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TRANSFORMATION OF NEW SMART TOILET ARCHITECTURE IN THE ERA OF COVID-19 PANDEMIC IN NIGERIA

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Introduction

According to Leslie D, Patrick F. H., David A. C., Mark F., Jonathan A. E., Kevin V. W. (2020), the rapid spread of severe acute respiratory syndrome corona virus 2 (SARS-CoV-2) that results in corona virus disease 2019 (COVID-19), corporate entities, federal, state, county, and city governments, universities, school districts, places of worship, prisons, health care facilities, assisted living organizations, daycares, homeowners, and other building owners and occupants have an opportunity to reduce the potential for transmission through

Abstract

The transformation agenda in this on-going work was as a result of the global COVID-19 pandemic, since late 2019 till date, which paved way for the purpose of harnessing new approaches and opportunities in Smart Toilet Architecture as one of the solutions to the menace in Nigeria. The recent concern for the introduction of Smart Toilet Architecture have led to the revival on the rate of Open Defecation (OD) and also that of health, sanitation and hygiene in the Nigerian built environment. The professional practice of the construction team in actualizing open defecation free status of health, sanitation and hygiene of the National Development issues can never be overestimated in

Response to many challenges of Sustainable Development Goals (SDG) number 6 on sanitation. Also, a healthy nation is central to all physical, social, technological, economic growth and sustainability. The Nigerian health sector is known to be faced with inadequate sanitary facilities like toilets, hand washing facilities, services and equipment. Hence, this work focused on the functional requirements that are converted to engineering specifications, systematic design approach in Smart Toilet architecture design and construction that is applied for the conceptual design. Systematic design approach involves functional analysis of the design problem, required of the new smart toilet is decomposed to obtain sub-functions. Furthermore, solutions are generated to the design problems at sub-function level and the solutions are combined by solution matching to obtain combinatorial optimal solutions based on the listed criteria and solution options. A new smart toilet product was finally evolved with a leg pedal control sliding door with fixed hand washing facilities. In conclusion, the study under investigation also further discusses issues of immense contribution to the design, construction and operation of COVID-19 compliant Smart Toilet which recommended that government with stakeholders should strictly enforce the law the 'Use of Toilet Campaign', advocacy on health, sanitation and hygiene in the Nigerian built environment, sanitation marketing and finance towards the attainment of Smart Toilet Architecture towards Open Defecation Free (ODF) and COVID-19 free Nigeria.

KEYWORDS: Advocacy, Health, open defecation, sanitation and technological.

built environment. As a result of the built environment, COVID-19 and the copper according to Kathryn (2020) proclaimed that [Great Lakes Stainless](#) is a manufacturer in Traverse City that has designed and produced copper plating to cover door handles and other touch points. The company says copper is the only metal that is registered to kill off germs and reduce the transference of viruses. Scotty (2019) also narrated that a pair of students in Hong Kong have created a self-cleaning door handle as the device uses ultraviolet light to cause a chemical reaction that kills germs which in tests, it was able to kill 99.8% of microbes on the door handle. Hence, partial or full lockdowns was observed at least half of the global communities as a result of the COVID-19 and the architectural stay at home is the best drug known so far. When the novel corona virus tore through China

but the research done so far in China hasn't generated enough data for conclusive answers even with an experimental antiviral drug called remdesivir, the anti malarial drug chloroquine (or the related hydroxychloroquine), a combination of two HIV drugs, and those same two HIV drugs along with the anti-inflammatory interferon beta (Nicole, 2020).

COVID-19 and the special project proposals had attracted global participants in research all over the world to contribute immensely in the fight against Corona virus infections with leading health experts from around the world have been meeting at the World Health Organization's Geneva headquarters to assess the current level of knowledge about the new COVID-19 disease, identify gaps and work together to accelerate and fund priority research needed to help stop this outbreak and prepare for any future outbreaks (WHO, 2020). Also, COVID-19 and the world religions of Judaism, Christianity and Islam have united and come together to fight their common enemy of COVID-19 pandemic as Faith leaders from Christianity, Judaism and Islam support government efforts to control the corona virus (Mohammed, Burton and Bob, 2020).

Therefore, the news cycle around the world over is now entirely focused on the corona virus pandemic, the dangers of [COVID-19](#) and the importance of contact tracing, social distancing, isolation and quarantine are the prevention methods (Narayana, 2020). Another good prevention method of the dangers of [COVID-19](#) is through good water sanitation and hygiene (WASH). Good WASH and waste management practices, that are consistently applied, serve as barriers to human-to-human transmission of the COVID-19 virus in homes, communities, health care facilities, schools, and other public spaces (World Bank, 2020).

Again, the professional practice of the construction team in actualizing Open Defecation Free (ODF) status of health, sanitation and hygiene of the national development issues can never be overestimated in response to many challenges of Sustainable Development Goals (SDG) number 6 on sanitation. The toilet is a space inside or outside the building for defecation and urination with comfort and privacy. Therefore, the toilet architecture deals with all the relevant aspects of internal and external considerations of providing a comfortable space to defecate for households and public environments. In reality, Open Defecation (OD) remains a huge obstacle for people and is responsible for thousands of unnecessary deaths. Eradicating it is crucial to

achieving SDG Goal number 6 on sanitation. Some Bauchi communities were triggered effectively with Community Led Total Sanitation (CLTS) and embark on a journey of rapid collective behavioural change; achieving ODF status and getting certified as such are important milestone in the process rather than the end of the journey. Therefore, toilet architecture changes with situations and conditions, needs and requirements of the community in order to migrate from OD to ODF.

Sanitation and hygiene is a public health issue not just an individual household concern. Even if only a few families do not practice safe sanitation and hygiene, the whole community is at risk. Therefore the aim is to achieve 100% coverage of improved sanitation and safe hygiene practices. The achievement of which is both a collective responsibility and benefit. According to the UNICEF/WHO (2012), 82% of the 1.1 billion people practicing open defecation live in 10 countries and Nigeria is one of them. The others are India, Indonesia, Pakistan, Ethiopia, Nepal, China, Sudan, Niger and Mozambique. It means that to continue with the use of un-improved pit latrines that become a reservoir of open defecation with flies in and out, cockroaches in multitudes, smell from kilometers, impossible to wash, maintenance is close to zero, easy to collapse, un friendly to children, adults skeptical to get injured we can to shift the paradigm. To overcome this challenge there is the need to shift from the use of local unimproved pit latrines to something innovative and have suitable latrine designs that would not only be cost-effective, environment-friendly and easy to construct but also would be acceptable to people especially less privileged arise the concept of low-cost but high-quality toilet called 'SMART TOILET' with other good natural or artificial features. Here, natural SMART TOILET will be highly emphasized and transformed as a result of cost, materials availability, manufacturability, environment and performance.

According to SMEDAN (2019), SMART means;

S- Specific, M- Measurable, A- Achievable, R- Result-oriented, T- Target bound
Sensitization and promotion of durable but affordable toilet facilities is very important. This is a situation of improved toilet designs that fits into all socio-economic standard of a household and at the end achieves an assured privacy, free from contamination and infections as well as total demarcation of feces to human contact. Smart toilet is easy to clean and maintain, it uses less water to flush, free from cockroaches, houseflies, nesting ground for mosquitoes,

smell and irritation to use. It is more of a comfort toilet and easy to use by all age groups. It ensures hygienic separation of human excrete from human contact. In most African countries, especially some states in Nigeria have actually migrated to the next higher level in terms of hygiene as open defecation free (ODF) area. The types of toilets are as a result of different spaces (open/close, public/private, internal/external, tangible/intangible) and levels (upper/lower, large/small, necessity/luxury) are: Traditional pit toilets, San Plat toilets, Conventional improved pit toilets, VIP toilets, Pour-flush toilets, Compost toilets, Mobile toilets, Smart toilets, other toilets.

OBJECTIVES

The objectives of this paper are to:

1. Design a functional Smart Toilet that is COVID-19 compliant.
2. Identification of new approaches and methodologies in transforming healthy Smart Toilet designs.
3. Supply and facilitate standard design methods, materials and technology for a new Smart Toilet product in the era of COVID-19 pandemic.

STATEMENT OF THE PROBLEM

In the late 2019, the World recorded the epidemics of Corona Virus, emanating from China. Today, the U.S was highlighted as the first worst country in terms of mortality rate due to COVID-19 pandemic. The provision of safe water, sanitation and hygienic conditions is essential to protecting human health during all infectious disease outbreaks, including the COVID-19 outbreak. Ensuring good WASH and waste management practices in communities, homes, schools, marketplaces, prisons and health care facilities will further help to prevent human-to-human transmission of the COVID-19 virus. The rights to water and to sanitation are part of the right to an adequate standard of living (WHO, 2020). Most Nigerians do not have access and provision for safe water, sanitation, and hygienic conditions which is essential to protecting human health during the COVID-19 outbreak. Prevention of human-to-human transmission of the COVID-19 virus may be supported by promotion of the rights to water and sanitation, and supporting water and wastewater infrastructure and technicians to ensure good and consistently applied WASH and waste management practices in communities, homes,

schools, marketplaces, and healthcare facilities. Hence, this work is needed to understand the risk of contaminated drinking water, environmental transmission, and how to ensure toilet users are supported throughout the crisis with the use of new Smart Toilet product to prevent COVID-19 infections. Considering these facts requires serious attention by the stakeholders in finding solutions to the menace of COVID-19 pandemic, using new Smart Toilets at various spaces and levels which will go a long way in order to create conducive environment for a healthy living, stop open defecation, strategically provide hand washing facilities and transform Nigeria to be COVID-19 free.

LITERATURE REVIEW

Due to the global relevance of COVID-19, the world has come to realize the fact that it is not a Chinese Virus, but a universal pandemic. Citing concerns with “the alarming levels of spread and severity,” the WHO called for governments to take urgent and aggressive action to stop the spread of the virus (Human Right Watch, 2020). Internationally, many countries of the were affected with high mortality rates as a result of highly contagious Corona Virus infections have reached over two million deaths are increasing geometrically. A Science Fiction book once predicted the tragedy of the COVID-19 pandemic in the City of Wuhan according to an online conspiracy theory, the American author Dean Koontz predicted the coronavirus outbreak in 1981. His novel *The Eyes of Darkness* made reference to a killer virus called “Wuhan-400” – eerily predicting the Chinese city where Covid-19 would emerge. But the similarities end there: Wuhan-400 is described as having a “kill-rate” of 100%, developed in labs outside the city as the “perfect” biological weapon (The Guardian, 2020).

Another Science Fiction movie titled ‘Contagion’, featuring Jennifer Ehle and other famous actors showcased similar effects of the so called COVID-19 pandemic. What these movies have that real life lacks is pacing. Steven Soderbergh’s snappy Contagion, from 2011, opens with a title card reading “DAY 2,” leaving us wondering for the rest of the movie about the day we missed, while frantic pressure accompanies the spread of the MEV1 virus. Gwyneth Paltrow dies foaming at the mouth, and drums beat along to the action. Meanwhile, scientists hunt for the origin of the disease, tracing it back through time to look for an antidote (Josephine, 2020). While, Africa is not left

out in the fight against the COVID-19 pandemic as the cases and casualties are increasing arithmetically. The natural herbs from Madagascar is a welcome idea in combating COVID-19 pandemic. The president of Madagascar Andry Rajoelina has officially launched what he calls a local herbal remedy, which he claims can prevent and cure the [coronavirus](#) (Eye Witness News, 2020). Also, COVID-19 and West African countries are not left behind with several efforts of using local herbs and indigenous unorthodox medicine, procedures and protections, such as localized face masks and ventilators to curb the menace of the infections. COVID-19 and the testing equipment from Senegal is a welcome idea in combating COVID-19 pandemic. According to Marc (2020) the COVID-19 pandemic has pushed Senegal to speed up the rollout of a public e-commerce platform, projects for internet infrastructure development and legislation governing data collection, paving the way for new business opportunities. In Nigeria, efforts of the government and the citizens can never be underestimated in the fight against COVID-19 pandemic as the Federal Government has announced a N36m cash prize for any Nigerian that finds cure for coronavirus and Lassa fever (Punch, 2020).m According to the Nigeria Centre for Disease Control (NCDC), the development of an interim national case management guideline for COVID-19 are:

1. Standard of management of COVID-19 cases
2. Sample collection procedure from suspect cases of COVID-19
3. Transfer of suspect / ill persons
4. Safe and dignified burial for suspect/confirmed cases (NCDC, 2020)

About 70 million people, out of a population of 171 million, lacked access to safe drinking water, and over 110 million lacked access to improved sanitation in 2013. Open defecation rates, at 28.5 per cent pose grave public health risks. Every year, an estimated 124,000 children under the age of 5 die because of diarrhoea, mainly due to unsafe water, sanitation and hygiene. Lack of adequate water and sanitation are also major causes of other diseases, including respiratory infection and under-nutrition (World Bank, 2009).

Also, it is very important in order to promote developing countries to meet the Sustainable Development Goals (SDG) on water, sanitation, waste management and to improve learning outcomes which can even be tailored and targeted specifically to meet the needs of low-income communities (World Bank, 2009). Nigeria is a country which places a great emphasis on

cleanliness. A decree from the days of military government which is still in force mandates that the final Saturday of every month is **Sanitation Day**, meaning that travel is banned and a curfew enforced until 10 am. Families are told to use the time when they are confined to tidy the home. Unfortunately, once household waste is tidied, the problems begin. Nigeria's booming population, an asset in economic growth terms, is placing great pressure on solid waste management (SWM) systems which are in many cases already either antiquated, informal or non-existent (Guardian News, 2016).

The aim of the health sector reform is to improve efficiency in performance, ensure transparent and responsible management, limit political interference, eliminate government's involvement in utility management, management and technical operations, encourage private investment in generation to address inadequate supply and free government funds to finance other critical welfare programmes. As a result, Bio-Power Environmental Solutions Ltd says the establishment of high-quality public toilets can generate revenue, create 11,000 jobs and promote a healthier environment in the country (The Cable, 2017). Recently, an interesting alternative to creating septic tanks with re-use materials has proven to help in controlling sanitation problems and regulate waste disposal at low cost (thedomesteadsurvival.com, 2015). Hence, the smart toilet architecture will exhibit the new approaches to design and construction with innovations towards the attainment of open defecation in Nigeria using Smart Toilet as related in the Table 1 below:

Table 1: A comparative analysis between an Unimproved Toilet and Smart Toilet

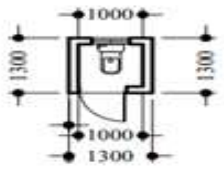
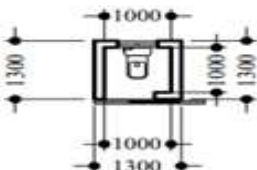


| S/NO | UNIMPROVED TOILET FEATURES | SMART TOILET FEATURES |
|------|--|--|
| 1. | High amount of water to flush | Low amount of water to flush and clean |
| 2. | Possibility of odour and flies | No odour and No flies as seal works against odours and pathogens transmission |
| 3. | Unhygienic separation of excreta from human contact | Waste not in direct contact with the body |

| | | |
|----|---|---|
| 4. | Latrine with poor slab or platform | Good slab or platform ensures no collapse structure |
| 5. | High cost and low quality | Low cost but high quality |
| 6. | Waste disposal problems and lack of initiatives | Hygienic disposal of waste to wealth initiatives |

Source: Developed by the Authors, 2020

Also, it is very good to exhibit the new approaches to design and construction with innovations towards the attainment of COVID-19 free environment by also using the new Smart Toilet as related in the Table 2 below:

Table 2: A comparative analysis between a Smart Toilet and COVID-19 compliant Smart Toilet

| S/NO | NORMAL SMART TOILET FEATURES | COVID-19 COMPLIANT SMART TOILET FEATURES |
|------|--|--|
| 1. | Normal door swings outside | Special door swings outside with leg pedal or special sliding door |
| 2. | Conventional hand washing facilities like Tippy Taps and wash hand basins | Advanced hand washing facilities like leg pedal hand washing facilities and character recognition systems |
| 3. | Common finishes and effects like ordinary plasters, paints, tiles and door ironmongery | Improved finishes and effects like self-cleaning walls, washable paints, tiles, sanitizing door handles, door leg pedals and copper door ironmongery |
| 4. | Latrine with simplified mechanical and electrical services reticulation | Better Latrine with improved mechanical and electrical services reticulation such as auto flush, disinfecting and more user friendly |
| 5. | Good waste to wealth disposal system | High technological and hygienic disposal of waste to wealth and energy initiatives |
| 6. |  |  |
| 7. |  |  |

Source: Developed by the Authors, 2020

METHODOLOGY

The research methodology entails generation of requirement, engineering specifications and Conceptual Design. The requirements for COVID-19 based smart toilets are obtained via information gathering from medical facility sites, medical personnel, patients and other expected users of such toilets. The requirements are converted to engineering specifications. Thereafter, a systematic design approach in Smart Toilet architecture design and construction is applied for the conceptual design. Systematic design approach involves functional analysis of the design problem. During functional analysis, the main function required of the new smart toilet is decomposed to obtain sub-functions. Furthermore, solutions are generated to the design problems at sub-function level. Thereafter, the solutions are combined by solution matching to obtain combinatorial solutions. Morphological Chart which comprises of functions and solutions is constructed. Selection of the optimum solution is based on criteria such as cost, materials availability, environment, manufacturability performance, weight, efficiency e.t.c. all these criteria are based on compliant of the Smart Toilet to the COVID-19 prevention.

Requirements Generation

The requirements were generated by consulting medical facilities related handbooks, manuals, and articles. Equally, medical practitioners and other expected users of the facility were interviewed. The bits of information extracted via all the stated means are listed below.

1. Expected number of the users
2. Expected age of the users
3. Expected human parts in context
4. Expected gender analysis
5. Expected weather variance
6. Expected locations of the sanitary facilities
7. Expected population of the users
8. Expected users' peak periods
9. Expected activity levels of the users
10. Expected literacy levels of the users
11. Expected behavioural change and attitude of the users

Engineering Specifications

Furthermore, the information gathered from the requirement list are converted to engineering specifications. The specifications are meant to enhance communication of the user requirements to the product. As such the product will be user centered. The information generated from the engineering specification was used in developing functional analysis for transforming the systematic conceptual design of the Covid -19 based smart toilet.

Conceptual Design

Trevisan *et al.*, defined design as an intelligent process of systematically generating, evaluating and stipulating concepts for artifacts whose form and function satiate customers' needs and satisfy a set of constraints (Trevisan *et al.*, 2018). The approach to conceptual design adopted is systematic as explained in according to Ramdhani and Jamari (2018), conceptual design process entails; concept clarification, concept generation, concept selection and concept development. The main function of the toilet is to enable a person either with or without COVID-19- to urinate and defecate in a public toilet without transmitting the disease to others or having the disease transmitted to them. Before decomposing a function, the main function must be well defined. Defining function entails expressing it input and output flow with their respective properties. Flows are the entities that are inputted, processed then outputted by feature. Inference can be made from the relationship between input and output function. (Yuan, L., Liu, Y., Lin, Y., & Zhao, J. 2017). The main function is decomposed to obtain the sub-function analysis listed below:

Functional Analysis

1. To disinfect a person with/without COVID-19 before the Smart Toilet.
2. To allow access for a person with/without COVID-19 into the Smart Toilet.
3. To enable a person with/without COVID-19 control the Smart Toilet door by leg pedal or slide.
4. To enable a person with/without COVID-19 defecate or urinate in the Smart Toilet.

5. To enable a person with/without COVID-19 flush the Smart Toilet after use.
6. To sanitize a person with/without COVID-19 before leaving the Smart Toilet.
7. To enable a person with/without COVID-19 control the Smart Toilet door by leg pedal or slide.
8. To disinfect a person with/without COVID-19 after the Smart Toilet.

Development of Morphological Matrix

Morphological matrix based conceptual design have proven to be highly effective in concept generation. However, each of the concepts are often evaluated quantitatively thereby making the evaluation process difficult. Besides, the influence of the uncertainty posed by the predesigned evaluations of the designers and customers are seldom taken into consideration while building most morphological charts (Ma et al., 2017). Morphological Chart enhances the generation of combinatorial solution (Summers, 2019). The main idea behind this work is to relate the functions listed above to some suggested solutions as tabulated in the Morphological Chart / Matrix of Functions below:

| S/NO | FUNCTIONS (Fs) | S O L U T I O N S | | | | |
|------|----------------|-------------------|-----|---|---|-----|
| | | 1 | 2 | 3 | 4 | 5 |
| 1. | F1 | S11 | S12 | - | - | S1m |
| 2. | F2 | S21 | S22 | - | - | S2m |
| 3. | | | | | | |
| 4. | | | | | | |
| 5. | | | | | | |
| 6. | Fn | Sn1 | Sn2 | - | - | Snm |

Source: Developed by the Authors, 2020

The guiding principle here uses the selection of optimum criteria such as cost, materials availability, environment, manufacturability, performance and

weight, followed by solution matching to measure the efficiency and validity of the Smart Toilet.

CONCLUSION

The smart toilet architecture deals with all the relevant aspects of internal and external considerations of providing a comfortable and healthy space to defecate and move from open defecation to open defecation free between 2025 to 2030 (Abdulmageed, 2018). The functional requirements are converted to engineering specifications, systematic design approach in Smart Toilet architecture design and construction that is applied for the conceptual design. Systematic design approach involves functional analysis of the design problem, required of the new smart toilet is decomposed to obtain sub-functions. Furthermore, solutions are generated to the design problems at sub-function level and the solutions are combined by solution matching to obtain combinatorial optimal solutions based on the listed criteria and solution options. A new smart toilet product was finally evolved and transformed with a leg pedal control sliding door with fixed hand washing facilities.

POLICY SUGGESTIONS

The following suggestions will be very important in the new smart toilet in the era of COVID-19 pandemic and other deadly contagious diseases:

1. The need for the government of the day to provide enabling environment and funding of the health sector for the production of new smart toilet and strictly enforce the law the 'Use of Toilet Campaign', advocacy on health, sanitation and hygiene in the Nigerian built environment, sanitation marketing and finance towards the attainment of Smart Toilet Architecture towards ODF and COVID-19 free Nigeria
2. Also, stakeholders in Public and Private Participation should sponsor and organize massive enlightenment programmes, sensitization, advocacy, workshops, promotions, conferences, seminars and symposia in collaboration with all the media houses so that training and re-training will take place in the health sector.
3. If the above are well implemented to its fullest, such a system of new smart toilet architecture would yield better sanitation markets, better

toilet structures, and healthier, ODF and COVID-19 free communities in Nigeria.

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