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Hazard Analysis of Microbiological Exposure Risks for Dental Nurses in Banyuwangi Regency Using the HAZOP Method

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A B S T R A C T

This study aims to analyze the risk management of microbiological exposure hazards of Dental Nurses in Banyuwangi Regency using the HAZOP method. This type of research is quantitative analytical with a Cross-sectional approach. Microbiological hazard risk management in dental nurses uses the HAZOP method. The results of this study indicate that, during the identification process, potential hazards for dental nurses due to exposure to microbiological hazards include exposure to or splashes of patient saliva/droplets, exposure to patient fluids or blood, scratches from used sharp instruments, punctures from used syringes, improper sterilization of equipment, failure to screen for patient illnesses, contracting a patient's illness, failure to use personal protective equipment (PPE) or improper use of PPE (not according to standards), lack of concentration on work, lack of occupational health and safety (K3) training, unsafe and inappropriate work procedures, poor air circulation, unavailability of sinks and disinfectants in the workspace, and insufficient trash in every room/corner. In the risk assessment process, there were 7 low-risk potential hazards, 4 medium-risk potential hazards, and 2 high-risk potential hazards. The conclusion of this study is that the potential hazard factor with the greatest risk of causing disease is when dental nurses are exposed to patient saliva or droplets

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INTRODUCTION

Infection is a very real danger in the Dentistry environment. The field of Dentistry work cannot be separated from the possibility of direct or indirect contact with microorganisms in the patient's oral cavity. This causes infection control to be needed in various treatments in the field of dentistry including tooth extraction. Various infections can be transmitted through dental treatment, which come from various viral, bacterial, fungal infections, including Hepatitis B and HIV / AIDS. There is a very high risk for dentists to get cross-infection in performing dental extractions because they can have direct contact with blood, saliva, and contaminated tools. Lack of attention to infection prevention and control measures in dental health care facilities can have an impact on dental medical personnel who provide services as well as patients and visitors (Wagiman et al., 2022)

Research conducted by the American Dental Association (ADA) shows that the transmission of Hepatitis B disease to health workers, especially dentists who are not immunized, has a greater risk than the general population in the United States, which is 76%, while HIV transmission through blood transfusion / contaminated blood products has a very high risk of up to 90% and is found in about 3-5% of total cases worldwide. The incidence of accidents due to bloodborne virus exposure in dentists and dental assistants in Saudi Arabia was reported at 29.2% within 12 months, while in Laos it was 26% within 6 months. In Iran, the virus exposure was reported to be higher due to sharps injuries at 54.5%, while Croatia reported needle stick incidents at 57.8%, cuts at 20.9% and conjunctival exposure at 13.4%. In Poland over the past 12 months, the incidence of dental injuries was reported to be 60.4%, needle stick incidence was 16.7%, conjunctival splash was 54.7%, mucous membrane exposure was 28.1% and body fluid exposure to skin wounds was 27.6%. (Ramdan Im at al., 2017)

Percutaneous injuries reported in dental professionals in the United States are more commonly experienced by dental assistants (75%), followed by dental hygienists (18%) and dentists (7%). The Dentist and Dental Nurse or Dental and Oral Therapist profession is a profession that is prone to cross-infection with several infectious diseases due to frequent exposure to saliva and blood. This microbiological exposure is also possible in Dentistry practices due to the possibility of inhalation of aerosols or droplets containing viruses or direct contact with mucous membranes, oral fluids, and instruments and surfaces that have been contaminated by viruses (World Health Organization, 2020)

Microbiological exposures that can be transmitted through blood or air in dental practices include hepatitis B, hepatitis C, hepatitis D, hepatitis G, tuberculosis, severe acute respiratory syndrome (SARS), pneumonia, influenza and HIV AIDS. According to WHO 2020, HIV continues to be a major global public health problem, which has so far claimed 36.3 million lives. In Indonesia in 2020 there were 543,100 people with HIV and AIDS (Tahira et al. 2022)

HIV (Human Immunodeficiency Virus) AIDS (Acquired Immune Deficiency Syndrome) is one of the diseases that can hamper human activity and development. Infection with this virus results in a decrease in the body's immune system. The immune system is considered reduced if it is no longer able to fight

viral and bacterial infections, resulting in a disease. Meanwhile, AIDS describes the various symptoms and infections associated with a reduced immune system. The level of HIV in the body and the onset of certain infections are indicators that HIV infection has progressed to AIDS HIV/AIDS cases are also a very serious infectious disease problem in Banyuwangi Regency. Based on data from 2018 to 2022 sourced from the SIHA (HIV/AIDS Information System) report, the findings of new HIV cases in 2018, 2019, 2020, and 2021 tended to decrease each year while in 2022 there was an increasing trend.

The findings of new HIV cases in Banyuwangi District (2022) have decreased, from 644 case findings in 2019, down to 530 cases in 2020, as well as cases in 2021 experiencing a decrease of 83 new HIV case findings compared to 2020, this is because in 2021 the COVID-19 pandemic caused limited access to health services, people were afraid to visit health care facilities, and program priorities were more concentrated on handling the COVID-19 pandemic and imposing restrictions on social contact. The distribution of HIV case findings during 2022 in Banyuwangi district was reported as 536 case findings, a 20% increase in cases compared to case findings in 2021. The distribution of HIV cases is most concentrated in Muncar sub-district, Banyuwangi sub-district, Srono sub-district, Blimbingsari sub-district and Rogojampi sub-district. Case finding is optimal because there are many HIV testing services in Banyuwangi Regency.

Hazard is a potential source of damage or a situation that has the potential to harm humans because it contains hazards that can cause accidents or interfere with a person's safety and health. Hazard can be minimized by implementing good Occupational Safety and Health (OHS). Occupational Safety and Health hazards in terminology are classified into two, namely occupational safety hazards, which are types of hazards that have an impact on the occurrence of accidents that can cause injuries to death, as well as damage to company equipment; and occupational health hazards, which are types of hazards that have an impact on health that cause health problems and occupational diseases. Occupational Safety and Health is implemented with the aim of reducing or eliminating sources of danger that have the potential to cause harm (Haitham & Kumar, 2025).

Management has a role to organize and ensure the delivery of information and understanding of Occupational Safety and Health from the leadership to the lowest staff. To identify various problems that interfere with the running of the process and the risks contained in an equipment that can pose a detrimental risk to humans / facilities in an occupational safety and health management system can be done by various methods. Employee awareness in complying with procedures to minimize the risk of accidents in the workplace is influenced by occupational risk management. Hazards in the workplace that can cause accidents and occupational diseases can be reduced or eliminated using occupational risk management which includes hazard identification, potential hazard analysis, risk assessment, risk control, and monitoring and evaluation.

In the process of identifying and analyzing potential hazards, the Hazard and Operability study (HAZOP) method can be used (Ikhtiar et al., 2024). Hazard and Operability Study (HAZOP) is a hazard analysis technique used in preparing

and establishing the safety of a new or modified system for the presence of potential hazards or operability problems. HAZOP is a method for investigating hazards that is organized, structured and thorough to identify various problems that hinder the process and risks contained in a piece of equipment that can pose an adverse risk to humans / facilities in the system. The purpose of using HAZOP itself is to systematically review a process or operation on a system to determine whether process deviations can lead to unwanted events or accidents. Work accidents can come from human factors, and environmental factors. HAZOP systematically identifies every possible deviation from the operating conditions that have been set from a plan, looking for various causal factors that allow the abnormal conditions to arise, and determine the adverse consequences as a result of deviations and provide recommendations or actions that can be taken to reduce the impact of potential risks that have been successfully identified (Ministry of Health, 2017).

Based on the above background, it is important to analyze the risk of microbiological exposure hazards using the HAZOP method for Dental Nurses in Banyuwangi Regency. The potential for considerable harm is not only at risk to Dentists, but Dental Nurses also have considerable potential for harm. This can occur if the Dental Nurse lacks a level of vigilance and preventive action from various sources of potential microbiological exposure hazards during activities in the Dental and Oral Care work unit.

LITERATURE REVIEW

Concept of Hazard and Risk

Hazard is a source, condition or action that has the potential to cause human accident or injury, damage, or health problems (OHSAS 18001). Hazards have the potential to cause harm, such as injury, illness, loss and damage to property, damage to ecosystems, or a combination of all. Hazard is the potential inherent in a material, situation, system, or device.

Hazards are classified into five types, namely mechanical hazards, electrical hazards, physical hazards, biological hazards, and chemical hazards.

1. Mechanical Hazards

Mechanical hazards are risks posed by the movement of equipment or objects, either driven by a driving machine or by manual effort from the workforce.

2. Electrical Hazards

Electrical hazards come from electrical energy, which can cause fire, electric shock, and short circuit. The majority of work environments are exposed to electrical hazards, both from equipment that uses electrical energy and from electrical installation networks.

3. Physical Hazards

Physical hazards come from physical factors such as noise that can cause damage to ear organs, pressure, vibration, hot or cold temperatures, exposure to UV or infrared rays, light or lighting and radiation from radioactive objects.

4. Biological Hazards

Sources of biological hazards are living organisms, both flora and fauna, whose existence is closely related to the work environment or is a by-product of the work process.

5. Chemical Hazards

Chemical hazards originate from chemical compounds, either from the form or content in the material.

Risk Concept

Risk is defined as a combination of hazard elements and potential impacts that can arise from a process, either in the present or in the future. Especially in the field of insurance, risk is defined as a financial loss that arises due to uncertainty about an unwanted event.

As for the types of risk according to the OHSAS 18001 standard, Occupational Safety and Health (OHS) Risk is defined as a combination of the probability of the occurrence of a hazard and the severity of the resulting health problems or injuries. This OHS risk is always related to sources of danger that come from four main aspects: people, equipment, materials, and the work environment. The following are types of risks in the field of Occupational Safety and Health (OHS):

1. Safety Risk

Safety risks arise from any force or potential hazard sufficient to cause property damage or injury. Safety risk is a risk that has a low probability of occurring but has major consequences. Safety risks are acute and fatal and can occur at any time. Losses that occur in OHS risks are health problems, *time lost injuries*, property damage, and production losses.

2. Health Risk

Health risk is a risk that is likely to occur but the consequences are low. This risk can occur at any time continuously and has a chronic impact that has a long-term impact. Diseases that occur include respiratory disorders, neurological disorders, reproductive disorders and metabolic or systemic disorders.

***Hazard And Operability Study* (HAZOP)**

HAZOP is a safety review carried out in a structured method, based on an organized way to evaluate the safety and operation of complex machinery, or production lines. Estimating the potential hazards or threats that may arise through the HAZOP method can be achieved by using opportunity benchmarks and consequence benchmarks to obtain a number in the Risk table. After understanding the parts of the work that have been confirmed to have hazards, preventive measures can be implemented to reduce or even eliminate the risk of harm listed in the risk table.

The main purpose of implementing HAZOP (*Hazard and Operability Study*) is to examine processes or system activities in a structured manner to assess potential deviations that could lead to incidents or accidents. Systematically,

HAZOP identifies any deviation from the normal operational state, investigates the triggers that cause the abnormal condition, determines the adverse consequences, and recommends mitigation measures to reduce the detected risks.

METHODOLOGY

This type of research is quantitative analytic with a cross-sectional approach. Quantitative analytic research is "research by obtaining data in the form of numbers or qualitative data that are summarized. While the Cross-sectional research method is a study to study the relationship between the independent variable and the dependent variable by measuring once and at the same time. (8) This study aims to analyze the risk management of microbiological exposure hazards of Dental Nurses in Banyuwangi Regency with the HAZOP method.

Risk management of microbiological hazards in dental nurses using the HAZOP method. This method is used to determine the severity of the event and the consequences of each existing risk, as well as identify risks and appropriate risk control measures. In addition, researchers also conducted bivariate test analysis using Fisher's Exact Test and Chi-Square Test to test the most dominant potential hazard factors in Dental Nurses in Banyuwangi Regency.

RESEARCH RESULT

The study was conducted in Banyuwangi Regency with 53 dental nurses who are members of PTGMI Banyuwangi Regency, the results of this study are as follows:

Table 1. Analysis of Potential Hazard Factors of Microbiological Exposure that are most at risk of causing Disease in Dental Nurses in Banyuwangi Regency.

No.	Potential Hazards Most at Risk	Low		Medium		High		Sig
		n	%	n	%	n	%	
1.	Exposed or splashed by patient's saliva/droplet	38	72%	15	28%	0	0%	0.076
2.	Exposure to patient fluids or blood	51	96%	2	4%	0	0%	0.001
3	Scratched by sharp tools used	47	89%	6	11%	0	0%	0.011
4	Pricked by a used syringe.	47	89%	6	11%	0	0%	0.011
5	Sterilization of tools that are not in accordance with procedures	46	87%	5	9%	2	4%	0.000
6	Not screening patients for disease	52	98%	1	2%	0	0%	0.038
7	Not using PPE	50	94%	3	6%	0	0%	0.002
8	Not using PPE appropriately (according to standard)	44	83%	4	8%	5	9%	0.000
9	Limited availability of PPE	51	96%	2	4%	0	0%	0.001
10	Lack of concentration on work	13	25%	28	53%	12	23%	0.029

11	Lack of OHS training	51	96%	2	4%	0	0%	0.001
12	Inappropriate work procedures	37	70%	9	17%	7	13%	0.001
13	Unsafe work procedures	41	77%	8	15%	4	8%	0.000
14	Poor air circulation	48	91%	3	6%	2	4%	0.000
15	Unavailability of disinfectant sinks in the workspace	51	96%	2	4%	0	0%	0.001

Researchers conducted a comparative test on several potential hazard factors that are most at risk of causing infectious diseases in dental nurses in Banyuwangi Regency. The results of the test obtained results, due to exposure or splashing of saliva / droplets can be at risk of causing infectious diseases in dental nurses with a sig value of 0.076. As for some diseases that can be transmitted by patients to dental nurses, namely: Tuberculosis, HIV, Cough, Influenza, Pneomonia, Hepatitis, herpes, and varicella. While in dental nurses in Banyuwangi there are 2 nurses who have been exposed to infectious diseases, namely influenza and varicella.

Based on the results of observations, interviews and also secondary data that have been found by researchers, there are several potential hazards identified. The risks, sources and causes of several potential microbiological hazards are as follows:

Table 2. Risk Identification of Microbiological Exposure Hazards in Dental Nurses in Banyuwangi Regency

NO	HAZARD POTENTIAL	RISK	SOURCE	CAUSE
MEDICAL ACTIVITY				
1	Exposure to or splashing of patient's saliva/droplet	Contracting the disease	Patient's mouth	Not using PPE, no face shield, not using a mask
2	Exposed to patient's fluid or blood	Infected with disease	Patient's blood or body fluids	Not using complete PPE, not careful
3	Scratched by used sharp tools	Injury & disease transmission	Used medical devices with sharp surfaces	Lack of concentration , not wearing gloves
4	Pricked by a used syringe.	Injury, infection, disease transmission	Used syringe	Unsafe placement of used syringes or closure of syringes, not immediately disposed of in a safety box,

				lack of concentration
5	Sterilization of tools that are not in accordance with procedures	Unsterilized tools, cross-transmission	Used patient medical devices	Lack of training, haste, negligence
6	Not screening the patient for disease	Did not know the patient's infectious condition, disease transmission occurred	History of infectious patient disease	Performing actions not according to SOP, not using PPE in accordance with the patient's condition
7	Contracting the patient's disease	Infectious disease: TB, influenza, pneumonias, hepatitis, herpes, HIV, and mortality	Exposure to saliva, blood, body fluids or contaminated equipment	Not using PPE, not washing hands
8	Not using PPE or using PPE inappropriatel y (not according to the standard)	Disease transmission, protection is not maximized	Saliva/blood/patien t infected with infectious disease	Lack of concentration , negligence, PPE is not available,
9	Lack of concentration on work	Unsafe work actions, negligence at work	Dental nurse	High workload, fatigue, work stress
10	Unsafe and inappropriate work procedures	Risk of injury, High risk of exposure to infectious diseases	Inappropriate work techniques/processe s	Negligence, lack of concentration , absence of work supervision and evaluation.
NON-MEDICAL ACTIVITIES				
11	Lack of OHS training	Not knowing safe	Lack of knowledge & skills of dental nurses towards	No regular training

		procedures, injury	occupational health & safety (K3)	
12	Poor air circulation	Droplets remain in the air	Poor ventilation	Closed space, no exhaust, Ventilation area <15%-20% of floor area, Height of workplace measured from floor to ceiling area <3 M
13	Unavailability of sink and disinfectant in the workspace	Unable to wash hands directly, the process of cleaning hands after action is not maximized	Unavailable sink and disinfectant facilities	Not provided by management, no regular checking of facilities.
14	Trash is not always in every room/corner	Environmental pollution, contracting diseases	Polluted environment.	Not provided by management, no regular checking of facilities.

The risk assessment method used in this research is Hazard and Operability Study (HAZOP), where the source of information for filling HAZOP uses Expert Opinion Technique. The Expert Opinion technique involves a number of experts who are considered to have the knowledge and expertise to provide opinions on the likelihood and consequences of risks. In this study, three experts were involved who were considered to have a deep understanding of the risk management of microbiological exposure hazards in Dental Nurses.

Risk Assessment Analysis Results

Dental nurses face a high risk of exposure to patient saliva, droplets, and aerosols. This exposure mainly occurs when clinical actions are performed without the use of adequate personal protective equipment (PPE), such as masks, gloves, and especially face shields. Unpreparedness of PPE or negligence in using it increases the likelihood of direct contact with pathogenic microorganisms. These conditions can lead to the transmission of diseases such as COVID-19, tuberculosis, influenza, or other infections transmitted through droplets. With a likelihood value of 4 and severity 2, this potential risk has a score of 8 which is categorized as a high risk, thus requiring serious attention in control efforts.

In addition to saliva and droplets, dental nurses can also be exposed to patient fluids or blood when invasive actions are performed. This exposure is often caused by incomplete use of PPE or lack of care in managing potentially infectious tools or materials. The impact is significant as blood can be a medium of transmission for serious diseases, such as HIV, Hepatitis B, Hepatitis C, as well as other viral infections such as herpes and varicella. Although the severity of the disease is high, this condition is given a moderate risk assessment (score 6) because the likelihood is at level 3. However, this risk still requires strengthening SOPs and increasing compliance with consistent use of PPE.

Another risk that often occurs is that dental nurses experience scratches due to sharp tools that have been used on patients. These scratches generally start from a lack of concentration or not using the right gloves. Open wounds become a pathway for pathogenic microorganisms to enter, and this can lead to infection and the risk of contracting diseases carried by patients. Although the likelihood is rated 2, the severity reaches 3 so the total score is still in the medium risk category (6). This indicates that although the incidence is not very frequent, the impact is great enough to require increased vigilance, training, and safe methods of handling sharp instruments.

Needle sticks remain a real threat to dental nurses. These incidents are often caused by unsafe needle placement, the habit of not immediately disposing of needles in safety boxes, and low concentration due to high workload. The impact is in the form of open wounds and the risk of transmission of various blood transmitted diseases. However, since the frequency of occurrence is relatively low (L=2) and the impact is at a moderate level (C=2), this risk is categorized as low with a score of 4. Nonetheless, improvement of the medical waste management system and implementation of mandatory safety boxes are still very much needed to prevent future occurrences.

Another risk arises when nurses do not properly screen patients for diseases or perform actions that are not in accordance with SOPs. Such negligence can increase the potential for cross-infection, especially when PPE is not used according to the patient's condition. The low incidence (L=2) and moderate severity (C=2) results in a low risk score (4), but the long-term impact can be considerable if it occurs repeatedly. On the other hand, the lack of awareness to apply SOPs properly often stems from non-standardized work habits that require regular evaluation and supervision in dental facilities.

Not using PPE properly is one of the most common sources of risk in dental services. This can be triggered by lack of concentration, limited availability of PPE, minimal training, or unsafe work procedures. These conditions increase the risk of disease transmission without adequate protection. This risk is considered to be in the medium category (score 6) because the likelihood reaches 3 and severity 2. Although not considered a high risk, this issue is crucial because the use of PPE is the main line of defense in reducing microbiological exposure. Therefore, interventions such as training, supervision, and provision of adequate PPE are very important.

High workload, fatigue, and work stress also have a major impact on the concentration of dental nurses. Lack of concentration can lead to procedural

errors, occupational injuries, and increase the risk of cross-contamination and disease transmission. The risk assessment shows that this condition has a high likelihood (4) with severity 2, so the total risk reaches 8 and is categorized as high risk. The fatigue factor should receive special attention through setting realistic work schedules, stress management, and implementing task rotations so that nurses continue to work in optimal and safe conditions.

In the aspect of non-medical activities, several environmental factors also contribute to the risk of microbiological exposure. Poor air circulation, lack of facilities such as sinks and disinfectants, and inadequate waste management can trigger the transmission of airborne diseases such as TB, COVID-19, and influenza. Although each risk is in the low category due to a score of 2-4, the impact remains significant if they occur simultaneously. In addition, the lack of OHS training leads to health workers' ignorance of safe procedures, thus increasing the risk indirectly. Thus, efforts to improve facilities, provide hygiene facilities, and periodic OHS training are needed as an integral part of reducing potential microbiological hazards in dental service facilities in Banyuwangi Regency.

Recommended Risk Control Measures

Risk Control serves to reduce and even eliminate the risk of microbiological exposure to dental nurses in Banyuwangi Regency. Risk control in this study was carried out according to the level of risk according to risk management using the OHSAS 18001: 2007 reference. Recommendations for risk control measures for microbiological exposure to dental nurses in Banyuwangi Regency need to be carried out systematically, measurably and continuously. One of the main priorities is strengthening the use of Personal Protective Equipment (PPE) that meets the standards. Dental nurses must use medical masks, face shields, gloves, and aprons according to the risk level of the action. Medical actions that produce aerosols, such as scaling and tooth filling, must use a combination of masks and face shields to reduce exposure to droplets and saliva. In addition, discipline towards the use of PPE should be monitored through periodic internal audits so that risks due to negligence or unsafe work habits can be minimized.

Technical controls such as the use of powerful suction are essential to reduce the spread of droplets and aerosols. The application of suction during medical procedures has been shown to reduce aerosol particles containing microorganisms by more than 90%. In addition, dental nurses need to maintain a safe distance when communicating with patients, especially when patients are not wearing masks. Initial screening of the patient's health condition is also mandatory, including asking for a history of infectious diseases, coughing conditions, fever, or a history of close contact with infectious patients. The results of this screening can be the basis for the use of advanced PPE if needed.

To reduce the risk of blood exposure, full PPE must be used for potentially bleeding procedures, such as minor extractions or periodontal procedures. Gloves must be changed after every procedure and not used for contact with non-sterile surfaces. Implementation of the WHO 5 moments of handwashing is a key

strategy in preventing cross-infection and is the foundation of good hand hygiene practices. Regular training on proper handwashing techniques is also necessary to ensure that all dental nurses apply these standards consistently.

The risk of injury from sharp instruments can be reduced through the use of sharp protectors and the provision of safe containers for used instruments. Any sharp instruments should be handled carefully and placed in a fixed location that is easily accessible but safe from the risk of accidental contact. Gloves must be worn when handling used instruments to reduce the risk of scratches. Education on safe work behavior is needed to change the work culture that has not prioritized safety.

The risk of needlesticks can be reduced by directly disposing of used needles into a puncture-resistant safety box. Dental nurses are encouraged to use a one-handed technique when closing the syringe to avoid the risk of puncture during recapping. In addition, the use of alternative technologies such as Woodpecker super pens, anesthetic ointments, or automated anesthesia injectors can reduce dependency on traditional syringes. The use of gloves during syringe handling is also an additional safety measure that must be implemented.

The risk of not screening patients for diseases can be controlled through the provision of an initial questionnaire form that collects information on history of infectious diseases, respiratory symptoms, or other infectious diseases. In addition, special SOPs for handling high-risk patients should be developed and understood by all health workers. Dental nurses should also wear masks even at the initial patient encounter as a form of primary prevention. This systematic screening helps catch risks early and prevent unexpected exposure.

To overcome the problem of PPE non-compliance, training in the use of PPE according to standards and strict supervision are required. PPE that is damaged or does not meet standards must be removed and replaced with appropriate PPE. Dental nurses need to be given knowledge about the appropriate type of PPE based on the severity of the procedure and the patient's condition. Disciplinary audits of PPE use are an important part that must be carried out regularly by clinic or health center management.

Risks due to lack of work concentration can be reduced through humanized working hours, shift rotation, and increasing the number of officers to reduce individual workload. Stress and fatigue have a significant influence on the accuracy of medical actions and can lead to potentially dangerous procedural errors. Therefore, providing adequate rest hours, supervision between shifts, and stress management need to be implemented to maintain the physical and mental condition of dental nurses.

Non-standardized work procedures are a major risk factor for errors, injuries, and cross-contamination. Control efforts include re-education of safe work SOPs, regular Occupational Safety and Health (OHS) training, and mentoring for new employees. Old unsafe work methods need to be replaced with more standardized procedures. Medical equipment used also needs to be evaluated for safety to avoid creating additional risks.

For non-medical activities, improving room ventilation is a top priority. Dental rooms should have adequate airflow with exhaust fans or ventilation

according to safety standards (ventilation area should be at least 15-20% of the room area). Sinks with automatic taps, hand disinfectant, and availability of labeled trash cans should be ensured in every room. Tool sterilization needs to be improved with the use of automatic sterilizers and the assignment of special personnel. OHS training should be conducted regularly so that all risk control procedures can be carried out consistently and continuously.

DISCUSSION

Potential Hazard Factors of Microbiological Exposure in Dental Nurses in Banyuwangi Regency

Researchers conducted a comparative test on several potential hazard factors that are most at risk of causing infectious diseases in dental nurses in Banyuwangi Regency. The results of the test showed that exposure or splashing of saliva / droplets can be at risk of causing infectious diseases in dental nurses with a sig value of 0.076. This study is in line with research, For the act of suctioning mucus (suctioning) performed by nurses can be at risk of exposure to blood, inhalation of droplets, and exposure to patient vomit to have a risk value of 270 (priority 1) and the risk evaluation value is 90. Droplet transmission occurs when a person is in close contact (within a radius of 1 m) with someone who has respiratory symptoms (for example, coughing or sneezing), so that a person is at risk of infection through the mucosa (mouth and nose) or conjunctiva (eyes). Transmission can also occur through exposed objects in the environment around an infected person.

Health facilities such as hospitals as a means of health care can be a source of infection for sick people who are treated, health workers and everyone who comes to the hospital. Infections that exist in this health care center can be transmitted or acquired through health workers, sick people, visitors with career status or due to hospital conditions. As for some diseases that can be transmitted, namely Tubercolosis, HIV, Cough, Influenza, Pneomonia, Hepatitis, herpes, and varicella. While from the results of research on dental nurses in Banyuwangi there were 2 nurses who had been exposed to infectious diseases, namely influenza and varicella.

Influenza viruses spread between humans through airborne droplets or through contact with contaminated hand surfaces. Influenza disease is not dangerous other than that, according to Pratiwi and Kartono, influenza disease can cause death, 0.1% of the death rate is caused by influenza virus infection. Symptoms of influenza are that the body feels cold but the body is feverish and the body temperature reaches 39 C. In general, the symptoms of influenza are coughing, sneezing, fever, dizziness and the body will feel more painful, especially in the joints and throat, eye irritation, and stomach pain and so on. Chickenpox, known as varicella, is a highly contagious disease caused by the varicella-zoster virus, which also triggers shingles (snake pox) upon reactivation. Although it primarily affects children, varicella poses a greater risk to adolescents, adults, pregnant women, individuals with weakened immune systems, and newborns. Chickenpox is an airborne disease and spreads worldwide through coughing, sneezing, and contact with skin lesions.

Symptoms begin to appear 10 to 21 days after exposure; the average incubation period is about 2 weeks.

Risk Identification of Microbiological Exposure Hazards in Dental Nurses in Banyuwangi Regency

The results of the identification of the risk of microbiological exposure hazards to dental nurses in Banyuwangi Regency are as follows:

1. Exposure or Splashing of Patient Saliva / Droplets

Dental nurses can be exposed or splashed with patient saliva / droplets in all medical dental nursing actions, this can risk transmitting diseases from patients to nurses originating from the patient's mouth. This can be caused by the patient's saliva / droplets inhaled by dental nurses especially when not using PPE including face shields and masks. Droplets are small particles (shaped like raindrops) that are usually produced when someone coughs or sneezes. Some droplets fly into the air and some fall to the floor or surrounding surfaces. Dust from these surfaces will stay in the room during the activities in the room. Microorganisms in the air are an element of pollution that is very significant as a cause of symptoms of various diseases including eye irritation, skin irritation, acute respiratory infections (ARI) and several airborne infectious diseases such as tuberculosis, influenza, whooping cough and so on.

2. Exposure to Patient Fluids or Blood

Dental nurses can be exposed to fluids and blood when performing medical actions to dental nurses, this can risk the transmission of patient diseases to nurses originating from the patient's blood or body fluids especially when the patient's blood or body fluids hit the surface of the skin, mucous membranes or open skin. This can be caused by dental nurses not using complete PPE and dental nurses who are not careful during the action.

Exposure to patient fluids or blood can be through direct contact, indirect contact, and splashing. Direct contact occurs when dental nurses directly touch soft tissue or infectious lesions, blood or saliva of infected patients where microorganisms directly enter or penetrate the body through small wounds on the skin or around the operator's fingers. Indirect contact occurs when microorganisms enter the body through contaminated media or intermediate objects carrying a wide variety of pathogenic microorganisms originating from the patient's blood and saliva, for example unsterilized dental equipment. While splashes of blood, saliva or nasopharyngeal secretions in the form of spatters and aerosols can be generated when using henpis, ultrasonic scalers, water sprays. These spatters may contact the skin or mucosal wounds, eyes and mouth of the dental team or be inhaled through breathing. This risk is often overlooked as some of it will dry as a clear film on skin, clothing and other surfaces.

3. Scratched by Used Sharp Instruments

Dental nurses can be scratched by used sharp instruments when using tools that have sharp surfaces such as scissors, and scalpels. This can pose a risk of injury and transmission of disease from patient to caregiver with a source of medical instruments that have sharp surfaces that have been used. The cause of this is when the dental nurse's procedure is not careful or does not use gloves.

4. Pricked by a Used Syringe

Dental nurses can be pricked by used needles that have been contaminated with infectious fluids from patients containing blood or fluids that come from the body due to medical procedures. This poses a risk of transmitting disease, injuring or causing infection to the nurse, with the source of the used syringe. This is due to the unsafe placement of the use of syringes or closure of syringes, used syringes are not immediately disposed of to the safety box, and the lack of concentration of nurses when working.

Staff should always be vigilant and careful at work to prevent trauma when handling needles, scalpels and other sharp instruments used after procedures, when cleaning instruments and when disposing of needles. Do not recap used needles, manipulate by hand, bend, break or remove needles from syringes. Dispose of needles, syringes, knives, scalpels and other consumable sharp instruments in a puncture-proof container before placing them in the incinerator. When the special container is ¾ filled, it must be replaced with a new one to avoid scattering

5. Sterilization of Tools that are not in Accordance with the Procedure

Sterilization of tools that are not in accordance with procedures can be caused by staff errors when sterilizing tools (not according to standards) or caused by sterile tools that cannot function optimally / damaged. Sterilization of tools or materials is the process of destroying and eliminating all forms of life of living microorganisms. Inappropriate sterilization of tools has the risk of causing non-sterile tools that cause cross-transmission both from patients to nurses or nurses to patients and patients to other patients originating from used medical devices.

6. Not Using PPE or Using PPE Inappropriately (not According to Standards)

Dental nurses who when performing treatment actions on patients do not use personal protective equipment or use PPE inappropriately or not according to standards can risk causing personal protection that is not maximized, causing transmission of disease from patients to nurses from saliva, blood or body fluids of patients infected with infectious diseases. This can be caused by PPE in the room that is not available, nurses lack concentration when working so that nurses are negligent. Personal protective equipment (PPE) is equipment that must be used when working according to work hazards and risks to maintain the safety of workers and people around them. In its use, PPE is divided into three levels based on the level of risk involved. Level 1 is used for low-risk situations, Level 2 for moderate risk, and Level 3 for high risk. Level 1 is used by pre-examination triage health workers with exposure to many people but unknown disease

infection status (low risk), level 2 is used by health workers whose duties often contact with many people or perform services but unknown disease infection status (moderate risk), level 3 is used by health workers who perform direct contact services for suspected/probable/confirmed disease patients (high risk) and including those who perform aerosol action, respiratory specimen collection, and autopsy on suspected/probable/confirmed disease patients (very high risk)

7. Lack of Concentration on Work

Lack of concentration is a state when nurses cannot think clearly, do not focus on the task or do not maintain attention when performing actions on patients. Lack of concentration in nurses can lead to unsafe work actions and also negligence towards the safety of the nurses themselves and also patients. This can be caused by high nurse burden, fatigue or work stress. The signs of lack of concentration include: restlessness, difficulty sitting still, inability to perform complex tasks, lack of focus, and making careless mistakes. According to Arifin (2021) Mental workload and work stress have a significant influence on the occurrence of concentration disorders. The workload that continues to arrive can affect the mental health conditions of workers so that it is very likely to trigger the onset of stress in the workplace. The stress that arises will have an impact on the difficulty of concentration for workers so that workers will have difficulty completing their work.

8. Lack of OHS Training

Lack of K3 (Occupational Safety Health) training, is when nurses are not provided with meters regarding occupational health and safety (K3) at the beginning of entry or periodically. Providing K3 material or training is an activity organized to equip, improve and develop workers' abilities regarding K3, which contains procedures for carrying out work and knowledge of the hazards around them and their prevention. If nurses are not equipped with OHS training, there is a risk that nurses will not know safe procedures because the knowledge and skills of dental nurses regarding K3 in patient care are low.

9. Unsafe and Inappropriate Work Procedures

Nurses do not perform safe work procedures such as: not using PPE, performing actions without washing hands and performing actions according to SOP, can risk causing injury or a high risk of exposure to infectious diseases. The causes of dental nurses performing unsafe and inappropriate work procedures are due to negligence, lack of work concentration, and also the absence of work supervision and evaluation. Safe and appropriate work procedures are when work procedures are in accordance with SOPs so that patient safety goals are met. As according to the regulation of the Minister of Health (Permenkes) Number 11 of 2017 concerning Patient safety goals namely:

a. identify patients correctly
b. improve effective communication
c. improve the safety of drugs to watch out for
d. ensure the correct location of surgery/procedures
e. reduce the risk of infection due to health care

f. reduce the risk of patient injury from falls

10. Poor Air Circulation

Poor air circulation is a situation where circulation is not in accordance with standard air circulation rules, this can cause droplets to remain in the air. Air circulation is the process of changing the air in a room by introducing air from outside and removing air inside. Standard circulation is when the ventilation area is 15%-20% of the floor area.

11. Unavailability of Sinks and Disinfectants inthe Workspace

The unavailability of a sink and disinfectant in the workspace risks cleaning hands after finishing the action is not optimal or even if there is no sink, dental nurses cannot wash their hands immediately after the action. This can be caused by not checking the facilities regularly by the work unit management. In accordance with the Minister of Health Regulation No. 24 of 2016 concerning technical requirements for hospital buildings and infrastructure and also the Minister of Health Regulation No. 19 of 2024 concerning the implementation of community health centers, that health facilities, both hospitals and health centers, must be equipped with Hand Hygiene facilities in the form of sinks and hand disinfection facilities.

12. Waste is Not Always Present in Every Room / Corner of the Room

Unavailability of infectious waste in every corner of the room causes the risk of environmental pollution and can lead to disease transmission. Disease transmission can occur directly through contact with hazardous substances or indirectly through intermediaries such as disease-spreading animals or contaminated food/water/used medical equipment. The unavailability of each room is due to the fact that there is no regular checking of facilities by the management of the work unit.

Risk Control of Microbiological Exposure Hazard to Dental Nurses in Banyuwangi Regency

According to Hidayat and Danang (2024), the control of hazard risk is as follows

1. Increased OHS Training and Socialization

Although most employees have good knowledge of safety procedures, work accidents still occur. Therefore, training and socialization on OHS must be carried out on an ongoing basis, with an emphasis on hands-on practice and regular reminders of the importance of compliance with safety procedures. This training should involve real-life examples as well as simulations of hazardous conditions to enhance employee understanding and readiness.

2. Improved Supervision and Discipline Enforcement

Research shows that there is a significant relationship between compliance with safety procedures and workplace accidents. Therefore, strict supervision and discipline enforcement are essential. Companies can strengthen supervision mechanisms by adding safety inspectors in each work area and imposing strict sanctions on employees who violate safety procedures.

3. Improving Employee Work Attitudes

Poor work attitudes contribute greatly to work accidents. To overcome this, companies need to create a strong safety culture in the workplace. One effective way is to provide incentives to employees who demonstrate good work attitudes in complying with safety procedures and the use of personal protective equipment (PPE).

4. Provision and Maintenance of Good Equipment

Equipment that is not in good condition can be a major cause of workplace accidents. Therefore, companies should ensure that all work equipment is in a safe and well-maintained condition. Regular maintenance procedures and replacement of obsolete or damaged equipment should be implemented to prevent potential hazards.

5. Periodic Evaluation and Improvement of the OHS System

Companies should conduct regular evaluations of the implementation of SMK3, involving employees in the process. This includes gathering feedback from workers on the challenges and obstacles they face in carrying out safety procedures. This evaluation can serve as a basis for making improvements in the existing OHS system.

6. Strengthening Communication and Employee Engagement

Involving employees in the process of planning and implementing SMK3 can increase ownership of the safety policy. Companies can hold regular meetings or discussion forums to listen to employee input on work safety and increase their awareness of the importance of OHS.

Controlling the risk of microbiological exposure to dental nurses in Banyuwangi needs to be analyzed through a revised hierarchy of control approach in modern OHS standards (NIOSH, 2019-2024). In the hazard of exposure to patient saliva and droplets, elimination and substitution are not possible because body fluids are an integral part of dental actions. Therefore, control relies on engineering such as the use of *high-volume suction*, which according to recent research can reduce aerosols by 70-90%. From the perspective of the *Exposure Pathway Interruption* theory (Xu et al., 2020), engineering interventions work by directly interrupting the agent-host transmission *pathway*. At the administrative level, patient health screening, safety distancing, and PPE compliance audits are forms of systematic reinforcement through *behavior-based safety management* (Cooper, 2017-2023). The use of medical masks, respirators, and *face shields* strengthens the last layer of protection as emphasized in the *Multiple Barrier Infection Control* theory.

Exposure to patient blood has higher risk characteristics than saliva due to the high potential for transmission of bloodborne pathogens such as HBV, HCV, and HIV. HAZOP identified that engineering through *suction* and local ventilation is effective in reducing the potential for direct contact. Theoretically, administrative controls such as the *five moments of hand hygiene* follow the WHO guidelines (2017-2024) to break the chain of infection through the *Standard Precaution Theory* approach. The use of high-level PPE - masks, face shields and gloves - represents a *defense-in-depth* strategy, an increasingly popular concept in health risk management since 2018 to integrate multiple layers of protection to withstand the failure of any one component.

The risk of being punctured or scratched by a sharp instrument was analyzed through the *Human Error and Skill-Based Failure* theory (Reason, 2017-2022). Elimination and substitution cannot be done because sharp tools are an instrumental necessity in dental procedures. Engineering in the form of applying *sharp protectors* and *safety-engineered devices* has been supported by global research that 60-80% of needle injuries can be prevented when protective technology is used. Administration in the form of storage of sharp instruments in a special place and training in the *no recap* technique are part of an *error reduction strategy* that reduces the risk of operational errors. The use of PPE in the form of gloves serves as a physical barrier that reduces the severity of injury.

In the danger of being punctured by a used needle, the elimination approach is carried out through the direct action of throwing the needle into a *safety box*, according to OSHA and WHO standards (2019-2024). *The Hierarchy of Controls Optimization* theory states that if physical elimination is possible, then priority should be placed on that step. Engineering in the form of using *super pen woodpecker* and automatic injector technology is a form of tool substitution, although not material substitution. Administrative measures such as the one-hand scoop method are behavior-based strategies that have been shown to reduce the risk of *recapping injury* by 90% in the last five years of research. Gloves as PPE are the last layer of protection but should not be the only form of control.

At the risk of improper sterilization of equipment, the modern theory of *Infection Prevention System Reliability* (IPS-R, 2021-2024) emphasizes the importance of consistency of the sterilization process through engineering such as the use of automatic autoclaves with temperature and pressure sensors. Administration in the form of assigning special sterilizers and periodic inspections is an application of the *process ownership* concept, which in recent studies has been shown to reduce sterilization errors by 50%. The use of gloves and apron as PPE protects staff from exposure to heat, steam, and microbiological contaminants, as well as being an important element in the application of *clean handling* principles.

Other hazards such as not screening patients for diseases, the potential for contracting diseases, and the use of non-standard PPE are closely related to the *Health Belief Model* (HBM, 2018-2023) theory, where perceived risks, perceived benefits, and self-efficacy determine health worker compliance. Administration such as screening SOPs, PPE audits, and retraining are methods that increase *cues to action to* encourage safe behavior. Proper use of PPE closes the gap of droplet

and airborne transmission, according to the principles of the *respiratory protection program* updated during the COVID-19 pandemic.

Behavioral ergonomics aspects such as lack of work concentration and lack of OHS training were analyzed with *Fatigue Management* theory (ISO 2019-2024), which states that fatigue contributes to 30-40% of work incidents in health facilities. Administration in the form of shift arrangements, work rotation, provision of rest periods, and cross-shift supervision directly improve workers' *alertness levels*. Periodic OHS training, especially training for new employees, was proven in a recent study to increase *safety compliance* by 62%. These administrative controls are part of the *organizational safety climate*, an important component that influences worker behavior and compliance.

Environmental hazards such as poor air circulation, absence of sinks/handrubs, and absence of adequate trash bins were analyzed using the *Environmental Infection Control* theory (CDC, 2024). *Engineering controls* such as the installation of exhausts, air purifiers, standard ventilation, and the provision of automatic sensor sinks are forms of *engineering controls* that significantly reduce the presence of microorganisms in the air and on surfaces. Administrative measures such as limiting the number of people in the room and regularly checking the availability of disinfectants support *source control* and minimize cross-contamination. These environmental interventions are increasingly relevant as the design of healthcare workspaces has been shown to influence the level of risk of nosocomial infections.

CONCLUSIONS AND RECOMMENDATIONS

Exposure to patient saliva or droplets is the most risky potential microbiological hazard factor for dental nurses because it is the main route of transmission of diseases such as COVID-19, TB, and influenza. The identification process shows that dental nurses in Banyuwangi Regency face various potential hazards, ranging from exposure to saliva/droplets, exposure to patient blood, needlesticks, scratches by sharp tools, sterilization of tools that are not in accordance with procedures, to unsafe working environmental conditions such as poor ventilation, lack of hand washing facilities, and an unoptimal medical waste sorting system. In addition, human factors such as PPE non-compliance, lack of patient screening, unsafe work procedures, work fatigue, and lack of OHS training further increase the risk of exposure to pathogenic microorganisms. In the risk assessment process, 7 hazards were found in the low risk, 4 medium risk, and 2 high risk categories, with the high category dominated by droplet exposure and fatigue/concentration factors that can trigger procedural errors. To control all of these potential hazards, researchers applied a hierarchical control approach, namely elimination, substitution, engineering, administration, and the use of PPE. This approach is implemented through various strategies such as replacing safer work devices, improving room ventilation, providing hygiene facilities, tightening sterilization SOPs, conducting periodic OHS training, improving workload management, and requiring the use of PPE according to standards. All of these steps are expected to minimize the risk of microbiological exposure and improve the safety of dental nurses in Banyuwangi Regency in a sustainable manner.

The recommendations of this study emphasize the need to improve the microbiological exposure risk control system through strengthening service SOPs, adding regular OHS training, and optimizing the use of PPE according to standard medical procedures. In addition, supporting facilities such as room ventilation, availability of sinks, disinfectant dispensers, and medical waste sorting systems need to be improved to meet safety standards. Regular evaluation of the workload and compliance of dental nurses in implementing safe work procedures is also needed. Future research is recommended to explore organizational and behavioral factors that influence OHS compliance, and test the effectiveness of engineering and training-based interventions in reducing the risk of microbiological exposure in dental service facilities.

ADVANCED RESEARCH

Further research is focused on developing and testing evidence-based safety interventions to reduce the risk of microbiological exposure in dental nurses, such as evaluating the effectiveness of clinical OHS training, piloting a program to improve PPE compliance, or analyzing the impact of room ventilation engineering on reducing bioaerosol levels in dental rooms. In addition, in-depth research on behavioral, managerial, and cultural factors of occupational safety in dental service facilities can be conducted using a mixed methods approach to understand the determinants of OHS compliance more comprehensively.

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