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Prevalence of musculoskeletal disorders among blacksmith workers in Sawan Village Sawan District Buleleng Regency Bali

Gde Bagus Raditya Nugraha Nukarna*, Ni Luh Putu Ariastuti, Komang Ayu Kartika Sari

Program Studi Sarjana Kedokteran dan Profesi Dokter, Fakultas Kedokteran, Universitas Udayana

Corresponding author: *E-mail: gusadit627.2000@gmail.com

Abstract

Background: Blacksmithing work poses high risks for occupational diseases, including musculoskeletal disorders (MSDs), such as hearing loss, injuries from sharp tools, and muscle strain from hammering activities. In Sawan Village, there are 25 workplaces with at least two workers per location, most of whom report fatigue and discomfort.

Purpose: To describe the prevalence of musculoskeletal disorders among blacksmith workers in the village.

Method: A descriptive study design with a cross-sectional method and total sampling technique, involving 50 workers from 25 blacksmithing centers. Data were collected using risk factor questionnaires, Nordic Body Map (NBM) questionnaires, and measurements of body weight and height. Data analysis was conducted through cross-tabulation using SPSS software, based on risk factors and the severity of the disorders.

Results: Showed that most workers were under 45 years old (75%), had a BMI classified as thin-normal (72.72%), had 11-20 years of experience (59.09%), worked ≤ 8 hours per day (54.55%), and took breaks lasting less than 60 minutes (43.18%). Musculoskeletal disorders were predominantly found in the wrists and hands, with all respondents (100%) categorized as having a low-risk level.

Conclusion: 44 workers reported musculoskeletal complaints, all within the low-risk category.

Suggestion: Interventions in the form of improving work ergonomics, regulating rest periods, and occupational health education are essential to reduce the risk of MSDs and improve the quality of work of blacksmiths.

Keywords: Blacksmithing; Musculoskeletal Disorders; Nordic Body Map.

INTRODUCTION

Work, regardless of its nature, inevitably involves risks and accidents. From light to heavy tasks, each job has its own risks and potential workplace accidents. To ensure that work is carried out effectively and efficiently, a system is needed to manage and mitigate these risks, commonly referred to as an occupational safety and health (OSH) system. According to the World Health Organization (WHO), OSH is designed to create a safe, comfortable, healthy, and environmentally friendly workplace, benefiting both the environment and the workers. This system aims to boost work efficiency and productivity, ultimately improving the health and

well-being of all parties involved in the workplace (World Health Organization, 2022; Hody, Croisier, Bury, Rogister, & Leprince, 2019).

Therefore, adhering to OSH norms and regulations is essential to improve worker welfare, protect production assets, and ensure sustainable business continuity. The nature of blacksmithing involves movements that carry a high risk of occupational illnesses. These include hearing loss from hammering materials like iron or steel, injuries caused by hammer impacts or sharp tools, musculoskeletal disorders from repetitive hammering, and poor ergonomic posture. Previous

Prevalence of musculoskeletal disorders among blacksmith workers in Sawan Village Sawan District Buleleng Regency Bali

studies found that occupational accidents among blacksmiths occurred at a rate of 84.21% in 2006, 78.94% in 2007, and 89.47% in 2008. Previous studies blacksmiths suffered from varying degrees of musculoskeletal disorders, ranging from mild discomfort to severe pain in skeletal muscles, joints, and nerves caused by poor working postures (Asnel & Pratiwi, 2021; Govaerts, Tassignon, Ghillebert, Serrien, De Bock, Ampe, & De Pauw, 2021).

Like other illnesses, musculoskeletal disorders are influenced by various factors. Previous studies identified multiple risk factors associated with musculoskeletal disorders, including work posture, ergonomic conditions of tools, total physical load, the use of heavy equipment, repetitive tasks, mental load (rest, working hours, time pressure, work duration), vibrations during work, temperature conditions, and psychosocial factors (work relationships, social support, and job satisfaction) (Tuček & Vaněček, 2020; Chen & Shan, 2019). Gender also plays a role, as women are 2.52% more likely to experience musculoskeletal disorders than men. This is due to women's maximum physical capacity being about 70% of men's, and their smaller muscle mass resulting in lower muscular strength (Kaewdok, Sirisawasd, & Taptagaporn, 2021).

In previous research, it was stated that musculoskeletal disorders are one of the problems found in an individual's movement system, ranging from mild to severe complaints. These disorders can result from repetitive or prolonged movements. Blacksmithing is a profession that involves repetitive movements and various working positions, such as bending and bowing at the back and neck. Hammering, grinding, and such postures make blacksmiths prone to musculoskeletal disorders. These complaints can be caused by environmental factors, work-related factors, and individual factors (Susanti & Septi, 2021; Tarwaka & Sudiajeng, 2004).

Musculoskeletal complaints due to environmental factors are influenced by the conditions around the workplace, such as air circulation, heat in the work area, lighting, and more. Working in a hot environment caused by burning metal blocks with poor air circulation reduces workers comfort levels and increases workplace accidents, such as excessive sweating (Hargreaves & Spriet, 2020). From a work perspective, musculoskeletal

complaints may result from demands to work in non-ergonomic or uncomfortable positions. Blacksmithing involves frequent bending, hammering, bowing, and grinding, which are non-ergonomic positions. Individual factors include age, work duration, health conditions, life history, and more (Kurnianto, 2019).

An initial survey in Sawan Village, Sawan Subdistrict, Buleleng Regency, found 25 workplaces, each employing 2 to 3 workers. Blacksmithing activities are carried out in simple buildings. These include cutting iron, burning iron in wood furnaces until it glows red, hammering hot iron into desired shapes, cooling iron with water, and smoothing or welding it, all within the same basic structures. The preliminary survey revealed that few blacksmiths used protective equipment or had access to first aid kits. Interviews with respondents uncovered incidents such as burns, hammer injuries, hearing issues, and cuts during work. Some blacksmiths in Sawan Village also reported discomfort in their lower backs, upper extremities, and backs. Based on this, blacksmiths in Sawan Village are at high risk of experiencing musculoskeletal disorders, but no data exists regarding the prevalence of these complaints.

RESEARCH METHOD

The research design used in this study is a descriptive research method with a cross-sectional approach. The research was conducted in Sawan Village, Sawan District, Buleleng Regency, Bali, from February to July 2024, starting from the preparation of the research framework, implementation of the research, data collection and processing, to the preparation of the research report. The inclusion criteria are subjects who have received and agreed to Informed Consent, blacksmiths with a minimum age of 18 years, blacksmiths who work in the research location and reside in the Sawan Village area and the exclusion criteria were subjects who had side jobs where the working hours exceeded or were equal to the subject's working hours as a blacksmith and subjects who did not provide their Informed Consent or who did not agree to be research subjects.

The population in this study were workers who had experience in various iron forging industries. The population that can be reached in this study are all workers from various types of iron forgings in the Sawan Village area. There are around 25 forging

Gde Bagus Raditya Nugraha Nukarna*, Ni Luh Putu Ariastuti, Komang Ayu Kartika Sari

Program Studi Sarjana Kedokteran dan Profesi Dokter, Fakultas Kedokteran, Universitas Udayana
Corresponding author: *E-mail: gusadit627.2000@gmail.com

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Prevalence of musculoskeletal disorders among blacksmith workers in Sawan Village Sawan District Buleleng Regency Bali

centers in Sawan Village, each center consisting of 2 to 3 people. Each center is further divided into various types of forgings, namely sword forging, blade forging, sickle forging, gong forging, axe forging, and miniature forging. Most of these forges have the same working hours and days, some work every day, some only work from Monday to Friday. The research sample is a portion of the reachable population selected to be research subjects

representing the target population. The sample consisted of blacksmith workers in Sawan Village who were willing to participate in the study. BMI category variables have the following classifications is less than 18.5, thin 18.5-24.9, normal 25.0-29.9, overweight 30.0 or more is obese. This research has received an ethical approval letter from the Faculty of Medicine, Udayana University with ethics letter number: 1391/UN14.2.2.VII.14/LT/2024.

RESEARCH RESULTS

Table 1. Frequency Distribution of Respondent Characteristics (N=44)

Variable	Results
Age (n/%) (Mean±SD)(Range)(Year)	(40.45±8.53) (20-57)
20-40	16/36.4
41-49	22/50.0
50-57	6/13.6
Body Mass Indexing (BMI) (n/%)	
≤18.4	1/2.3
18.5-25.0	31/70.4
≥25.1	12/27.3
Length of Service (n/%)	
≤10	13/29.5
11-20	26/59.1
>20	5/11.4
Working Hours (n/%)	
≤8 Hours	24/54.5
>8 Hours	20/45.5
Duration of Break (n/%)	
<60 Minutes/Day	19/43.2
60-100 Minutes/Day	12/27.3
>100 Minutes/Day	13/29.5
Last Education Level (n/%)	
High School/Equivalent	34/77.2
Diploma	5/11.4
Bachelor's Degree	5/11.4
Gender (n/%)	
Male	29/65.9
Female	15/34.1

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Variable	Results
Body Position (n/%)	
Standing	10/22.7
Squatting	10/22.7
Bending	6/13.7
Leaning	18/40.9
Smoking History (n/%)	
Smokers	11/25.0
Non-smokers	33/75.0
Other Jobs (n/%)	
Yes	5/11.4
No	39/88.6

Based on the table, 22 (50%) respondents were in the age range of 40-49 years. The majority of blacksmith workers had a Body Mass Index (BMI) in the range of 18.5-25.0 with a total of 31 respondents (70.4%). In addition, 26 blacksmith workers had work experience ranging from 11-20 years or 59.1% of the total workforce. Furthermore, 24 workers (54.5%) stated that they had working hours of less than or equal to 8 hours, while 20 workers (45.5%) stated that they worked more than 8 hours. Most blacksmith workers stated that their break time was less than 60 minutes (43.2%). 34 workers (77.2%) reported that their highest level of education was high school. The majority of blacksmith workers were male, namely 29 people (65.9%). The leaning position during the sharpening process is the most common position, which is 18 respondents (40.9%), followed by the standing and squatting positions, each with 10 respondents (22.7%), and the bending position when hammering, which is 6 people (13.7%). In addition, 33 blacksmiths (75%) are non-smokers and 39 blacksmiths (88.6%) do not have other jobs.

Table 2. Distribution of the number of musculoskeletal complaints in blacksmith (N=44)

Location	Risk (n/%)	
	Low	High
Upper Neck	39/88.6	5/11.4
Nape	41/93.2	3/6.8
Left Shoulder	39/88.6	5/11.4
Right Shoulder	35/79.5	9/20.5
Left Upper Arm	35/79.5	9/20.5
Back	37/84.1	7/15.9
Right Upper Arm	40/90.9	4/9.1
Waist	39/88.6	5/11.4
Hip	38/86.4	6/13.6
Buttocks	39/88.6	5/11.6
Left Elbow	37/84.1	7/15.9
Right Elbow	38/86.4	6/13.6
Left Forearm	40/90.9	4/9.1
Right Forearm	40/90.9	4/9.1
Left Wrist	33/75	11/25
Right Wrist	35/79.5	9/20.5
Left Hand	34/77.3	10/22.7

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Location	Risk (n/%)	
	Low	High
Right Hand	42/95.5	2/4.5
Left Thigh	39/88.6	5/11.4
Right Thigh	40/90.9	4/9.1
Left Knee	37/84.1	7/15.9
Right Knee	38/86.4	6/13.6
Left Calf	40/90.9	4/9.1
Right Calf	40/90.9	4/9.1
Left Ankle	41/93.2	3/6.8
Right Ankle	41/93.2	3/6.8
Left Foot	42/95.5	2/4.5
Right Foot	41/93.2	3/6.8

From the table above, it can be observed that musculoskeletal disorders (MSDs) among blacksmith workers in Sawan Village are found to be in the low-risk range. It is evident that the upper extremities (left wrist (25%), right wrist (20.5%), and left hand (22.7%)) are the areas with a higher vulnerability to MSDs compared to other body parts. Furthermore, from the total sample of 44 respondents, it can be seen that all 44 individuals (100%) fall within the low-risk value range.

DISCUSSION

It can be observed that the upper extremities are the body parts exposed to high MSDs risk values, with the highest number of respondents. Specifically, 11 respondents (25%) have a high risk of MSDs in the left wrist, 9 respondents (20.5%) in the right wrist, and 10 respondents (22.7%) in the hands. This result may occur because the hands are the body parts most exposed to vibrations caused by the hammering process in blacksmithing work. Based on previous research revealed a significant relationship between mechanical vibrations and the musculoskeletal complaints experienced by those workers. The study showed that the relationship between work posture and mechanical vibrations had a proportionate influence of 91.8% on musculoskeletal complaints, while the remaining 8.2% was influenced by individual factors such as gender, body mass index, length of service, working hours, and others (Sari, Ningrum, & Qadrijati, 2020).

Based on the results of cross-tabulation between risk factors and total MSD risk values among respondents. From the table, it can be seen that those under 45 years of age (75%) have a higher

percentage of musculoskeletal disorder risk values than those aged 45 years or older (25%). This result is in contrast to a study that found that blacksmith workers aged over 40 years old, totaling 18 respondents, represented 53% of the total answers given. While workers aged >40 years reported moderate musculoskeletal complaints (Pratama, 2017). In another study, regarding factors affecting muscle tension in blacksmith workers, it was stated that there were 26 respondents over 35 years old, divided into two categories: moderate and high complaints. Those with moderate complaints numbered 11 respondents (47.8%), while those with high complaints numbered 15 respondents (93.8%) (Sari, Chairudina, Suryono, & Marlik, 2023). As workers reach the age of over 41 years, muscle strength and endurance begin to decline, and muscle elasticity decreases. This will lead to an increased risk of musculoskeletal disorders during physical activities (Pratama, 2017). Blacksmithing is a type of work closely related to physical actions, including the hammering process, body positions that endure pressure during forging, and repeated extremity positions throughout the work process. Age is a significant factor in blacksmithing; the older a blacksmith worker is, the more changes occur in their musculoskeletal system, such as changes in bones, muscles, cartilage, and more. This contrasting result may be due to a higher number of workers under 45 years old in the blacksmithing industry. This finding indicates the need for immediate action or intervention to reduce risk values and improve the work quality of blacksmith workers (Sari et al., 2023).

The use of BMI as a research variable has been adjusted according to the BMI standards set by the

Gde Bagus Raditya Nugraha Nukarna*, Ni Luh Putu Ariastuti, Komang Ayu Kartika Sari

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Prevalence of musculoskeletal disorders among blacksmith workers in Sawan Village Sawan District Buleleng Regency Bali

Ministry of Health. Based on the results from the cross-tabulation, the majority of blacksmith workers fall into the underweight to normal BMI category, with 32 respondents (72.7%), while those in the overweight category number 12 respondents (27.3%). It can be seen that those with a normal-underweight BMI have a higher percentage than those in the overweight category. This result is in line with research that shows the results between Body Mass Index (BMI) and work posture with musculoskeletal disorders in fishermen. The study did not find any relationship between Body Mass Index (BMI) and work posture with musculoskeletal disorders in fishermen. According to researchers, this result is influenced by the greater number of fishermen with normal BMI compared to those with abnormal BMI (Thamrin, Pasinringi, Darwis, & Putra, 2021).

The length of service of blacksmith workers is divided into three categories: those with a length of service of less than or equal to 10 years, 11 to 20 years, and more than 20 years. The cross-tabulation results found that blacksmith workers from the three categories are divided into those with 11-20 years of service, numbering 26 respondents (59.1%), who are exposed to low MSDs risk values. Those with more than 20 years of experience number 5 individuals (11.4%), while those with less than or equal to 10 years of experience have a percentage of 29.5%. Workers with 11 to 20 years of experience have a risk value percentage of 59.1%, which is the highest compared to other length of service values. These results are in accordance with previous studies that examined blacksmith workers who were divided into two categories, namely workers with a work period of ≤ 5 years and workers with a work period of > 5 years. The results showed that workers with a work period of ≤ 5 years who reported low musculoskeletal complaints numbered 12 people (52.2%), while workers with high complaints numbered 3 people (18.8%). In contrast, workers with a work period of more than 5 years reported low complaints numbered 11 people (47.8%) and high complaints numbered 13 people (81.2%) (Sari et al, 2023). On the other hand, previous research shows that workers with a work period of less than or equal to 10 years amounted to 8 people with a percentage of 23%, those with a work period of 11 to 20 years amounted to 16 people with a percentage of 47%,

and those with a work period of more than 20 years amounted to 10 people with a percentage of 30%. Length of service provides insight into how experienced a worker is in their job. This experience reflects the working environment, body positions during work, and all factors accumulated over time that can play a role in the musculoskeletal complaints experienced by workers. Therefore, it can be understood that length of service can be considered a significant factor; the more frequently a person is exposed to risk factors, the greater the risk of experiencing musculoskeletal complaints among respondents. Despite the high length of service indicating skill and expertise in the field, it does not mean that workers will not make mistakes or experience negligence in their work, such as musculoskeletal complaints among blacksmith workers (Pratama, 2017).

The use of the variable "working hours" measured in hours per day is divided into two categories: those with working hours of less than or equal to 8 hours, and those with working hours of more than 8 hours. From the cross-tabulation results, it can be seen that 24 respondents (54.5%) work less than or equal to 8 hours, while 20 individuals (45.5%) work more than 8 hours. Those working less than or equal to 8 hours have a higher percentage compared to those working more than 8 hours. This finding aligns with research, found a correlation between working hours and musculoskeletal complaints among blacksmith workers (Mabilehi, Ruliati, & Berek, 2019).. Working hours indicate a relationship between musculoskeletal disorders and movements and actions performed periodically. Working hours exceeding 8 hours can significantly lead to pain in extremities such as the shoulders, upper back, arms, and hands (Aprianto, Hidayatulloh, Zuchri, Seviana, & Amalia, 2021). Repetitive movements can cause fatigue and the accumulation of lactic acid; therefore, throughout the work period, muscles must receive adequate oxygen and nutrients to meet the demands of physical work. Prolonged work without sufficient breaks can lead to a decline in physical condition and pain in the affected body parts. Additionally, insufficient rest can disrupt the recovery and repair processes of the body to optimal conditions (Mabilehi, Ruliati, & Berek, 2019; Nakayama, Shayan, & Huang, 2019).

Rest duration was one of the variables assessed

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Prevalence of musculoskeletal disorders among blacksmith workers in Sawan Village Sawan District Buleleng Regency Bali

in this study. It was found that 19 respondents (43.2%) worked with a rest duration of less than 60 minutes per day (Category 1), 12 respondents (27.3%) took a break between 60 and 100 minutes per day (Category 2), and 13 respondents (29.5%) took a break more than 100 minutes per day (Category 3). The results showed that workers with a rest duration of less than 60 minutes per day had a higher percentage of MSDs risk compared to workers with a rest duration of between 60 and 100 minutes and more than 100 minutes. This finding is in accordance with research conducted on warehouse workers using the REBA, RULA, and OWAS methods which concluded that musculoskeletal disorder complaints were not influenced by the length of rest time but were influenced by work posture and repetitive actions and stated that the risk value increased the longer an activity was performed repeatedly, especially in a non-optimal body position (Utomo, Sulistiarini, & Putri, 2021).

Regarding the last level of education, there are 34 respondents (77.3%) who completed their education at the high school level or equivalent, exposed to high-risk values, while 10 respondents (22.7%) with higher education are exposed to low MSDs risk. Education at the high school level or equivalent have a higher percentage of MSDs risk compared to those who completed higher education. This result is influenced by the dominance of workers who completed their education at the high school level or equivalent.

Furthermore, it is seen that blacksmith work is mostly done by male workers, which is 29 respondents or 65.9%, while female workers are 15 respondents or 34.1%. The cross-tabulation results show that male workers (65.9%) have a higher percentage of MSDs risk than female workers (34.1%). This finding is in accordance with previous research which found that male workers with mild complaints numbered 11 people (47.8%), while those with severe complaints numbered 16 people (100%). In contrast, in female blacksmith workers, there were 12 people (52.2%) who had mild complaints and none had severe complaints. The higher number in male workers may be associated with better physical structure and the heavier nature of the work that requires greater muscle strength. This causes male workers to be more susceptible to

disorders or complaints in the musculoskeletal system compared to female workers (Sari et al, 2023)

From another variable, blacksmith workers with other jobs or side jobs 5 respondents, accounting for 11.4%. These jobs include farming, with 1 respondents (20%), farming combined with livestock raising, with 3 respondents (60%), and 1 respondents (20%) who also works as a vendor in the market. Those who work solely as blacksmiths number 39 respondents (88.6%). Those with other jobs are at a higher risk of MSDs, which may be due to their additional activities, such as farming (digging and harvesting) and livestock raising. The majority of blacksmith workers are in a leaning position, with 18 respondents (40.9%) out of 44 respondents, followed by those standing upright and squatting, each with 10 respondents (22.7%), and those bending over, numbering 6 respondents (13.6%). This is in line with previous research stating that blacksmiths have a high risk of MSDs. In a bent position, there is excessive pressure on the back muscles, especially in the waist area, especially at L4 and L5. Blacksmith work is also done repeatedly and often, causing lactic acid buildup. This lactic acid buildup causes discomfort and fatigue. Static positions, the body experiences a blockage of blood flow, resulting in a lack of oxygen and glucose supply to the static areas. The accumulation of lactic acid also causes discomfort as an indicator that lactic acid levels in the static area are excessive and need to be eliminated (Pratama, 2017).

In the forging work, it is evident that workers perform repetitive movements that expose them to vibrations caused by the hammer striking the iron plates. These vibrations propagate to the hands, wrists, and arms of the blacksmith workers. Continuous exposure to vibrations while working can accumulate over time and potentially lead to Hand Arm Vibration Syndrome (HAVS), a condition caused by vibration exposure to the hands. This disorder can manifest as narrowing of blood vessels, peripheral nerve damage, and joint and muscle disorders, depending on the duration of exposure experienced by workers periodically.

It can be seen that most of the blacksmith workers were non-smokers, with 33 respondents (75%) stating that they had never smoked. Meanwhile, 11 respondents (25%) reported that they

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Program Studi Sarjana Kedokteran dan Profesi Dokter, Fakultas Kedokteran, Universitas Udayana
Corresponding author: *E-mail: gusadit627.2000@gmail.com

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Prevalence of musculoskeletal disorders among blacksmith workers in Sawan Village Sawan District Buleleng Regency Bali

smoked lightly (less than 1 pack per day). There were no blacksmith workers who were classified as heavy smokers who smoked more than 1 pack per day. The cross-tabulation results showed that non-smokers dominated with a number of 33 respondents and a percentage (75%). In contrast, those who smoked lightly numbered 10 respondents, accounting for (25%). This shows that non-smokers (75%) have a higher percentage of risk value compared to light smokers (25%).

Based on previous research, non-smoker respondents with low complaints 12 respondents (52.2%), while those with high complaints numbered 3 respondents (18.8%). In contrast, in smoker respondents, 12 respondents (52.2%) reported low complaints, while 13 respondents (81.2%) reported high complaints. Meanwhile, in the previous study it was found that respondents who smoked 1 pack per day had a moderate risk, 15 respondents (75%), and 4 respondents who smoked ≥ 2 packs per day had a high risk of experiencing musculoskeletal disorders (Sari et al, 2023; Pratama, 2017).

CONCLUSION

Blacksmiths are at high risk of developing musculoskeletal disorders (MSDs), especially in the upper limbs such as the hands and wrists due to exposure to repetitive vibrations during the forging process. Factors such as age, Body Mass Index (BMI), length of service, daily work duration, rest time, work position, education, gender, and side jobs also influence the level of risk.

SUGGESTION

Interventions in the form of improving work ergonomics, regulating rest periods, and occupational health education are essential to reduce the risk of MSDs and improve the quality of work of blacksmiths.

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Corresponding author: *E-mail: gusadit627.2000@gmail.com

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Prevalence of musculoskeletal disorders among blacksmith workers in Sawan Village Sawan District Buleleng Regency Bali

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Gde Bagus Raditya Nugraha Nukarna*, Ni Luh Putu Ariastuti, Komang Ayu Kartika Sari

Program Studi Sarjana Kedokteran dan Profesi Dokter, Fakultas Kedokteran, Universitas Udayana
Corresponding author: *E-mail: gusadit627.2000@gmail.com

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