Performance Evaluation of Fibre Glass Fabricated Needle Crusher

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Abstract- ***The improper disposal of used medical needles presents a significant risk of needle stick injuries and infection transmission in healthcare settings. Existing needle disposal methods often fall short in terms of practicality, accessibility, and effectiveness, prompting the need for innovative solutions. This study introduces and assesses the performance of a fabricated needle crusher designed to address these challenges. The research focuses on four Primary Health Centers in Oluyole Local Government area, Ibadan, evaluating the efficiency and safety of the needle crusher through a comparative analysis with a metallic needle crusher from a previous study. The methodology involves key informant interviews, observation checklists, and an assessment of the needle crusher's performance, efficiency, and capacity. The needle crusher comprises three sections: insertion, crushing, and end-product, operating manually with a fiber-glass outer covering. The assessment includes a description of the foundry process used for recycling the crushed needles. Results indicate that the fiber-glass fabricated needle crusher demonstrates superior efficiency, portability, and safety compared to its metallic counterpart. The crushed needles, subjected to heat, turn to ashes, suggesting a coated diamond material. The study projects the global weight of needles, emphasizing the need for proper recycling and reduction measures. A detailed comparison between the metallic and fiber-glass fabricated needle crushers is presented, highlighting the latter's advantages in efficiency, size, power requirement, and mobility. In conclusion, the fiber-glass fabricated needle crusher proves to be a more efficient and portable solution, free from power source requirements and operational hazards. Subjecting the crushed needles to heat through the foundry process confirms their unique material properties. Recommendations include adopting the needle crusher in Primary Health Care Centers, with potential improvements in machine efficiency and power source options for enhanced usability.***

Indexed Terms- ***Needle Crusher, Assessment, fibre-glass Performance, Primary Health Centers***

I. INTRODUCTION

The improper disposal of used medical needles poses a significant risk of needle stick injuries and the transmission of infections among healthcare professionals and patients (Joukar, *et. al.,* 2018; Alfulayw, *et. al.,* 2021; Mshelbwala *et.al* 2016). Needle crushers are typically used in healthcare settings to dispose of used needles safely, preventing accidental needle stick injuries and reducing the risk of infection transmission. The fabrication of such devices is essential to meet the specific needs of healthcare facilities and improve the overall safety of healthcare professionals and patients.

Despite the availability of various needle disposal methods, there remains a notable gap in the implementation of safe and efficient solutions. Existing needle disposal methods may be inadequate or pose safety concerns, highlighting the need for an efficient and safe solution. The existing options often fall short in terms of practicality, accessibility, and overall effectiveness. Furthermore, the environmental impact of needle waste necessitates innovative approaches to needle disposal that are both secure and eco-friendly. In response to these challenges, the development and assessment of a fabricated needle crusher become imperative. There is a pressing need for a reliable and safe needle disposal device that addresses the shortcomings of current methods, ensuring the well-being of healthcare professionals,

patients, and the broader community. The development and assessment of a fabricated needle crusher aim to address these issues by providing a device that effectively renders needles unusable while prioritizing user safety and environmental considerations. The evaluation of the fabricated needle crusher aims to contribute to the advancement of needle disposal technology, offering a solution that is not only effective but also meets the stringent safety standards required in healthcare settings.

II. METHODLOGY

Four Primary Health Centres were selected from Oluyole Local Government area, Ibadan. They are Agric General PHC, Adaramagbo PHC, Agbanle Npanu and Odo- Ona Elewe PHC, the selected PHC are close to the main road which are accessible except for Agbanle Npanu. They all have provision for the treatment for in-patients and out-patients. The major treatments and activities that are mostly carried out include treatment for expectant mothers, nursing mothers, children for administering of immunization and vaccines also giving first-aid treatment to accident victims. The selected PHC has maximum of 32 bed spaces and minimum of 7 bed spaces. Table 1 gives the brief description of each PHC. The performance of fabricated fibre-glass needle crusher used and was compared with fabricated metallic needle crusher from previous study. The waste (needles and plastics) were subjected to heat through the foundry process and melting process respectively as a form of recycling and reuse of the waste.

Table 1: Brief description of the selected PHC

PHC	Location	Activities	Total No of staff	No of in-patients	No of out-patients	Comments
Agric General	It is located along Omiyale area mosfala/ Muslim area.	Treatment for various ailments, administering of immunization and vaccines	13	Minimum of 6	Maximum of 853	Easy road network accessibility
Adaramagbo	It is located along Academy/Olomi Lagos/Ibadan expressway.	Treatment for various ailments, administering of immunization and vaccines, giving first – aid treatments to accident victims	29	Minimum of 13	Maximum of 891	Easy accessibility and availability of equipments

Agbanle Npanu	It is located around Agbanle Npanu New garage area	Treatment for various ailments, administering of immunization and vaccines	6	Minimum of 1	Maximum of 200	Poor accessibility
Odo-Ona Elewe	It is located along Oluyole extension area	Treatment for various ailments, administering of immunization and vaccines giving first – aid treatments to accident victims	23	Minimum of 11	Maximum of 902	Good road network to the health facility

The key informant interview was used to obtain the monthly records from the Monitoring and Evaluation Officer (MEO) of the Local Government selected in Ibadan. Observation checklist was used to document other information on the PHC and the evaluation of the selected fabricated needle crusher

- Description of Needle crusher

The needle crusher comprises of three parts/sections and the clamping part to enhance easy installation. The three sections are insertion section, crushing section and end-product section. The insertion section is the section at the topmost part of the machine which looks like a kite shaped hole, where the syringe was inserted for crushing only one syringe could be crushed at a time. The crushing section is inner part of the machine which comprises of two teethed gear interconnected together to pick the needle from the syringe by cutting and folding into harmless sizes, a rotating handle is connected to the smaller gear from the outside to enable easy rotation for crushing. The end product section is magnetic part of the machine that serves as the collecting point for the crushed needles, for easy holding of the product together. Finally, the bottom part is bolted for easy clamping and operation unto any plain surface

The apparatus required for the operation include needle crusher, a flat table, two or three empty container for disposing the plastic part of the syringe. The operation was carried out at a small open section, using the needle crusher. The needle crusher fabricated with fibre-glass materials as the outer covering protecting the gears interconnected for the crushing of the needles and a portion of which it can be clamped to a flat table to allow balance position for the crusher, it was operated manually, so as to test for efficiency and time taken.

After the needle crusher has been clamped, the safety boxes are cut open to allow easy access of removing the needles to avoid injuries on the operator. The needles are removed from the safety boxes and inserted into the machine (Crusher) one at a time, thereafter the handle was turned clock wisely as shown in Plate 8, to remove the needle from the syringe and it was folded to harmless sizes, then the plastic part of the syringe was put into another container for recycling, thereafter the crushed needles fell beneath the crusher having magnet within it.

III. ASSESSMENT OF THE EFFICIENCY OF NEEDLE CRUSHER

The efficiency; this will show the extent at which the machine can be used to have a good result. It was calculated using the formula;

Efficiency = (Input/ output) ×100%

….Eqn. (1)

The capacity; capacity of the machine to know the amount of needles to crush and the expected output to calculate the efficiency, after determining the following;

a. The number of safety boxes used for the collection of sharps
b. The number of sharps in each of the boxes
c. The weight of the boxes after filled

The time taken; to crush the needles with varying the weight for input loading.

Identifying the operating conditions and where there should be substitution for power for the operation. There will be short comparison between the Metallic fabricated needle crushing machine and the fibre glass fabricated needle crushing machine.

- Description of the Foundry process

Foundry process is a factory that produces metal castings. Metals are cast into shapes by melting them into liquid, pouring the metal in a mold, and removing the mold material or castings after the metal has solidified as it cools. The most common metal processed are Aluminum and cast iron However, other metals such as bronze, brass, steel are also used to produce casting in foundry. It comprises of the furnace which is the device used for producing heat for the melting, heat exchanger, air circulatory blower, ignition, electric control switch, chimney for the passage of the smoke into the atmosphere, also the melting pot with ladle for melting the material into liquid form, palm kernel shell was also used to aid the burning process.

- Recycled and Reused of the Crushed needles

The crushed needles were taken to the blacksmith unit of the Works and Maintenance Department of University of Ibadan. The crushed needles were poured inside melting pot and placed on the furnace to undergo foundry process black engine oil was added to increase the melting point.

- Needle Crusher Performance per time

The performance of the machine described the rate at which the machine operates. It is an expression of how many needles the machine can safely crush and separates per unit measure of time. The performance of the machine = 2.2needles approximately 2needles per minute, and 131needles per hour. The loading capacity is just the insertion of a syringe at a time for efficient result.

Weight of Syringes for Each Safety Box Generated

Weight of the empty safety box = 1.00106kg ≡ 1.001kg =

Average weight of filled safety box= 2.10kg

Average weight of the syringe in each safety box= 2.10 – 1.00kg = 1.1kg

Each of the syringe = 1.1kg ÷ 110pieces = 0.01kg ≡ 0.01kg

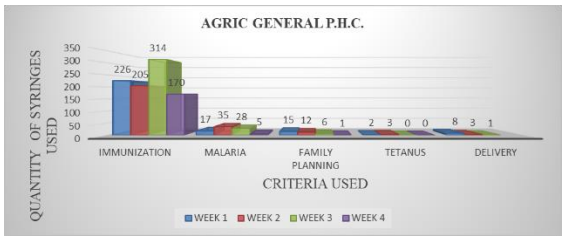

Chart 1: Graphical representation of syringe used for at Agric. General P.H.C.

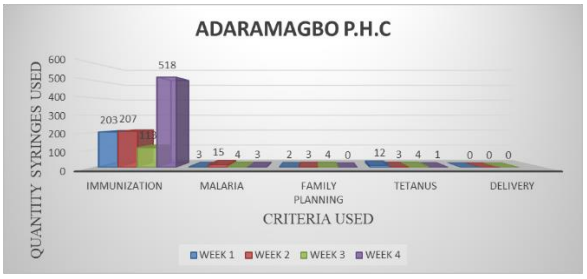

Chart 2: Graphical representation of syringe used for at Adaramagbo P.H.C.

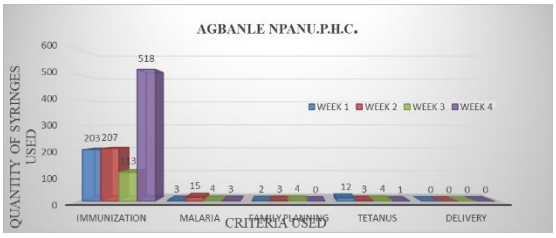

Chart 3: Graphical representation of syringe used for at Agbanle Npanu P.H.C.

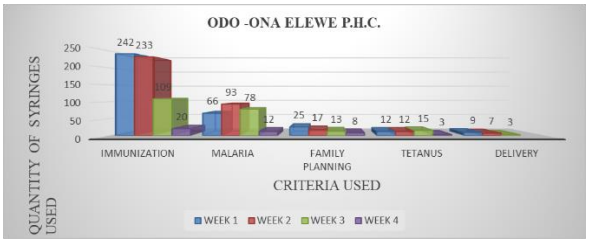

Chart 4: Graphical representation of syringe used for at Odo -Ona Elewe P.H.C.

Future Projection for Type and Amount of Needles Likely to be Used Globally

The World Health Organization in 2011 stated that about 16 billion injections are administered globally every year. Based on the assumption that they are all 21g needle for the varying sizes of syringe end (0.05ml, 0.1ml, 0.2ml, 0.5ml), and that each needle weighs 1gramme.

Total weight of needles = 16,000,000,000, X 1gramme
= 16, 000, 000,000grammes = 16,000,000 Kg
And 1 tons is 1000Kg

The total global weight of needle is 16000 tons.

These huge volumes of plastic if properly separated can be recycled, reused, reduced and refuse. Even the theme for 2018 World Environment Day stated “Beat Plastic Pollution”, which suggested that in order to tackle the menace of plastic pollution we must review production, usage, and management of plastic. It is also important for policy makers and governments worldwide to safeguard precious environmental resources and indeed public health by encouraging sustainable production and consumption through legislation.

- Crushed Needles Subjected to Heat.

After the crushed needles were subjected to heat for about 2hours 35minutes, it all turned to ashes, which indicated that the needles are coated diamond to allow it pass through any climatic regions as it has long life span to avoid corrosion, rusting etc. However, to prove this ordinary mild steel iron was placed inside the furnace and it melted off within a short period of 25minutes. The plastic was subjected to heat as well, was not pure due to the ink for calibration on the plastic before melting but can be separated using the colour separation method.

Table 2: Comparison of needle crusher (metallic needle crusher from previous study and fibre- glass fabricated), using the following parameters

Parameters	Metallic fabricated needle crusher	Fibre glass fabricated needle crusher	Comments
Efficiency	92.7%	100%	Fibre-glass fabricated is more efficient.
Time taken	150 needles per second	131 needle per hour	Shorter time is required for metallic fabricated
Loading capacity	3000 needles	1 needle	Much quantity of needles can be crushed using metallic.
Size	Large (Bulky)	Small	Metallic fabricated requires large surface area for operation.
Power requirement	Electricity / Battery	No power required	No power required but can be improved on for easy operation.
Mobility	Too bulky to be moved	Portable to be carried about	There is easy mobility for fibre-glass fabricated

Picture			Fibre-glass fabricated is portable while metallic fabricated is bulky

CONCLUSION

The following conclusions are drawn from research

1. The use of the fibre glass fabricated needle crusher is more efficient, portable and power source free to be operated by the health practitioners and free of hazards compared to other methods that has either one or two sides effects.
2. Subjecting the crushed needles to heat through the foundry process turned them to ashes which indicated that the needles are coated diamond after a mild steel iron was also subjected to heat through the foundry process to prove the material content of the needles.

RECOMMENDATIONS

From the findings in this study, the following are recommended;

1. Although, there are variations in the numbers of sharps generated from the Primary Health Centers depending on the location of the Health Care Centre and the period of the month and the performance of the used fabricated needle crusher for this work.
2. The Primary Health Care Centers can adopt the use of this certain needle crusher, by just clamping the crusher on a table beside the nurses or in a treatment room, so that just after the syringe or other sharps it will be crushed immediately without any storage except for the plastic end for recycling.
3. For future fabrication of the Needle crusher there should be improvement on the efficiency of the machine to reduce the human energy used, by either introducing an electric switch on the side, battery unit or solar power charging point in the absence of electricity or battery. Solar energy can always be an alternative power generation on the needle crusher and a sensory compartment units inside the needle crusher so that once the syringe is inserted the sensory unit pick it up and send to the crushing unit,

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