

# Analysis of Heavy Metals Plumbum (Pb) and Cadmium (Cd) Contained in Green Mussels (*Perna Viridis* L.) in the Jepara Sea

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**Abstract.** Heavy metals are chemical elements with high densities and can cause various health and environmental problems due to their toxicity, non-biodegradability, and accumulation. Understanding and controlling heavy metal pollution is crucial to protect human health and the environment. The purpose of this study was to analyze the heavy metal content of plumbum (Pb) and cadmium (Cd) in green mussels (*Perna viridis* L.) around the Jepara sea. This research method used Atomic Absorption Spectrophotometry (AAS) conducted in the Food Science Laboratory of Soegijapranata Catholic University, Semarang, using green mussel (*Perna viridis* L.) samples from four different locations. The data showed the presence of heavy metals in the samples, and based on the results obtained, none of the data exceeded the threshold set by SNI 2009, BPOM 2022, and WHO 2017.

Green mussels (*Perna viridis* L.) from the Jepara sea are still edible because they do not exceed the specified maximum limit. However, the results of Atomic Absorption Spectrophotometry for the heavy metal lead (Pb) from the Kedung Malang sea showed a fairly high result of 0.8491 mg/kg, which is quite close to the threshold set by SNI 2009, which is 1.0 mg/kg.

**Keywords:** cadmium, plumbum, SAA (Spechtrphotometry Atomic Absorption).

## INTRODUCTION

Heavy metals are toxic pollutants that can cause lethal and sublethal effects, such as impaired growth, behavior, and morphological characteristics in various aquatic organisms (Aris *et al.*, 2021). Heavy metals can enter aquatic organisms through the gills, body surface, digestive tract, muscles, and liver. These heavy metals can accumulate in aquatic organisms, including plumbum (Pb), mercury (Hg), arsenic (As), cadmium (Cd), chromium (Cr), and copper (Cu) (Pratiwi, 2020).

Lead is an element that cannot be degraded or destroyed, making it a toxic and hazardous heavy metal. Sources of plumbum (Pb) include exhaust from motorized vehicle transportation, automotive workshops near fish farms that produce wastewater from used oil spills, and the use of motorboats using addictive gasoline (Jusuf *et al.*, 2021). Through various intermediaries, such as air, food, or water contaminated by heavy metals, these metals can be distributed to parts of the human body and some will accumulate (Kusuma *et al.*, 2022). Heavy metal pollution in waters can lead to the accumulation of heavy metals in aquatic biota. One aquatic biota currently widely cultivated is the green mussel. Green mussels are a well-known commodity and are consumed as food. These animals have low mobility and tend to live sedentary lives, making them more susceptible to contamination by pollutants such as heavy metals. The heavy metal cadmium (Cd) is included in the non-essential metals, along with plumbum (Pb), mercury (Hg), and arsenic (As). These non-essential metals have no function in the human body but can be toxic and poisonous (Adhani & Husaini, 2017).

The natural ability of green mussels as filter feeders, as they live at the bottom of waters, results in high levels of heavy metals being absorbed into their meat. The presence of heavy metals in the meat will impact the survival of these organisms and consumers of green mussel meat. The accumulation of metals in green mussel meat, if continuously absorbed, will increase the levels of heavy metals in the meat (Riswanti *et al.*, 2023). Plumbum (Pb) heavy metal contamination in blood cockles (*Anadara granosa*) in the Naga estuary of Banda Aceh (Mujahidurrasyid *et al.*, 2024). Accumulation of Pb metal in water, sediment, and green mussels (*Perna viridis*) in Tambak Lorok waters and analysis of safe limits for human consumption (Kusuma *et al.*, 2022). Identification of heavy metal contamination (Hg, Cu, Pb, Zn, As, and Ag) in green mussels (*Perna viridis*) on Pasaran Island, Lampung Province (Muhammad *et al.*, 2024).

## METHODS

### Research Type and Design

This experimental study aimed to determine the heavy metal content of plumbum (Pb) and cadmium (Cd) in green mussels (*Perna viridis* L.) in the Jepara Sea. This research design used a

quantitative descriptive method to analyze the heavy metal content in green mussels (*Perna viridis* L.) using atomic absorption spectrophotometry on green mussel meat samples.

### **Time and Place of Research**

The research was conducted in the period of April – May 2025. This research was conducted at Soegijapranata Catholic University, BSB Campus, Jl. Rm. Hadisoebeno Sosro Wardoyo, Jatibarang, Mijen District, Semarang City, Central Java.

### **Population and Sample**

The population in this study includes aspects of the object to be studied. The population in this study includes green mussels (*Perna viridis* L.) in the Jepara Sea. This study aims to analyze the content of heavy metals plumbum (Pb) and cadmium (Cd) in green mussels in the Jepara Sea using the Atomic Absorption Spectrophotometry (AAS) method. The samples used in the study were green mussel species (*Perna viridis* L.) taken directly around the sea of Jepara City (Kedung Malang Sea, Panggung Sea, Semat Sea, Bulu Sea). Samples were taken from fishermen who had just anchored, each weighing 2 kg and 100 grams of meat were taken. Samples were taken in good and fresh condition and then the samples were destroyed. Samples were analyzed using Atomic Absorption Spectrophotometry (AAS).

### **Data analysis**

The data analysis in this study used a descriptive analysis method. The data from this study describe the concentrations of heavy metals plumbum (Pb) and cadmium (Cd) in green mussels using atomic absorption spectrophotometry (AAS). The results are presented descriptively to provide an overview and provide a summary of the data.

## **RESULTS AND DISCUSSION**

### **Sample Preparation**

In the sample preparation stage, the method used is digestion. Sample digestion aims to break the bonds between metal elements and the sample matrix to obtain the metal in its free form, which can be analyzed using an atomic absorption spectrophotometer. The type of digestion used is dry digestion, the most common method, which completely burns the organic components and leaves the inorganic residue as ash for further analysis. In dry digestion, the ashing temperature must be considered because many ash elements can evaporate at high temperatures. The advantages of this dry digestion method are simplicity and avoidance of impurities, but it can result in the loss of certain microelements. This dry digestion method is carried out by placing the sample in an ashing furnace and heating it with a gradual increase in temperature (Dharmadewi, 2019).

In this study, the first stage involved heating the shellfish sample in an oven at 100-105°C for approximately 16 hours. The second stage involved ashing in a furnace at 550°C for 3 hours until a white ash was formed. In the test, HNO<sub>3</sub> was added with the aim of dissolving or binding the metal that was destroyed from the organic sample in the ashing process.

### **Atomic Absorption Spectrophotometry (AAS) Test**

The method used in this study was an atomic absorption spectrophotometer. Atomic absorption spectrophotometry (AAS) is a method based on the absorption of light by atoms. Atoms absorb specific wavelengths of light, which are related to the properties of their elements. The wavelengths used in this study were 228.8 nm for cadmium (Cd) and 283.3 nm for plumbum (Pb).

This is consistent with research by Erlina (2003), who found that 228.8 nm and 283.3 nm are the optimum wavelengths for each metal ion, producing the strongest resonance lines for electronic transitions from the ground energy level to the excited state. Atomic absorption spectrophotometry is dependent on the ratio, but not on temperature (Tati *et al.*, 2023). The advantages of the atomic absorption spectrophotometry method used in this study are that the process is fast, highly sensitive, specific to the elements being analyzed, requires a small sample amount, and can be used to determine very low element levels (Martinez *et al.*, 2019).

### **Results of Lead (Pb) Analysis of Green Mussels**

Based on research conducted at 4 points in the Jepara sea area, the results of lead metal analysis data were obtained in Table 1.

**Table 1 Results of Pb Atomic Absorption Spectrophotometry Test**

| Green mussel sample | Mean $\pm$ SD       | Unit  | Maksimum Limit |
|---------------------|---------------------|-------|----------------|
| Laut Semat          | 0,0789 $\pm$ 0,1367 | mg/kg | 1,0 mg/kg      |
| Laut Bulu           | 0,4708 $\pm$ 0,4476 | mg/kg | 1,0 mg/kg      |
| Laut Kedung Malang  | 0,2830 $\pm$ 0,4902 | mg/kg | 1,0 mg/kg      |
| Laut Panggung       | 0,2215 $\pm$ 0,3836 | mg/kg | 1,0 mg/kg      |

Sumber : (data pribadi 2025)

Based on the results of plumbum (Pb) analysis using atomic absorption spectrophotometry, the average lead content of green mussels (Semat Sea) was 0.0789 mg/kg, while the average lead content of green mussels (Bulu Sea) was 0.4708 mg/kg, while the average lead content of green mussels (Kedung Malang Sea) was 0.2830 mg/kg, and the average lead content of green mussels (Panggung Sea) was 0.2215 mg/kg. The results showed that lead levels in green mussels found around the Jepara Sea did not exceed the maximum limits of 1.0 mg/kg (SNI, 2009; BPOM 2022) and 1.5 mg/kg (WHO 2017).

Heavy metal accumulation occurs in green mussels because they form complex compounds with organic substances, preventing them from being readily excreted by the green mussels. Heavy metals such as plumbum (Pb) accumulate in gill tissue, which is then responded to by secreting mucus that coats the gills, resulting in reduced filtration in green mussels (Muhtaroh, 2024).

Plumbum (Pb) is a highly toxic poison that impacts humans and the environment. Detoxification enzymes in green mussels (*Perna viridis* L.) are relatively low compared to other vertebrates, making it difficult to remove toxic contamination from the body (Yaqin, 2018). This condition is likely caused by fishing boat activity and waste in the waters, resulting in lead (Pb) heavy metal waste contaminating the waters (Dian *et al.*, 2021).

According to Younis *et al.* (2015), seasonal changes influence environmental conditions in water bodies. Furthermore, water quality can be influenced by water sources, flow rates, nutrients, and algae. Another factor is the presence of agricultural waste and discharges, hazardous chemicals, and natural contaminants (e.g., animal feces) that reach natural water sources, which can contaminate groundwater through seepage. Heavy metals can damage the environment and the lives of marine organisms, one of which is affected by human activities through waste disposal. Almost all waste generated from human activities contains metal elements (Sasongko *et al.*, 2022).

The entry of pollutants into the sea can damage the marine ecosystem itself and will gradually accumulate in the waters and the marine biota that live there. This can disrupt life and even cause death not only for the biota within it, but also for humans who consume it (Barokah *et al.*, 2019).

### Cadmium (Cd) Analysis Results of Green Mussels

Based on research conducted at 4 points in the Jepara sea area, the results of lead metal analysis data were obtained in Table 2.

**Table 2 Results of Cd Atomic Absorption Spectrophotometry Test**

| Green mussel sample | Mean $\pm$ SD       | Unit  | Maksimum Limit |
|---------------------|---------------------|-------|----------------|
| Laut Semat          | 0,0592 $\pm$ 0,0115 | mg/kg | 1,0 mg/kg      |
| Laut Bulu           | 0,0310 $\pm$ 0,0136 | mg/kg | 1,0 mg/kg      |
| Laut Kedung Malang  | 0,0071 $\pm$ 0,0123 | mg/kg | 1,0 mg/kg      |
| Laut Panggung       | 0,0534 $\pm$ 0,0131 | mg/kg | 1,0 mg/kg      |

Sumber : (data pribadi 2025)

The analysis of cadmium (Cd) heavy metal levels in several green mussel samples showed significant variations in concentration values. Based on the data obtained, Cd levels in green mussel samples included, green mussel samples (Semat Sea) had an average concentration of 0.0592 mg/kg, green mussel samples (Bulu Sea) had an average concentration of 0.0310 mg/kg, green mussel samples (Malang Sea) had an average concentration of 0.0212 mg/kg, and green mussel samples (Panggung Sea) had an average concentration of 0.0534 mg/kg. The results showed that cadmium levels in green mussels

found in the Jepara Sea did not exceed the maximum limit for cadmium (Cd) heavy metal contamination set for mollusks, namely 1.0 mg/kg (SNI, 2009; BPOM, 2022) and 0.42 mg/kg (WHO, 2017).

Cadmium (Cd) is a highly toxic metal, especially for humans who frequently consume it. If the concentration and composition of cadmium (Cd) in a body of water is high or exceeds the threshold, the water is likely polluted. This is because the metal can contaminate and accumulate in aquatic ecosystems, including shellfish, oysters, and fish (Harahap *et al.*, 2022). Cadmium is a type of heavy metal that is hazardous to human health. Some of the negative effects that can be caused by cadmium include damage to the kidneys, liver, testicles, immune system, nervous system, and circulatory system (Alyani *et al.*, 2017). Lead metal (Pb) is generally used as a material for making batteries, ceramics, and medical/scientific equipment, but if there is lead metal in the body that has levels exceeding the threshold, it can affect the body's metabolism such as inhibiting hemoglobin synthesis which results in anemia, nerve disorders that result in epilepsy, hallucinations and can even cause brain damage while cadmium metal (Cd) is a metal whose presence is widespread in nature, Cd metal is also widely used in everyday life, one of which is as a raw material in making paint. Cd metal if accumulated in the body will cause high blood pressure, affect the reproductive system, and can cause the growth of cancer cells (Yani, 2018).

## CONCLUSION

Based on the results of this study, it can be concluded that:

1. Green mussels (*Perna viridis* L) found around the Jepara Sea (Semat Sea, Bulu Sea, Kedung Malang Sea, Panggung Sea) contain the heavy metals lead (Pb) and cadmium (Cd) at varying levels.
2. The plumbum (Pb) content in the KHLS sample was 0.1367 mg/kg, the KHLB sample was 0.4476 mg/kg, the KHLKM sample was 0.4902 mg/kg, and the KHLP sample was 0.3836 mg/kg. Cadmium (Cd) levels in the KHLS sample were 0.0115 mg/kg, the KHLB sample was 0.0136 mg/kg, the KHLKM sample was 0.0123 mg/kg, and the KHLP sample was 0.0131 mg/kg. This means none of them exceeded the maximum plumbum (Pb) and cadmium (Cd) contamination limit set by the Indonesian National Standard (SNI), which is 1.0 mg/kg.
3. Green mussels (*Perna viridis* L) from the Jepara sea are safe for consumption because their plumbum (Pb) and cadmium (Cd) content does not exceed the safe limit.

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# Factors Affecting Inter-Dialysis Weight Gain (IDWG) in Chronic Kidney Disease Patients in the Hemodialysis Room of Soewondo Pati Regional Hospital

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**Abstract.** Chronic Kidney Disease (CKD) is a progressive and irreversible decline in kidney function that requires renal replacement therapy in the form of hemodialysis (HD). One of the main clinical problems often faced by hemodialysis patients is non-adherence to fluid intake restrictions, which directly impacts the increase in interdialytic weight gain, or Interdialytic Weight Gain (IDWG). The level of IDWG reflects accumulation of the patient's body fluid volume between two hemodialysis sessions and is significantly influenced by the patient's individual internal characteristics. The study used a quantitative descriptive research design with a univariate analysis approach to identify profiles of demographic and clinical characteristics that act as influencing factors for the level of IDWG. The study involved a total sample of 119 respondents who underwent routine hemodialysis therapy in the Hemodialysis Room at RAA Soewondo Pati Regional Hospital. Data collection was carried out using a characteristics questionnaire and a weight measurement observation sheet. The distribution of characteristics shows that the dominant individual factors among patients include the early elderly age group (46-55 years) with 40 respondents (33,6%), male gender with 69 respondents (58,0%), the most recent educational level of elementary school with 38 respondents (31,9%), not working status with 47 respondents (39,5%), and the duration of having long undergone hemodialysis therapy  $\geq 24$  months with 63 respondents (52,9%). Demographic and clinical characteristics (age, gender, education level, occupation, and duration of HD therapy) are important factors that physiologically and psychosocially affect the ability to control interdialytic fluid and the magnitude of IDWG values in patients with chronic kidney failure.

**Keywords:** Interdialytic Weight Gain (IDWG), Chronic Kidney Failure (CKD), Hemodialysis

## INTRODUCTION

Non-communicable diseases (NCDs) are diseases that cannot be transmitted between NCDs currently account for about 74% of global deaths, with around 41 million people dying each year from NCDs (Ministry of Health of the Republic of Indonesia, 2023). One of them is Chronic Kidney Disease (CKD), which affects 11.7%-15.1% of the population worldwide. CKD ranks 10th as a cause of death among adults with diabetes mellitus, hypertension, women, older adults, and members of minority racial groups are more likely to suffer from chronic kidney disease (Kovesdy, 2022).

Basic Health Research data show the proportion of hemodialysis in Indonesia as 19.33% (Ministry of Health of the Republic of Indonesia, 2018). Pernefri (Indonesian Nephrology Association) in 2022 stated that CKD patients undergoing Hemodialysis (HD) were 19.33% (2,850) (PERNEFRI, 2022). More specifically, Central Java Province ranks second after West Java Province as the province with the number of CKD patients undergoing hemodialysis in 2023 totaling 13,311 patients (Dinkes Jateng, 2023).

The hospital in Central Java with the most CKD patients is RSUD dr. Moerwadi Surakarta (Solo) with about 250-300 HD patients in 2023, likewise at the Internal Medicine Clinic of RSUD RAA Soewondo Pati; it records an increase of 1.15% in CKD cases undergoing hemodialysis therapy each month. Medical record data of RSUD RAA Soewondo Pati showed that in 2024 there were 1,945 patients with CKD.

Patients with end-stage CKD experience a drastic loss of kidney filtration function, so they require replacement therapy in the form of hemodialysis to maintain body homeostasis. During the period between two dialysis sessions (interdialytic), patients are required to comply with very strict fluid intake restrictions in order to prevent excess body fluid volume (fluid overload). This fluid accumulation is measured objectively through IDWG. The safe limit for IDWG increase is not exceeding 3% to 4,8% of the patient's dry weight. An IDWG increase that exceeds the safe threshold can trigger fatal complications such as intradialytic hypertension, severe hypotension, congestive heart failure, muscle cramps, shortness of breath (dyspnea), pulmonary edema, up to sudden death. Therefore, a deep understanding of factors from the internal characteristics of patients that influence IDWG fluctuations become very crucial for clinical management of patient care (Rahayu, 2025).

## METHODS

This study was designed using a quantitative descriptive method through a univariate analysis approach. This method is specifically focused on presenting, identifying, and analyzing the distribution of external, internal, and clinical factors arising from individual patient characteristics that influence the level of IDWG.

The population in this study involved all chronic kidney failure patients receiving routine hemodialysis therapy in the Hemodialysis Room of RSUD RAA Soewondo Pati. Sample determination used technique purposive sampling while considering clinical inclusion and exclusion criteria, thus a definitive sample size of 119 respondents was obtained. The instruments used included a respondent characteristic data sheet questionnaire (name, age, gender, education level, employment status, and duration of HD therapy) and an observation sheet of pre-HD and post-HD session weight records to calculate the percentage of IDWG values. Data analysis used descriptive statistics in the form of frequency distribution and percentage values.

## RESULTS AND DISCUSSION

Based on primary data collected from 119 respondents in the Hemodialysis Unit of RSUD RAA Soewondo Pati, a profile distribution around respondent characteristics (age, gender, education level, employment status, and duration of hemodialysis therapy) was obtained and presented in a structured table as follows:

### 1. Respondent Age

**Tabel 1** Frequency Distribution Based on Age of CKD Patients in the HD Room of RSUD RAA Soewondo Pati (n=119)

| Age                      | Frequency | Percentage (%) |
|--------------------------|-----------|----------------|
| Late adolescence (17-25) | 6         | 5              |
| Early adulthood (26-35)  | 10        | 8.4            |
| Late adulthood (36-45)   | 25        | 21             |
| Early elderly (46-55)    | 40        | 33.6           |
| Late elderly (56-65)     | 30        | 25.2           |
| Senior (>65)             | 8         | 6.7            |
| Total                    | 119       | 100            |

### 2. Respondent Gender

**Tabel 2** Frequency Distribution Based on Respondent Gender of CKD Patients in HD Room RSUD RAA Soewondo Pati (n=119)

| Gender | Frequency | Percentage (%) |
|--------|-----------|----------------|
| Female | 50        | 42             |
| Male   | 69        | 58             |
| Total  | 119       | 100            |

### 3. Respondent Education

**Tabel 3** Frequency Distribution Based on Education of Respondent CKD Patients in the HD Room of RSUD RAA Soewondo Pati (n=119)

| Eduaction          | Frequency | Percentage (%) |
|--------------------|-----------|----------------|
| Elementary school  | 38        | 31.9           |
| Junior high school | 29        | 24.4           |
| Senior high school | 37        | 31.1           |
| Higher education   | 10        | 8.4            |
| No schooling       | 5         | 4.2            |
| Total              | 119       | 100            |

### 4. Respondent Occupation

**Tabel 4** Frequency Distribution Based on Respondent Occupation Patients CKD in the HD Room RSUD RAA Soewondo Pati (n=119)

| Occupation                  | Frequency | Percentage (%) |
|-----------------------------|-----------|----------------|
| PNS                         | 11        | 9.2            |
| TNI/Polri                   | 1         | 0.8            |
| Private                     | 17        | 14.3           |
| Farmer                      | 30        | 25.2           |
| Entrepreneur/Businessperson | 13        | 10.9           |
| Unemployed                  | 47        | 39.5           |
| Total                       | 119       | 100            |

##### 5. Duration Of HD Of Respondents

**Tabel 5** Frequency Distribution Based on the Duration of HD of Patients' Respondents CKD in the HD Room of RSUD RAA Soewondo Pati (n=119)

| Duration of HD | Frequency | Percentage (%) |
|----------------|-----------|----------------|
| ≤12 months     | 20        | 16.8           |
| 13-24 months   | 36        | 30.3           |
| ≥24 months     | 63        | 52.9           |
| Total          | 119       | 100            |

Demographic and clinical characteristics above act as important internal factors underlying adherence to patient fluid management behavior and fluctuations in achieving IDWG levels:

The data analysis results show that the majority of respondents are in the early elderly age range (46-55 years) with 40 people (33.6%). Age increases linearly with progressive decline in the body's physiological functions, including the remaining nephrons function in CKD patients. Additionally, aging factors cause weakening of cognitive function and changes in osmoreceptors in regulating the thirst center in the hypothalamus, so elderly patients often have difficulty controlling daily interdialytic fluid intake consistently (Ginting, 2019).

Male respondents dominated the course of therapy with 69 respondents (58.0%). From a biological standpoint, males have a body composition with a larger proportion of muscle mass and body surface area, which naturally results in a higher basal water requirement and a thirst threshold reached more quickly. Furthermore, men generally have higher external physical activity levels and social interactions outside the home, which triggers a psychological urge to consume fluids more often than women (Jalalzadeh et al., 2021).

The respondents' last education level was dominated by elementary school graduates (SD) with 38 respondents (31.9%). Education is a foundational basis for forming an individual's health awareness. The low level of formal education impacts the limitations of the patient's cognitive grasp in understanding the implications of the dangers of accumulating excess body fluid volume. This makes it difficult to adapt to adherence to fluid diet restrictions, thus triggering instability in IDWG value increases (Saragih, 2024).

In terms of occupation activity, the data distribution is dominated by patients who are not working, namely 47 respondents (39.5%). This unemployment condition is mostly due to chronic uremic syndrome, anemia, or extreme fatigue after dialysis experienced by CKD patients, which limits their productive movement. The absence of work activity provides psychosocial impacts including increased stress, boredom, and anxiety at home, where emotional conditions are often redirected destructively in the form of excessive water consumption to relieve xerostomia or dry mouth symptoms (Sinuraya & Lismayanur, 2019).

Clinical parameter of therapy duration, the majority of respondents have undergone long-term hemodialysis (≥24 months) with 63 respondents (52.9%). The duration of HD has dual implications for patient behavior adaptation. New patients (≤12 months) are generally vulnerable to IDWG spikes due to not yet achieving self-management stability (self-care) and psychological coping mechanisms towards the fluid diet limitations. Conversely, although patients with duration ≥24 months theoretically have a mature understanding of fluid management, they still face risks clinical saturation which at any time can reduce its adherence level (Bayhakki & Hasneli, 2018).

## CONCLUSION

The results of a univariate descriptive analysis of 119 respondents in the Hemodialysis Unit of RSUD RAA Soewondo Pati can be concluded that Interdialytic Weight Gain (IDWG) in chronic kidney failure patients is complexly influenced by variations in individual characteristic factors.

These internal determining factors include the patient's age (dominated by the early elderly group), sex (dominated by males), the latest education level (dominated by primary school graduates), employment status (dominated by those not working), and the clinical duration of therapy (dominated by long-term treatment  $\geq 24$  months).

The close relationship between these demographic factors and adherence to fluid intake management indicates the need for counseling approaches and educational intervention from a medical team that is individual (tailored intervention) by taking into account the social and economic background and the cognitive capacity of each patient in order to minimize the risk of fatal complications due to excess body fluid volume (Campbell, J. I., Thomsen, J. L., & Martins, 2021).

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