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Impact of Occupational Hazards on the Technical Efficiencies of Oil Palm Processors in Edo State, Nigeria

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Abstract*— This study examined the effect of occupational hazards on the technical efficiencies of oil palm processors in Edo State. A multistage sampling procedure was used in selecting 210 oil palm processors in the study area. Data were analyzed using percentages, frequencies, Occupational Hazard Indices and Stochastic Frontier Production Analysis (SFPA). Results revealed that 79%, 90.5% and 80.5% of the processors were male, married and educated respectively. Also, the mean age, processing experience and household size were 42 years, 15 years and 7 persons respectively. The most prevalent occupational hazards experienced were smoke irritation (100%), presser injury (94.3%) and spikelet injury (83.8%). The occupational hazards indices computed were, lost time rate, incidence rate and severity rate with values of 15.85, 23.77 and 2.4 respectively. SFPA revealed that the mean technical efficiency of the oil palm processors was 0.75. Furthermore, palm fruits ($\beta = 0.662$, $p<0.01$), the volume of water used ($\beta = 0.180$, $p<0.05$) and labor in man-day ($\beta = 0.415$, $p<0.01$) increased the production of palm oil. Also, processing experience ($\beta = -0.110$, $p<0.05$),), loss time rate ($\beta = 0.087$, $p<0.05$), incidence rate ($\beta = 0.03$, $p<0.1$), and severity rate ($\beta = -0.098$, $p<0.01$), decreased technical efficiency. The study concluded that occupational hazards had a negative influence on the technical efficiency of oil palm processors. The study recommended that stakeholders in oil palm processing should create health awareness and consistently research occupational hazards peculiar to oil palm processing as well as safety practices to enhance technical efficiency.

Keywords*— Maximum Likelihood, Occupational hazards, Palm Oil Processing. Technical Efficiency, Stochastic Frontier Production Analysis.

I. INTRODUCTION

I.1. Background of the Study

The demand for palm oil is rising globally, and people are discovering more and more uses for it in their daily lives. The greatest source of edible oil in the world, palm oil makes up around 25% of the world's production of edible oils and fats, according to the Malaysia Palm Oil Council (MPOC, 2007). Exporting this commodity has benefited nations like Indonesia and due to increased demand for the commodity and Indonesia's palm oil export competitiveness, the country's palm oil exports increased dramatically between 1991 and 2001 and 2005 to 2007

(Amzul, 2010). Margarine, soap candles, lipstick bases, waxes and polish bases in condensed form, and confectionary products can all be made with palm oil (Embrandiri *et al*., 2011). Based on these diverse uses, oil palm was referred to as a crop of multiple values by Akangbe *et al*., (2011). According to Omoti (2004), before 1965 Nigeria was the world's top producer and exporter of palm oil, but since 1975, this has declined due to an imbalance between local demand/consumption and production. This economic turn caused Nigeria to become a net importer of palm oil (Olagunju, 2008). Nigeria produced 3% of the world's palm oil, placing it as the fourth-largest producer overall. The upstream production of palm oil was estimated at 0.98 million tons by the Nigerian Institute for Oil Palm Research (NIFOR) (Proshare, 2018). Ironically, despite the availability of modern tools and equipment for planting, harvesting, and processing agricultural products as well as ongoing research on agricultural mechanization, the majority of Nigerian rural farmers—including those who grow oil palm—remain dependent on outdated agricultural production techniques. This puts workers in danger from a variety of physical, biological, chemical, mechanical, and emotional risks that are common to many professions, including the production of palm oil. Workplace risks specific to oil palm processing include: falling from palm trees during harvesting, which can result in broken legs or even paralysis; injuries from particles getting into the eyes; being pierced by a spikelet from a palm fruit bunch; smoke from the fire made during processing the crude palm oil, which can affect the eyes and respiratory system; and burns that can happen during boiling the fruits or during threshing if leg chopping is involved (James, 2015). The ability of a farm to use inputs in the best proportions given their separate pricing is reflected in a farm's allocative efficiency, which may be quantified, as well as technical efficiency (TE). However, this study looks at how the technical efficiency of the processors is impacted by workplace dangers related to processing palm oil. There is little doubt that a dangerous encounter has an impact on a person's physical agility. This study concentrated on the metrics that influence how labor uses resources and the injuries that occur among palm oil processors. Additionally, it lists the different workplace dangers and illnesses that are common among processors in the research area.

Researchers have conducted numerous investigations on each idea of technical efficiency (Ekunwe and Orewa, 2007) and occupational dangers (Rawlance *et al*., 2015). The risks of a given profession seriously impact the practitioners' health and have a detrimental impact on their ability to do their jobs (Oluoch, 2015). Hazard analysis and critical control points (HACCP), a preventive program focused on recognizing, accessing, and controlling hazards, is now acknowledged internationally for managing the food safety aspect of palm oil production, processing, distribution, and preparation, according to Christe and Sathianathan (2006). However, because the government failed to establish connections with traditional farmers so that they could be taken into account when formulating legislation, it is unclear to what extent traditional palm oil processors were taken into account in this type of hazard control study. The majority of processors are somewhat aware of the risks involved in processing activities, especially those who are inclined to use traditional techniques of processing, but they must continue manufacturing to satisfy their financial responsibilities. The main issue, though, continues to be a failure to consider the detrimental effects this may have on their technical efficiency.

As a result, this study added to the body of evidence by:

- identifying and assessing the predominant occupational hazards faced by oil palm processors
- investigating the effect of occupational hazards on technical efficiency.

I.2. Literature Review

Any source that could cause harm, injury, or detrimental health effects to something or a person under specific circumstances is a hazard (World Health Organization (WHO), 2001). However, an occupational danger is one that typically results from the workplace. As a result, it is an injury received while performing a job or duty. A malfunctioning component may cause disease or even death. A serious risk to a worker's bodily or mental health that arises from their employment in a particular task, job, profession, or occupation is known as an occupational hazard. Workplace risks are caused by being exposed to a dangerous environment. Occupational hazards typically originate from many sources, some of which may be harmful equipment or employee behavior. Dangerous working conditions and unsafe behavior are the main causes of workplace dangers (Kalejaiye, 2013). However, other factors contribute to occupational dangers, many of which are frequently intimately linked to jobs. Numerous research studies have supplied data on illnesses and occupational dangers in the agriculture industry (Joseph and Minj, 2010). In agricultural settings, machinery has the highest incidence and fatality rates of injuries (Yiha and Kumie, 2010). Numerous pesticide exposures cause toxicity and, in rare instances, work-related cancer and death (Fieten *et al*., 2009). Allergies, lung ailments, zoonotic infections, and parasitic diseases are possible side effects of frequent contact with toxic and wild animals, plants, and biological agents (Kesavachandran, *et al*., 2008). Stress, musculoskeletal disorders (repetitive motion disorders, back disorders), psychiatric disorders, and noise-induced hearing loss are also common (Bernard *et al*., 2011; Rocha *et al.*, 2010; Wesseling *et al.*, 2010). Production is the process by which some products and services are changed into new products. There are three different categories of production: primary (which encompasses all branches of production that may not be readily consumed at first but are used for subsequent production), secondary, and tertiary (comprises of all kinds of manufacturing and constructing works i.e. turning the new materials produced in primary production into finished goods.) and tertiary production, which entails the delivery of direct services like the distribution of goods and services at each stage of production to the ultimate consumers (Nweze, 2002). Land, labor, capital, and management are examples of production factors.

Stochastic Frontier Analysis (SFA) has been used in many efficiency studies. For instance, it was discovered that most farmers were technically inefficient, with 70% of them operating with less than a 0.60 efficiency score while measuring technical efficiency in Kenya's maize production using SFA (Kibaara, 2005). According to this study, the usage of hybrid and tractors, the presence of male-headed families, the age of the farmer, access to credit, and the length of formal education all have a beneficial impact on technological efficiency. According to the findings of this study, the Ministry of Agriculture should direct its extension service program toward the women who perform 80% of the work but receive only 5% of the funding. Using SFA, the technical efficiency of sorghum production in Adamawa State, Nigeria, was also calculated. It was found that the mean technical efficiency of sorghum was around 73%. (Wakili, 2012). The research indicated that the farmers' educational backgrounds, household size, interactions with extension agents, and sorghum farming experience were the main factors that were relevant in explaining efficiency. To discover and analyze factors impacting efficiency, the technical efficiency of Arabica coffee farmers in Cameroon was studied using a maximum likelihood method and a translog stochastic production frontier. The range of technical effectiveness was 0.24 to 0.98, with an average of 0.90. (Nchare, 2007). A study that used the SFA one-stage simultaneous estimate approach to estimate the technical efficiency of maize smallholder farmers in Southern Malawi and identify the variables that account for variances in technical efficiency was carried out (Chirwa, 2007). With an average technical efficiency of 46.23% and a low of 8.12%, it was shown that many families were technically inefficient. Utilizing hybrid maize and joining a club improved effectiveness. The study's findings suggest that to increase social capital and encourage the use of hybrid seeds by smallholder maize farmers, farmer organizations need to be revived or new agricultural cooperatives need to be established.

II. MATERIALS AND METHODS

This study was carried out in Edo State. Edo State Agricultural Development Programme (EDADP) zone, which divided the state into 3 zones was adopted. A multistage sampling procedure was used. In the first stage, three blocks were selected from each zone giving a total of nine blocks. In the second stage, four cells were randomly selected from each block. Finally, six respondents were randomly selected from each cell. This gave a total of 216 respondents. However, 210 sets of questionnaires were used for the analysis as they provided sufficient information. Frequency, mean and percentages were used to capture the socioeconomic characteristics of the respondents, the various occupational hazards encountered by the respondents and the various illnesses experienced. Occupational hazards that were considered include piercings from fruit spikes, burns from oil splashes/spills, hot objects, fire burns, injuries from tools and equipment (cutlass, presser) as well as snake and insect bites. Several indices were used to assess the occurrence of occupational hazards. Occupational Safety and Health Administration (OSHA) stressed that several rates could be computed for the occurrence of occupational hazards (OSHA, 2015). Some of these are lost time case rate, incidence rate, severity rate and proportional rate.

i. Proportional Rate: expresses the occurrence of various occupational hazards as a fraction of the total number of hazards under consideration. It is therefore a value between 0 and 1.

$$PR = \frac{n}{N} \quad (1)$$

Where:

n = number of observed occupational hazards experienced by the i^{th} processor; and

N = total number of expected occupational hazards

ii. Total Incident Rate: a mathematical calculation that describes the number of recordable incidents per 100 full-time employees in any given time frame.

$$\text{TIR} = {}^{r}/_{W} * 200000 \quad (2)$$

Where:

TIR = total incidence rate

r = number of recordable cases; and

w = number of employee labor hours worked

iii. Lost Time Case Rate: a mathematical calculation that describes the number of lost time cases per 100 full-time employees in any given time frame.

$$\text{LTR} = {}^{n}/_{W} * 200000 \quad (3)$$

Where:

LTR = lost time rate

n = number of lost time cases; and

w = number of employee labor hours worked

iv. Severity Rate: a mathematical calculation that describes the number of lost days experienced as compared to the number of incidents experienced.

$$\text{SvR} = {}^{t}/_{i} \quad (4)$$

Where:

S_vR = severity rate

t = total number of lost workdays; and

i = total number of recordable incidences

The standard base rate for the calculations is based on a rate of 200,000 labor hours. This number (200,000) equates to 100 employees who work 40 hours per week and who work 50 weeks per year. Using this standardized base rate, any company can calculate its rate(s) and get a percentage per 100 employees (OSHA, 2015).

The cobb-Douglas functional form of the stochastic production function was used to estimate the production function and predict the technical efficiencies of the processors in the study area. The choice of this model is because it allows for the presence of technical inefficiency while accepting that random shocks beyond the control of the processor can affect output.

The empirical model of the stochastic production frontier function is specified as follows:

$$\ln Ti = \beta 0 + \beta 1 \ln R1 + \beta 2 \ln R2 + \beta 3 \ln R3 + \beta 4 \ln R4 + \beta 5 \ln R5 + Vi - Ui \quad (5)$$

Where:

T = quantity of palm oil (liters)

R_1 = fruit (bunches)

R_2 = fuel (liters)

R_3 = labor (labor days)

R_4 = water (liters)

R_5 = transport (hours)

$\beta_0, \beta_1, \beta_2, \ldots, \beta_5$ = Parameter estimates

The technical efficiency of the individual respondent was computed as an index and the average technical efficiency for the system was determined. Using several socio-economic factors and indicators for illness burden as explanatory variables and the efficiency index as the dependent variable, the inefficiency model was estimated. The model assumes that the inefficiency effect U_i is independently distributed with mean u_i and variance $\sigma^{2.}$ The model is specified as:

$$\mu i = do + d1z1 + d2z2 + d3z3 + d4z4 + d5z5 + d6z6 + d7z7 + d8z8 + d9z9 + e \quad (6)$$

where:

μ = inefficiency (number)

Z_1 =age of respondents (years)

Z_2 = household size (number of persons)

Z_3 = education level of farmer (1 = formal education; 0, otherwise)

Z_4 = processing experience (years)

Z_5 = sex of the farmer (1 = male; 0, otherwise)

Z_6 = lost time rate

Z_7 = incidence rate

Z_8 = severity rate

$d_o, d_1, d_2, d_3, \ldots, d_9$ = regression estimates

III. RESULTS AND DISCUSSION

3.1 Socioeconomic Characteristics of the Oil Palm Processor

The socioeconomic traits of oil palm processors in the research region were listed in Table 1. The responders were 42 years old (±8.9) on average. Anzanku *et al*., (2006) reported that oil palm processors in Nassarawa State were within the age range of 30 and 50 years, and this opinion was shared by the outcome of this study as the majority (78.1%) of the respondents were between the ages of 31 and 50, otherwise known as their "active years." This suggests that the respondents will likely enjoy higher output because they have not yet experienced some constraints like weakness, which hinders production and comes with aging. Male workers made up the majority of those who processed oil palm (79.0%). It is implied that oil palm processing is a laborious job, which explains why fewer women were involved in it. This result supports James (2015) results that, oil palm processing was predominately male with a male-to-female ratio of roughly 4 to 1. James (2015) investigated the effects of occupational hazards on the socioeconomic characteristics of oil palm processors in Delta State. The majority of respondents (90.5%) were married. This data confirms Emokaro and Ugbekile's (2014) assertion that married people primarily operate the oil palm processing industry in Edo State. The assumption is that a sense of duty would be ingrained as marital status encourages devotion due to the requirements of the family that must be satisfied, and this would subsequently improve productivity.

In addition, 19.5% of the processors had no formal education, 16.2% had only completed their primary education, 51.0% had completed only their secondary school, and 13.3% had completed their university education. According to this finding, 80.5% of the respondents were literate and had some kind of formal education. The high level of reading among the respondents is anticipated to have a good impact on their consciousness and awareness of safety practices, as well as their productivity. Their standard of living would eventually be affected by this. This supports Erhabor and Emokaro's (2007) assertion that an educated producer in Edo State produces 13% more than an uneducated producer. The average amount of processing experience among the respondents was 15 years (±4.7), with the maximum amount of experience among 1.4% being 10 years. The majority (96.2%) of those with oil palm processing expertise had between 11 and 20 years of experience, and 0.9% had more than 30 years. According to the theories put out by Karki (2004) and Onyenweaku, and Nwosu (2005), experience and technical efficiency are positively correlated. Therefore, respondents with more experience are likely to be technically more adept than respondents with less experience. The mean household size was seven people (±2), with 19.0% of respondents having no less than five members, 79.5% having six to ten members, and 1.4% having more than ten members. This suggests that the firm must be profitable enough for the processors to be able to adequately provide for their families. Large household sizes also reduce the negative effects that a worker's absence from work due to illness would have on the performance of the business This is because there would be sufficient hands to replace any weak hands. Due to the ready availability of family labor, big family sizes also have the propensity to lower production costs. This outcome confirms the report by Agwu (2006) that the average household size among oil palm processors was six people.

3.2 Occupational Hazards of Processors

Regarding the occurrence of hazards, every respondent said that they had dealt with instances of the dangers that are typical of the oil palm processing industry. In this study, the local palm oil processors primarily suffered from smoke irritation (100%) presser injury (94.3%), spikelet injury (83.8%), burns from fire and oil splashes (55.7%), cutlass injury (42.9%), bee stings (22.4%), and snake bites (19.1%) in addition to other ailments. The respondents' frequent exposure to these risks as a result of their lengthy tenure in the industry demonstrates a direct correlation between their risky events and their years of processing experience. According to James (2015), workers who stay at their jobs for less time (less than five years) are less likely to have a work-related injury, and because processors typically have 15 years of industry experience, they are more likely to be exposed to occupational dangers.

Table 1: Socioeconomic Characteristics of the Respondents.

Variables	Frequency	Percentage	Standard Deviation	Mean
Age				
≤30	19	9.0	8.895	42
31 – 40	78	37.1		
41 – 50	86	41.0		
51 – 60	20	9.5		
61 – 70	6	2.9		
>71	1	0.5		
Total	**210**	**100.0**		
Sex				
Male	166	79.0		
Female	44	21.0		
Total	**210**	**100.0**		
Marital Status				
Single	9	4.3		
Married	190	90.5		

Widowed	11	5.2		
Total	**210**	**100.0**		
Educational Level				
Non-Formal	41	19.5		
Primary	34	16.2		
Secondary	107	51.0		
Tertiary	28	13.3		
Total	**210**	**100.0**		
Processing Experience				
≤10	3	1.4.0	4.692	15
11 – 20	202	96.3		
21 – 30	3	1.4		
>30	2	0.9		
Total	**210**	**100.0**		
Household Size				
1– 4	20	9.5	2.085	7
5 – 8	155	73.8		
>8	35	16.7		
Total	**210**	**100.0**		

Table 2: Illness Experiences and Occupational Hazards.

Variables	Frequency	Percentage
Hazard Experience		
Yes	210	100.0
Occupational Hazards (n= 210)*		
Spikelet Injury	176	83.8
Burns (Fire, oil splash)	117	55.7
Cutlass injury	90	42.9
Smoke irritation	210	100.0
Bee sting	47	22.4
Presser Injury	198	94.3
Snakebite	40	19.1

*Multiple responses

3.3 Occupational Hazard Indices

The indices from the International Labour Organization (ILO) that were used to measure the impact of occupational risks are shown in Table 3. The indices include the proportionate rate, severity rate, incidence rate, and lost time rate (ILO, 1998). According to the findings, approximately 14 processors out of every 100 processors have missed time at work due to an illness or injury. The number of instances where processors lost actual production hours is taken into account when calculating the lost time rate, which also calculates the typical number of processors who have missed time at work because of illnesses or accidents connected to their jobs. As a result, a high lost time rate has a negative effect on the processing industry, and managers of oil palm processing enterprises should make sure that precautions are made to protect their employees in order to lower the lost time rate's value. According to the incidence rate data, there have been around 15 recordable injuries or illnesses among every 100 processors. Smaller businesses with recordable events (injuries or illnesses) are more likely to have high incident rates or incident rates that vary dramatically from year to year, according to OSHA (2015). They went on to say that in smaller enterprises as opposed to larger ones, the impact of a single injury or sickness on incidence rates is substantially greater. They said that when an employer compares his company's accident and illness experience to that of other companies with similar work and workforce sizes, the incidence rates become more meaningful. The severity rate, a metric that determines the average number of days lost per incident that can be recorded, also reveals that the processors had a severity rate of 2.4. Accordingly, an average of 2.4 days will be lost as a result of work-related illnesses and injuries for each event that can be recorded. According to the proportional rate of occupational hazards experienced, 60% of the risks that oil palm processors are exposed to were experienced by those in Edo State. This finding suggests that the business's potentially dangerous situations are not being given the required attention, and this neglect may increase the frequency of work-related injuries.

Table 3: Occupational Hazard Indices.

Index	Number
Lost Time Rates	
Number of lost time cases	368
Number of employee labor hours worked	5300050
LTR	13.89
Incidence Rate	
Number of recordable hazardous cases	392
Number of processor labor hours worked	5300050
IR	14.79
Severity Rate	
Total number of lost workdays	944
Total number of recordable hazardous cases	392
SR	2.4
Proportional Rate	0.6

3.4 Analysis of Factors Influencing Efficiency of Oil Palm Processors in the Study Area

Table 4 displays the findings from the Maximum Likelihood Estimates (MLE) of the Cobb Douglas Stochastic Frontier Production Function (SFPF) and the inefficiency model. Sigma squared was statistically significant in the results (2 = 1.33, p 0.01), supporting the given assumption about the distribution of the composite error term as well as the goodness of fit. The percentage of the total divergence from the frontier that can be attributed to the processors' inefficiency is shown by the gamma (γ). It demonstrates that the technical inefficiency of the processors was responsible for around 71.0% of the drop in output below the frontier. The findings also showed that even though the processors used a variety of inputs, palm fruits (β= 0.66, $p < 0.01$), water (β=0.18, $p < 0.05$), and labor (β= 0.42, $p<0.01$) were the main inputs that had the greatest impact on the output of each oil palm processing enterprise in the study areas. The outcome demonstrates a considerable increase in palm oil production of 0.66 liters per unit increase in oil palm fruit. Processors should consequently pay close attention to the number and quality of fresh fruit bunches processed each time. The condition of these fresh fruit bunches is crucial since the quality of the fruit (in terms of oil content, appearance, and rancidification) is also significant. Additionally, an essential input that emphasizes how vital it is for processing palm fruits is that a unit increase in the amount of water utilized during processing greatly increased production by 0.18 liters. The amount of water needed increases with how much the fresh fruit bunches are processed. It is crucial to know how much water should be used for each output.

The output of palm oil was also greatly boosted by 0.42 liters per additional man-day of labor. The amount and quality of labor used by any producing business have a significant impact on the production of that business. To guarantee that labor is used effectively, the proper precautions must be taken. Specialization in the workforce should not be disregarded because it will increase labor productivity. Production involves all types of labor, both skilled and unskilled, and processors should make sure that this aspect of production (labor) is used effectively. The conclusions of Muhammad-Lawal *et al*., (2009), Amaza and Maurice (2005), and Oniah *et al*., (2008) that the coefficient of labor was positive and significant and that an increase in labor consumption would lead to an increase in output levels are supported by this result. The inefficiency model as revealed in Table 4 examined how the technical efficiency of oil palm processors was affected by variables such as sex, age, education level, processing experience, household size, lost time rate, severity rate, and incidence rate. Processors' inefficiency was considerably influenced by their processing experience (d = -0.11, p<0.05). This implies that the technical inefficiency diminishes as the processors gain expertise in the processing industry, hence improving their technical efficiency. This result defies Usman's (2012) findings, which suggested that the technical efficiency of rice farmers in Niger State was not greatly impacted by experience. Processor efficiency was strongly impacted by the lost time rate (d = 0.09, p<0.05), severity rate (d = 0.10, p<0.01), and incidence rate (d = 0.03, p0.1). This suggests that the technical efficiency of the oil palm processors would decrease if the values of these inputs increased by a unit.

Table 4: Determinants of Oil Palm Processing Output and Efficiency.

Variables	**Coefficient**	**t-value**	**P- value**
Constant	0.798	1.47	0.850
Fruits	0.662***	6.86	0.002
Water	0.180**	2.04	0.022
Fuel	0.056	0.65	0.754
Transport	-0.061	-0.88	0.262
Labour	0.415***	3.65	0.003
Inefficiency Model			
Sex	0.344	0.29	0.676
Age	-0.041	-0.56	0.201
Educational level	1.489	1.04	0.300
Processing experience	-0.110**	-2.97	0.049
Household size	0.120	0.48	0.879
Loss time rate	0.087**	2.68	0.026
Incidence rate	0.030*	1.99	0.078
Severity rate	0.098***	3.57	0.001
Variance Parameters			
Sigma squared	1.328***	11.22	0.000
Gamma	0.711***	5.67	0.000
Log-likelihood	-156.353		

***Significant at 1%; **Significant at 5%; *Significant at 10%

IV. CONCLUSION AND RECOMMENDATIONS

It is impossible to overstate the connection between the nature of a job and its impact on technical efficiency. This study has shown how important it is to take precautions when performing hazardous occupations because doing so will help to increase productivity. According to this study, there are several occupational hazards associated with processing oil palm, and these risks have an immediate impact on the technical efficiency of the processors. The study's primary risks were presser injury, smoke irritation and spikelet damage. This study also demonstrated that, although most processors were technically efficient in terms of how they used the majority of their inputs, there was still space for advancement. According to the study's findings, the following recommendations were suggested:

- Processors of oil palm should make sure that only high-quality fruits are used. This is due to fruits' substantial contribution to the output of the processors.
- Adoption of safety procedures and thorough, reliable research on occupational dangers are both necessary. This would help oil palm processors become more aware of the risks associated with

their line of work and help them take the necessary precautions to guarantee that they are not exposed to these risks.

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