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# Keeping Food and People Safe: Evidence from Nigerian Wholesale Markets

[version 1]

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## Abstract

This study draws on primary data from the universe of 299 wholesale markets (WMs) trading in fish, tomatoes, and green leafy vegetables in seven Nigerian states and the Federal Capital Territory (Abuja) to analyze food safety security conditions affecting traders and consumers in food markets. We find significant deficiencies in hygiene and food safety infrastructure: fewer than half of markets have functional toilets, only one-third provide handwashing stations, and roughly one-third dispose of waste as infrequently as once a month or less. Surprisingly, hygiene and food safety infrastructure is less prevalent in the more affluent South than in the poorer North. In contrast, security services are relatively more common, with two-thirds of markets employing security guards. Notably, privately

managed WMs outperform government-managed ones in both hygiene and security provision. These findings highlight a crucial need to increase public and private investments in WM hygiene infrastructure—such as piped water, sanitation facilities, and electricity to enhance food and human safety.

**Keywords**
Wholesale markets, Food safety infrastructure, security,

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## 1. Introduction

Wholesale markets (WMs) are important to food security in Africa and other developing regions (Reardon et al. 2021). A billion tons of food move through supply chains in Africa per year and much of that moves to retailers and consumers via WMs (Liverpool-Tasie, 2024). Millions of wholesalers, retailers, and consumers visit WMs daily. The conditions in WMs regarding food safety, personal hygiene, and security are thus crucial issues. Numerous case studies of WMs in Africa have pointed to limited access to clean water and inadequate sanitation infrastructure and noted that this can increase the risk of food contamination and facilitate the spread of infectious diseases (Sane et al. 2024; Abatan et al. 2025). These studies have pointed to a shortage of piped water and drainage systems and limited knowledge of food safety hazards and application of best practices to provide safe food by market actors (Nordhagen et al. 2025; 2023). Case studies have also pointed to security challenges in African WMs: weak governance structures hinder WMs ability to resolve internal conflicts (Davies et al., 2022) and their effectiveness in delivering food safety and personal security services (Resnick et al., 2025).

There is an important gap in the above literature. The great majority of studies are case studies of particular markets or a limited set of markets. There is a dearth of WM-survey based studies that permit analysis of several factors which we expect to be crucial in explaining differences over WMs' hygiene and security services. For example, there can be important variations across regions (such as more and less economically developed), location of market (rural versus urban), size of market, and governance regime of the market (such as democratically elected and inclusive governance with women engaged in leadership), and degree of product perishability (such as less perishable processed fish and highly perishable green leafy vegetables (GLVs) and tomatoes. Moreover, survey data allow statistical tests that case studies cannot generate.

To address this gap in the literature, we undertook a comprehensive survey of 299 fish, tomatoes, and GLVs) WMs located across seven states and the Federal Capital Territory (Abuja) in Nigeria. These are the leading states in the production of those products in Nigeria (NAERLS, 2022). Our sample was a census of WMs selling those products. A primary survey was conducted as there were no publicly available secondary data on the services and infrastructure of WMs in Nigeria. In this study, we capture hygiene and sanitation services using measures of market access to water, toilets, handwashing stations, and the frequency of waste disposal. We capture the provision of market security services using the presence of security guards, ratio of traders per security guard, cost of security service provision, and time of security services (during both day and nighttime hours vs just during the day or night vs no security). We employ probit, Tobit, and ordered probit models to analyze how market geographical location, infrastructure, WM size, governance characteristics, and shocks affect the presence, extent, and cost to WM traders of hygiene, sanitation, and security services.

This study makes several contributions to the literature. First, it identifies the extent to which hygiene, sanitation, and security services are present across WMs heterogeneous locations, including regions within the same country (Nigeria's more affluent South and the poorer North (NBS, 2025) and rural vs. urban areas). These special variations correlate with differences over cultural norms and local market governance and trading practices. With a few exceptions (e.g., Davies et al. (2022) for the case of Zambia and Resnick et al., 2025 for Nigeria), previous studies have looked at food safety infrastructure in the context of one market or one region within a country (Clark, 2010; 1994; Hapke and Ayyankeril, 2007) or focused on traders in rural markets (Wenndt et al., 2025; Subramanian and Qaim, 2011) or only in urban markets (Abatan et al., 2025; Nordhagen et al., 2025, 2023; Resnick et al., 2019). Thus, our study is one of the few substantial-sample survey-based studies of WMs in Africa and thus takes a step beyond case studies.

Second, while there have been a few studies of the presence of services in WMs (such as Resnick et al. (2025) in Nigeria), we add to the literature by analyzing the extent of service provision, the associated costs, and the main determinants of these services. This study not only assesses service availability but also provides an initial evaluation of whether incentives are aligned to encourage their use and support efforts to improve public health and safety.

Third, most WM studies of hygiene and security services have not differentiated by product type. We examine variation in services by the type of product and expect this to matter for several reasons. Selling animal products has zoonotic and infectious disease risks (Lin et al. 2021). In addition, vegetables are a main source of foodborne diseases in Africa (Grace et al. 2018). Highly perishable and delicate products like GLVs can have greater waste disposal challenges; products one may store for several days at the market (such as processed fish and tomatoes) can have security challenges as the stock needs to be guarded. Poor sanitation and inadequate sewage management have been identified as significant contributors to the high levels of foodborne pathogens found in tomatoes sold at retail markets in northwestern Nigeria

(Shenge et al. 2015). Studies have also reported bacterial and microbial contamination in fish sold across markets in Nigeria, which largely results from poor hygiene, inadequate handling and storage practices, and the use of contaminated water during processing (Grema et al. 2020; Grace et al. 2018; Adeyeye 2015).

Fourth, we contribute to the relatively sparse literature on insecurity (and security systems) in food supply chains in Africa. The literature on insecurity and food systems has tended to focus on the impact of insecurity and political instability on farmers (e.g., Adelaja et al. 2023). There have been a few studies beyond the farm, to date limited to traders per se (Vargas et al., 2024; Kimenyi et al. 2014) or trade networks (Liu et al. 2024) with little attention paid to WMs. To our knowledge there has not been a study over WMs of extent, costs to traders, and determinants of security service provision. The few prior studies have focused on the impact of insecurity on market activities (e.g., Olurotimi and Liverpool-Tasie 2025) and the presence of security guards (Resnick et al. 2025) but not the extent, cost, and determinants across markets.

The paper proceeds as follows. Section 2 describes the data used and the study context. Sections 3 and 4 present the study hypotheses and empirical approach. Section 5 includes the main study results for the extent and drivers of hygiene-related services and costs (5.1) and security services and costs (5.2) while Section 6 concludes.

## 2. Data

This study uses primary data collected from all the WMs for fish, tomatoes, and GLVs across seven Nigerian states and Abuja, the Federal Capital Territory (FCT) between July 2023 and February 2024.[1] These states are major regional producers of at least one of the study commodities (tomatoes, GLV or fish) and represent a wide diversity of geographic, agro-ecological, and economic settings (see Figure 1).

The data were collected from respondents via focus groups. Each focus group was composed of a diverse group of market actors knowledgeable about the history and current operation of the market. This included overall market leaders (e.g., the market chairperson, treasurer, or other executives); product section leaders (i.e., leaders of product specific associations), traders who had a long history in the market, and other stakeholders. Some questions posed were about the entire WM while other questions asked about the specific products and specific product forms (i.e., fresh or processed). To develop a sampling frame for the WM survey, we listed all WMs selling any of the study products in the seven states and the FCT between October 2022 and January 2023. This yielded a list of 244 WMs that were verified as distinct WMs and 55 new WMs (largely seasonal WMs) that were found between January and July 2023. The entire universe of 299 wholesale markets was surveyed by enumerators via the SurveyCTO platform on tablets to ensure consistency and data quality.

The questionnaires captured detailed information about market-level characteristics, such as the number of different kinds of WM infrastructure (e.g. functional toilets, handwashing stations, and electricity from the grid, generators, or solar panels) and who provides them (e.g., government versus private sector) and the costs for users. Information was also collected on whether markets had any form of security, the number and times of operation and who provides the service. Other information collected about the wholesale markets includes the number of traders and other businesses operating in the market, location (rural vs. urban), and proximity to towns as well as information on market governance including who runs the day-to-day operations of the market.

Nigeria has two major regions- the South and the North- with the North region being less densely populated and more reliant on agriculture (Oseni et al. 2015; Oseni and Winters 2009). In recent years, the North has been confronted with insecurity, disrupting farming and trading (Ojo et al. 2023; Adelaja and George 2019). In this study, the states of Cross River, Ebonyi, and Oyo are part of the South region whereas Borno, FCT, Kaduna, Kebbi, and Plateau states are part of the North region.

## 3. Study hypotheses

We develop measures to capture two broad sets of services associated with hygiene and sanitation: access to functional toilets and waste management services. Access to functional toilets is measured by 1) the presence of functional toilets in a market[2]; 2) number of traders per functional toilet available; and 3) the cost to traders of using a toilet in the WM. Waste

[1]We defined a wholesale market as an established place where two or more wholesalers trade any of our study products. A wholesaler is an intermediary who procures (by possession or for a commission as brokerage) a product from a supplier (a farmer, processor, or other wholesaler) and supplies (by sale if he/she possesses it, or by mere delivery if he/she works for commission) that product to a non-final user (a processor, a retailer (who by definition only sells to final users such as consumers), or another wholesaler).

[2]A wide range of functional toilets are present in markets: flush / pour-flush toilet to sewer connection (N = 48); flush / pour-flush toilet to tank or pit (N = 33); pit latrine with slab (N = 44); flush / pour-flush toilet to open drain (N = 4); pit latrine without slab/open pit (N = 5); and other (N = 4). More than one type of functional toilet exists in a few markets.

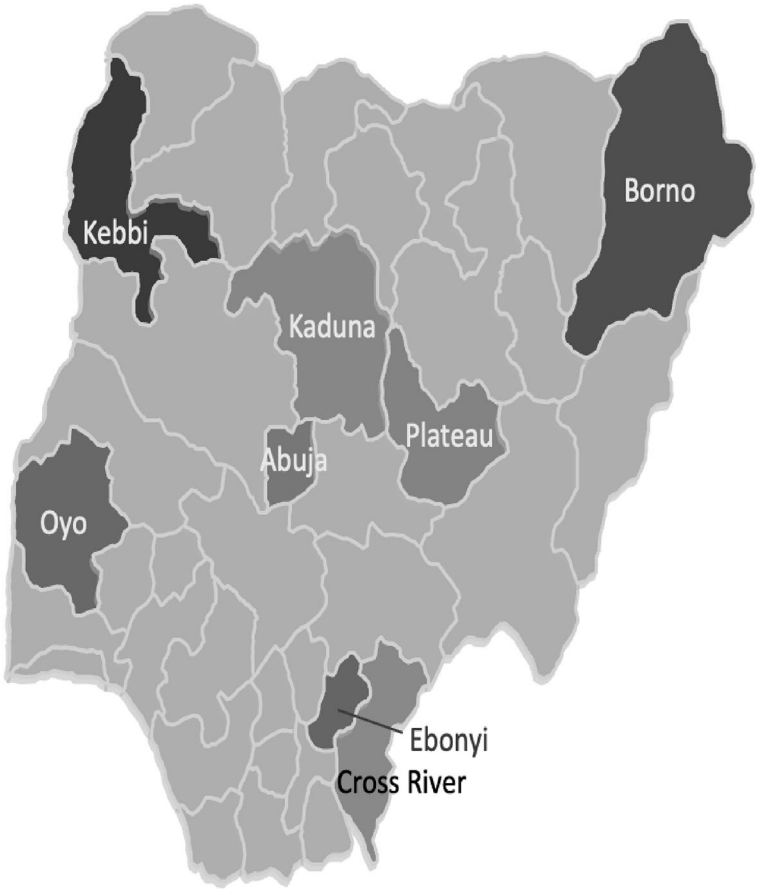


**Figure 1. The wholesale markets were surveyed in seven states and the Federal Capital Territory.** Source: Authors.

management is captured with: 1) the frequency of waste disposal in the market; and 2) the monthly cost of waste disposal per trader. Provision of security services in WMs is captured with 1) presence of security guards; 2) number of traders per security guard; 3) daily cost of security services for traders in the WM; and 4) presence of security guards during daytime and nighttime.

The explanatory variables for the study were selected to evaluate two sets of hypotheses about the presence, extent, and cost of food safety and security service provision based on literature related to market governance, need, and capacity (e.g., Resnick et al. (2025); Davies et al. 2022; Unnevehr 2022). WM capacity is captured by market location and infrastructure. WM size, type, and operations represent WM needs. WM governance is represented by: 1) a binary variable if the day-to-day market operations are run by the public sector (i.e., city/town, LGA, municipality, state, or host community); 2) by the share of the WM space that is on land owned by the public sector (i.e., community land, government provided space, and/or where the government offered a developer a concession to develop the market). Definitions and descriptive statistics of the variables are provided in Table 8.

We distinguish WMs in rural versus urban and peri-urban locations as well as between WMs in the South versus the North. Over half of WMs are in urban and peri-urban areas. We expect greater service provision in urban markets and near a populous town due to greater trading activities, and therefore greater incentives to keep food and people safe. About 40% of the WMs in this study are located in the South. We hypothesize that markets located in the relatively poorer North provide fewer services than those in the South.

Public infrastructure is critical to food safety management capacity (Unnevehr 2022). In our census of WMs, 13 markets do not have access to water. Of the 286 markets with access to water, 65% access it through pipes, boreholes, or wells. Only 29% of WMs (87 markets) and 12% of WM stalls across the overall sample have access to electricity from the grid[3], with an average of only 1.63 hours per day. Conditional on WM access to electricity, 43% of WM stalls have access to electricity from the grid, for an average of 5.6 hours per day, which is about half the time that they are open (markets are open, on average, 12 hours per day). We expect markets that have invested in infrastructure (e.g., pipe-borne water, wells, and boreholes, as well as electricity from the grid) to have greater capacity in providing hygiene, sanitation, and safety services.

We capture the diversity over WMs of needs for services by considering WM size and age, operating hours, duration (days of the week and months of the year open), and product types. The size of the WM, proxied by the number of traders, varies from 10 to 20,000 traders (of all products), with an average of 2002 traders per WM (for all products). We expect that larger WMs, which typically have more traders active each day, will have a greater demand for security services to manage both people and products, as well as for hygiene and sanitation services.

The data show that WMs are open between 2 and 12 months per year. On average, WMs operate 4 days per week, with some of them being open only one day and others every day. On average, WMs are open for 12 hours per day. WMs that operate all year round (or operate daily), compared to those that are seasonal (or operate weekly or every few days), and those that are open for longer hours each day, are expected to require more hygiene and security services. However, larger WMs in urban areas and WMs operating very frequently may also incur higher costs to provide these services, which could either discourage service provision or increase the costs associated with these services.

WMs that sell horticultural products in large quantities might generate more waste (because of their perishability), necessitating frequent waste disposal. Fish WMs sell processed (sun-dried or smoked), live, or frozen. In fish WMs, there may be a stronger demand for security services to protect processing and storage investments, including freezers and kilns, compared to horticultural WMs where products are sold largely unprocessed. Even among horticultural products, there might be important differences. We control for the type of products sold. The survey data shows that 68% of WMs sell tomatoes, and 59% and 32% sell GLVs and fish.

WM governance data show that 10% of markets reported that the government directly oversees their day-to-day operations and over 94% of the market space is on land owned by the public sector (as defined above). It is expected that the level of public oversight would affect the services provided. Since markets are under the jurisdiction of the Local Government Area (LGA), markets on public land (versus privately owned land) and where the public sector is involved in the day-to-day running of the market might enjoy better services as their presence allows for the market needs to be more easily observed and/or communicated. On the other hand, studies have shown that awareness might not be enough if there is no incentive (e.g., due to low accountability checks) or low capacity (due to limited technical or financial resources) to provide the services (Resnick et al. 2025).

We also control in the security regressions for the number of thefts, violent incidents, and natural disasters (such as floods and fires) reported in the previous year. The relationship between these shocks and service provision is ambiguous. On one hand, WMs may increase their security services in response to a greater number of lagged shocks. But more shocks may indicate insufficient security service provision. We also account for the age of the WM, as we expect newer markets to offer more services. A summary of the study hypotheses is presented in Table 9.

## 4. Empirical approach

We start with the following empirical model

$$Y_i = \alpha + \boldsymbol{X_i}\beta + \varepsilon_i \quad \mathrm{i} = 1, \ldots, \mathrm{n} \qquad \text{(eq.1)}$$

where $Y_i$ captures the presence, extent, or cost of a service in market i, $X_i$ is a vector of explanatory variables capturing market capacity, need, and governance.

[3]Of the 87 markets with access to electricity from the grid, 73 indicated that the grid was their main source of electricity. Electricity from individually owned and managed generators is by far the main source of electricity across all markets (144 markets out of 299). Access to electricity from solar systems, either personal or shared, remains marginal (21 markets out of 299). No information is provided on the number of hours per day or share of stalls that have access to electricity through generators and solar systems.

In Equation 1, $\beta$ is a vector of parameters associated with our explanatory variables, and $\varepsilon_i$ is the normally distributed error term. For binary outcome variables, where *Yi* is either equal to 1 if the service is provided or equal to zero otherwise, probit regression models are applied. Given the set of explanatory variables, $X_i$, the probability that $Y_i = 1$ is

$$\text{Prob}\,(Y_i = 1|X_i) = \Phi\,(X_i\beta) \quad \text{(eq.2)}$$

and Φ is the standard normal distribution (Green 2003). The probit regression coefficient estimates are not directly interpretable. However, their signs show the direction of the relationship between the explanatory variables and the probability that the service is provided. The individual marginal effects are calculated and then averaged to obtain the effects of X on Y across all cases (average partial effects). The delta standard errors are reported.

Tobit models are used for outcome variables that are characterized by a great concentration of values at one corner, such as zero, represented as follows:

$$Y_i = 0 \text{ if } Y_i^* \leq 0 \quad \text{(eq.3)}$$

$$Y_i = Y_i^* \text{ if } Y_i^* > 0 \quad \text{(eq.4)}$$

$$Y_i^* = c + X_i'\gamma + \mu_i \quad \text{(eq.5)}$$

where $Y_i$ is the observable outcome variable, $Y_i^*$ is the latent outcome variable, and $c$ and are $\gamma$ are parameters. Tobit models rely on the assumption that the error term is normally distributed. Bootstrap standard errors are reported. Ordered probit models are employed to estimate relationships between ordinal dependent variables, with more than two outcomes that can be ordered, and a set of explanatory variables.

## 5. Results

### 5.1 Hygiene and sanitation services

#### 5.1.1 Presence, extent, and cost to traders of hygiene and sanitation services

Table 1 shows conditional access to functional toilets. First, access to functional toilets is inadequate. Of the 299 markets, only 44% have functional toilets. Conditional on having toilets, the average number of functional toilets is 10, with an average of 506 traders per toilet. The average cost for a trader to use a toilet is 60 Naira (about 5 US cents), which is similar to the 65 Naira reported by vegetable traders in markets in Southwest Nigeria (Abatan et al. 2025).

**Table 1. Descriptive statistics of the conditional access to and cost of using a toilet.**

| | Share of markets (N = 299) | Share of markets with toilets (N = 132) | Share of markets with toilets that have hand-washing stations (N = 132) | Average number of toilets per market (N = 132) | Average number of traders per toilet (N = 132) | Average charge per usage (naira) (N = 132) |
|---|---|---|---|---|---|---|
| **Overall** | - | - | 29% | 10 | 506 | 60 |
| **Region** | | | | | | |
| North | 60% | 65% | 22% | 12 | 376 | 54 |
| South | 40% | 35% | 41% | 6 | 745 | 71 |
| **Location** | | | | | | |
| Urban | 26% | 42% | 33% | 15 | 653 | 68 |
| Peri-urban | 27% | 33% | 37% | 7 | 418 | 59 |
| Rural | 47% | 25% | 12% | 5 | 374 | 44 |
| **Type** | | | | | | |
| Fish | 32% | 42% | 32% | 12 | 417 | 58 |
| Tomato | 68% | 62% | 32% | 9 | 637 | 62 |
| GLV | 59% | 53% | 36% | 9 | 694 | 62 |

Source: Wholesale market survey 2024. Note: The percentage of types of markets exceeds 100% since more than one product can be sold in a given market.

Second, access to toilets varies by region and rural/urban locations. Among the WMs with toilets, two-thirds are in the North (contrary to expectation) compared to one-third in the South. WMs in the North have twice as many toilets, on average, as in the South. Among the WMs with functional toilets, one-quarter are in rural areas compared to three-quarters in urban or peri-urban areas. Controlling for market size, more toilets are available for traders in WMs in the North than in the South as well as in rural compared to peri-urban and urban WMs.

The conditional cost to traders of using a toilet is higher in urban WMs compared to peri-urban and rural WMs as well as higher in the South relative to the North. The most common types of functional toilets available in the North include pit latrines with slab (42%) followed by flush toilets connected to the sewer system (26%), flush toilets connected to a tank or a pit (21%), and other (11%). In the South, 52% provide flush toilets connected to the sewer, 30% have flush toilets connected to a tank or a pit, 11% have pit latrines with slab, and 7% have other types.[4] The higher cost per usage in the South may be because less rudimentary toilets are provided and those require better sewer systems, which are more expensive to build (Mamo et al. 2023). Conditional on having toilets, only one-third of the WMs have handwashing stations near toilets, with the lowest frequency in rural markets and those in the North.

Table 2 shows low levels of waste disposal frequency with variation across locations. Only 24% of markets dispose of waste daily. Forty-nine percent (49%) of WMs dispose of waste weekly with the remaining 27% disposing of waste monthly or less frequently (e.g., annually). Surprisingly, the frequency of waste disposal is higher in the North than in the South: 18% and 39% of markets in the South dispose of waste daily or weekly compared to 28% and 56% in the North region. As expected, more urban markets dispose of waste daily compared to peri-urban and rural markets. Of the 299 markets, 57% report a cost to dispose of waste. The conditional WM cost of waste disposal per month averages 50,800 Naira, and it is twice as high in the South compared to the North.[5]

Table 3 shows that 96% of the WMs have access to water but very few have access to public functional pipe-borne water or treat water (from any source) in the WM. All fish WMs have access to water compared to 94% markets where tomatoes and GLVs are sold. Most WMs access water through boreholes followed by other sources (e.g., jerrycans, rivers, wells). In the North, 36% and 30% of the markets access water through wells and boreholes. In contrast, wells and boreholes are the main sources of water for 12% and 52% of markets in the South. Over half of urban markets access water through boreholes compared to 31% and 36% for peri-urban and rural markets. Only 5% of WMs have access to public functional pipe borne water, and even fewer report it as their main source. 9% of urban markets have access compared to 6% of

**Table 2. Descriptive statistics of waste disposal frequency and conditional monthly cost of waste disposal.**

| | Frequency of waste disposal (N = 299) | | | | Monthly cost of waste disposal (naira) (N = 170) | Monthly cost of waste disposal per trader (naira) (N = 170) |
|---|---|---|---|---|---|---|
| | Daily | Weekly | Monthly | Other | | |
| **Overall** | 24% | 49% | 9% | 18% | 50800 | 144 |
| **Region** | | | | | | |
| North | 28% | 56% | 7% | 9% | 39008 | 168 |
| South | 18% | 39% | 13% | 30% | 81662 | 81 |
| **Location** | | | | | | |
| Urban | 34% | 42% | 4% | 20% | 72150 | 126 |
| Peri-urban | 18% | 50% | 15% | 17% | 24293 | 36 |
| Rural | 22% | 52% | 9% | 17% | 55440 | 227 |
| **Type** | | | | | | |
| Fish | 21% | 45% | 14% | 20% | 86211 | 73 |
| Tomato | 23% | 53% | 7% | 17% | 36186 | 178 |
| GLV | 18% | 54% | 9% | 19% | 32692 | 32 |

Source: Wholesale market survey 2024.

[4]See Table 10 in appendix for additional information on toilet types across markets in the North and South.
[5]In the study WMs, the costs for toilet use are per trader while the costs for waste disposal are typically at market level and paid by the market leadership committee.

**Table 3.** **Descriptive statistics related to water infrastructure (conditional on having access to water).**

| | Share of markets with access to water (N = 299) | Share of markets with access to pipe borne water (N = 286) | Share of markets with _____ as their main source of water (N = 286) | | | | Share of markets that treats water (N = 286) |
|---|---|---|---|---|---|---|---|
| | | | Pipe-borne water | Borehole | Wells | Other | |
| **Overall** | 96% | 5% | 3% | 39% | 26% | 32% | 6% |
| **Region** | | | | | | | |
| North | 93% | 6% | 4% | 30% | 36% | 30% | 5% |
| South | 99% | 4% | 2% | 52% | 12% | 34% | 7% |
| **Location** | | | | | | | |
| Urban | 99% | 9% | 4% | 53% | 21% | 22% | 11% |
| Peri-urban | 97% | 6% | 6% | 31% | 28% | 35% | 6% |
| Rural | 93% | 2% | 1% | 36% | 28% | 35% | 3% |
| **Type of market** | | | | | | | |
| Fish | 100% | 6% | 4% | 40% | 13% | 43% | 3% |
| Tomato | 94% | 5% | 4% | 41% | 32% | 23% | 7% |
| GLV | 94% | 6% | 4% | 42% | 23% | 31% | 7% |

Source: Wholesale market survey 2024.

peri-urban and 2% of rural WMs. Four percent (4% of WMs in the North have access to pipe-borne water compared to 2% in the South). Only 6% of the WMs treat water before using it. Abatan et al. (2025) found that traders wash vegetables before sale, but the water is not frequently changed, increasing food contamination risks.

### 5.1.2 Determinants of WM provision hygiene and sanitation services

Table 4 presents probit and Tobit results for factors associated with the provision of functional toilets (Model 1), number of traders per functional toilet (Model 2), and cost to traders in the WM of using functional toilets (Model 3). The average partial effects are presented in the text and coefficient parameters are presented in the appendix. Six key points stand out.

**Table 4.** **Regression results- Access to, number, and cost of functional toilets.**

| | Model 1- Probit Market has access to functional toilets | Model 2- Tobit Ratio of traders per functional toilet | Model 3- Tobit Cost per toilet use |
|---|---|---|---|
| | Average partial effect[1] | Average partial effects[2] | Average partial effects[2] |
| ***Market Location*** | | | |
| South region | -0.150*** (0.050) | -34.0 (78.4) | -8.38 (5.46) |
| Urban area | 0.367*** (0.053) | 420*** (109) | 34.3*** (6.82) |
| Peri-urban area | 0.230*** (0.051) | 227*** (71.0) | 20.2*** (5.86) |
| Distance to town | 0.007*** (0.002) | 5.95*** (1.94) | 0.291*** (0.104) |
| ***Market Size*** | | | |
| Number of traders | 0.039** (0.017) | 148*** (33.2) | 5.34*** (1.63) |
| ***Market Infrastructure*** | | | |
| Distance to paved roads | -0.009 (0.016) | -13.6 (31.0) | -2.18 (2.038) |
| Access to water | 0.175*** (0.047) | 154** (68.9) | 11.4** (5.17) |

**Table 4.** *Continued*

| | Model 1- Probit Market has access to functional toilets | Model 2- Tobit Ratio of traders per functional toilet | Model 3- Tobit Cost per toilet use |
|---|---|---|---|
| | Average partial effect[1] | Average partial effects[2] | Average partial effects[2] |
| ***Market Type*** | | | |
| Fish | 0.011 (0.063) | -8.33 (104) | 3.13 (6.35) |
| Tomato | -0.074 (0.065) | 62.7 (121) | -3.19 (7.27) |
| GLV | -0.023 (0.056) | 4.80 (98.3) | -6.02 (6.09) |
| **Market Operation** | | | |
| Year of establishment | -0.0001 (0.0008) | 1.05 (1.00) | 0.010 (0.076) |
| Months of operation | 0.069** (0.028) | 46.8 (183) | 54.0*** (5.66) |
| Day of operation | 0.023** (0.009) | 7.00 (14.7) | 1.97* (1.01) |
| Hours of operation | -0.012 (0.010) | -20.2 (15.5) | 0.429 (1.04) |
| **Market Governance** | | | |
| Public sector land | 0.003** (0.001) | 1.90 (1.58) | 0.211 (0.924) |
| Run by public sector | -0.072 (0.081) | -157 (136) | -4.61 (8.78) |

Source: Wholesale market survey 2024.
[1]Delta-method standard errors.
[2]Bootstrap standard errors (100 replications).

First, WM location strongly affects provision of functional toilets. Contrary to our expectations, on average, a WM's being in the South decreases the probability of having functional toilets by 15 percentage points compared to markets in the North. That WMs in the South tend to have flush toilets, which are more expensive to build and require access to water, might explain the lower probability that South WMs provide toilets (see Table 10). Being in an urban or peri-urban area is associated with a higher probability of a WM having a functional toilet by 37 and 23 percentage points, respectively, all else equal. However, we find that the further away a WM is from a 50,000-inhabitant town, the more likely it is to have toilets, with the probability increasing by 0.007 per kilometer. This might indicate that traders located in more remote markets have less alternative toilet options and thus more need of a functional toilet in the WM.

Second, we find that infrastructure promotes toilet provision: access to water through pipes, boreholes, or wells increases the probability that a WM provides functional toilets by 17.5 percentage points, all else equal. However, distance from the WM to paved roads is not statistically significant.

Third, as expected, WM size is positively associated with the probability of availability of functional toilets, with the probability increasing by 0.039 as the (natural log) number of traders increases by 1. As expected, larger markets, which have greater needs for toilets, are more likely to have functional toilets. Also consistent with the needs hypothesis, we find that markets that are open most months of the year and days of the week are more likely to provide functional toilets than seasonal and non-daily markets. While the types of products being sold in the markets (tomatoes, GLV or fish) do not significantly influence access to toilets, market governance does. WMs with a greater share of their land owned by the public sector are more likely to offer access to toilets, but the effect is small.

Fourth, the Tobit results for the number of traders per toilet (Table 4- model 2) show that with the exception of region, all other WM location variables that explained the probability of having a functional toilet also explain (with the same signs) the number of toilets available to traders. While the ratio of traders per toilet is higher for larger WMs and for those with access to water through market infrastructure, the products sold in the market, duration of operation, and governance do not affect the number of functional toilets, all else equal.

Fifth, the Tobit model results for the cost per toilet use (Table 4 – model 3) are similar to those of the probit model explaining access to toilets (Table 4- model 1), except that the region and governance variables are insignificant. Markets that are located further from a populous town pay more to use toilets, again suggesting that traders have fewer alternatives for toilet access in more remote areas. Larger markets and those with water infrastructure in urban or peri-urban areas are more likely to pay more to use toilets. The cost to traders of using toilets is also higher in WMs that are open year-round

and most days of the week. This could reflect higher costs of providing, maintaining, and cleaning toilets clean for large markets that have longer business operating times.

Table 5 reports results for the ordered probit regression for the factors associated with a higher frequency of waste disposal (Model 4) and the Tobit regression for monthly waste disposal costs to traders (model 5). The lowest outcome for Model 4 is infrequent waste disposal, which includes every other month, annually, and never; the highest outcome is daily waste disposal.

Six key points emerge. First, contrary to our expectation that WMs in the South would be more likely to offer services related to food safety, we find that these markets tend to dispose of waste less frequently than in the North. On average, being in the South decreases the probability of a WM disposing of waste daily by 14 percentage points. However, waste disposal costs to traders are significantly lower in the South.

Second, peri-urban markets and those farther from paved roads are less likely to dispose of waste daily. This could indicate that these markets have fewer space constraints, allowing more waste to accumulate compared to markets that are closer to homes in rural areas or dense urban centers.

Third, we observe some evidence of service provision in line with needs. Larger markets and those that operate daily are more likely to dispose of waste daily. However, WMs that are open year-round are less likely to do so consistently. This

**Table 5. Regression Results - Frequency and Cost of Waste Disposal.**

| | Model 4- Ordered Probit Frequency of waste disposal | Model 5- Tobit Monthly waste disposal cost/trader |
|---|---|---|
| | Average partial effect on the probability of the best frequency (daily)[1] | Average partial effects[2] |
| ***Market Location*** | | |
| South region | -0.140*** (0.041) | -75.6** (31.8) |
| Urban area | 0.014 (0.057) | 25.6 (35.3) |
| Peri-urban area | -0.092** (0.040) | -26.7 (29.2) |
| Distance to town | 0.0007 (0.0009) | -0.016 (0.692) |
| ***Market Size*** | | |
| Number of traders | 0.043*** (0.015) | -27.7* (15.2) |
| ***Market Infrastructure*** | | |
| Distance to paved roads | -0.018** (0.007) | -15.2 (16.7) |
| Access to water | -0.036 (0.037) | 43.6 (32.2) |
| ***Market Type*** | | |
| Fish | -0.094* (0.054) | 49.0* (29.3) |
| Tomato | -0.084* (0.050) | 38.8 (31.7) |
| GLV | -0.003 (0.048) | -18.7 (28.4) |
| **Market Operation** | | |
| Year of establishment | 0.001** (0.0006) | 0.967 (0.681) |
| Months of operation | -0.022* (0.012) | -28.9* (16.4) |
| Days of operation | 0.030*** (0.007) | 5.67 (4.39) |
| Hours of operation | -0.0001 (0.0080) | -5.55 (10.5) |
| **Governance** | | |
| Public sector owned land | 0.0006 (0.0008) | -0.417 (1.04) |
| Run by public sector | -0.155** (0.069) | -73.9* (42.5) |

Source: Wholesale market survey 2024. Note: Daily corresponds to a higher outcome than weekly, monthly, and infrequently, monthly corresponds to a higher outcome than monthly and infrequently, and monthly corresponds to a higher outcome than infrequently. Infrequent waste disposal includes every other month, annually, and never.
[1]Delta-method standard errors.
[2]Bootstrap standard errors (100 replications).

counterintuitive finding may reflect efforts to cut costs due to the high operational expenses associated with maintaining services throughout the year, compared to seasonal markets. Recently established markets are more likely to dispose of waste daily but the effect remains small. On average, WMs in the North are more recently established than WMs in the South: the average (median) year of establishment of markets in the North is 1978 (1980) compared to 1967 (1974) in the South. This may explain their more frequent disposal of waste.

Fourth, markets selling fish and tomatoes are less likely to dispose of waste daily compared to WMs not selling these products. This is contrary to our expectation that fish markets would be more likely to dispose of waste daily to minimize food safety risks. For tomatoes, there are often diverse uses for marred or rotting tomatoes – such as selling them to livestock farmers, food vendors or consumers (Onwuzoo, 2023) so waste in tomato markets may not be as high.

Fifth, the governance of markets has a significant impact on waste disposal frequency. WMs being operated by the public sector decreases the probability of daily waste disposal by 15 percentage points, consistent with Resnick and Sivasubramanian (2023) which notes that market traders often do not perceive any benefits from paying taxes and Resnick et al. (2025) that notes that governments often have low incentives or capacity to provide market services.

Finally, the data presented in Table 5 - model 5, indicate that monthly waste disposal costs charged to traders are lower for larger WMs in the South that do not sell fish, operate year-round, and are publicly run. This suggests that there are economies of scale in waste disposal.

## 5.2 Security services

### 5.2.1 Presence, extent, and cost to traders of security services

Table 6 shows that 68% of the WMs employ security guards, with no major difference between North and South. Though initially surprising given that insecurity is often considered more prevalent in the North, there is recent evidence of increased violent conflict in the South (Amnesty International 2024). Olurotimi and Liverpool-Tasie (2025) note that between 2013 and 2022, fatalities associated with Armed Conflict Location and Event Data (ACLED) conflicts increased significantly in the South. Fewer rural markets have security guards compared to those in urban and peri-urban areas.

**Table 6. Descriptive statistics of the security service outcome variables.**

| | Share of markets with security guards (N = 299) | Average number of security guards (N = 203) | Average number of traders per security guard (N = 203) | Average daily cost for security services (naira) (N = 203) | Share of markets with no security (N = 96) | Share of markets with day or night only security (N = 128) | Share of markets with day and night security (N = 75) |
|---|---|---|---|---|---|---|---|
| **Overall** | 68% | 7 | 454 | 5634 | - | - | - |
| **Region** | | | | | | | |
| North | 68% | 6 | 389 | 2852 | 59% | 63% | 57% |
| South | 68% | 7 | 553 | 9911 | 41% | 37% | 43% |
| **Location** | | | | | | | |
| Urban | 77% | 8 | 458 | 6022 | 19% | 31% | 27% |
| Peri-urban | 70% | 7 | 375 | 2883 | 25% | 27% | 28% |
| Rural | 62% | 5 | 500 | 7124 | 56% | 42% | 45% |
| **Type of market** | | | | | | | |
| Fish | 76% | 7 | 423 | 6486 | 24% | 36% | 35% |
| Tomato | 66% | 7 | 460 | 3089 | 72% | 66% | 67% |
| GLV | 68% | 7 | 576 | 5399 | 58% | 61% | 55% |

Source: Wholesale market survey 2024.

Conditional on providing security service, markets employ, on average, seven security guards, with an average of 454 traders per guard. This ratio is higher in rural areas. Among markets that provide security services, the average daily cost to the market is 5,634 Naira. This is equivalent to N169,020 per month.[6] Costs tend to be lower in peri-urban markets that sell tomatoes and in the North. Among markets with some security, 63% offer security either during the day or at night only, while 37% provide security during both day and night.

### 5.2.2 Determinants of security services

We present the probit results for whether markets have security guards (see Table 7, model 6) and then present the Tobit results on the number of traders per security guard and the daily cost to the market for security services (Table 7- models 7 and 8). Five key points stand out. (1) Security provision is strongly correlated with needs. Larger markets, markets that are open all days of the week, and markets open for longer hours are more likely to have security guards. (2) Markets located further away from a town with 50,000 inhabitants are more likely to have security guards. (3) Government-run

**Table 7. Regression results- Access, cost, and time of security services.**

| | Model 6- Probit Market has security guards | Model 7- Tobit Ratio of traders per security guard | Model 8- Tobit Daily cost of security services | Model 9- Ordered Probit Timing of security services (Day & Night) |
|---|---|---|---|---|
| | Average partial effects[1] | Average partial effects[2] | Average partial effects[2] | Average partial effects on the probability of the most times[1] |
| ***Market Location*** | | | | |
| South region | -0.019 (0.058) | -14.9 (66.8) | -0.273 (0.412) | 0.007 (0.048) |
| Urban area | -0.009 (0.071) | -31.0 (71.5) | 0.238 (0.488) | -0.024 (0.052) |
| Peri-urban area | -0.002 (0.061) | -55.9 (65.9) | 0.613 (0.468) | 0.013 (0.052) |
| Distance to town | 0.003* (0.001) | 0.025 (1.03) | 0.010 (0.009) | 0.0004 (0.0010) |
| ***Market Size*** | | | | |
| Number of traders | 0.036* (0.020) | 149*** (35.0) | 0.335** (0.157) | 0.048*** (0.016) |
| ***Market Infrastructure*** | | | | |
| Distance to paved roads | -0.001 (0.011) | -11.5 (11.1) | 0.033 (0.108) | 0.007 (0.011) |
| Hours of electricity | -0.004 (0.012) | -7.26 (9.07) | 0.021 (0.076) | -0.004 (0.007) |
| Stalls with electricity | 0.002 (0.002) | 1.14 (1.05) | 0.015* (0.008) | 0.002* (0.001) |
| ***Market Type*** | | | | |
| Fish | 0.085 (0.070) | 32.2 (69.9) | 0.716 (0.605) | 0.040 (0.052) |
| Tomato | -0.124* (0.070) | -57.6 (50.9) | -0.850 (0.631) | -0.067 (0.050) |
| GLV | 0.088 (0.061) | 57.3 (80.1) | 0.100 (0.482) | -0.006 (0.053) |
| **Market Operation** | | | | |
| Year of establishment | 0.001 (0.001) | 1.36** (0.685) | 0.005 (0.007) | 0.0001 (0.0007) |
| Months of operation | 0.022 (0.018) | -0.240 (17.8) | 0.191 (0.168) | 0.001 (0.018) |
| Days of operation | 0.031*** (0.010) | 3.36 (8.27) | 0.172*** (0.066) | 0.017** (0.008) |
| Hours of operation | 0.027** (0.011) | -5.24 (7.92) | 0.148*** (0.057) | 0.011 (0.008) |

[6]The average monthly cost per security guard is N46,230. In comparison, the national minimum wage was N30,000 before it was officially increased to N70,000 per month in 2024 (Omotere 2025).

**Table 7.** *Continued*

| | Model 6- Probit Market has security guards | Model 7- Tobit Ratio of traders per security guard | Model 8- Tobit Daily cost of security services | Model 9- Ordered Probit Timing of security services (Day & Night) |
|---|---|---|---|---|
| | Average partial effects[1] | Average partial effects[2] | Average partial effects[2] | Average partial effects on the probability of the most times[1] |
| **Governance** | | | | |
| Publicly owned land | -0.003* (0.001) | -1.65* (0.855) | -0.012 (0.007) | -0.001* (0.001) |
| Publicly run | -0.238*** (0.081) | -280*** (106) | -1.59** (0.685) | -0.163** (0.079) |
| **Shocks** | | | | |
| Number of incidents/thefts | -0.0004* (0.0002) | -0.531 (0.533) | -0.003 (0.003) | -0.0005** (0.0002) |
| Number of natural disasters | -0.011 (0.007) | -3.63 (26.5) | -0.059 (0.156) | -0.011 (0.007) |

Source: Wholesale market survey 2024. Note that the dependent variable is in the natural log form: ln (daily cost of security services).
[1]Delta-method standard errors.
[2]Bootstrap standard errors (100 replications).

**Table 8.** **Explanatory variables.**

| Explanatory variables | Mean | Min | Max |
|---|---|---|---|
| ***Market Location*** | | | |
| Market is located in the South (1/0) | 0.398 | 0 | 1 |
| Market is located in an urban area (1/0) | 0.258 | 0 | 1 |
| Market is located in a peri-urban area (1/0) | 0.268 | 0 | 1 |
| Average distance to the nearest town of 50,000 inhabitants (km) | 11.5 | 0 | 118 |
| ***Market Size*** | | | |
| Number of traders in market (traders) | 2002 | 10 | 20000 |
| ***Market Infrastructure*** | | | |
| Average distance from the market to a paved road (km) | 0.487 | 0 | 25 |
| Market has access to water from pipe-borne, wells, and/or borehole (1/0) | 0.655 | 0 | 1 |
| Number of hours per day that electricity is available from the grid (hour) | 1.63 | 0 | 24 |
| Share of stalls in the market with access to electricity from the grid (%) | 12.6 | 0 | 100 |
| ***Market Type*** | | | |
| Fish is sold in the market in wholesale (1/0) | 0.318 | 0 | 1 |
| Tomato is sold in the market in wholesale (1/0) | 0.679 | 0 | 1 |
| GLV is sold in the market in wholesale (1/0) | 0.585 | 0 | 1 |
| ***Market Operations*** | | | |
| Year of establishment (year) | 1973 | 1742 | 2023 |
| Number of months in a year that the market operates (month) | 11.6 | 2 | 12 |
| Number of days in a week that the market operates (day) | 4.09 | 1 | 7 |
| Number of hours in a day that the market operates (hour) | 12.3 | 4 | 24 |

**Table 8.** *Continued*

| Explanatory variables | Mean | Min | Max |
|---|---|---|---|
| ***Market Governance*** | | | |
| Share of land publicly owned (i.e., community land, government provided space, and/or government offered a developer a concession to develop the market) (%) | 94.4 | 0 | 100 |
| The market is publicly run (i.e., city/town, LGA, municipality, state, or host community) (1/0) | 0.100 | 0 | 1 |
| ***Shocks*** | | | |
| Number of thefts and incidents (e.g., assaults, altercations, and traffic accidents causing bodily harm) last year (units) | 32 | 0 | 1482 |
| Number of natural disasters (fire and flood) last year (units) | 0.562 | 0 | 40 |

Source: Wholesale market survey 2024. Note: 1. Included in the hygiene service regressions only. 2. Included in the security service regressions only.

**Table 9. Hypotheses related to drivers of provision of market services (Expected direction).**

| ***Market Location*** | ***Hygiene and sanitation services*** | ***Security services*** |
|---|---|---|
| Market is located in the South (1/0) | + | + |
| Market is located in an urban area (1/0) vs. rural | + | + |
| Market is located in a peri-urban area (1/0) vs. rural | + | + |
| Average distance to the nearest town of 50,000 inhabitants (km) | - | - |
| ***Market Size*** | | |
| Number of traders in the market (traders) | + | + |
| ***Market Infrastructure*** | | |
| Average distance from the market to a paved road (km) | - | - |
| Market has access to water from pipe-borne, wells, and/or borehole (1/0) | + | NA |
| Number of hours per day that electricity is available from the grid (hour) | NA | +/- |
| Share of stalls in the market with access to electricity from the grid (%) | NA | +/- |
| ***Market Type*** | | |
| Fish is sold in the market in wholesale (1/0) | +/- | +/- |
| Tomato is sold in the market in wholesale (1/0) | +/- | +/- |
| GLV is sold in the market in wholesale (1/0) | +/- | +/- |
| ***Market Operations*** | | |
| Number of months in a year that the market operates (month) | + | + |
| Number of days in a week that the market operates (day) | + | + |
| Number of hours in a day that the market operates (hour) | + | + |
| ***Market Governance*** | | |
| Share of land publicly owned (%) | +/- | +/- |
| Market is publicly run (1/0) | +/- | +/- |
| ***Shocks*** | | |
| Number of thefts and incidents (e.g., assaults, altercations, and traffic accidents causing bodily harm) last year (units) | NA | +/- |
| Number of natural disasters (fire and flood) last year (units) | NA | +/- |

Note: Table 9 summarizes the general hypotheses for the two sets of services (associated with food safety or security), with recognition that there might be alternative hypotheses for specific measures of food safety and security services, such as the extent and cost.

markets actually provide less security than private ones, with a 24 percentage point lower probability. Conditional on having security services in the markets, government-run WMs have lower trader-to-security guard ratios as well as lower costs paid for security by traders. (4) WMs with guards have experienced fewer shocks. (5) Larger, more recent, and private WMs have higher traders-to-guard ratios. (Table 7-model 7).

**Table 10. Type of functional toilets across markets in the North and South regions.**

| Type of toilets | Number of markets with this type of toilets | Number (share) of markets with this type of toilets in the North | Number of markets with this type of toilets in the South |
|---|---|---|---|
| Flush/pour-flush toilets to sewer connection | 48 | 24 (26%) | 24 (52%) |
| Flush/pour-flush toilets to tank or pit | 33 | 19 (21%) | 14 (30%) |
| Pit latrine with slab | 44 | 39 (42%) | 5 (11%) |
| Composting toilet | 0 | 0 (0%) | 0 (0%) |
| Flush/Pour-flush toilets to open drain | 4 | 3 (3%) | 1 (2%) |
| Pit latrine without slab/ open pit | 5 | 3 (3%) | 2 (5%) |
| Bucket | 0 | 0 (0%) | 0 (0%) |
| Hanging toilets/latrine | 0 | 0 (0%) | 0 (0%) |
| Other | 4 | 4 (5%) | 0 (0%) |
| Total (any types) | 138 | 92 (100%) | 46 (100%) |

Note: Six markets have more than one types of toilets, which explains that the total number of toilets in Table 10 above exceeds the total number of markets with access to toilets reported in Table 1. All six markets are located in the North region.

**Table 11. Regression results- Access to, number, and cost of functional toilets.**

| | Model 1- Probit Market has access to functional toilets | Model 2- Tobit Ratio of traders/toilet | Model 3- Tobit Cost per toilet use |
|---|---|---|---|
| | Coefficient parameters[1] | Coefficient parameters[1] | Coefficient parameters[1] |
| ***Market Location*** | | | |
| South region | -0.562*** (0.196) | -68.0 (136) | -17.0* (10.1) |
| Urban area | 1.38*** (0.241) | 841*** (209) | 69.4*** (11.4) |
| Peri-urban area | 0.864*** (0.210) | 455*** (146) | 40.9*** (10.9) |
| Distance to town | 0.025*** (0.006) | 11.9*** (3.62) | 0.591*** (0.191) |
| ***Market Size*** | | | |
| Number of traders | 0.146** (0.065) | 296*** (62.5) | 10.8*** (3.33) |
| ***Market Infrastructure*** | | | |
| Distance to paved roads | -0.034 (0.059) | -27.2 (36.2) | -4.42 (3.86) |
| Access to water | 0.657*** (0.184) | 308** (136) | 23.2** (9.91) |
| ***Market Type*** | | | |
| Fish | 0.042 (0.238) | -16.7 (192) | 6.35 (14.1) |
| Tomato | -0.277 (0.243) | 125 (222) | -6.46 (14.3) |
| GLV | -0.087 (0.211) | 9.60 (165) | -12.2 (10.9) |

**Table 11.** *Continued*

| | Model 1- Probit Market has access to functional toilets | Model 2- Tobit Ratio of traders/toilet | Model 3- Tobit Cost per toilet use |
|---|---|---|---|
| | Coefficient parameters[1] | Coefficient parameters[1] | Coefficient parameters[1] |
| **Market Operation** | | | |
| Year of establishment | -0.001 (0.003) | 2.11 (1.99) | 0.020 (0.150) |
| Months of operation | 0.258** (0.109) | 93.8 (71.4) | 110*** (11.0) |
| Day of operation | 0.086** (0.036) | 14.0 (27.5) | 3.99** (1.71) |
| Hours of operation | -0.044 (0.038) | -40.3 (27.7) | 0.871 (1.72) |
| **Market Governance** | | | |
| Publicly owned land | 0.011** (0.005) | 3.81 (2.90) | 0.428 (0.273) |
| Publicly run | -0.269 (0.308) | -315 (233) | -9.36 (17.4) |
| **Constant** | -4.49 (6.31) | -8202* (4455) | -1546*** (336) |
| | Prob>chi2 = 0.0000 | Prob>F = 0.0004 | Prob>F = 0.0000 |

Source: Wholesale market survey 2024.
[1]Robust standard errors.

**Table 12. Regression results - Frequency and cost of waste disposal.**

| | Model 4- Ordered Probit Frequency of waste disposal | Model 5- Tobit Monthly waste disposal cost/trader |
|---|---|---|
| | Coefficient parameters[1] | Coefficient parameters[2] |
| ***Market Location*** | | |
| South region | -0.515*** (0.159) | -151** (72.8) |
| Urban area | 0.051 (0.209) | 51.2 (85.2) |
| Peri-urban area | -0.339** (0.146) | -53.5 (74.5) |
| Distance to town | 0.002 (0.003 | -0.031 (1.85) |
| ***Market Size*** | | |
| Number of traders | 0.160*** (0.054) | -55.4** (24.2) |
| ***Market Infrastructure*** | | |
| Distance to paved roads | -0.066** (0.026) | -30.4* (18.7) |
| Access to water | -0.134 (0.138) | 87.1 (66.8) |
| ***Market Type*** | | |
| Fish | -0.348* (0.197) | 98.0 (88.0) |
| Tomato | -0.310* (0.185) | 77.6 (85.7) |
| GLV | -0.011 (0.176) | -37.4 (77.4) |
| **Market Operation** | | |
| Year of establishment | 0.004** (0.002) | 1.93 (1.22) |
| Months of operation | -0.082* (0.044) | -58.0*** (20.8) |
| Days of operation | 0.109*** (0.027) | 11.3 (12.6) |
| Hours of operation | -0.001 (0.029) | -11.1 (13.0) |
| **Governance** | | |
| Publicly owned land | 0.002 (0.003) | -0.834 (1.31) |
| Publicly run | -0.571** (0.252) | -148 (116) |

**Table 12.** *Continued*

| | Model 4- Ordered Probit Frequency of waste disposal | Model 5- Tobit Monthly waste disposal cost/trader |
|---|---|---|
| | Coefficient parameters[1] | Coefficient parameters[2] |
| **Constant** | --------- | -2748 (2526) |
| | Prob>chi2 = 0.0000 | Prob > chi2 = 0.0000 |

Source: Wholesale market survey 2024. Note: Daily corresponds to a higher outcome than weekly, monthly, and infrequently, monthly corresponds to a higher outcome than monthly and infrequently, and monthly corresponds to a higher outcome than infrequently. Infrequent waste disposal includes every other month, annually, and never.
[1]Robust standard errors.
[2]Standard errors.

**Table 13. Regression results- Access, cost, and time of security services.**

| | Model 6- Probit Market has security guards | Model 7- Tobit Traders/ security guard | Model 8- Tobit Daily cost of security services | Model 9- Ordered Probit Time of security service provision |
|---|---|---|---|---|
| | Coefficient parameters[1] | Coefficient parameters[1] | Coefficient parameters[1] | Coefficient parameters[2] |
| ***Market Location*** | | | | |
| South region | -0.063 (0.191) | -29.9 (123) | -0.486 (0.732) | 0.025 (0.165) |
| Urban area | -0.028 (0.233) | -62.1 (129) | 0.423 (0.823) | -0.081 (0.177) |
| Peri-urban area | -0.008 (0.201) | -112 (127) | 1.08 (0.766) | 0.044 (0.176) |
| Distance to town | 0.009* (0.005) | 0.051 (1.93) | 0.018 (0.015) | 0.001 (0.003) |
| ***Market Size*** | | | | |
| Number of traders | 0.120* (0.066) | 299*** (64.7) | 0.597** (0.252) | 0.162 (0.053) |
| ***Market Infrastructure*** | | | | |
| Distance to paved roads | -0.002 (0.036) | -23.0 (17.4) | 0.059 (0.143) | 0.022 (0.038) |
| Hours of electricity | -0.014 (0.041) | -14.5 (14.4) | 0.038 (0.125) | -0.012 (0.025) |
| Stalls with electricity | 0.007 (0.005) | 2.27 (1.79) | 0.026** (0.013) | 0.006* (0.003) |
| ***Market Type*** | | | | |
| Fish | 0.278 (0.232) | 64.5 (110) | 1.27 (0.914) | 0.137 (0.177) |
| Tomato | -0.408* (0.233) | -115 (102) | -1.50* (0.917) | -0.227 (0.171) |
| GLV | 0.288 (0.203) | 115 (126) | 0.179 (0.792) | -0.021 (0.181) |
| **Market Operation** | | | | |
| Year of establishment | 0.002 (0.003) | 2.71* (1.40) | 0.008 (0.012) | 0.0004 (0.0024) |
| Months of operation | 0.073 (0.059) | -0.480 (30.4) | 0.339 (0.274) | 0.002 (0.063) |
| Days of operation | 0.102*** (0.034) | 6.74 (17.6) | 0.306** (0.119) | 0.057** (0.028) |
| Hours of operation | 0.089** (0.036) | -10.5 (15.2) | 0.263** (0.114) | 0.037 (0.026) |
| **Governance** | | | | |
| Publicly owned land | -0.008* (0.005) | -3.30** (1.46) | -0.021* (0.011) | -0.005* (0.003) |
| Publicly run | -0.782*** (0.277) | -561*** (214) | -2.92** (1.36) | -0.555** (0.271) |
| **Shocks** | | | | |
| Number of incidents/thefts | -0.001* (0.0007) | -1.06* (0.578) | -0.004 (0.003) | -0.002** (0.001) |
| Number of natural disasters | -0.038 (0.025) | -7.26 (21.4) | -0.105 (0.119) | -0.036 (0.024) |

**Table 13.** *Continued*

| | Model 6- Probit Market has security guards | Model 7- Tobit Traders/ security guard | Model 8- Tobit Daily cost of security services | Model 9- Ordered Probit Time of security service provision |
|---|---|---|---|---|
| | Coefficient parameters[1] | Coefficient parameters[1] | Coefficient parameters[1] | Coefficient parameters[2] |
| **Constant** | -6.65 (6.02) | -6690** (3052) | -23.0 (25.0) | |
| | Prob>chi2 = 0.0000 | Prob>F = 0.0081 | Prob > F = 0.0000 | Prob > chi2 = 0.0009 |

Source: Wholesale market survey 2024.
[1]Robust standard errors.

WM infrastructure does not affect the presence and ratio of traders-to-guards, but it affects the cost to traders of security services. WMs with a greater share of stalls with access to electricity from the grid charge traders more for security. More electricity use might be correlated with product storage and processing and thus more needs for guards for these assets.

Finally, the ordered probit model estimates on the timing of guards' presence (Table 7- model 9) show that larger markets are more likely to have security guards both day and night. Being open for more days per week, being run by the private sector, using more grid electricity, and being private are linked to security guards being there day and night.

## 6. Conclusions

WMs in Nigeria are important for national food systems but are challenged by food safety, hygiene, and theft and conflict problems. This study contributed to the literature on these challenges and service provision to address them by bringing in evidence from a substantial survey of WMs and analyzing the presence, extent, and cost to traders of services provided by the WMs. The data analysis revealed several key findings.

First, hygiene and sanitation services are overall low and inadequate. Of the 299 markets surveyed, 13 markets lack access to water, 167 markets have no toilet facilities, and two-thirds of those with toilets do not have accompanying handwashing stations. One-third of the WMs dispose of waste only monthly or even less frequently. These deficiencies pose significant risks to both traders and buyers.

Second, WM region and urban vs rural, size, infrastructure, and governance (public versus private run) are key determinants of hygiene services. Rural markets and those in the South are less likely to provide access to functional toilets. WMs with access to water through pipes, boreholes, or wells are more likely to provide access to functional toilets, as are larger markets. The products being sold in the markets (tomatoes, GLVs, or fish) do not significantly influence access to toilets. WM governance does affect toilet provision, with government markets more likely to offer access to toilet facilities, but the effect is small. With a very few exceptions, the drivers of access to toilet facilities also explain the number of toilets available to traders and the cost per toilet use.

Third, in addition to being less likely to provide toilets, WMs in the South dispose of waste less frequently than in the North. Peri-urban markets and those located farther from paved roads are less likely to dispose of waste daily. The provision of sanitation services seems aligned with needs, with larger markets and those operating daily more likely to dispose of waste daily. Contrary to expectations, markets selling fish and tomatoes are less likely to dispose of waste daily compared to those that do not sell any of these products. The governance of markets has a significant impact on waste disposal frequency, with publicly operated markets less likely to dispose of waste daily. The monthly waste disposal costs are influenced by a similar set of variables, including region, size, type, operational characteristics, and governance.

Fourth, compared to hygiene services, a greater proportion of wholesale food markets provide security services, with 68% of them employing security guards, while access to electricity from the grid remains limited across markets. Key determinants of security provision include market size, operational characteristics, governance structure, and shocks experienced the previous year. Security service provision appears to be highly correlated with needs, with larger markets, those open all days of the week and for longer hours more likely to have security guards.

Contrary to expectation, publicly run markets and those with greater share of marketspace publicly owned have lower probability of having security guards. However, conditional on having security services in the markets, we find that publicly run markets have lower trader-to-security guard ratios as well as lower costs paid for security by traders. The number of thefts and incidents reported in the previous year also significantly influences the presence of security services

but not the occurrence of natural disasters. Larger markets are associated with higher trader-to-security guard ratios and security costs.

Market infrastructure does not explain the presence of security guards but affects the cost and timing of security services. Markets where a greater share of stalls have access to electricity from the grid have higher costs and probability of having security services during both day and night times. Market operations and associated need affect the timing of security provision. Being open for more days significantly and positively affects the presence of security guards during day and night. Larger markets are also more likely to have security guards during both day and night.

Taken together, the analysis reveals a limited provision of services and highlights the need for further investment in infrastructure to support adequate hygiene, sanitation, and security services, including effective management of runoff water and sewage to prevent water contamination and reliable access to electricity. Upgrading rudimentary toilet facilities, including handwashing stations, to make them hygienic and water-efficient would reduce the risk of food contamination and the spread of germs and diseases. Improving access to reliable electricity- particularly for markets that operate early in the morning and late at night, could enhance personal safety and help reduce food spoilage, especially for traders who rely on refrigeration to store perishable products.

## Data availability statement

Data will be made available on request.

## Ethical approval and consent statement

All studies in this project involving humans were approved by Michigan State University Institutional Review Board and were conducted in accordance with the local legislation and institutional requirements. This project has the Michigan State University IRB Study ID: STUDY00007403 and was determined exempt Category: Exempt 2ii. The participants provided their written informed consent to participate in this study.

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