Determinants of efficient last-mile delivery: evidence from health facilities and Kaduna Health Supplies Management Agency

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Abstract

Purpose – Africa has been identified as an area where higher mortality happens due to un-accessibility to health care, drugs and other health facilities. Nigeria, as one of the African countries, is not excluded from such difficulties. This study aims to examine the determinants of efficient last-mile delivery at selected health facilities and the Kaduna State Health Supplies Management Agency (KADSHMA).

Design/methodology/approach – The study sourced data from KADSHMA and the health facilities' staff, with a total of 261 observations used. Likewise, the respondents were picked from warehouses of each health facility and KADSHMA. The data was analysed using the partial least square structural equation modelling analysis to estimate the relationship among the variables of the study.

Findings – The study's findings revealed that all five variables of the study (i.e. determinants) were significantly affecting the efficient lastmile delivery. Four constructs (delivery cost [DC], delivery time [DT], mode of delivery [MD] and facilities technology [FT]) have shown a positive and significant association with efficient last-mile delivery, whereas one variable (product mix [PM]) indicated a negative and significant association with efficient last-mile delivery. The study concludes that DC, DT, MD, FT and PM played significant roles in efficient last-mile delivery.

Research limitations/implications – The study provides that specific means of transportation should always be on standby to transport health supplies. Time schedules should always be prepared and adhered to when transporting health supplies to the facilities, and each facility should network with robust technology to ease communication in terms of order and order planning. Additionally, facilities should try as much as possible to reduce the varieties of products when ordering health supplies, as it will increase the efficiency of the delivery.

Originality/value – To the best of the authors' knowledge, this study is the first of its kind that considered these five variables (DC, DT, MD, FT and PM) with impact on the last-mile delivery in one model, especially in the Nigerian case. This is a great contribution to knowledge, more importantly, to the last-mile delivery of the health sector. The result confirmed the importance of these determinants (DC, DT, FT and PM) of last-mile delivery efficiency in saving lives.

Keywords Last-mile delivery, Health facilities, Delivery cost, Delivery time, Mode of delivery, Facilities technology, Product mix,

Paper type Research paper

1. Introduction

Nigeria, as one of the giants of Africa, is seen to have abundant of people and resources but encounters a huge number of problems ranging from insecurity, economic crises, health facilities, high death rate and many more. The mortality rate is identified as one of the problems at the top gear in Africa, with particular emphasis on Nigeria, which resulted from a lack of access to drugs and other health facilities to the patient at the last-mile point due to the last-mile delivery issues. Last-mile delivery is seen as the last part transportation of products (drugs and other health facilities) from the warehouse to the customers (Seifen, 2016). Last-mile logistics/delivery is seen as the last-point transportation activities in the supply chain, which connects products from the

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Journal of Humanitarian Logistics and Supply Chain Management 14/1 (2024) 4–16 Emerald Publishing Limited [ISSN 2042-6747] [DOI 10.1108/JHLSCM-05-2022-0054] distribution centres or warehouses to the facilities or point of consumption. This study considered last-mile delivery as the last point of order fulfilment that is from the warehouse to the facilities.

Companies, businesses and government agencies that deal with customers/end-users of products/services must have to depend on efficient last-mile transportation for them to certify their customers efficiently and effectively (Gevaers *et al.*, 2011). Last-mile delivery is an important stage that fulfils customers promise if managed effectively; otherwise, it messes up all processes of supply chain efficiency. For example, the delay of

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medical supplies for a critical patient in the hospital that leads to death has rendered all processes right from order to delivery as useless. However, some of the process components of lastmile delivery, such as technology used, cost incurred, a system of delivery, vehicles mode and many others, are responsible for the failure of efficient last-mile delivery (Macioszek, 2017).

Considering the importance of the determinants variables: delivery time (DT), delivery cost (DC), mode of delivery (MD), facility technology (FT) and product mix (PM) for the last-mile delivery, if these variables are managed effectively, they will improve the efficiency of the last-mile delivery, which consequently improves the lives saving of patients at last mile. This is what this study is intended to achieve.

Some studies were conducted on last-mile delivery. Efficient last-mile delivery was reported to have a positive and significant impact on inventory management, which leads to high customers' satisfactions (i.e. achieving high patient satisfaction) (**Yvkoff**, 2015). Studies have reported that last-mile delivery is considered as one of the most polluting and expensive part of the supply chain if it is not managed appropriately with extra care (Gevaers *et al.*, 2011). In the same vain, Gevaers *et al.* (2014) stress that last-mile logistics is an important last part of the supply chain, which takes almost 50% of the logistics cost of a product. Although Onghena (2008) reported that between 13% and 75% of the total logistics cost are incurred as a result of inefficiencies and poor environmental performance of the processes used in the last-mile delivery of products.

Products shortage, products late delivery, products damages and spoilage are some of the problems encountered during lastmile delivery, which causes failure or inefficient last-mile delivery. Being it the last part of the supply chain and a significant role played in providing and distributions, it needs to be enhanced so as to have an efficient supply chain (Ede, 2013). However, where last-mile delivery is managed well and improved upon, customer satisfaction will surely improve, as predicted in Yvkoff (2015)'s studies.

Having an efficient last-mile delivery is an indication that lives will be saved. This could be achieved through integrated logistics channels that give the facility a good advantage that leads to achieving high efficiency in satisfying the patients' needs. Such integrated logistics channels include; transport type, containers sizes, vehicle size, drivers and vehicles availability scheduling system, DC, facility technology, PM and many more.

Efficient last-mile delivery is expected to solve some of the challenges that lead to mortality as a result of non-access to health supplies. For example, 7.3 billion people, almost half of the world's population, including one billion in remote areas, were reported to lack access to health supplies and services (World-Bank-Report, 2017; World Health Organisation: Kumar *et al.*, 2008). Such health services include; treatments for malaria, HIV, tuberculosis, vaccinations, among others (World-Bank-Report, 2017).

According to World Health Organisation (2017) report, the rate of children and infant mortality has been increasing to the extent that 1 in every 3 is dying before the age of five in sub-Saharan Africa for over a decade now. In a similar vein, UNICEF (2017) disclosed that every day Nigeria losses 2,300 children between the age of five years and below. However, where households access health facilities and services,

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especially in remote areas, the mortality rate tends to reduce drastically (Kumar *et al.*, 2008).

A high mortality rate is linked to the lack of access to health supplies and services to the patients. Inefficient last-mile delivery is counted among the other problems attributed to the high rate of mortality. These and many other problems prompted the Kaduna State Government to launch health sector reforms, which also led to the creation of the Kaduna Health Supplies Management Agency, which serves as a health supply hub in Kaduna State, with the expectation to have efficient last-mile delivery, drugs availability, health supplies to facilities at the right time, with the right quantities and in good conditions.

After a while, the agency was able to record a huge success, which led to a time decrease from fourteen days to four days. Stock management accuracy also significantly increased from 55% to 98%. Products expiring rate decreased from 5% to 2%, Time of picking stocks period reduced to 2 to 3 h instead of three to four days. Accuracy of stocks picking changed from 60% to 95%, and many other successes were achieved, as reported in KADSHMA (2017) report.

Nevertheless, there are other issues that need to be investigated to enhance the efficiency of last-mile delivery so as to save human lives by reducing the mortality rate, which is the focus of this study. The study is restricted to the determinants of efficient last-mile delivery, with a focus on health facilities.

This study used DC, DT, MD, facility technology and PM to examine the last-mile delivery efficiency in the health sector, which other studies have not done. These variables show the importance of lives saving through efficient last-mile delivery of health supplies, especially in remote areas, with the support of these theories: Supply Chain Operations Reference (SCOR) model, which analysed weaknesses and strengths of organisational supply chain performance (Council, 2012), Kansei Engineering Theory that examines customers' satisfaction with service delivery (Chen *et al.*, 2015) and Interpretive Structural Modelling (TISM) theory, which asserts contributions of individual factors to solve problems.

Studies in the field of last-mile logistics of the supply chain have discussed some challenges encountered during the lastpart of delivery (Boyer *et al.*, 2009; Hübner *et al.*, 2016; Minten *et al.*, 2013). Some scholars focus on the last-mile cost, inefficiencies and disruption in the supply chain (Abbas *et al.*, 2022; Boyer *et al.*, 2009; Gevaers *et al.*, 2011; Reis *et al.*, 2013). Some looked at channels of distributions (Cardenas *et al.*, 2017; Miko *et al.*, 2020); some last-mile financing (Miko, 2021); and some studies looked at the last-mile distributions during the disaster (Balcik *et al.*, 2008; Battini *et al.*, 2014; Maghfiroh and Hanaoka, 2018; Penna *et al.*, 2018; Sengul-Orgut *et al.*, 2017). Other studies were conducted in last-mile distributions of non-health sectors (Mangiaracina *et al.*, 2020; Pronello *et al.*, 2017).

Most of the studies in this area have skipped or failed to focus on the determinants of last-mile delivery, especially in the health sector. Investigating the determinants of efficient lastmile delivery in the health sector will improve access to health supplies and services for patients, which will save lives. In line with these discussions, the present study investigates the extent to which the determinants of last-mile delivery can increase the efficiency of last-mile delivery of health supplies in Nigeria.

2. Literature review

2.1 Efficient last-mile delivery

Last-mile transportation or logistics or delivery is considered as one of the critical parts of the supply chain, which could enhance the supply chain if monitored properly. Last-mile delivery is seen as the last point transportation from the origin of products (medicine, health supplies and health services) to the point of consumption (facilities and patients). Ojo (2014) opined that last-mile delivery is an important part of the supply chain, which deals with the flow of goods, drugs, medicine and health supplies from the point of stocking to the point of consumption. However, logistics is seen as the plan and process management of the transportation of products and services from the point of origin to the point of consumption (Mentzer et al., 2008). Logistics is the wider concept of transportation, while last-mile logistics is the last part of product transportation. Coyle et al. (2013) defined logistics as "glue that binds the market environment and the business activities" which facilitate the smooth flow of goods and services, such as products, drugs and other health facilities for the purpose of customers' satisfaction. Coyle et al. (2013) opined that logistics management serves as a tool that assists businesses (supplies of goods and services) to deliver products to customers at different levels (such as last-mile delivery) of consumption for the betterment or satisfaction of customers.

Any successful and efficient supply chain must have efficient last-mile delivery. Last-mile delivery plays a vital role in making the supply chain efficient, but there are some challenges that make the last part transportation to be inefficient, which may result in disappointment of the customers. Such challenges include; traffic congestion, accidents, poor road network, poor condition of the road, lack of infrastructures, limited parking space and so on. On the other hand, there are human-related challenges, such as customers' characteristics: proximity of the customers, geographical location of customers, management skills and technology availability (Chopra, 2003; Pronello *et al.*, 2017).

Many studies have been conducted in relation to last-mile delivery, such as consumers' driven logistics (Galkin *et al.*, 2019), cost decrease (Ranieri *et al.*, 2018), products containerisation (Dell'Amico and Hadjidimitriou, 2012), shipping of products and micro hubs (Ballare and Lin, 2020), efficiency and sustainability (Tiwapat *et al.*, 2018), last-mile distributions of relief materials during the disaster (Balcik *et al.*, 2008; Battini *et al.*, 2014; Maghfiroh and Hanaoka, 2018) and last-mile delivery in the era of Covid-19 (Suguna *et al.*, 2021).

There are a number of studies that reported different challenges that face last-mile delivery. Such studies include **Patel and Parmar** (2020), who investigated the logistics of Amazon Company in the period of Covid-19, and it was reported that Amazon informed customers on their delivery of last-mile within a day, but Amazon was unable to solve the problems of cost and time efficiency of the last-mile delivery. As reported by the study, the cost incurred for the last-mile delivery accounted for 41% of the total supply chain cost, which is more than the cost of any sector of the supply chain. However, electric-powered delivery trucks, Sidewalk Robot, Drones and third parties collaborations were among the areas to invest more to achieve last-mile efficiency. Volume 14 · Number 1 · 2024 · 4–16

Bauer et al. (2020) have investigated the last-mile delivery during the Covid-19 pandemic that changed the live styles of people around the world. It was reported that last-mile logistics accounted about 40% of the total logistics costs worldwide, especially during the pandemic, which made it difficult to move goods from one location to another. Another major concern that was reported is the increase in last-mile delivery vehicles, which added more pressure to the Carbon generated by the lastmile delivery operators. These issues have called for the shift by the last-mile delivery players to more sustainable environmental logistics such as micro-mobility that has less or no Carbon emission. A study by Unnikrishnan and Figliozzi (2020) on the impact of Covid-19 on home delivery reported that home delivery had solved the problem of lock-down which gives the opportunity to order, and order more especially those with the habit of order to home delivery before the Covid-19 era.

Similarly, other studies considered last-mile distribution during a disaster. Such studies include a study by Balcik *et al.* (2008), who examined vehicle-based last-mile distributions of humanitarian relief supplies from local distribution centres to the demand areas. The study detected that allocations, optimal routing and penalty cost issues could be easily identified in a small disaster, whereas in big disaster nodes, allocations, DT and vehicle capacity could not be controlled.

Maghfiroh and Hanaoka (2018) examined the dynamic vehicle routing application for last-mile delivery during disaster response. The study considered models that have mixed vehicles, multiple trips, many locations with different conveniences, unpredicted demands and anticipated new demands for last-mile response. The study disclosed that different conditions and complexities of disaster required different strategies and approaches.

Battini *et al.* (2014) studied the case study of routing model of material deliveries of last-mile for humanitarians using the availability of logistics asset variations. The study discovered that logistics asset characteristics and their availability have a significant effect on the delivery system in terms of total cost and shortages. Penna *et al.* (2018)'s study focused on the complex vehicle routing problem used in response to the natural disaster of earthquakes using mixed vehicles, multiple trips, multiple depots and vehicle needs in delivering relief materials to the last-mile. Algorism was used to determine the number of vehicles required. The study indicated that the method is good to make distributions to last-mile efficient.

Sengul-Orgut *et al.* (2017) examined the developed stochastic models used to efficiently distribute donated foods to the hungerrisk population areas. The study developed and used a single period, a two-stage stochastic model which depended on the workforce and budget of the local charitable agencies assigned to distribute donated foods in an equitable manner and waste minimisation. The first stage of the model was to take decision before observing the distribution capacity of receiving location, and the second stage of the model was to correct decision at distribution time when the capacity is observed. The study testifies that the model is efficient in the distribution of donated foods to hunger-risk population areas. Considering effective determinants of efficient last-mile delivery will help in enhancing the last part transportation.

2.2 Determinants of last-mile delivery

Based on the literature survey, the present study considered DC, DT, MD, FT and PM as determinants of efficient last-mile

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delivery. Empirical studies proved the evidence of research on determinants factors (such as DC, DT, MD, FT and PM) and last-mile delivery (Mentzer *et al.*, 2008; Reisman and Chase, 2011; Suguna *et al.*, 2021; Venter, 2009). These determinants are expected to enhance the capability and efficiency of last-mile logistics, especially in health supply products.

2.2.1 Delivery cost and last-mile delivery

DC is seen as the cost incurred on the process of delivering drugs, medicines and consumables to the facilities. Efficient last-mile logistics are expected to save cost. Scott et al. (2009) and Allen (2012) reported that some of the factors that were adding cost to last-mile delivery were poor road infrastructure and poor planning, most especially in developing countries. Aized and Srai (2014) disclosed that most of the businesses that experienced inefficiencies at the last-mile logistics suffered due to the high cost, which affected the supply chain of their businesses. Aized and Srai (2014) also stated in another vain that the movement of goods around the world is distracted by congestion which adds more cost to it, especially at the last-stage delivery. Christopher (2016) stresses that lastmile DC cannot be avoided and in trying to do that it may lead to the inability to deliver products, goods, drugs and consumables to the consumers, the facilities and the right destination in time, as required by the customers. Gevaers et al. (2011) find that due to the uniqueness of individual's delivery, which involves the extra usage of some factors, such as warehouse, technology, vehicles, fuel and labour. It made the last-mile delivery to cost high.

Lim and Srai (2018) examined the last-mile delivery in e-commerce of Omni channel of retailing. The study reported that designing of the last-mile logistics of the supply chain is the most costly section of the supply chain, and it is difficult to trade-off product range and convenience with business-wide data visibility as well as efficient last-mile delivery due to the increase in the internet transactions base. Mangiaracina *et al.* (2020) examined the efficiency of last-mile delivery. It was observed that e-commerce is in the front line of growth with worldwide retail industry, which was valued at more than \notin 2500bn in the year 2018. However, the last-mile delivery was rated as ineffective and the most costly due to the service level that was obstructed by the small order dimension and a higher level of dispersion of endpoints which cost almost half of the overall logistics expenses.

Operational plan for last-mile logistics is very important and may help in achieving efficient last part delivery. However, for health supplies, it may be different because lifesaving is the primary objective of efficient last-mile delivery, and the cost is not an issue in trying to save lives. So, any extra cost can be incurred to avail the health supplies available at the facilities. This study hypothesises that:

H1. DC significantly contributes to the efficient last-mile delivery.

2.2.2 Delivery time and last-mile delivery

DT is seen as the time taken to deliver items or products to the facilities or point of consumption. In another angle, DT refers to the facilities and time available for receiving deliveries or operations. Warehouse operational hour is one of the factors of consideration for the effective distribution of products and

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health supplies to facilities. Factors such as product availability, order fulfilment accuracy and order fulfilment speed have a strong relationship with warehouse operational time (Ojo, 2014; Reis *et al.*, 2013). Managing these factors to suit the available operational time will enhance last-mile delivery.

Other challenges, such as poor road infrastructures, lack of parking space, damaged products or health supplies, poor delivery facilities, high demand for facilities and replenishment time variability, have an effect on delay in last-mile delivery of health supplies or other products (Ojo, 2014), whereas Agatz *et al.* (2008) opine that, achieving last-mile efficiency is achieving supply objective, and failure in last-mile delivery is a failure in achieving supply chain efficiency.

Similarly, other studies observed that poor road network factor, limited parking space and delay led to high fuel consumption and higher carbon pollution (Mentzer et al., 2008; Reisman and Chase, 2011; Venter, 2009). Narashimman (2020) examines last-mile delivery in the context of customer satisfaction and same-day delivery. It was reported that customers' behaviours were changing towards adopting e-commerce due to the spread of the Covid-19 pandemic, which led to the satisfaction of customers in the last-mile delivery through faster delivery or same-day delivery. Fulfilling customers' delivery faster or on the same day adds an edge over competitors. Jacobs et al. (2019) examine the last-mile delivery activities in the food and grocery industries. It was observed that last-mile delivery is seen as a primary expectation of customers due to the higher online shop by customers in the food and grocery business, especially during rush hours. It was reported that there is a massive increase in online shopping to the tune of about 63% of the customers shop online, which make last-mile delivery much more important for businesses to succeed. Furthermore, the introduction and implementation of a new autonomous-delivery model by the developed markets attracted customers and retained them due to the efficient last-mile delivery services opened to them which led to the excited customers to pay for more money for faster lastmile delivery.

DT from two angles (warehouse operating hours and time of delivering items to the facilities) have greater roles to play in making last-mile logistics to be efficient. The present study hypothesises that:

H2. DT significantly contributes to the efficient last-mile delivery.

2.2.3 Mode of delivery and last-mile delivery

MD is classified as a delivery by any type of road machinery. Combinations of different MD machineries will give an advantage to the facility to have efficient last-mile delivery. Angheluta and Ungureanu (2011) reported that managing lastmile logistics should include proper organisation of vehicle sizes, drivers' availability and arrangement, containers, sizes and scheduling system. Effective strategies need to be used to deal with small orders, which may receive pressure from both the buyer and the supplies, for the purpose of saving lives or so, accuracy and risk of stock out (Fernie and Sparks, 2014). Hinzmann and Bogatzki (2020) examine the last-mile delivery vehicles that are concerned with the customer standard's delivery and demand fulfilment. The study reported that the ADVs mode of transportation will serve as a good transportation Efficient last-mile delivery

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system that improves last-mile delivery and do away with customers' disappointment of parcel delivery. Furthermore, technology acceptance of autonomous delivery of Drone and autonomous delivery of Robots will be examined by the study. Rozycki and Kerr (2020) investigated the last-mile logistics using before and after the Covid-19 pandemic. The author reported that autonomous ground vehicle were used in a few markets closer to the environment using public roads for last-mile delivery. Transportation using Drone is done on demand for escaping traffic, or medical delivery for saving lives which furthermore reduces cost and improves delivery performance. In a global autonomous last-mile delivery market study, it was reported that geographical widespread, whether condition were among the many reasons that make it difficult to make essential items available in the remote areas (Market Study Report, 2021).

Using different modes of delivery will reduce the risk of failure to deliver health supplies to the facilities, as at when due, because Hilux, motorcycle and small vehicles can deliver faster and can successfully deliver to remote areas, where there is no access to road. The study hypothesises that:

H3. MD significantly contributes to the efficient last-mile delivery.

2.2.4 Facilities technology and last-mile delivery

Facilities' technology refers to the availability and usage of appropriate technology for processing order to the last-mile. Data integration between the facilities and warehouses will reduce stock out and enhance efficient last-mile logistics (Denning and Freathy, 1996; Fernie and Sparks, 2014). Technologies used will indicate the level of stock available and when to order stock, and that will enable logistics preparation which will lead to efficient last-mile delivery (Fernie and Sparks, 2014). Where there are communication gaps which may be due to the absence of technology, it will cause inefficiencies in the last-mile logistics (Damji, 2003; Fernie and Sparks, 2014). Bopage et al. (2019) have projected a strategic model to increase the efficiency of lastmile logistics in e-commerce parcel delivery. The study reported that retailers were pressurised to fully manage their stocks and provide effective distributions to the customers, most especially by using technology to manage the delivery process, distributions speed, good prices and good services delivery, as well as market expansion to accommodate and deliver large numbers of orders. The study further explains that the speed at which customers received their order is a factor that, among other factors, determine success. Meyer (2020) examines the last-mile delivery optimisation due to the increase in online purchases as a result of the Covid-19 pandemic. Before Covid-19, customers relied on manual operations, which has a human error, consumed time, higher cost and long processes. Automated system such as route planning tools enhances scheduling delivery, services and cost and last-mile delivery.

Other issues that may likely come up due to the unavailability of technologies usage in a facility, most especially in the logistics wing, are of three types: amount failure, typical failure and omissions and conditions failure (Andrejić and Kilibarda, 2007). One or all may accidentally happen, which could result in inefficiency of the last-mile delivery. This study hypothesises that: Volume 14 · Number 1 · 2024 · 4–16

H4. FT significantly contributes to the efficient last-mile delivery.

2.2.5 Product mix and last-mile delivery

PM refers to the different number of goods ordered or supplied to facilities or customers at a time. PM delivery may course problems when delivering products to the facilities if not managed effectively. Issues such as different products packaging, different destinations of products, selection and delivering of different products may distract the efficiency of last-mile delivery (Boyer and Hult, 2005; Punakivi *et al.*, 2001). Suguna *et al.* (2021) examine the factors responsible for manipulating last-mile delivery in the era of Covid-19. The study reported that delivery density, health, cost, type of goods, routine efficiency, infrastructure, customers' expectations, customers' behaviours, unpredictability in transit and meeting timeline were identified as major factors influencing last-mile delivery during the Covid-19 era. Solving issues of PM will facilitate efficient last-mile delivery (Punakivi *et al.*, 2001). The present study hypothesises that:

H5. PM significantly contributes to the efficient last-mile delivery.

2.3 Theoretical framework

This study considered and adopted three theories (SCOR model and TISM) as the theoretical framework of the study. SCOR model, which was developed by the Supply Chain Operation Council, to analyse the challenges of organisational logistics network (Council, 2012). The SCOR model is a model with 40 measurements of key performance which universally applied to organisation's supply chain (Council, 2012). The model is used to measure the level of supply chain performance of an organisation, weaknesses and strengths, for the purpose of efficiency enhancement (Council, 2012; Li et al., 2011). SCOR Model outlines five management processes: plan, source, make, deliver and return. These processes are very important and relevant to this study in trying to enhance efficient last-mile delivery (Li et al., 2011). SCOR model is very relevant to this study, and it will guide as to how to model lastmile logistics efficiency.

Kansei Engineering Theory originated in Japanese, which means "Human Psychological Feeling," in 1970. The theory is used to analyse the satisfaction of customers with respect to a particular service delivered to them (Chen *et al.*, 2015). Some studies (Hsiao *et al.*, 2017; Masudin *et al.*, 2020; Restuputri *et al.*, 2020) have used the Kaisen Engineering Theory to evaluate customers' satisfaction on logistics. This study used this theory to evaluate the last-mile customers' satisfaction on the efficiency of last-mile delivery of health supplies in Kaduna State facilities.

TISM model theory was developed to analyse the interrelationships of factors to solve a particular problem. The theory was developed by Warfeld (1976) and later updated by Sushil (2012). The theory explains how Factor A is influencing Factor B and interprets the nodes that are linked to the variables. The theory is used in the manufacturing field (Menon and Suresh, 2019), project management field (Wuni and Shen, 2019), Covid-19 research studies (Sreenivasan and Suresh, 2021) and other related fields. The current study used the TISM model theory to explain the interrelationship of factors

(determinants of last-mile delivery) and understand how determinants (factors) influenced the last-mile delivery of medical supplies in Kaduna State facilities.

3. Methodology

This study used a survey method to investigate the determinants (DC, DT, MD, FT and PM) of efficient last-mile delivery. The section is prepared as follows: conceptual framework, population and sample size, sampling technique, questionnaire design, variables measurements and technique of data analysis.

3.1 Conceptual framework

The research framework indicates the connections that exist within the dependent variable (efficient last-mile delivery) and independent variables (DC, DT, MD, FT and PM) as presented in Figure 1.

3.2 Sample and data collection

The population of the study comprises of all staff of government facilities in Kaduna State and staff of Kaduna State Health Management Agency, which is the Kaduna health supplies hub, under the 2017 reform.

The sample size of this study was collected from 86 + 1 facilities from North Zone and Kaduna State Health Supplies Management Agency (KADSHMA) of Kaduna State, as indicated in Table 1. With the aid of questionnaires, the data were collected from three of the most senior officers in the warehouses of each facility, from 86 and KADSHMA's warehouse. A total of 261 responded questionnaires were recorded.

3.3 Questionnaires design

The present study has adopted instruments previously used by other studies, such as Miko *et al.* (2020), to collect information. A developed instrument was used to survey officers in the warehouse of each facility and Kaduna Health Supplies Management Agency's warehouse in Kaduna State.

Figure 1 Framework



Table 1 Classification of facilities under transformation of 20	17
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Senatorial zone	Central	North	South	Total	
Primary health care	49	77	59	185	
Secondary health care	8	9	12	29	
Tertiary health care	1			1	
Total	58	86	71	215	
Note: KADSHMA Report, 2	2017				

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3.4 Exogenous variables measurements

Table 2 explains an outline of the items used to measure the study variables.

The measurements of the determinants of the last-mile delivery rely on five variables (dimensions), as displayed in Figure 3 and outline in Table 2. The variables were measured with varying numbers of items; for instance, DC measured with modified five items sourced from Rushton (2017), number of locations at a time, volume of the delivery at a time, number of personnel on a delivery, model of the MD and MD. DT was measured with seven items adopted from Rushton (2017), which include: lead time, time of delivery, loads time, type of truck, infrastructure, driver's culture and delivery window hours. MD, eight items: vehicle configuration, fuel type, terrain to be covered, restriction at the point of loading or delivery, method of loading or delivery, body type, vehicle economy and ancillary equipment required, were used to measure it, as it is modified and adopted from Rushton (2017), Six items (information technology generation, information technology infrastructure provision, information technology, real-time data tracking, information technology data cloud and technical support) were used to measure facility technology, as adopted from Rushton (2017). Products mix was measured with six items: number of products, size of products, weight of products, product package nature, products identification nature and emergency need of the products Rushton (2017).

3.5 Endogenous variable measurement

Last-mile delivery is an endogenous variable, which is measured with eight items developed by Gevaers *et al.* (2009) and Mavhungu (2019). The items were window time, maximum lead time, delivery frequency, return possibility, product variety, availability, fleet capacity and customer expectations, as indicated in Table 2. Five-point liker-scale was used in the study.

4. Result and analysis

4.1 Questionnaires distributed and responses

The study distributed 261 questionnaires using the survey monkey website, and all the questionnaires were responded to based on request. The data was successfully collected using the head of facilities and agencies to inform their staff to respond to the questionnaire sent to them. Table 3 displayed the information as follows:

4.2 Outliers verification

The study used Boxplot to check the existence of outliers in the study data. The result shows that there were three outliers (40, 121 and 202) in the date, as displayed in Figure 2.

The outliers were removed, and further test was conducted that testified that there is no existence of any outliers in the data.

4.3 Multicollinearity

The multicollinearity test was conducted to check whether the variables have an excessive correlation in the study. The result, as indicated in Table 4, shows mean value of 1.16 and the individual variable VIF were less than the benchmark of 10. This justifies that there is no multicollinearity in the data.

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Table 2 Items for variables measurements and sources

Variable name	Variable name Items used	
Last-mile delivery	Window time	Gevaers <i>et al.</i> (2009), Mavhungu (2019)
	Maximum lead time	
	Delivery frequency	
	Return possibility	
	Product variety	
	Availability	
	Fleet capacity	
	Customer expectations	
Delivery cost	Number of locations at a time	Rushton (2017)
	Volume of the delivery at a time	
	Number of personnel on a delivery	
	Model of the mode of delivery	
	Mode of delivery	
Delivery time	Lead time	Rushton (2017)
	Time of delivery	
	Loads time	
	Type of truck	
	Infrastructure	
	Driver's culture	
	Delivery window hours	
Mode of delivery	Vehicle configuration	Rushton (2017)
-	Fuel type	
	Terrain to be covered	
	Restriction at the point of loading or delivery	
	Method of loading or delivery	
	Body type	
	Vehicle economy	
	Ancillary equipment required	
Facility technology	Information technology generation	Rushton (2017)
	Information technology infrastructure provision	
	Information technology	
	Real-time data tracking	
	Information technology data cloud	
	Technical support	
	••	

Table 3 Questionnaires distributions

Questionnaires	No.	%
Number of questionnaires links distributed	261	100
Number of questionnaires collected	261	100
Total	261	100

4.4 Heteroskadesticity

The result of the heteroskadesticity test of the study indicated that there is the absence of heteroskadesticity in the data. This means that the residual changes are not constant, and the graph is scatted as presented in Figure 3.

4.5 Partial least square structural equation modelling analysis

Partial least square structural equation modelling analysis (PLS-SEM) is one of the estimators that is not concerned with the normality of the data. Research studies recognised PLS-SEM as a good estimator of non-parametric data, which estimates causal relationships among the constructs as used in

Rajakaruna *et al.* (2017). The model of this study has 261 observations which is considered as a complex model.

SEM analysis has two sections of analysis (Chin, 1998); section one is the estimation of measurement model, such as validity and reliability, whereas section two is the estimation for the hypothesis testing (Rajakaruna *et al.*, 2017).

4.5.1 Measurement of the outer model

The measurement of validity and reliability of constructs in a study is done through the analysis of discriminant validity, analysis of content and convergent. The measurement will show the analysis of reliability and validity of the variables of study. The result of the present study measurement of the constructs is presented in Figure 4 and Table 2.

4.5.1.1 Content validity. Content validity is the weight contributions of each item to the construct (which is called loading) in the study model (Hair *et al.*, 2010). Content validity shows each item's contribution to the construct, as indicated in Figure 4. Scholars indicated that the threshold for accepting item loading is 0.40 and above, whereas Hulland (1999) indicated that the standard loading is 0.7 and above. The result of this study indicated that the items loading are higher than

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Figure 2 Outliers



Table 4 Multicollinearity test

Variables	VIF	1/VIF
DC	1.34	0.746
DT	1.26	0.794
FT	1.14	0.877
LMD	1.13	0.885
MD	1.1	0.909
PM	1.03	0.971
Mean VIF	1.16	

5.0, which is above the threshold. This shows that all items were considered and accepted.

4.5.1.2 Convergent validity. According to Hair et al. (2010), convergent validity shows the group weight of items contributed to measure a construct. Scholars reported that composite reliability and AVE were used by scholars to measure convergent validity. The threshold of 0.5 and above of AVE is considered accepted, as reported by Bagozzi and Yi (1988). The AVE of the study were over and above 0.5, as presented in Table 5.

Figure 3 Regression standardised predicted values



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Figure 4 Outer model measurement



For internal consistency, the composite reliability is recommended to use over Cronbatch's alpha because it is less biased. The threshold of composite reliability is 0.7, whereas the current study result reported composite reliability of 0.8 and above, which is above the minimum threshold. This indicated that there is strong internal consistency in the instruments.

4.5.1.3 Discriminate validity. Discriminate validity is reporting the extent of the association between variable of study. The criterion for the discriminate validity is when values in diagonal are more than the values in off diagonals, as reported in the SEM literature (Fornell and Larcker, 1981). The variables correlation in the current study shows that no value that is higher than the square root of AVE based on the second criteria for measuring discriminate validity as presented in Table 6. All the variable measurements have met the requirement for estimation.

4.5.2 Hypothesis testing model (inner model)

Estimation method of PLS technique has two models; first model (i.e. outer model or measurement model) must have met the requirement of the construct validity and reliability. The second model (i.e. estimation model) will be analysed using the output of the run algorithm and bootstrapping as presented in Table 7. This shows that the R^2 of the model indicated 12%, this shows that the model variables (DC, DT, MD, FT and PM) accounted for 12% of the efficient last-mile delivery, and the other 88% were explained by other factors.

Table 3 Outer model medsuremen	Table 5	Outer	model	measuremen
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Variables	Cronbach's alpha	Composite reliability	AVE
DC	0.8417	0.8863	0.6157
DT	0.7833	0.8314	0.5625
FT	0.7561	0.8347	0.5089
LMD	0.8675	0.8926	0.5144
MD	0.7955	0.8489	0.5854
PM	0.9005	0.9136	0.6391

 Table 6
 Correlations discriminate validity

Constructs	DC	DT	FT	LMD	MD	PM
DC	1.0000					
DT	0.7702	1.0000				
FT	0.7229	0.5980	1.0000			
LMD	0.2935	0.1301	0.8233	1.0000		
MD	0.5836	0.4646	0.6703	0.2682	1.0000	
PM	0.7528	0.2840	0.7174	0.1710	0.6054	1.0000

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Constructs	Coefficients	SD	T.stat.	Supported			
$DC \rightarrow LMD$	0.3261	0.1843	1.9690**	Supported			
$\text{DT} \rightarrow \text{LMD}$	0.0507	0.1598	1.9176**	Supported			
$FT \rightarrow LMD$	0.0535	0.1949	1.8748**	Supported			
$\text{MD} \rightarrow \text{LMD}$	0.1558	0.1422	1.9955**	Supported			
$\text{PM} \rightarrow \text{LMD}$	-0.2270	0.2012	1.7283*	Supported			
Note: ** and * indicating significance at 5 and 10% level							

Table 7 reported that the result of DC ($\beta = 0.3261$, t = 19690, p = <0.005) is indicating that there is a positive and significant association between DC and efficient last-mile delivery at 5% level of significance. This indicates that the cost of delivering goods, health supplies, medicine and other health consumables have a very important role on efficient last-mile delivery. It tells that the exorbitant fee paid for last-mile transportation increased the efficiency of last-mile logistics. This shows that the study accepted *H1*.

DT result indicated ($\beta = 0.0507$, t = 1.9176, p < 0.005) a significant positive relationship between DT and efficient lastmile delivery at 5% level of significance. It shows that the specification of order fulfilment time has an effect on the efficiency of last-mile logistics. This indicated *H2* is accepted by the study.

MD shows a result of ($\beta = 0.1558$, t = 0.9955, p > 0.005), it indicating that MD has 5% significant association with lastmile delivery, which is positive. This implies that the MD influences the efficiency of the last-mile delivery. For example, delivery in car (taxi) may be faster than delivery using lorry, which may take longer time before delivery. Similarly, lorry may not go to some areas compared with car (taxi). The study result proves H3 is accepted.

Furthermore, the PM result ($\beta = -0.2270$, t = 1.7283, p = 0.1) indicated a negative relationship of PM and efficient last-mile delivery at 10%. This implies that PM influence on the efficient last-mile delivery is 10% negatively. For example, products of different sizes may affect the vehicle load generally, which may cause inefficiency to last-mile delivery. The result testifies *H5* has been tested and accepted by the study.

FTs shows that positive and significant associations exist within FTs and efficient last-mile delivery at 5% level of significant as presented in the result ($\beta = 0.0535$, t= 1.8748, p = <0.005). The result shows that technologies used by the facilities that aid the orders process and other associated order process activities have a positive influence on efficient last-mile delivery. *H4* is accepted as proposed by the study.

5. Conclusion and implications

The present study aimed to examine the determinants of efficient last-mile delivery, with evidence from Kaduna State Health Facilities and Kaduna State Health Management Agency. The study model was tested using the data collected from 261 respondents of warehouse staff of 86 Health Facilities and KADSHMA. Smart PLS-SEM was used to estimate the relationship between the dependent and independent variables of the study. The outcome of the study revealed that all the variables of the study (i.e. determinants) were significantly affecting the efficient last-mile delivery. Four constructs (DC, DT, MD and FT) indicated a positive and significant association with efficient last-mile delivery, whereas one variable (PM) indicated a negative and significant association with efficient last-mile delivery. The study concludes that DC, DT, MD, FT and PM played a significant role in efficient last-mile delivery.

5.1 Theoretical implication

The present study provided evidence of SCOR model theory and TISM extensions, using the determinants of last-mile delivery (DC, DT, MD, FT and PM), which demonstrated significant influence on the efficiency in last-mile delivery. The findings of the study are in line with the theories (SCOR, TISM and Kansei), which show that last-mile efficiency can be achieved if these determinants (DC, DT, MD, FT and PM) are managed carefully as postulated in the theories. Moreover, the findings of this study underpin the SCORS model theory and other theories of logistics and transportation by its findings.

5.2 Practical implication

The findings of the present study could contribute to solving practical issues, especially in the health supply chain in Nigeria. The findings show that DC, DT, MD, FT and PM will significantly improve the efficiency of the last-mile logistics and will consequently improve the availability of health supplies and reduce the stock breakout. Furthermore, it will improve lives Volume $14 \cdot Number 1 \cdot 2024 \cdot 4-16$

saving, especially in remote areas. Thus, enough funds should be provided by the government to fund the facilities to transport health supplies without considering cost, which will save lives, especially when emergency drugs are needed or during the pandemic. At all times, specific means of transportation (like Drum or any other means of transportation that can supply health supplies when needed, at the location needed and at the needed time) should be kept aside as standby by the Health Supplies Hub. For the purpose of health supplies, transportation and time schedule should be prepared and adhered to always by the Supply hub using robust technology to avoid disappointment. When transporting health supplies to the facilities, each facility should network with robust technology that will ease communication in terms of order and order planning. Facilities should try as much as possible to reduce the variety of products when ordering health supplies from the supply hub as it will increase the efficiency of the delivery. The study recommended further research to investigate other internal and external factors that need to be improved upon to improve the efficiency of the last-mile delivery of health supplies.

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