Research Paper

Evaluating Waste Material Among Construction Project: Identify Reason Waste and Suggestion Improvement Designer, Contractor and Client Practice

Ali Hussain[†]

Building Engineering Department, Education of Thiqr Directorate

(Received January 21, 2021; Revised June 11, 2021; Accepted June 11, 2021)

Objectives : This research evaluate the level of construction waste materials in Iraq construction industry and compare construction material waste among three types of executing projects including specialist contractors, general building contractor and government department.

Methods : The target materials in this study were brick, cement, sand, steel, gravel and thermo-stone. SPSS V24. Descriptive and inferential analyses were applied in this study.

Results and Discussion : Field observation show that the highest percentage of waste was “Brick” with 15.21% followed by “Sand” with 12.52% and “Thermo-stone” with 12.02%. The lowest percentage of waste in Iraq construction project was “Steel” and “Cement” with 3.96% and 4% respectively. The results of a comparison between these three groups confirmed that for all types of construction project waste, the governmental project had the highest percentage (12.77%), special contractor (11.19%), a general building contractor (9.71%). The major waste from materials was handling with 31.9%, concrete construction with 28.09% and 24.26% the finishing.

Conclusion : The percentage of losses in the construction sites is very high compared to the permissible limit implementing inexpensive preventive measures, mostly related to managerial practice improvements.

Keywords : Construction Material, Construction Waste, Building

[†] **Corresponding author**

E-mail: qasareng@gmail.com

Tel: 009647800694595

© 2021, Korean Society of Environmental Engineers

This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/4.0/>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

1. Introduction

According to the modern production philosophy, waste is understood as any inefficiency that results in the use of equipment, materials, labor, or capital in larger quantities than those considered as necessary in the production of a product.¹⁾ Waste includes both the incidence of material losses and the execution of unnecessary works, which generate additional costs but do not add value to the product.²⁾

Construction waste is also defined as any losses produced by activities that generate direct or indirect costs but do not add any value to the product from the client.³⁾ The researcher prefers to define the construction waste as the surplus materials that are generated from construction, renovation and demolition activities.

According to the U.S. Environmental Protection Agency (USEPA), construction waste materials also include packaging material and rubble material that results from construction, remodeling, repair, and demolition operations of pavements, houses, commercial buildings and other structures in addition to any improvement materials may be used in construction sites.⁴⁾ According to the Chartered Institute of Building, construction waste takes up a significant portion, ranging from one-fourth to one-third, of the total waste produced in many countries. Most of it is buried in landfills due to its non-combustible nature. Moreover, the problem of stockpiling inert materials recovered from construction waste has become more common and serious. Insufficient earth-filling projects used to absorb the high quantity of inert materials have led to such stockpiling. It is also difficult and economically inefficient to sort inert materials to meet project specifications for the use of filling materials.¹⁾

For many people in the construction industry, the concept of waste treatment is directly associated with the action of removing the waste from the site to the landfills. The main reason for this view is the fact that the waste issue is a reality in the construction industry. Although such waste is very important from an environmental perspective, this approach has been criticized since the beginning of industrial engineering.⁵⁾ The economic loss caused by material waste is smaller than the ones related to the inefficiency of human work. Ford also suggested that human work should be the focus of waste prevention, since the value of materials depends, to a great extent, on the work that has been spent on them. Other types of material waste beyond debris also need to be considered. A study by ⁶⁾ classified construction

waste by losses included direct and indirect material waste. The direct waste consists of a complete loss of materials since they are irreparably damaged or simply lost. In this case, the wastage usually needs to be removed from the site such as the sand process before usage with cement on finishing activities. In contrast, indirect waste occurs when materials are not physically lost; causing only a monetary loss, for example, waste due to concrete slab thickness larger than specified by the structural design.³⁾

2. Causes of construction waste

Many causes lead to generating material wastage in construction projects. The main causes are found to be design errors, wrong specifications, lack of execution information, mistake assessment of material quantities, difficulty in movement, poor stock of materials, inefficient process of materials, inexperienced workers, and poor site management and performance.⁷⁾

It is estimated that 33% of the construction waste is due to the unemployment of waste reduction measures by architects during design.⁸⁾ Minimization of the construction waste through design is a complex task because buildings usually embody a diverse range of materials. On the other hand, various project parties contributed directly or indirectly to raise the generated waste. However, there is a consensus that design changes occurring whilst construction is the main factor that generates construction waste.⁸⁾

Specifications complexity and lack of execution information lead to assumptions made by contractors and sub-contractors, which result in over-ordering of materials. The unforeseen construction conditions and long project durations allow for modifying the design to be more modern.⁹⁾

Generated waste during the execution phase is mainly due to poor communications leading to mistakes, bad overlapping between design and construction, incorrect estimating, obstacle transportation, bad storage, uncompleted handling, poor workmanship, lack of supervision, and inefficient site management. This leads to construction waste prevention issues being at the bottom of the priority list. Lack of recycling and reuse, education, technology process change, and material reduction techniques during the project activities minimize the possibility to avoid a lot of the generated waste in construction sites.¹⁰⁾

2.1. Material waste in construction site

Material wastes found in the site can be concrete, steel reinforcements, cement, blocks, mortar, and aggregate.

2.1.1. Steel reinforcement

Due to its weight and shape, steel reinforcement can be cumbersome to handle. Thus, controlling its usage in building sites is relatively difficult.¹³⁾ Cutting steel is reinforcement out of the design and detailing. Damages caused by storage and rusting are also some of the other reasons for steel wastage.¹⁴⁾ Other reasons that may also leads to waste are loss in mud, damage to mesh and bars, and excessive use of tying wire.⁹⁾

2.1.2. Concrete

Mixed concrete can be classified into two: concrete ready-mixed (premixed concrete) and concrete site-mixed. Concreting is a major part of the building process. The substructure and superstructure of buildings make use of concrete, making it the most extensively used material.¹¹⁾ A survey of twenty-two construction sites in Hong Kong revealed that ready mixed concrete was used 80% of the work. About 3-5% of the material ends up being wasted. Most of the loss was because of broken formwork, excessive material ordering, and poor concrete placement quality that resulted in redoing the work.⁹⁾ In the case of ready mix concrete supply, the top reason for wastage is the mismatch between the quantity of concrete ordered and the actual amount required.¹⁴⁾

2.1.3. Cement and mortar

It is relatively more complicated to analyses the waste of cement since it is used as a component of mortar and casts in-place concrete in many different processes like plastering, brickwork, and floor screed. Nonetheless, this material is considered to be relatively expensive.¹²⁾

Mortar is mostly utilized to set blocks and bricks and finish off buildings' facings. Scraping out the mortar from the spaces between the facing bricks is said to be the main cause of waste here. Other causes of waste are spillage during transport and mixing too much mortar. When too much mortar is mixed, residues in mixers, tubes, and wheelbarrows are created.

2.1.4. Sand, lime, and mortar premixes

The wastage of mortars consumed in fabricating brickworks and plasters has been previously outlined. The major sources of cement wastage also account for the majority of issues associated with lime and sand, and also pre-mix of lime and

sand mortars. These materials are normally transported via lorries, and so added wastage may be associated with inadequate controls in deliveries and with handling prerequisites.³⁾ Certain Brazilian firms have begun utilizing ready-use packaged mixes of mortars. This packaging has tended to resolve many of the control issues associated with deliveries, handling, and distribution. Even though data is insufficient reports indicate that such technical improvements can reduce mortar wastage compared to that of conventional on-site production of mortars.¹³⁾

2.1.5. Bricks and blocks

Brick and block materials are among the most commonly employed types, and cutting is the major source of wastage. Unloading supplies may result in increases in losses from damages due to the materials' fragility. Leftover brick supplies at many locations also tended to be eventually disposed of as waste.¹⁴⁾ A mix of reasons can explain brick and block material wastage at the majority of locations which performed weakly. Issues associated with material deliveries, such as inadequate controls for the numbers of brick or block delivered as well as losses incurred in the materials as these were unloaded, were observed at many site.¹⁵⁾

3. Research methodology

3.1. Site observation

The researcher directly visited thirty-four construction sites in Iraq as soon as obtaining the approval of the organization's companies wishing to cooperate with the researcher. Site monitoring is described in **Table S1** (Supplementary material). The study focused to measure activities in the begging that included the mean material in the local construction industry sand, gravel cement, steel reinforcement, bricks, and thrmoston. The researcher observes the procedure work of each activity (material delivery, transportation of material, handling, stock, rejection of activities, labor mistakes, cutting in steel). The observation of construction sites is not only pointed out the work activates but report how the staff prepare to achieve each activity (**Table S1** (supplementary material)).

3.2. Data measured

Study by (Formoso CT, Asce LSM, Cesare C De, Isatto EL) measured the waste percentage of materials in relation difference between the amount of materials effectively purchased by the company (M purchased), less the amount

of existing inventories (Inv) to the amount of materials defined by the measurement of work done (M designed).¹³⁾

Waste percentage

$$= [(M \text{ purchased} - \text{Inv}) - M \text{ designed}] / M \text{ designed} \text{]-Eq(1)}$$

To evaluate the research objectives and also to answer the research questions, collected data was entered to SPSS Ver 24. Prior to data analysis data cleaning was done for checking of missing cases or wrong entry. After cleaning data both descriptive and inferential analysis were applied.

To calculate the highest percentage of waste in construction projects frequency analysis used to measure and determine the waste materials pattern in the Iraq construction industry. Differences in the mean scores of all types of waste material, a one-way repeated measure ANOVA was conducted to assess the differences among types of waste material. An ANOVA with repeated measures is used to compare three or more group means where the participants are the same in each group. This usually occurs in two situations when participants are measured multiple times to see changes to an intervention, or when participants are subjected to more than one condition/trial and the response to each of these conditions wants to be compared. To evaluate three types of projects including specialist contractors, general building contractor, and government department's projects, frequency analysis was applied.

3.3 Result analysis

According to these results, the highest percentage of waste in construction projects belonged to "Brick" with 15.21% followed by "Sand" with 12.62% and "Thermo-stone" with 12.13%. The lowest percentage of wastes in Iraq construction project was observed for "Steel" and "Cement" with 3.96% and 4% respectively as shown in **Fig. 1**.

Fig. 1. Percentage of different waste among construction projects.

To evaluate the differences in the mean scores of all types of waste material, a one way repeated measure ANOVA was conducted to assess whether there were differences among types of waste material.

The result of Mauchly's test indicated that the Sphericity assumption was violated ($c^2 = 226.136$), ($p < 0.001$). Therefore, Greenhouse-Geisser estimation was used to evaluate the differences among means of different waste materials. The results of repeated measure ANOVA showed that difference among these six types of waste material was statistically significant $F_{(1.33, 43.948)} = (1902.654)$, ($p < 0.05$), ($\eta^2 = 0.983$) therefore to evaluate the details for the mean difference of these six types of waste material, post hoc test (Bonferroni) was applied to compare the mean scores. The results of Bonferroni test **Table S2** (Supplementary material) showed that the difference among all tests was significant ($p < 0.05$). According to this test, it was observed that the percentage of sand significantly was lower than brick while it was significantly more than gravel, cement and steel. There was no significant difference between sand and thermos tone. These results also showed that the percentage of gravel was significantly lower than brick and thermos stone while it was significantly more than cement and steel. There was no significant difference between cement and steel but the percentage of steel significantly was lower than brick and thermos stone. The results of the pairwise comparison also indicated that brick significantly was more than thermos stone. This means that the average of material waste varies from one material to another in the same project

3.4. Waste Material pattern and executing the type of projects

A total of thirty four projects were considered for evaluation of waste patterns as given in **Table S2** (Supplementary material). From these thirty four construction projects fourteen projects were under specialist contractors and the same number of projects belonged to the general building contractor. Only six projects were managed under government departments. In this part of the data analysis, the difference between the three types of projects was investigated (**Table S2** (supplementary material)).

3.4.1. Sand

Descriptive statistics (**Fig. 2**) showed that the highest percentage of sand as waste belonged to governmental projects (14.22%) followed by a special contractor with (12.89%) and

Fig. 2. Percentage of sand as waste among three types of construction projects.

the lowest amount of sand as waste produced by general building contractors (11.67%). This highest percentage in site executing by government department caused by many factors such use repair on finishing work, bad estimation in foundation work, waiting for equipment repair, damage material in the site, and materials do not meet specification. The mixed between sand and gravel in sites activities work make damage in both. It must to separates material and prepare an adequate place before doing any activities to avoid this highest wastage. Multiple storages to executing activities in these sites made sand spared in a large area which causes other losses.

3.4.2 Gravel

The results of data analysis (**Fig. 3**) for a percentage of gravel among three types projects indicated that the highest percentage of gravel as waste material was observed among governmental projects (12.77%) followed by conducted projects by a special contractor with 11.19% and the lowest amount of gravel as waste produced by general building contractors (9.71%). A total of thirty four projects were considered for evaluation of waste patterns as given in **Table S2** (Supplementary material). From these thirty four construction projects fourteen projects were under specialist contractors and the same number of projects belonged to the

Fig. 3. Percentage of gravel as waste among three types of construction projects.

Fig. 4. Percentage of cement as waste among three types of construction projects.

general building contractor. Only six projects were managed under government departments. In this part of the data analysis, the difference between the three types of projects was investigated (**Table S2** (supplementary material)).

3.4.3. Cement

Descriptive statistics for cement waste showed in **Fig. 4** that the highest percentage belonged to governmental projects (5.92%) followed by a special contractor with 4.61% and the lowest amount of cement waste material observed by general building contractors (2.56%). Cement is a major component in building activities such as casting, brickwork and finishing phase. Cement waste is relatively complex to evaluate, losses in these sites are caused by poor storage and handling works. The workers careless about cement bagged some of them split and speared to the ground. Concrete is an elastic material that generated pressure to farm celling or foundation. This made an increase in cement value.

3.4.4. Steel

The results of data analysis as shown in **Fig. 5** for a percentage of steel among three types projects indicated that the highest percentage of steel as waste material was observed among governmental projects (5.88%) followed by conducted projects by a special contractor with 4.49% and the lowest amount of gravel as waste produced by general building contractors (2.58%).

The reasons for losses in steel caused by cutting and rusting. Designer in some part of the activities required using different diameter. Cutting too small pieces cause an unusable amount of insufficient steel bars. Lack in structure standardization the major case in steel reinforcement losses.

3.4.5. Brick

Brick waste was another types of waste in construction

Fig. 5. Percentage of steel as waste among three types of construction projects.

Fig. 6. Percentage of brick as waste among three types of construction projects.

projects The results of a descriptive analysis on percentage of brick waste (**Fig. 6**) showed that the highest percentage of brick as waste belonged to governmental projects (17.03%) followed by a special contractor with 15.71% and the lowest amount of brick as waste produced by general building contractors (13.92%). The major cause in brick losses cutting in a standard size to consider with the designer requirement. Multiple handling of the same batch of bricks inflow building process. Design layout in wall works needs using a lot of cutting in bricks by using tools. The workers did not cure the remaining quantities of bricks consumption the newer pieces to complete building activity a large amount of cutting remaining in the ground and generated a high waste of losses in bricks.

3.4.6. Thermos tone

The results of data analysis (**Fig. 7**) for a percentage of thermos tone among three types projects indicated that the highest percentage of thermos tone as waste material was observed among governmental projects (15.97%) followed by conducted projects by a special contractor with 13.01% and the lowest amount of thermos tone as waste produced by general building contractors (9.59%). Poor handling was the mean case of thermo stone waste. Loading and unloading from storage to site activities cause a lot of damage and broking.

Fig. 7. Percentage of thermo stone as waste among three types of construction projects.

Fig. 8. Frequency of major construction wastes in Iraq construction industry.

Thermo stone is a lightweight cheaper than bricks and bigger size. It is preferred in building interval wall and building activities especially second floor and so on. However, the problem in handling works is not efficient to lessen the high percentage of waste in thermo stone.

3.5. Major construction wastes in Iraq construction industry

According to the results (**Fig. 8**) for major construction waste in Iraq construction project, it was found that the majority of respondents selected the highest waste from the material was handling with 31.9% actions implementing activities such as building brick wall go through several stages, as they require the mortar handling phase and the brick construction project. Eight researcher study find that material handling process minimize waste generation.¹⁶⁾ These stages often require a large effort and a sufficient number of workers and the contractor may resort to reducing the number of workers required to implement each activity, which leads to workers feeling tired and exhausted, generates indifference and interest in the resulting losses and as they intend. The worker needs to spread the mortar on the wall to fix the bricks on it and

does not care about the falling off mortar as a result of that.

Concrete construction with 28.09% the second major construction waste.¹⁷⁾ The concrete mixing process requires three stages. The first stage is the unloading of the concrete from the factory in the baking, then from the molding pump to the pouring pump, then from the casting pump to the section to be poured. Through the phases of emptying and filling these wastes occur in addition to the presence of errors in the wood formwork that may not be well fixed or errors in measurements during implementation.

24.26% of respondents selected the finishing the third major construction building. Finishing work requires sand treatment to obtain a suitable gradient for fucus purposes. During the fucus work, some parts of the mortar fall off and mix with other waste, which makes its use undesirable reuse, in addition to the quantities charged for the purpose to obtain tropical walls.¹⁸⁾

Formwork with 10.6% Loses of the framework related to design the fourth ranking in major construction building. Often designers resort to demonstrating the aesthetic of the building at the expense of generating waste, environmental and economic damage in addition to the presence of mistakes in some designs.¹⁹⁾

Temporary hoarding with 5.11% had the lowest frequency as major construction waste. Companies usually resort to fencing the site before starting the project and setting up temporary services during the implementation of the projects. Often not used at the end of the project. The result of chi-square indicated that this difference was statistically significant ($\chi^2=62.85$, $p<0.001$).

3.6. Discussion

The study showed that the percentage of losses in the construction sites is very high compared to the permissible limit. Most of these losses are caused by material handling, Concrete construction, finishing as major construction waste and two other items including formwork and temporary hoarding. In addition to the losses resulting from the work of delivery materials to the site, poor storage, design mistakes, human errors and mistake in estimating quantities related to the implementation of each activity. This is due to the unwillingness of contractors and companies to reduce the wastes, as well as that these wastes different from site to another for the same construction material, and the waste in the same site different from one material to another.

The government should set laws that limit the phenomenon

of generating wastes and impose taxes on companies to limit their spread to reduce the negative effects on the environment and reduce the costs incurred by them.

The designer must take into account the losses generated must make designs more friendly environment, easy to implement, and somewhat avoids the unnecessary aesthetics of buildings and the extra cost. Such as minimize the different of steel diameter, building dimensions are close to standard steel dimensions or their multiples. The design of the building has a longer service life and the maintenance process can be sustainable and use of reusable materials.

The tinder must be prepared accurately, unnecessary any additional quantities, as well as containing a permissibility rate for the use of construction wastes. The study observed that the waste in the building can be used, especially the parts that can be achieved on the site, such as lintel and precast for building entrances, passage and indoor playgrounds.

The company has to hire with a staff capable of managing the site and has experience in how to manage the delivery of materials to and from the site, store materials and the use of skilled manpower in the implementation of the work and monitor the activities of the project on carried out with control over construction wastes during the implementation of the project in addition to estimate the quantities used for each work activity executed and the project schedule.

4. Conclusions

He objective was to measure and determine the waste material pattern in Iraq construction industry. Both frequency analysis and repeated measure ANOVA were used to cover the objective of the study. According to the results of frequency analysis, the highest percentage of waste in construction projects belonged to “Brick” with 15.21% followed by “Sand” with 12.52% and “Thermo-stone” with 12.02%. The lowest percentage of waste in Iraq construction project was observed for “Steel” and “Cement” with 3.96% and 4% respectively. ANOVA was conducted to assess whether there were differences among types of waste material showed there was a significant difference among 6 wastes types ($p < 0.05$) including sand, gravel, cement, steel, brick and thermos-stone. The second part of this objective was related to comparing among three types of projects including specialist contractors, general building contractor, and government department’s projects. The results of comparison between these three groups confirmed that for all types of

construction project waste the governmental project had the highest percentage followed by special contractor the lowest percentage of all waste belonged to general building contractor.

Acknowledgement

I would like to thank all sites engineer and organization companies who willingly cooperate in recorded and measurement number of activities, including reinforced concrete structure, brickwork and finishing activities, share ideas on related issues during the site observation.

References

1. M. N. Mulenga, Towards sustainable construction waste minimization and management in Zambia and beyond. Rwanda, J. Eng. Sci. Technol. Environ., 1(1), 1-10(2018).
2. C. Luangcharoenrat, S. Intrachotoo, V. Peansupap, W. Sutthinarakorn, Factors influencing construction waste generation in building construction: Thailand's perspective, Sustainability, 11(13), 1-17(2019).
3. C. T. Formoso, E. H. Hirota, Method for waste control in the building industry, in Proceedings of the 7th Annual Conference of the International Group for Lean Construction, Engineering, Berkeley, USA, pp. 325-234(1999).
4. I. Saidu, W. Shakantu, The contributions of construction material waste to project cost overruns in Abuja, Nigeria, Acta Structilia, 23(1), 99-113(2016).
5. A. Turkyilmaz, M. Guney, F. Karaca, Z. Bagdatkyzy, A comprehensive construction and demolition waste management model using PESTEL and 3R for construction companies operating in central Asia, Sustainability, 11(6), 1593(2019).
6. E. R. Skoyles, Materials wastage - a misuse of resources, Batim. Int. Build. Res. Pract., 4(4), 232(1976).
7. J. Y. Wang, X. Kang, V. Tam, An investigation of construction waste made in Mainland China, in Proceedings of The CRIOCM 2006 International Symposium, Engineering Hong Kong(2006).
8. I. Bakas, E. Bøe, J. Kirkeby, B. J. Kjær, A.-K. Ohls, J. Sidenmark, M. U. Mandrup, Assessment of initiatives to prevent waste from building and construction sectors, Sustainable consumption and production, Environment, Nordic Council of Ministers, Copenhagen, pp. 1-83(2011).
9. C. S. Poon, A. T. W. Yu, S. W. Wong, E. Cheun, Management of construction waste in public housing projects in Hong Kong, Constr. Manag. Econ., 22(7), 375-689(2010).
10. A. Hussien, R. Samin, M. Idris, An analysis of, willingness and effective factors on waste minimization in construction industry: Iraq, 10(12), 77-83(2016).
11. D. Altuncu, M. A. Kasapşekin, Management and recycling of constructional solid waste in Turkey, Procedia Eng. 21, 1072-1077(2011).
12. A. Markos, H. Hailu, Concrete and concrete making materials wastage minimization in construction of housing project in Bole Bulbula site, Addis Ababa Science and Technology University, Ethiopia, pp. 2-37(2017).
13. C. T. Formoso, L. Soibelman, C. D. Cesare, E. L. Isatto, Material waste in building industry: main causes and prevention, J. Constr. Eng. Manag., 128(4), 316-326(2002).
14. L. Y. Shen, V. W. Y. Tam, C. M. Tam, D. Drew, Mapping approach for examining waste management on construction sites, J. Constr. Eng. Manage., 130(4), 472-481(2004).
15. A. A. Kadir, A. Mohajerani, Bricks: an excellent building material for recycling wastes - a review, in Proceedings of the IASTED International Conference, Environmental Management and Engineering, Canada, pp. 108-115(2011).
16. M. F. Hasmori, A. F. Zin, S. Nagapan, R. Deraman, N. Abas, R. Yunus, M. Klufallah, The on-site waste minimization practices for construction waste, in Proceedings of The 2nd Global Congress on Construction, Material and Structural Engineering, Malaysia, pp. 1-11(2020).
17. W. J. Park, R. Kim, S. Roh, H. Ban, Identifying the major construction wastes in the building construction phase based on life cycle assessments, Sustainability, 12(19), 8096(2020).
18. M. Marinelli, M. Dolan, J. Spillane, A. Konanahalli, Material waste in the Northern Ireland construction industry: on-site management causes and methods of prevention, in Proceedings of 30th Annual ARCOM Conference, Association of Researchers in Construction Management, Portsmouth, United Kingdom, pp. 113-122(2014).
19. S. O. Ajay, L. O. Oyedele, O. O. Akinade, M. Bilal, H. A. Alaka, H. A. Owolabi, K. O. Kadiri, Attributes of design for construction waste minimization: a case study of waste-to-energy project, Renew. Sustain. Energy Rev., 73, 1333-1341(2017).

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Author and Contribution Statement

Ali Hussain

Building Engineering Department, Education of Thiqr Directorate, Ph.D. Student, ORCID[®] 0000-0002-3291-7943: Data curation, Data analysis, Methodology, Writing - original draft, Writing - review and editing.