Quality Inspection Challenges During Housing Construction in Gauteng, South Africa

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Abstract
The role of inspections in ensuring good quality housing delivery cannot be overemphasised. There is limited research on the challenges faced in the housing construction inspection process to ensure that homes delivered to customers are high quality. This study investigated these challenges and how to improve the inspection process and construction quality. Twelve inspectors from quality assurance entities in South Africa were interviewed using semi-structured questions. Thematic content analysis revealed challenges related to manual and electronic (using a gadget) on-site data recording processes. These included freezing the gadget, insufficient information on the building and the owner, inaccurate data capture, difficulty retrieving stored information, inaccessibility to drawings, risk of theft, and difficulty in promptly issuing non-compliance reports due to system malfunctions and battery runout. By identifying the challenges of inspecting houses during construction, policies and appropriate strategies can be developed to improve the inspection process and ultimately, the quality of housing delivery in South Africa.

Keywords: Construction, housing development, inspection, quality assurance, South Africa

1. Introduction

Housing is a necessity and the main component of any society's social and economic development (Brkanić 2017). Regardless, quality housing delivery remains a global concern where most people still live in poorly constructed houses that threaten their lives (Manomano et al. 2016). It is evident that in developing countries, of which South Africa is inclusive, the quality of housing delivery is worse, remaining a huge problem (Habitat 2015; Musa et al. 2015). However, it is expected that by 2030, approximately 3 billion people worldwide, particularly those in developing countries, will need decent houses of good quality (Musa et al. 2015). These statistics emphasise the need for developing countries to put more effort into delivering quality housing to accommodate their increasing population. Housing quality broadly refers to a dwelling unit's physical condition, the physical environment's characteristics and quality, and client/end-user satisfaction (Mahachi, 2021). The Housing Corporation England (2007) defines good quality housing design as the delivery of desirable, affordable and high-quality homes and environments that utilise innovative approaches to satisfy needs and help address the aspirations of the occupants and the wider community. For this study, poor housing quality refers to poor physical condition, structural defects, poor design and negative impacts on health. Poor housing can negatively impact social lives, neighbourhoods and the environment (Easthope et al., 2017). Housing must respond to the variety of human needs and the shifting needs of individuals (Nedo, 2014). Therefore, house quality is not just the end product but also relates to the start of design and ensures the autonomy and power for the end user in the design and construction stages.

In South Africa, poor quality housing is a challenge, as the housing industry struggles with quantitative and qualitative shortcomings in housing delivery. Qualitatively, several houses delivered are

reportedly defective, leaving customers dissatisfied (Zunguzane et al., 2012; Nqentsu, 2017). For example, many homeowners report defects such as cracks and roof leakages in the houses provided (Zunguzane et al., 2012; Buys and le Roux, 2013). As a result, the government loses over 2 billion rands yearly on construction remedial works due to poor-quality housing delivery (Mhodi, 2015).

Poor housing quality has been attributed to the lack of proper building inspections to identify non-compliance with construction standards during the building process (Nyakala et al., 2021). On their part, Bortolini and Forcada (2018) highlighted that inspection methods are complex and labour-intensive, resulting in a lack of building inspection and building design errors, such as faulty design and specification not being correctly followed. In addition, non-compliance with standards may lead to the incorrect use or installation of materials, foundation failure, and structural imperfections (Kumar and Sriram, 2017). Moreover, the continued reliance on conventional inspection tools such as paperwork, step ladders, squares, and measuring tapes for conducting stage inspections leads to non-identification of faults (Rarani and Fore, 2014). This conventional inspection process is usually time-consuming, requiring interruptions during construction, with builders having to wait for the inspectorate's decision and approval letter on inspected structures to proceed to the next stage of construction (Ciampa et al., 2019). As a result, builders work under pressure to deliver housing projects according to predefined project schedules. These challenges, particularly the stage inspection approval, result in delays leading to possible missed inspections, which could also cause defects (Kwon et al., 2014).

Previous studies on housing quality delivery challenges exist. However, there is limited research on the inspection process challenges, especially with technological advancement and tools used in the construction building inspection. Chohan et al. (2015) developed a housing quality determinant model focusing on housing quality concerning design and neighbourhood spatial concerns. Nedo (2014) assessed the role of households and developers in delivering quality and affordable housing projects for dwellers in Indonesia. Emuze and Mhlwa (2015) focused on time and cost overruns in quality management on construction sites. More recent studies in South Africa also focused on other aspects of housing quality. For instance, Nyakala et al. (2021) assessed factors contributing to non-conformance of quality requirements in low-income housing projects from the perspective of house builders in the South African local government context. Mahachi (2021) developed and tested a quality assessment tool for measuring the quality of "as-built" housing construction elements against national technical standards and specifications, within a reasonable time and cost.

Therefore, this study investigated the challenges faced by inspection entities in South Africa in the housing inspection process. The research question was as follows: What are the challenges faced by the inspectorates of housing inspection entities in South Africa during housing development? The study findings are envisaged to be beneficial to housing inspectors and quality assurance entities in exploring and developing alternative inspection strategies to improve inspections and, in turn, housing quality during the construction process.

2. Housing Construction Inspection Challenges

Many countries experience the challenge of ineffective and inefficient inspection processes during construction. Although regulations regarding quality housing inspection in the construction of houses differ from different countries, similar challenges are associated with the housing inspection process, e.g., poor communication, poor artistry, and skill-shortage of inspectors, which all contribute to ineffective and inefficient inspection processes in the delivery of quality housing (Zunguzane et al., 2012). For the government's intention to address the housing backlog in South Africa, inspectors are required to carry out the task of quality assurance to ensure that builders construct according to the

building standards without looking the other way when there are poor construction works. However, inspections face challenges resulting in poor quality housing delivery. Lack of skills and capacity of inspectors, inadequate experience, and the owner's lack of participation in checking the quality of their houses were cited as challenges (Frauley, 2014). According to Liao (2014), government inspectors are underequipped, not well-trained, and incapable of carrying out the inspections like those of South Africa, Singapore, New Zealand, Brazil, Latvia, Vietnam, Spain, and Cyprus, especially given the workload (number of housing units) built in these countries. Inadequately trained and unequipped inspectors and insufficient inspection add to the challenges (Olojede et al., 2019). As a result, data capturers sometimes miss some information during the capturing process, and it later appears they did not undertake the inspection. Mkuzo et al. (2019) identified poor quality housing delivery in South Africa is due to the shortage of inspectors who should be on-site to ensure compliance on each stage of construction. Further, Khoza and Kabir (2014) found that the lack of collaboration between inspectors during the inspection process of housing construction also contributes to poor quality housing. On their part, Bortolini and Forcada (2018) highlighted that the problem could lie in the methods, as inspection processes are complex and labour-intensive. Rarani (2014) cited ethical concerns and professionalism as challenges to proper inspections. In some instances, inspection data are collected manually on paperwork, which adds more challenges to inspectors, where several hours are spent at the office to document data from the site after a labour-intensive inspection process on-site with the ticking of compliances or non-compliances of the housing construction in progress (Zhang et al., 2017).

Additionally, in Taiwan, the government employs temporary inspectors as the management system supports the inspection process due to a shortage of inspectorates conducting inspections (Liao, 2014). This challenge with the shortage of inspectors to inspect all houses was also found in South Africa by Mkuzo et al. (2019). Therefore, research is warranted to achieve customer satisfaction and avoid risk to the inspection organisation's warranty fund and added cost due to remedial works.

3. Research Methodology

The study employed a phenomenological qualitative design to explore the challenges experienced in the housing inspection process (Braun and Clarke, 2013). This approach was more suitable than the quantitative approach as this study intended to explore in-depth perceptions and experiences and not to prove a hypothesis, test theories, or draw generalisable conclusions from the data (Castleberry and Nolen, 2018). As participants were required to reflect on their day-to-day inspection work challenges based on the conventional method of inspecting, both junior and senior inspectorates in Gauteng province, South Africa, were approached. They were knowledgeable and informed about the stage inspection challenges faced daily during housing construction. In addition, they could also shed light on how digital technologies can assist in improving their inspection process. Through snowballing from the purposively recruited participants, more potential participants were identified. As a result, 12 housing inspectors were recruited for this study. The sample size was deemed sufficient when additional interviews could not identify new concepts, an endpoint called data saturation (Creswell, 2009). The semi-structured interviews allowed participants to express themselves fully to open-ended questions related to housing inspection entities' operational realities, performance problems, and challenges. While the interviewer had a topic list to guide the participants, questions were open-ended and flexible, allowing participants to guide the study throughout the narratives. The sessions lasted between 15 to 65 minutes.

The transcribed documents were emailed, and others were presented virtually for inspectorates to comment on authenticity and credibility (validation). This enhanced the study's reliability, as the participants verified that it reflected what transpired in their interviews. Inductive thematic analysis

was adopted to analyse the data with the aid of Atlas.ti v9 qualitative analysis software. The themes were identified from data rather than a more deductive approach favoured mostly by quantitative data analysis (Castleberry and Nolen, 2018; Malik et al., 2021). The analysis aimed to abstract core themes to develop a more concrete understanding of the challenges of the inspection process for housing construction. Appendix I shows the coding process within Atlas. ti v9. Prior to data collection, the institution's Ethics Committee approved the study.

4. Findings and Discussion

4.1 Participants' profile

Twelve participants working as inspectors, both seniors and juniors with three years of working experience, five years and above, were included. These were male and female from various ethnic and social backgrounds. Pseudonyms (1 to 12) were used to maintain participants' anonymity.

4.2 Challenges to the inspection process of houses under construction

Figure 1 presents a network of the identified challenges to the inspection process with three themes and relevant sub-themes of the study as well as the link expressed by participants on each theme. A discussion of the findings on each theme follows.

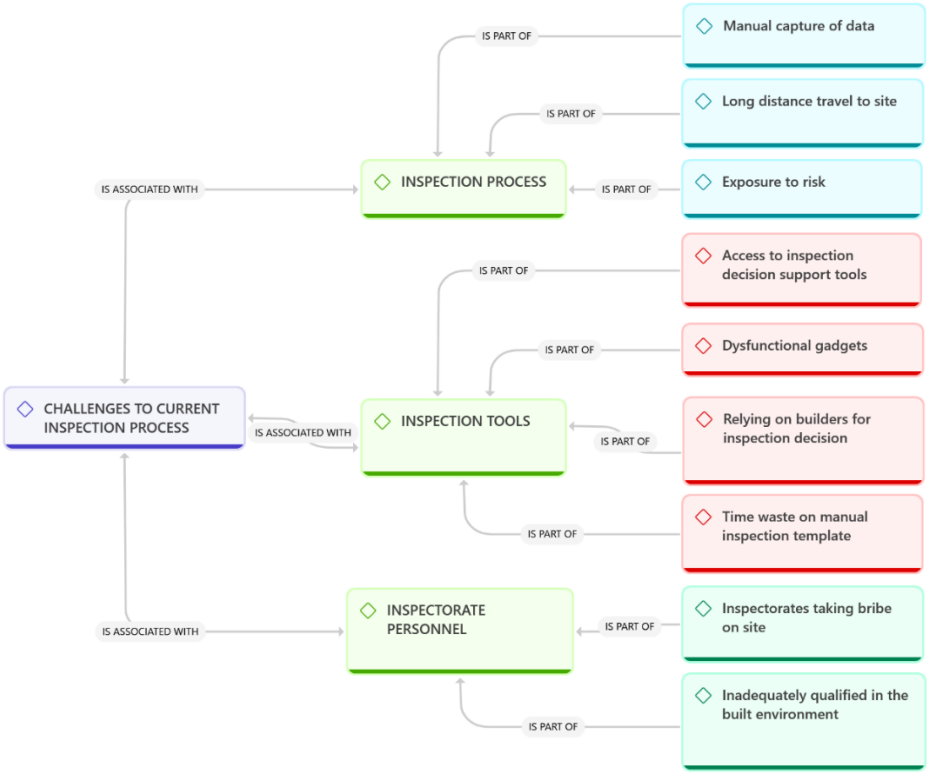

Figure 1. Challenges experienced by inspectorates (Atlas.ti output)

4.2.1 The inspection process

All participants found the inspection process to be challenging. They defined the challenges they experienced differently and expressed frustration in some cases. The participants' challenges were linked to the inspection process described in the first theme above. Under this theme of inspection process challenges, three sub-themes were identified.

Manual capture of data

The participants described manual data capture during inspection as one of the challenging processes. They mentioned that they sometimes experience the repetitive nature of capturing data using the manual method, which is deemed inefficient and ineffective. They also felt that it takes away time that could be used to manage other tasks or inspect more houses in order to achieve more quality housing delivery in South Africa. Participants 1, 3 and 5 in this study expressed that they find it difficult to capture data on their daily inspection task manually:

If you are using the manual, there is more challenge in that whatever you are doing needs to be taken back to the office to be captured so that one in the office will know what's been captured and whether the inspections are going as per enrolment (Participant 1).

The paper-based inspection means you must tick using a pen and submit papers in the office. The paperwork inspection is demanding because when you get home, you will still sit down and make checks to ensure everything is okay (Participant 3).

When I start compiling the data collected with the manual on that inspection template, I have to fill in the province, development name, builders' registration number, enrollment name, or number or fee. (Participant 5).

Findings revealed that, sometimes, data is manually captured by data capturers at the office, depending on their availability. Other times, they are captured by the inspectors. They expressed that data capturers sometimes miss information during the capturing process, and it later appears they did not do their inspections. They can also not plan for subsequent inspections when relevant and critical information is missing. Zulkifli et al. (2018) and Hegazy and Gad (2015) also observed these data-capturing concerns in their Malaysian and Canadian studies.

Long-distance travel to sites

Most housing inspectors who participated in the study experienced challenges with long-distance travel to sites. In particular, they indicated that they found it challenging to locate and commute to distant sites. Some inspectors expressed their frustration, stating:

To get to another site, you must drive and find that the buildings to inspect are 5km apart and get stuck in traffic before you get to another site. It is hectic (Participant 4).

The issue is driving from site to site. Sites are not the same. For example, in Soweto, there are already houses, so you will move from stand number 20 and check another house at number 90 (Participant 9).

Sometimes you find that you go to conduct an inspection, say for the pouring of concrete, but you get there and the builder is not ready after driving around 60km, which you could have used that time to inspect other houses (Participant 10).

The participants shared that this activity requires knowledge of the area where the site is located, as this also makes it easy to select the route to the site. The distance from the inspector's location to the site is critical to effective and efficient inspections (Asante and Sasu, 2018). However, inspectors reported excessive time spent on non-value activities such as travelling and locating the site to inspect. For example, an inspector spends more time stuck in traffic and not conducting inspections on a typical day. However, Kwon et al. (2014) found that a defect management system can improve quality inspection without site visits as it enables automatic inspection. As a result, inspectors cannot be stuck in traffic trying to get to the site. All the inspectors who participated in the study indicated that they travel long distances to get to a building site, and in some instances, they get stuck in heavy traffic levels, which consumes time that could be used to inspect other houses. The distance travelled from site to site was as much as 60 kilometres within Johannesburg in the Gauteng province.

Exposure to risk
Most of the participants described one more challenge with the inspection process, where they felt exposed to risk on their daily inspection task. Some felt that risk exposure was the result of the traditional method of the inspection process. Two participants expressed as follows:
With manual inspection, if I go to the mall, say with 70 paper-based inspections, and my car gets stolen, it means I lost all those inspections (Participant 3).
Doing an inspection manually is not easy… We exchange documents on-site. It is not an easy thing (Participant 4).

The way in which participants in this study described their experiences with the traditional inspection process and approach indicates that they are frustrated, especially given that they have to risk their lives exchanging hardcopy documents on-site with builders, exposing themselves to health risks. Also, carrying hardcopy documents increases the risk of losing all the data collected if the car gets stolen (Zulkifli et al., 2018). The inspection process in South Africa has many challenges that need to be addressed to improve the quality of housing delivery.

4.2.2 Inspection tools
As much as tools were described and listed, all participants experienced extreme challenges using them to carry out inspection tasks effectively. They expressed frustration when they felt that if they could get access to decision support tools instead of relying on builders for inspection support tools, they could improve the quality of housing delivery. They also described the challenges with the gadgets and the time wasted using the inspection template. In this theme, four sub-themes were identified.

Access to inspection decision support tools
All participants discussed how their day-to-day inspection activities were and felt that they were getting little support towards achieving their mandate, which is to inspect all houses and ensure quality during construction. They mentioned that they struggled to access inspection decision support tools, which frustrates them because, at the end of the day, it appeared they were not committed to their work. Some inspectors spoke powerfully about the challenge of not having access to inspection decision support tools that they experience on the daily inspection tasks. They felt that it complicated the inspection process and compromised inspectors' ability to inspect all houses effectively. Participants 1, 4 and 12 commented:

Then the challenge is the availability and the simplicity of accessing the SANS 10400 on this gadget, which we will be using so well, okay, this type of foundation, what is it that I am inspecting, what is the standard saying (Participant 1)
The challenge is that you do not have a hard copy of those two legislative documents. They are like our Bibles; we must drive around with them (Participant 4).
You will only get the plans from the office when you use the tablet. We don't have them ready on our tablet (Participant 12).

Generally, after a building has been allocated, the housing inspector's typical day regarding inspections starts with the inspector deciding and selecting several houses to visit for inspection for the day. This is a significant activity requiring information about the project and available resources, including institutional support tools like building plans. In addition, the most up-to-date information from the home builder is critical to assist the inspector in deciding which project to inspect for the day (Koen and Theron, 2010). However, participants indicated that it is not easy to access these decision-support tools at times. As a result, they continue to fail in the delivery of quality housing efficiently and effectively. The result suggests a lack of a typical data environment (CDE), as evidenced by Comiskey et al. (2018), which means that with CDE, inspection support tools can be easily accessed. It was found

that having CDE allows transparency where all inspectors can access data at any time, which will support the automatic inspection process and ultimately improve the efficiency and effectiveness of quality housing delivery.

Dysfunctional gadgets

The first theme above suggests that the manual inspection process of houses is ineffective. All participants felt the same, forming the next theme where the challenges of the inspection process are discussed. Under challenges with inspection tools, participants reported a gadget used to be dysfunctional, making it difficult for them to carry out inspection tasks efficiently. One of the complaints about the currently used gadgets during the inspection process was their dysfunctionality. Many of the participants stated that "*I" has many loopholes in it. It is not a very efficient tool for recording inspections, and getting your report is also very limited*." For example, participants 1,3, 6 and 7 mentioned that the gadget they use for inspection does not function well during their day-to-day activities of the inspection. This was portrayed in the following quotation:

If I go to the site with this gadget, I hope to do an inspection, and I will have easy access. If it can have GPS, when I punch in the street name, it gives me the map that says this street of erf number at the particular location to know if it's in Midrand, Waterfall, etc. It gives me an easy way of finding the site (Participant 1).

We have a challenge with the gadgets we use. With a lifespan of about 2 years, it may not operate correctly after this period. Some inspectors still use gadgets supplied three to four years ago, which may not be adequate (Participant 3).

Gadgets get stolen or crushed or become dysfunctional because of battery. So, if you cannot the tablet, you can do a manual inspection (Participant 6).

It is easily broken and always on your face because it reflects and shines. So, you have to find a shade to use it effectively. It has a short battery life. Sometimes, it takes a long time to activate, it freezes out of the blue, the camera works one day and does not work another day. Sometimes, the information you have punched in does not always reflect or report. Sometimes you fill in the information and save it, but when you return to open it, the information is not there. (Participant 7).

Participants mentioned that the gadgets are unreliable, as the battery does not last long during the inspection task, and they do not have supportive and relevant information. According to the participants, the tablet made reporting of inspections extremely difficult. However, the study by Kim et al. (2013) found that smartphones, coupled with mobile computing technology for on-site construction inspection purposes, have provided effective and efficient data management and are expected to pioneer the paradigm shift of the traditional method of the inspection process.

Relying on builders for the inspection decision

All participants complained about the time wasted on site to acquire approved building drawings from builders, as they rely on them to verify that they are building with the approved plans. This frustrated most inspectors, as Participant 5 said, "I am telling you I can be on-site for two hours waiting for that paper." Many participants considered this an addition to the challenges of the inspection process, which increases the potential risk of delivering poor-quality housing, where builders can also provide them with fraudulent building plans on-site. Other participants (1 and 4) stated that:

You find that approved drawings are not on-site, but with the main guy, who is not on-site. That is also another challenge we are facing. We rely on the on-site drawings (participant 1).

It will depend on the owner if they give you plans on-site. They might even give you a fraudulent plan. There is too much fraud out there. Doing things manually is not easy, especially now with COVID-19 issues. We exchange documents on-site. It is not an easy thing (Participant 4).

It is mentioned that inspectors do not have access to the drawings and specifications before they get to the site for a tour of duty, but rely on builders (Koen and Theron, 2010). They found it often difficult to rely on builders for inspection process decision support tools, as mentioned, most builders, supervisors, or owners are hardly found on-site during the tour of duty, which makes it more challenging for them because of the possibility of waiting hours to get the drawings or even the possibility of getting fraudulent drawing plans.

Time wasted on the manual inspection template

The inspection template, the tool used to assess and decide whether the builder complies with the requirements, has many sections that must be completed. According to participants 1 and 3 in this study, reporting often takes hours to finalise due to unnecessary items on the inspection template and processing time, which wastes time. In an interview, several participants commented on the inspection template and stated:

If you do it manually, submitting on the same day is challenging. You can allocate your time and say today, I will do the inspection, then tomorrow go to the office to record the inspected houses. It also depends on how far you are from the office to submit whatever I have done (Participant 1).
Activities on the inspection template form that do not apply should be greyed out. If the roof is steel, let it grey out the wood (Participant 3).

The opinion of participant 3 suggests that until there is automatic data reporting, then to spend time on the ticking of inspection template forms, the inspection process will continue to face challenges with inefficiencies and ineffectiveness of the inspection process, resulting in a waste of time. This is inconsistent with Sibiya's (2018) finding that inspection template forms can be a good tool to monitor and capture aspects of construction quality in a structured and consistent way. However, most participants perceived that inefficiency and ineffectiveness of the inspection process are being caused by time wasted on ticking off inspection template forms on each house inspected. As a result, they fail to inspect all targeted houses daily.

4.2.3 Inspectorate personnel

Some participants expressed their challenges as inspectors carrying out the inspection process. They felt that not all inspectors working with them were qualified to conduct inspections, based on their qualifications. Some of those inspectorates could take bribes on-site instead of correcting poor artistry. The other challenge mentioned by all participants is that some builders on site do not know them as inspectorates and end up wasting time explaining themselves instead of getting to the site and doing inspections. Under this theme, three sub-themes were identified.

Inspectorates taking bribes on-site

Some inspectors mentioned that among the challenges they experience during the inspection process, there are issues with bribery, where some inspectors do not see the importance of assuring quality, and they take bribes on-site. For instance, participants 4 and 6 articulated their concern about this:
linking the approval process with the gadget will make it easier to access the plan without the client having to go to the organisation with an approved plan, which at times they bribe for a stamp. That will minimise the fraud as well. Some just take stamps wherever and put it there and say it is approved (Participant 4)
Sometimes, dealing with people is very difficult. You might get inspectors who are not issuing non-compliance, not to say no deviations are happening on-site, but because they have a relationship with the contractor or they are on the contractor's payroll. So, in that way, even if non-compliance exists, somebody will just look the other way and not issue non-compliances (Participant 6).

They do not give non-compliance with the builders deviating from building regulations; instead, they accept bribes. Participants further emphasised that builders are allowed to continue building even when the houses might be delivered with poor standards, which ultimately could collapse, with the possibility of killing owners within such poorly constructed houses. They felt that if they could conduct themselves ethically, in a manner that shows professionalism within the built environment, builders would know them and respect them as the on-site people to assist in ensuring quality housing delivery, not to be bribed. Bribery and corruption on site were also revealed by Zunguzane et al. (2012), Rarani and Fore (2014) and Sibiya (2018).

Inadequately qualified in the built environment

When asked about the role of qualification as inspectors, some participants highlighted how it is difficult to work with some of their colleagues who are not qualified in the built environment. For example, Participants 4 and 6 mentioned that:

There is a complaint that their level of education is not sufficiently exposed to the built environment (Participant 4).

There are others as well, having N-4 to N-6, because they are inspectors who were appointed when the warranty was started. So, they had those qualifications, but they did not pursue their studies (Participant 6).

They felt that unqualified inspectorates could contribute to poor quality housing delivery. This was supported by Rarani and Fore (2014) and Olojede et al. (2019), who found that quality housing inspection is lacking in South Africa due to inspectors ' inadequate training. As a result, they use the traditional and manual data collection and capture procedures, hindering them in meeting their daily inspection target (number of site visits).

Overall, the findings from this study align with previous studies, which recommend that for housing inspectors to conduct adequate inspections on site, they need specific competencies such as built environment background education, technical skills, sound knowledge of construction processes, and the ability to identify compliance and non-compliance in the construction projects of houses (Hopkin et al., 2014). They must be equipped with material, financial and technological resources to equip them to do their work adequately. The participants also suggested enhancing their readiness with an automated inspection process. With the daily workload and high demand of inspectors to inspect all houses under construction, there is a need to capacitate inspectors so that the inspection process is fulfilled without compromising the quality of housing delivery.

5. Conclusions

The research investigated the challenges encountered by housing inspectors in Gauteng province, South Africa, which contribute to substandard housing delivery. Semi-structured interviews with 12 purposely selected inspectors indicated that the inspection process mainly depends on manual techniques, such as paper and pen, with minimal and complex utilisation of digital tools. Significant challenges encompass extensive travel lengths to and from the site, the absence of decision-support tools, malfunctioning devices, and manual data collection, all of which impede quality outcomes. To circumvent these challenges, it is recommended that inspection organisations explore alternative methods and tools for inspection to improve efficiency and effectiveness. Implementing an automated inspection process could be explored by quality assurance entities for housing delivery. Specific digital solutions, such as mobile BIM viewers, can enable inspectors to visualise building components on-site in real time, while GPS-enabled scheduling systems could streamline site allocation, optimise travel routes, and reduce inspection delays.

Additionally, cloud-based inspection platforms integrated with mobile devices can allow for real-time data capture, reporting, and communication between inspectors and stakeholders. Further research can be carried out focusing on improving the integrity and efficacy of building inspections, government and professional organisations establishing standardised training and certification programs, ensuring that building inspectors fulfil the required qualifications and are equipped with digital tools for enhanced efficiency. Furthermore, rigorous anti-corruption protocols should be implemented to curb unethical conduct, encompassing transparent regulatory frameworks, penalties, and digital surveillance technologies. Routine audits ensure adherence to construction regulations and prevent fraudulent practices. Moreover, increasing public awareness and promoting stakeholder engagement can improve accountability and compliance with inspection standards.

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