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Identification of Occupational Accident Risks in Nanomaterial Laboratories in Higher Education Based on Human Factors

The article describes a concept of health and safety to conduct research in Nanomaterial Laboratory in Two Public University in Malang, East Java, Indonesia. The utilization of nanomaterials in the world of education has been done in two universities in Malang, namely Malang State University and Brawijaya University. The nanomaterial laboratory as a means for research and development of nanomaterial science that often creates hazards and risks of work accidents for its users, but things that are often not realized. Dangers and risks of work accidents caused by the absence of standards. This research focuses on hazards and accidents in the nanomaterial laboratory using the HIRA (Hazard Identification and Risk Assessment) method, which is then followed by a variety of independent variables. The population in this study were nanomaterial researchers at two universities in Malang. Based on the results of trials between respondents' competency expertise with the level of risk of workplace accidents in the nanomaterial laboratory obtained p-value 0.00 (<0.05), meaning that there is a significant relationship between the respondents' scientific conservation and the level of work accident risk in the nanomaterials laboratory. Furthermore, the results of the study were also obtained between the research respondents with the level of risk of work accidents in the nanomaterial laboratory with a p-value of 0.00 (<0.05), meaning that there was a significant correlation between the respondent's research experience and the level of work accident risk in the nanomaterial laboratory.

Keywords: Nanomaterial, Laboratory, Accident Risk, Occupational Health, Human Factors

1. INTRODUCTION

The development of science and technology in various countries in the world today is increasing, one believes about the engineering of nanoscale materials or known as nanotechnology [1]. Nanotechnology is simply defined as the application of engineering fully into the tools or devices intended for industrial or commercial purposes. Nanotechnology in material technology is known as nanomaterial nanomaterials [2].

Nanomaterials are structures with 100 nanometers or less, can be utilized in various fields such as physics, chemistry, even biology and medical. Materials in this size range can be used on a large scale or with little interaction with chemistry. The results of these interactions can provide interactions with biological systems and environments that require toxicity [3]. Implement effective measures to reduce or eliminate the initial steps in preventing adverse effects on workers who produce or use nanomaterials [4].

The potential benefits of nanomaterials for health and the environment have been widely studied, however also this negative material for health and the environment or more specifically can cause poisoning that cannot be separated from trials. Among them are thinking about the side effects of using nanomaterials in the health field and the ability of nature to decompose these particles. These side effects come from the entry of foreign particles into the.

Nanomaterials have various uses in various fields in life. Several breakthroughs have emerged in the field of nanomaterials, such developments can be found in various products that we use every day, for example

in food and cosmetic packages; Besides nanomaterials are also used in the health sector, one of which is drug delivery in cancer therapy [5]. Through the development of nanotechnology in life, it is necessary to increase understanding of nanotechnology in society that can be introduced through the world of education [6]. Including the science of technology development or nanotechnology in the curriculum of learning in tertiary education institutions is one alternative that can be applied.

The nanomaterial laboratory as a supporting facility in the development of nanomaterial science is a place that has the potential to cause danger and risk to humans and the environment. The potential hazards that exist in nanomaterial laboratories are often not realized by the people involved in them, this is due to the lack of assessment standards and the lack of providing information about the potential hazards and risks of work accidents in nanomaterial laboratories [7]. Based on the Decree of the Minister of Health No.605/Menkes/SKNI1 of 2008 concerning Standards for Health Laboratory Centers and Health Laboratory Centers to ensure that each laboratory has good standards. These standards include labor standards, facilities, infrastructure and equipment standards, media and reagent standards, laboratory occupational safety and health as well as recording and reporting. Safety practices in laboratories at universities require great attention. Based on data from the OSHA (Occupational Safety and Health Administration) states that nearly ten thousand accident cases in research laboratories during 2005, injured two out of 100 scientists. Other data states that the average accident rate in an academic laboratory is ten to fifty times higher than that which occurs in an industrial laboratory [8].

Based on data collection through observation or observations on the condition of nanomaterial laboratories in Malang City University that has nanomaterial laboratory facilities, many risks and hazard threats are found in workplace accidents. The laboratory conditions can occur due to a relationship with several other supporting factors that can cause risk and danger threats there. Of the many findings of supporting factors that have a relationship with the level of risk of workplace accidents in the nanomaterial laboratory, researchers see that there is a very significant relationship to the two supporting factors that cause the high value of risks and hazards in the nanomaterial laboratory that are on individual respondent factors namely the scientific concentration owned and research experience he has ever done.

2. METHODS

This research is a descriptive analysis research with a cross-sectional approach. The object of research taken in this study is knowledge of occupational safety and health, work attitudes, and the level of work accident risk. This study focuses on the hazards and risks of workplace accidents in the nanomaterial laboratory using the HIRA (Hazard Identification and Risk Assessment) method and then is associated with several independent variables.

The population in this study were students and/or lecturers who were conducting nanomaterial research at Malang State University and Brawijaya University in 2019 as many as 67 people. While the samples in this study were drawn from populations that met the inclusion and exclusion criteria.

The data collected was obtained through a questionnaire that was used to determine occupational health and safety knowledge and work attitudes of nanomaterial researchers. Based on the research objectives and taking into account the type of data obtained, the data obtained can be analyzed by univariate, bivariate and multivariate analysis. Before data analysis is performed, the data is processed first. This research focuses on the danger and risk of accidents in the nanomaterial laboratory. The research sample of 35 respondents drawn from populations that meet the inclusion criteria and exclusion criteria. The data in this study were taken based on the results of interviews and questionnaire distribution, the data were then analyzed with 3 stages of univariate, bivariate, and multivariate techniques.

3. RESULTS AND DISCUSSIONS

Risk is the possibility that an accident will occur and can result in damage. So that risk factors are things or variables related to the likelihood of accidents that will occur and can cause damage. While the risk of workplace accidents is the possibility of an accident or loss in a certain period. Factors that influence the risk of work accidents are human factors, work factors, environmental factors, chemical factors, and biological environmental factors [9]. Based on data collection through observations or observations on the condition of the nanomaterial laboratories at Malang State University and Brawijaya University, the results for the nanomaterial laboratories at Malang State University are at a high level of risk while the UB nanomaterial laboratories are at a moderate level of risk.

According to Ibrahim (2017), there are three moving factors in a single chain that can cause work accidents, namely the environment, work, and humans [10]. It turns out that work accidents are not only

influenced by physical environmental factors, but one of the most important factors is humans. This is because humans are the ones who act as subjects of work actors, so the factors causing occupational accidents cannot be separated from human characteristics and behavior [11]. The statement is in line with observational data made by researchers, where the level of risk of work accidents in the nanomaterial laboratory is caused by several other supporting factors found in human characteristics. The following is a discussion of the relationship between the supporting factors that exist in the characteristics of respondents with the level of risk of workplace accidents in the nanomaterial laboratory.

3.1 The Relationship of Scientific Concentration of Respondents and the Level of Occupational Accident Risk in the Nanomaterial Laboratory

Correlation test results between the scientific concentration of respondents with the level of risk of work accidents in the nanomaterial laboratory get a significance value of 0.00 ($<p$ -value 0.005) which means that there is a significant relationship between the scientific concentration of respondents with the level of risk of work accidents in the nanomaterial laboratory. This is evidenced through the post hoc test results in which to rank the risk of occupational accidents in the nanomaterial laboratory at the highest concentration of scientific nanomaterials, for the level of risk of work accidents in the second-highest nanomaterial laboratory namely the concentration of Mechanical Engineering and for the level of occupational accident risk in the laboratory The lowest nanomaterials are at the Concentration of Material Physics. Thus it can be concluded that there is a significant difference in the level of risk of workplace accidents in the nanomaterial laboratory between the concentration of nanomaterial science, mechanical engineering, and material physics.

Expertise is one of the causes of accidents originating from unsafe action or the human factor itself. The ability to carry out to do a job or task based on skills and knowledge and is supported by the work attitude demanded by the job [12]. According to Tarwaka (2014), education and skills in something are essential especially in dealing with new technologies, so workers can use and at the same time maintain them in the event of damage that can be fatal to themselves and the environment. Running a job that is not following his expertise is one of the causes of accidents [13].

3.2 Relationship of Respondents Research Experiences with Occupational Risk at Work in the Nanomaterial Laboratory

Then for the correlation between respondents' research experience with the level of work accident risk in the nanomaterial laboratory has a significance value of 0.00 ($<p$ -value 0.05) which means that there is a significant relationship between the respondent's research experience with the level of work accident risk in the laboratory nanomaterials have significance value. These results are also proven through post hoc tests. It is known that there are significant differences in the level of occupational accident risk with respondents' research experience. For the highest order of occupational accident risk, the research experience is 3-5 times, then the research experience is < 3 times. Then research experience 6-10 times and research experience 11-15 times. It can be concluded that there are significant differences in the level of risk of work accidents in the nanomaterial laboratory with the research experience of respondents.

These results are in line with the opinion of the Pratama (2015) work period or long work experience is not a determining factor that the worker can behave safely while working. Work experience is the level of mastery of a person's knowledge and skills in his work that can be measured from the working period and from the level of knowledge and skills he has. Researchers assume the existence of a significant relationship that can occur in a nanomaterial researcher who has a lot of research experience or longer will provide an increase in his knowledge in working with nanomaterials so that the risk of accidents in the nanomaterial laboratory is also likely to occur. Also, this can be influenced by the characteristics of each human resource. As said by Harahap (2014), that the increase in knowledge according to Roffey Park Management Institute research is influenced by experience, the main abilities included are flexibility, creativity, ability to change and the desire to continue learning [14].

In addition to the concentration of knowledge and research experience of respondents, among the factors that can affect the level of risk of workplace accidents in the nanomaterial laboratory in this study is the knowledge of nanomaterial researchers about occupational safety and health and work attitudes in the nanomaterial laboratory. Based on the results of observations show that most researchers in the nanomaterial laboratory have work attitudes that are not following occupational safety and health, as for some indicators of the work attitude of researchers in the nanomaterial laboratory that look less good, namely:

1. Not wearing personal protective equipment (PPE) Most of the bad attitudes are caused by not using PPE when conducting research/experiments. 49% stated that they sometimes did not use PPE when

conducting research/experiments. That is because nanomaterial researchers have the notion that what they do is not so dangerous. Whereas in the process of research/experiment researchers use chemicals that are quite dangerous which can irritate the skin, in addition to the research process that uses high-pressure machines that can cause burns on the skin.

2. Chatting while researching as many as 74% stated that they sometimes chatted until they were joking while researching or experimenting. Although the reasons that are often put forward based on observation and a little question and answer are to eliminate boredom while waiting for the results of research/experiments, but still this unfavorable attitude opens space to cause a bad concentration of work accidents. This can be caused while doing research/experiments while chatting allows negligence or not concentration.
3. Not following the SOP Based on the results of the data obtained that only 12% of researchers stated that sometimes followed the SOP. Procedures that are followed according to the worker include the way the work must be done while doing research/experiments. The overall SOP that followed was more technical rather than safety.

4. CONCLUSION

Based on the above results it can be said that the concentration of expertise and work experience of nanomaterial researchers are two of the individual factors that influence the level of risk in nanomaterial laboratories. The main causes of accidents are related to the complex nature of work, workplace conditions and also human behavior, and the absence of occupational safety and health management. Most of the problems are that workers tend to underestimate long- standing risks such as falls, and violence that occurs in the workplace, so both of these need to be controlled. The conclusion that can be drawn from this research is that there is a significant relationship between the level of risk in the nanomaterials laboratory if analyzed with scientific concentration and research experience.

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