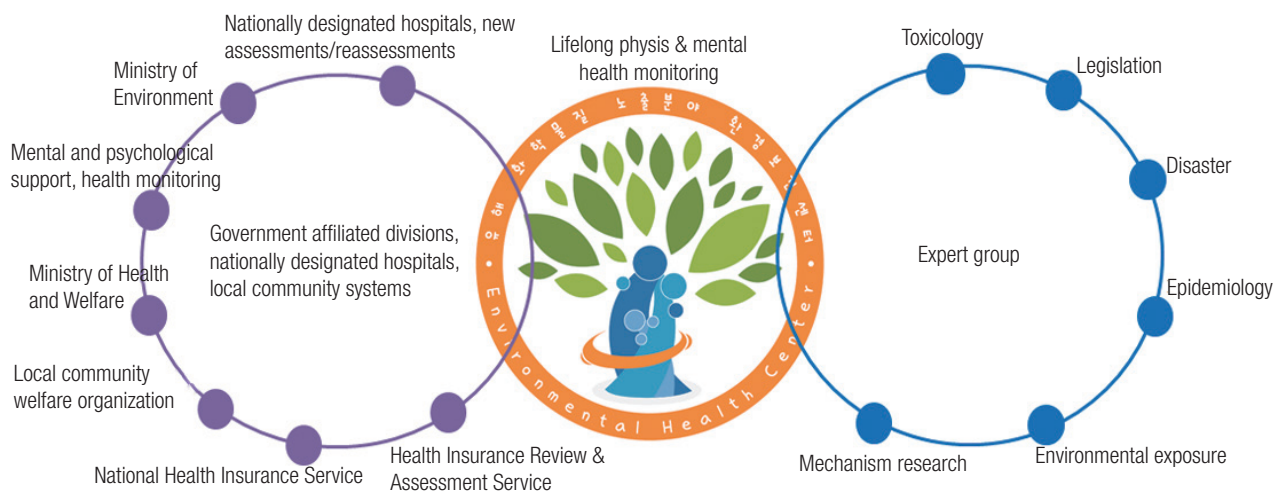


Figure 2. Integrated support center for humidifier disinfectant victims.

dence that ties the HD to the diseases, and establish how best to utilize the evidence and resolve the problem by long-term monitoring and treatment of the physical and mental health of the victims. Also, the attained knowledge and experience should be shared amongst professionals and government employees from relevant divisions to quickly address the problems faced by the victims. If we take the environment-related Minamata disease in Japan as an example, the Japanese government officially recognized that the cause of Minamata disease was poisoning linked to mercury exposure, and then passed a “Minamata Disease Special Management Law”, established a National Minamata Disease Research Center that functioned as a complete medical research facility with hospitals, epidemiological research, information centers, and environment centers. Currently, the Center is continuing research of chronic disabilities for Minamata disease patients and managing joint research businesses by holding annual symposiums to prevent another Minamata disease situation in the Philippines, Indonesia, and Vietnam [17].

## Conclusion

In conclusion, South Korea should establish a national integrated support center that can oversee all of the aforementioned systems and provide comprehensive medical support for the HD victims such as long and short term medical support, establishment of a mental support system that allows communication and manages the mental health recovery of the patients, and long term epidemiological investigation and mechanism research regarding the actual exposure and damage to find solutions to problems such as non-lung related diseases, CMIT/MIT mechanism research, and fetal exposure cases. In order to do so, the establishment of a stable support system through the passing of a special law is of the utmost importance.

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## Conflict of interest

The author has no conflicts of interest associated with material presented in this paper.

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