

Analysis Public Health Policy on Impact Carbon Monoxide Exposure in Speedboat Workers

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ABSTRACT

Carbon monoxide (CO) is an inanimate gas dangerous color and smell If inhaled in amount This toxic gas is produced from the incomplete combustion of carbon fuels, such as gasoline, coal, wood, and tobacco. Speedboat workers are often exposed to carbon monoxide from ship engines, which can cause serious health problems if not handled properly. Effective public health policies are needed to reduce the risk of exposure and create a safer working environment for workers. This study aims to analyze public health policies on the impact of carbon monoxide exposure on speedboat workers. Literature review was conducted by searching and analyzing journals from the Pubmed and Scindirect portals with predetermined inclusion and exclusion criteria. key identified using truncated words (in matter this *) with the word in the form of : "CO" OR "Carbon Monoxide" AND "Speedboat" OR "health policy" AND "emission" OR "pollution". Exposure carbon monoxide in speedboat workers is at risk tall to health, so that required more policies strict as well as step preventive For protect they. Exposure carbon monoxide in speedboat workers can cause problem health serious , so required more policies strict and adequate protection. Preventive measures like monitoring level carbon monoxide, use tool protector self and technology friendly the environment is very important For reduce risk . With the right approach, workers' health can be better protected, creating a safe and productive work environment.

Keywords: Carbon Monoxide, Health Policy, Maritime, Speedboat

INTRODUCTION

Various industries release hazardous substances into the air, polluting the air and posing a risk to workers. Some jobs at risk of carbon monoxide emissions include the roof tile industry, parking and traffic officers exposed to motor vehicle exhaust fumes, and vendors in high-traffic areas .

Carbon monoxide (CO) is a colorless, odorless gas that is dangerous if inhaled in large quantities. This toxic gas is produced from the incomplete combustion of carbon fuels, such as gasoline, coal, wood, and tobacco. Carbon monoxide (CO) is a toxic gas produced from the incomplete combustion of fossil fuels, including those used in speedboat engines. Exposure to CO in the workplace can cause serious health problems, such as increased levels of carboxyhemoglobin (COHb) in the blood, respiratory problems, and neurological effects. ^{2,3}

Inhalation of CO causes widespread health damage through both Hb- and non-Hb-mediated pathways. CO displaces O₂ from binding sites on hemoglobin. The resulting leftward shift of the O₂-Hb dissociation curve

causes generalized hypoxia. This leads to unconsciousness, convulsions, respiratory failure, and death. At lower exposure levels, COHb is 3.4 percent, corresponding to CO of approximately 25 ppm. ⁴ Recent research indicates that workers exposed to CO over a long period of time are at increased risk of cardiovascular and respiratory disorders. Furthermore, environmental factors such as poor ventilation and inefficient fuel use exacerbate the effects of CO exposure. ²

The study results indicate that stationary conditions are generally the most dangerous; however, many vessels underway have high CO concentrations near the aft deck. Most of the vessels evaluated produced dangerous CO concentrations: peak CO concentrations often exceeded 1,000 parts per million (ppm), while average CO concentrations were well over 100 ppm aft (rear). The peak and average CO concentrations for these two outboard engines were an order of magnitude lower than those found on most other vessels evaluated. These two new engines rely on newly developed technology to burn cleanly and comply with EPA regulations for outboard marine engines. ⁵

Working on a ship often involves significant mental and physical demands that are not easily compared to those experienced in land-based professions. Seafarers have a relatively unique role because they are on the job during working hours and outside of working hours only with their colleagues, making them a highly isolated work group. ⁶ Exposure to fuel exhaust emissions affects the health of workers at sea, including speedboat drivers.

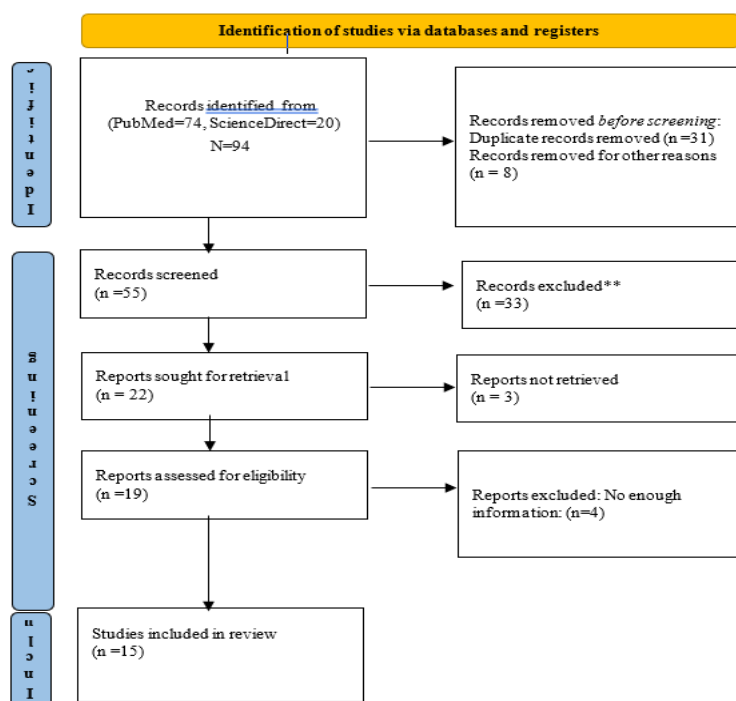
Mitigation efforts implemented in several countries include regulations on safe limits for CO exposure in the workplace, the use of personal protective equipment, and increasing worker awareness of the dangers of this gas. However, effective policy implementation remains challenging, particularly in the water transportation industry, which often has less stringent occupational safety regulations. Therefore, the authors aim to review and analyze public health policies regarding the impact of carbon monoxide exposure on speedboat workers.

MATERIALS AND METHODS

The method used in writing this article is a literature review, namely research by examining several international articles. The literature sources in this study are primarily from online database journals that provide journal articles in PDF format, such as Pubmed and Science Direct. To maintain the information up-to-date, the literature used primarily comes from literature collected over the past seven years (from 2020 to 2025).

Based on a database search, 16 articles were obtained that met the inclusion criteria, namely: 1) quantitative and qualitative research types and other relevant research; 2) the target population is CO2 exposure; 3) published between 2020-2025; 4) articles using English; and 5) articles in full text form. The key search terms were identified using truncated words (in this case*) with words such as : "CO" OR "Carbon Monoxide" AND "Speedboat" OR "health policy" AND "emission" OR "pollution".

Data were taken from articles that met the inclusion criteria and requirements and then presented in a table with columns containing author, year, country, research reference, objectives and study type and research results related to public health policies on the impact of carbon monoxide exposure on speedboat workers.



RESULTS AND DISCUSSION

A total of 15 articles met the requirements, and as a final result were obtained for review. The characteristics of the studies in the research from 15 journal articles were identified based on 3 (three) main variables including Policy and Regulation (5), Pollution and ship emissions (4), Environment and Health Impacts (6).

Policies and Regulations

Title	Author, Year, Country Reference	Objective	Study Design	Results
Carbon Dioxide Removal Policy in the Making: Assessing Developments in 9 OECD Cases	Schenuit et al, 2021, New Zealand ⁷	For evaluate development policy disappearance carbon dioxide (CDR) in nine OECD member countries	Qualitative	Research result show that CDR policy evolves through three approach main , namely modification gradually to policies that have been there is integration the beginning of the treat subtraction emissions and removals carbon as things that can exchanged , as well as entrepreneurship policies that are proactive push development technology and approaches new . Although study This only covers nine case , the findings produced potential For push studies comparison more carry on as well as more analysis deep about CDR policy that has been implemented or those who are still in stage development .
The public health implications of the Paris Agreement: a modeling study	Hamilton et al, 2021, Paris ⁸	For evaluate impact policy The Paris Agreement on health public	Modeling Study	Research result show that scenario more policies ambitious can reduce number death annual consequence pollution air , pattern eat something that is not healthy , and lack of activity physical . Compared with scenario policy moment this , scenario track sustainable produce reduction of 1.18 million death consequence pollution air , 5.86 million death related pattern eat , and 1.15 million death consequence lack of activity physical in 2040. If the policy climate more focus on health , then number death annual can reduce more far , namely 462,000 deaths consequence pollution air , 572,000 deaths consequence pattern food , and 943,000 deaths consequence lack of activity physique .
Potential implications of carbon dioxide removal for the sustainable development goals	Honegger et al, 2021, Germany ⁹	For evaluate How technology and practice disappearance carbon dioxide (CDR) can influence achievement of Sustainable Development Goals (SDGs)	Qualitative	Research result show that CDR can give benefit for mitigation change climate and support several SDGs. However , the CDR policy is less designed with Good potential cause challenges , such as conflict use land , water, biomass , and resources Power electricity . In addition , there is risk that community certain can marginalized from benefit policy this , which can impact negative on various SDGs
Carbon dioxide removal and mitigating deterrence in EU climate policy: Towards a research approach	Brad et al, 2023, Austria ¹⁰	For explore How technology disappearance carbon dioxide (CDR) can influence policy mitigation change climate in the European Union .	Qualitative	Research result show that although Still too early For identify impact direct from CDR technology against policy mitigation in the European Union , some opportunity important For prevent effect negative has missed in climate target formulation and design policy . This study focusing on Sustainable Carbon Cycle Strategy The European Union and negotiations related Framework Certification European Union Carbon Removal .
The ABC of Governance Principles for Carbon Dioxide Removal Policy	Honegger et al, 2022, Germany ¹¹	For identify principles of governance that can implemented in design policy disappearance carbon dioxide (CDR).	Qualitative	Research result show that more attention intense to dimensions normative in policy mitigation can help to unravel difference perspective and sources disagreement about the role of CDR in context policy climate certain . This study emphasize the need discussion more continued among CDR experts and practitioners to ensure that policies developed in harmony with governance principles that have been established

Based on table previously in research Study *Carbon Dioxide Removal Policy in the Making: Assessing Developments in 9 OECD Cases* aim For evaluate development policy disappearance carbon dioxide (CDR) in nine OECD member

countries in facing emission targets zero increasingly clean noticed since The 2015 Paris Agreement and the 2018 IPCC report . Research results show that CDR policy evolves through three approach main , namely modification gradually to policies that have been there is integration the beginning of the treat subtraction emissions and removals carbon as things that can exchanged , as well as entrepreneurship policies that are proactive push development technology and approaches new . Although study This only covers nine case , the findings produced potential For push studies comparison more carry on as well as more analysis deep about CDR policy that has been implemented or those who are still in development stage . ⁷

Study *The Public Health Implications of the Paris Agreement: A Modeling Study* aim For evaluate impact policy The Paris Agreement on health society . This study analyze scenario policy climate and benefits health that can obtained from implementation commitment national related subtraction greenhouse gas emissions glass in nine countries, including Brazil , China, Germany, India, Indonesia, Nigeria, South Africa, the United Kingdom , and the United States . Research results show that scenario more policies ambitious can reduce number death annual consequence pollution air , pattern eat something that is not healthy , and lack of activity physical . Compared with scenario policy moment this , scenario track sustainable produce reduction of 1.18 million death consequence pollution air in 2040. If the policy climate more focus on health , then number death annual can reduce more far , namely 462,000 deaths consequence pollution air . Research This emphasize that consider health in policy mitigation change climate can give significant benefits for public at a time help achieve safer global temperature targets . ⁸

Study *Potential Implications of Carbon Dioxide Removal for the Sustainable Development Goals* highlight that even though CDR is considered important For achieve the Paris Agreement targets in limit global warming of up to 1.5-2°C, the impact to aspect social , economic and environmental Still Not yet fully understood . Research results show that CDR can give benefit for mitigation change climate and support several SDGs. However , the CDR policy is less designed with Good potential cause challenges , such as conflict use land , water, biomass , and resources Power electricity . In addition , there is risk that community certain can marginalized from benefit policy this , which can impact negative on various SDGs. This study emphasize the need study more carry on For understand How CDR policy can designed to produce synergy with SDGs and avoid negative impacts . ⁹

Study *Carbon Dioxide Removal and Mitigation Deterrence in EU Climate Policy: Towards a Research Approach* aim For explore How technology disappearance carbon dioxide (CDR) can influence policy mitigation change climate in the European Union . This study highlight concern that expectation to availability CDR technology in scale big can hinder or replace effort subtraction higher emissions conventional . Research results show that although Still too early For identify impact direct from CDR technology against policy mitigation in the European Union , some opportunity important For prevent effect negative has missed in climate target formulation and design policy . This study focused on the European Union's Sustainable Carbon Cycle Strategy and negotiations related Framework Certification European Union Carbon Removal . ¹⁰

Study *The ABC of Governance Principles for Carbon Dioxide Removal Policy* aim For identify principles of governance that can implemented in design policy disappearance carbon dioxide (CDR). This study highlight that action mitigation change climate , including development and scale of CDR in the sector industry , energy , and agroforestry , emerged in the context of international norms that include governance objectives , provisions law , and expectation social . Research results show that more attention intense to dimensions normative in policy mitigation can help to unravel difference perspective and sources disagreement about the role of CDR in context policy climate certain . This study emphasize the need discussion more continued among CDR experts and practitioners to ensure that policies developed in harmony with principles of better governance . ¹¹

Literature rare academic but develop regarding CDR governance has show that configuration and design CDR policy , as well as the interaction with policy climate others , have implications important for the role of CDR in transition going to public with emission zero clean . ¹²⁻¹⁴ Based on comparison nine studies case , article This make an effort track to what extent has the CDR policy been implemented ? become part from regime policy climate domestic and how CDR integration is growing . While governance transition climate international towards governance a bottom-up, polycentric , and performative climate is taking place, ¹⁵ analyze facts on the ground about transformation going to deep decarbonization become more important. ¹⁶

Carbon Dioxide Removal (CDR) policy implemented in various countries has greater impact wide to environment and health society , including speedboat workers on the island vulnerable little ones to emission carbon monoxide (CO). Previous studies show that There is three approach main in CDR policy : modification gradual , integration beginning , and entrepreneurship policy proactive approach This influential to regulations emission carbon in a way overall , including CO originating from from burning material burn fossil in transportation sea . For example , policies that encourage use Bioenergy with Carbon Capture and Storage (BECCS) technology can help reduce CO₂ emissions , but also has the potential influence pattern CO emissions in sector maritime .

For speedboat workers on the island small , more CDR policy strict can give benefit in term long with push innovation technology more machines clean and efficient . However , without proper regulation , there is risk that

transition to technology low carbon can increase cost operational for community coastline dependent on transportation sea . Therefore that , CDR policy is necessary consider impact social and economic for group vulnerable communities to change regulations environment .

Ship Pollution and Emissions

Title	Author, Year, Country Reference	Objective	Study Design	Results
Investigation of sniffer technique on remote measurement of ship emissions: A case study in Shanghai, China	Li et al, 2022, Ghana ¹⁷	For develop sniffing based techniques boat For measurement emission distance Far from incoming and outgoing ships from Shanghai port on the sea open	Quantitative	Ratio factor CO ₂ emissions versus modified NO _x proposed For increase accuracy . It has been proven that with speed wind more tall than 2 m/s and test distance more short from 400 m, the sniffer technique shows high efficiency and accuracy For measurement emission distance Far the ship that fought direction wind with level detection more tall than 90% and FSC test error below 15%
Estimation of Shipping Emissions in Developing Country: A Case Study of Mohammad Bin Qasim Port, Pakistan	Hussain et al, 2022, Pakistan ¹⁸	For understand impact emission cruise to environment and provide data that can be used For develop policy subtraction emissions .	Quantitative	Research result show that carbon dioxide (CO ₂) is contributor the biggest emissions , reaching 92% of total emissions , followed by nitrogen oxide (NO _x) at 5%, and sulfur dioxide (SO ₂) by 1.5%. Research this also found that boat container contributes 64% of total emissions , while tankers contributed 24%. In addition , in November and December recorded as period with level emission the highest , namely more of 20% of total emissions .
Examining the influence of port ship activities on pollutant emissions in port environments	Gao et al, 2025, China ¹⁹	to understand the relationship between ship activity in ports and pollutant emissions in the port environment.	Quantitative	Research result show that nitrogen oxide (NO _x) emissions are proportion highest from emission pollutants produced by ships in port , followed by sulfur dioxide (SO ₂) and carbon monoxide (CO). Research this also highlights that length of coastline and population around harbor own impact positive to improvement emission pollutants , while container throughput own effect on the contrary .
Environmental Justice and Systems Analysis for Air Quality Planning at the Port of Oakland in California	Greer, 2022, California ²⁰	For analyze justice environment and systems planning quality air at the Port of Oakland, California	Quantitative	Telemedicine is effective in improving HbA1c and, thus, glycemic control in patients with type 2 diabetes. Furthermore, telemedicine interventions were also found to significantly improve other health outcomes and QoL scores. Subgroup analyses emphasized that telemonitoring interventions, delivered at a frequency of less than weekly and for a duration of 6 months, had the greatest effect on HbA1c reduction.

The table presented above shows that previous research developed a ship-based "sniffer" technique to remotely measure SO₂, NO_x, and CO₂ emissions from ships. This technique demonstrated high efficiency with a detection rate of over 90% and a measurement error below 15%, especially under conditions of wind speeds exceeding 2 m/s and a test distance of less than 400 meters. ¹⁷ Another study used an activity-based approach to estimate pollutant emissions from this port. The results showed that CO₂ was the largest contributor (92%), followed by NO_x (5%) and SO₂ (1.5%). Container ships accounted for 64% of total emissions, with November and December recording the highest emission levels. ¹⁸

A study used AIS data and geographic regression models to analyze pollutant emissions from ships in port. The results showed that NO_x was the primary pollutant, followed by SO₂ and CO. Shoreline length and population had a positive impact on emissions, while container throughput had the opposite effect. ¹⁹ Another study highlighted the environmental injustices experienced by communities surrounding the Port of Oakland due to air pollution. Using systems analysis, the study recommended environmental justice-based policies and environmentally friendly technologies to improve air quality. ²⁰

Various studies have shown that pollutant emissions from ships and ports have a significant impact on the environment and surrounding communities. Innovative measurement techniques such as ship-based "sniffers" and activity-based approaches have significantly contributed to understanding the distribution and scale of pollutant emissions. The resulting data allows for the identification of key emission sources, as well as the times and locations of highest emission concentrations, providing a solid foundation for more effective mitigation measures.

By integrating a green technology-based approach and environmental justice analysis, it is hoped that the policies designed will significantly reduce the negative impacts of air pollution. This step is crucial not only for maintaining the health of communities surrounding ports but also for supporting the sustainability of the global shipping industry. Collaborative efforts among stakeholders are key to realizing holistic and long-term solutions.

Environment and Health Impacts

Title	Author , Year , Country Reference	Objective	Study Design	Results
Mental health and psychological wellbeing of maritime personnel: a systematic review	Brooks et al, 2022, UK ²¹	For renew review previously with gather literature latest (2012-2021) about factors that influence mental health and well-being psychological	Review Systematic	Research result show that factor risk main For poor mental health among sailor covering age young , single status , health poor physical condition , exposure noise and vibration , feeling No safe , demands high work , long hours , night shifts or No irregular , poor sleep , lack of cohesion team , perception bad to management , support minimal social , lack of autonomy , uncertainty schedule , duration at sea , and commitment excessive ...
Effect of occupational exposure to welding fumes and noise on heart rate variability: An exposed-unexposed study on welders and airport workers' population	Lucas et al 2022, Mexico ²²	For evaluate impact exposure welding fumes and noise to system nerve autonomous , which is measured through variability beat heart rate (heart rate variability or HRV).	Quantitative	Research result show that welding workers have imbalance between system nerve sympathetic and parasympathetic compared to with group control (workers airport). HRV parameters such as frequency high (HF), standard deviation of normal RR interval (SDNN), and root mean square of the difference in beat intervals heart consecutive (RMSSD) more high in welding workers . In addition , the level of noise in a way significant correlated with HRV parameters in welding workers , but not in the group control
Carbon monoxide exposure potential associated with the use of recreational watercraft	Gerding et al, 2021, America ²³	For evaluate potential exposure carbon carbon monoxide (CO) associated with use boat recreation . The focus is on measurement CO concentration in various location on or near boat For understand risk health caused by emissions This .	Quantitative	Research result show that highest CO concentration found near the exhaust manifold machine , with mark maximum reached 42,600 ppm in one of the tested vessels . CO concentrations in several location exceed or almost beyond threshold set by the institution such as the US Environmental Protection Agency and the World Health Organization.
Carbon monoxide exposure inside UK road vehicles: a pilot study	Duggan, 2024, UK ²⁴	For evaluate level exposure carbon monoxide (CO) in vehicle road highway in England , as well as identify contributing factors to exposure	Quantitative	Research result show that 61% of the vehicles tested own detected CO levels , with a number of vehicle show dangerous level for health . The average CO level in the vehicle is 6.63 ppm, which exceeds The WHO recommended threshold is 3.49 ppm. The peak highest recorded CO levels is 192.17 ppm. This study also found that more vehicles old tend own higher CO levels high inside cabin , which is likely caused by a leak exhaust
Global , regional, and national mortality due to unintentional carbon monoxide poisoning, 2000 – 2021 : results from the Global Burden of Disease Study 2021	Bill, 2021, UK ²⁵	For analyze pattern demographic , temporal, and geographic from death consequence poisoning carbon monoxide which is not intentional during 2000–202 period	Quantitative	Research result show that in 2021 , the level global deaths due to poisoning carbon monoxide which is not intentional was 0.366 per 100,000 people, with a total of 28,900 deaths . Most of death occurs in men , and groups age 50–54 years own amount death highest . The Eastern European region has level death highest adjusted with age .
Air pollution, depressive and anxiety disorders, and brain effects: A systematic review	Zundel, 2022, America ²⁶	to explore the relationship between air pollution and depression and anxiety disorders, and its effects on brain structure and function.	Review Systematic	Research result show that exposure pollution air , especially PM2.5, NO2, and PM10, in general consistent associated with improvement symptom depression and anxiety . In addition , pollution air was also found relate with effect neurostructural and neurofunctional , such as improvement inflammation , stress oxidative , and neurotransmitter changes in various brain areas .

Previous table serve start from research that explores factors that influence mental health and well-being psychological worker maritime . Findings show that isolation social , conditions poor physical condition , and long

working hours is factor risk main . Research This recommend steps like improvement support social and educational For increase welfare maritime workers . ²¹

Study previously identify risk exposure carbon high levels of monoxide in users boat recreation , especially near exhaust machine . Concentration carbon monoxide often exceeds thresholds set by health agencies , indicating the need control administrative and technical For reduce exposure. ²³ This study find that a number of vehicles in England own level carbon dangerous monoxide inside cabin , which is likely caused by a leak exhaust . Findings This highlight the need testing quality air in vehicle For protect public health . ²⁴

Study This show that level global deaths due to poisoning carbon monoxide which is not intentional has decrease in a way significant since 2000. However , certain areas like Eastern Europe still own level high mortality . ²⁵ other studies research impact exposure to welding fumes and noise to variability beat heart . The result show that exposure combination of welding fumes and noise can cause imbalance system nerve autonomous , which has the potential increase risk cardiovascular disorders . ²²

This study reveal connection between pollution air with disturbance depression and anxiety , as well as effect neurostructural like inflammation and stress oxidative stress in the brain . Research This emphasize the need approach comprehensive For reduce impact pollution air to mental health. ²⁶

In addition , men as seeker living main risky exposed to CO. In almost every age , male die Because poisoning carbon monoxide at the level at least twice as much big than women . Findings This in line with what has been reported in other studies . ^{27,28} Male Possible more Possible in a way No on purpose put self they are at risk poisoning carbon monoxide moment operate machine , using equipment burner material grill (e.g. , roast), or exposed in the workplace . ²⁹

This matter reinforced by analysis factor our risk to injury consequence work . Although death consequence poisoning carbon monoxide in place Work has decrease Because regulation more work strict and poisoning alarm requirements carbon monoxide , some associated risks with environment Work still there are . ^{30,31}

Research that has been described in table previously show relatedness close between factor environment , exposure dangerous , and its impact to health physique and human mentality . From exploration welfare worker maritime conditions that are influenced by hard work until risk exposure carbon monoxide in vehicles , ships recreation, as well as global research on death consequence poisoning carbon monoxide , all highlight importance repair technology and policy mitigation risk . In addition , the impact pollution air to disturbance psychological like depression and anxiety, as well as change neurostructural , increasingly emphasize urgency steps preventive For protect health public in a way comprehensive, including worker with risk exposure high. The integration of these findings underscores the need for a holistic approach to addressing health challenges posed by environmental factors.

Speedboat workers face a variety of environmental risks that can impact their physical and mental health. High carbon monoxide exposure from engine exhaust, as identified in studies on recreational vessels, poses a serious threat to the health of speedboat workers. Furthermore, long working hours, social isolation, and stressful working conditions—similar to those experienced by maritime workers—are also risk factors affecting their well-being. Therefore, measures such as implementing technology to reduce carbon monoxide emissions, as well as providing social and educational support, are crucial to improving the quality of life and well-being of speedboat workers holistically. ³²⁻³⁸

CONCLUSION

Based on a public health policy analysis of the impact of carbon monoxide exposure on speedboat workers, it can be concluded that carbon monoxide exposure poses a serious threat to worker health, especially those exposed to it over the long term. Existing policies need to be strengthened with stricter regulations, better implementation of safety standards, and comprehensive education for workers regarding the risks and preventive measures. Furthermore, routine monitoring of carbon monoxide levels in the workplace, the use of adequate personal protective equipment, and the implementation of environmentally friendly technology in speedboat engines can be strategic steps in reducing the negative impacts of exposure. With a policy-based approach and preventive measures, worker health can be better protected, while creating a safer and more productive work environment.

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