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Management control and supply chain operational performance of public health emergency to pandemic control

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Abstract

Purpose – The purpose of this paper is to first, determine the implications of management control system (MCS) information characteristics for controlling the COVID-19 pandemic through four performance indicators (quality, speed of delivery, availability and cost-effectiveness) of the public health supply chain and second, the mediating effect of four dimensions (broad scope, timeliness, integration and aggregation) of the MCS on external integration, internal integration, customer integration and operational performance of public health institutions in Ghana.

Design/methodology/approach – Using covariance-based structural equations modelling and based on contingency theory, a hypothesized model was developed and tested. The sample involves a survey of 214 public health institutions in Ghana

Findings – Both external and internal integration were found to have a significant positive effect on MCS information and, in turn, on the supply chain operational performance of public health institutions. Also, customer integration has a significant positive impact on the four dimensions with a corresponding impact on supply chain operational performance.

Practical implications – The paper provides practitioners and policymakers with the usefulness of the contingency paradigm in enhancing the supply chain network of public health institutions during epidemics, hence, the need to adopt and develop the contingency approach in designing MCS within the public health sector. Effective public health management through a collaborative process between stakeholders (suppliers, customers and personnel) will mitigate stockouts of medical supplies and systematic disruptions in the public health supply chain.

Originality/value – The MCSs – supply chain integration interaction on organizational performance is one of the areas that has received very little attention in the literature particularly in service-oriented organizations. In this regard, this paper represents one of the few studies in Africa that examines performance implications of MCS – supply chain nexus with respect to public health emergencies service-orientec organizations. The paper contributes to the literature by providing invaluable insights into the usefulness of the MCS in enhancing the supply chain performance of public health emergencies.

Keywords Supply chain integration, Supplier integration, Internal integration, Management control system design, Production and operations management, Public health emergency, Customer integration, COVID-19 pandemic

Paper type Research paper

1. Introduction

This paper seeks to address the twofold questions. Firstly, does the design of management control system (MCS) information have any implications for the quality, speed of delivery, availability and cost-effectiveness decisions of the public health supply chain (PHSC) in

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controlling the COVID-19 pandemic? Secondly, do the four dimensions (broad scope, timeliness, integration and aggregation) of the MCS mediate the relationship between supply chain integration (SCI) and public health supply chain operational performance (PHSCOP) in a single comprehensive study? These research questions are based on the premise that although supply chain (SC) information infrastructure and management play a crucial role in SC performance (Sundram *et al.*, 2018), the information characteristics of MCS which take on this crucial supportive role by providing SC managers with the relevant information has received limited attention (Taschner and Charifzadeh, 2020; Nartey *et al.*, 2020). This is further evidenced in Taschner and Charifzadeh (2020), who found that the MCS – SC nexus has been a nascent area in the literature as research that examines MCS information characteristics in SC performance is largely underdeveloped and far limited especially in service-oriented organizations.

On the other hand, whilst in a global context, the COVID-19 pandemic has spawned a nascent research cluster to focus on the implications of the COVID-19 pandemic for SCs, existing works have to a large extent, focused on decision support (Govindan *et al.*, 2020; Currie *et al.*, 2020), SC resilience (Ivanov and Das, 2020; Ivanov and Dolgui, 2020b); or production recovery plans (Paul and Chowdhury, 2020). Research that examines the criticality of maintaining optimal medical stock levels through the quality, availability, flexibility and cost dimensions of PHSC has received limited attention. This paper addresses this void by examining the relationship between MCS informational characteristics, public health SCI and PHSCOP in a pandemic control environment.

The novel COVID-19 pandemic is a typical public health emergency (Gao and Yu, 2020) and has provided an environment that differs significantly from the normal operating environment of public health institutions especially regarding the supply of personal protective equipment (PPEs) and other medical equipment. Calls for the production and distribution of PPEs, testing kits, drugs and intensive care technology are loud (Bal *et al.*, 2020; Daigle *et al.*, 2020). Thus, production and distribution lines linking various supply chain networks (SCN) have come under stress given the global and political character of the crisis. In many countries, questions regarding who is to get PPEs, who is tested, which patients are allowed into the health centres and intensive care units (ICU), etc., are determined by public governance mechanisms put in place and available health facilities. Consequently, there has been a sudden growth in the demand for medical products by public health institutions to effectively respond to the pandemic. Also, the functioning of public health now depends on global trade as production capacities are limited. For example, due to limited production capacity in Europe, protective masks and raw materials for drugs have to be shipped from China and lung machines from the USA. Also, in the UK, the National Health Service (NHS), a talisman of collective fortitude against disease and illness, has struggled to cope with the inadequate provision of virus tests, ventilators and PPEs needed to fight the pandemic (Bryce *et al.*, 2020).

Yet, the management and control of the virus through public health management is highly correlated with the quality, speed of delivery, availability and cost-effectiveness of PPEs, medical products, equipment and other health facilities, as well as services offered by professionals or experts (Bal *et al.*, 2020). For example, a question that will figure prominently in the fight against the COVID-19 will be capable in terms of quality, delivery speed, availability and cost with regard to the procurement of PPEs, beds, professionals, medication and other COVID-19 relief items and decision-making in terms of control and prevention (Bal *et al.*, 2020). As noted by Aslund (2020), countries that are under-equipped in terms of PPEs, masks, ventilators or test kits are highly vulnerable to contracting the virus. According to Bal *et al.* (2020), every public crisis is also a crisis of medical products as well as experts and professionals. In other words, the production and distribution of medical supplies and the availability of medical professionals become critical when responding to public health emergencies. Currently, the world's attention has been directed towards public health performance in terms of diagnosing and treating persons with COVID-19 infections, making medical products accessible and instituting measures that will control and prevent the spread of the virus.

For example, all over the world, public health workers are continuously applauded for their effort and dedicated work to fighting the pandemic. However, the achievement of performance targets is highly associated with a constant supply of medical products and other health facilities (Kim, 2020). In this regard, performance in terms of fast-tracking orders with suppliers as well as ensuring product quality, availability, accessibility, prompt delivery, cost and responsiveness has become critical to public health emergencies (Bal *et al.*, 2020). This is because excessive expenditure on health facilities and other COVID-19 supplies has been an increasing trend, hence, governments are compelled to focus on the assessment and improvement of public health operations' efficiency especially in relation to suppliers of health commodities (Noto *et al.*, 2020). In addition, the virus appears to be among the global community for some years to come, hence, issues of financing public health emergencies and preparing for new waves of epidemics have become critical to public governance.

In recent years, SCI has become prevalent in the health-care sector because of its impact on minimizing costs, medical errors and wastes, enhancing operational efficiencies, quality of care and customer satisfaction (Polater and Demirdogen, 2018). To measure and enhance the operational efficiency of public health emergency response, a comprehensive and effective management information system that strategically collaborate SC partners (e.g. suppliers upstream and customers downstream) and collaboratively manages intra-and inter-organizational processes (internal integration) within public health institutions is deemed necessary (Stouthuysen *et al.*, 2019). This is because the contemporary health-care environment is characterized by a dynamic and increasing trend in competitive markets. The information characteristics of MCS can support basic control processes of the health SC and increase the effectiveness and efficiency of the quality, delivery, accessibility and the costs to positively affect public health emergencies. This makes the understanding of the link between MCS, SCI and performance in the context of public health emergencies to be important to health decision makers because they provide insights into strategies for pursuing SCI that will yield not only the optimum minimum operational costs but also the quality, speed of delivery and accessibility of COVID-19 supplies. It has been argued that MCS information characteristics indirectly mediate the effect of management decisions to affect public health performance and that managers need the information provided by MCS to address efficiency and quality of public health service (Pizzini, 2006; Macinati and Anessi-Pessina, 2014).

Whilst the accounting literature provides anecdotal evidence of the inappropriateness of traditional MCS practices to capture and provide SC data for managerial decisions (Schulze *et al.*, 2012) and the subsequent significant eroding of confidence in the MCS, there has been little empirical research to link SCI and MCS information characteristics (Nartey *et al.*, 2020). In addition, existing works on MCS design in public health (Pizzini, 2006; Hammad *et al.*, 2013; Macinati and Anessi-Pessina, 2014) have not been linked to SCI. Also, management control studies in SCs have conceptualized the SC from a single construct perspective rather than individual contextual dimensions (Fayard *et al.*, 2012; Dekker *et al.*, 2013; Reusen and Stouthuysen, 2017). Moreover, studies in SCI have predominantly focused on fast-moving consumer goods (FMCG) and discrete parts manufacturing concerns because the SC is most formal and apparent in manufacturing firms than service-oriented organizations (Flynn *et al.*, 2010; Wong *et al.*, 2011). Very limited attention has so far been paid to service-oriented organizations in SCM studies (Anderson and Dekker, 2015). However, growing evidence suggests that the dimensions of SCI have a positive influence on operational performance outcomes such as quality, cost, delivery and accessibility for all organizational types (Wong *et al.*, 2011). For example, studies such as Burns (2002) and Dacosta-Claro (2002) suggest that about 48% of health SC costs can be reduced through the implementation of effective SCI as well as management control practices.

For public health institutions to provide large numbers of COVID-19 cases with higher service quality and minimize governments spending and lower costs for their survival, rigorous control over their operations must be maintained. Consequently, both citizens and governments have paid more attention to public health services and their suppliers to achieve higher service quality, lower costs and enhance operational performance (Hammad *et al.*, 2013; Macinati and Anessi-Pessina, 2014). According to Dekker (2016), studies involving the MCS design and the dimensions of SCI could provide valuable insights, understanding and far better theoretically informed evidence and explanations of the management accounting function in SCM decisions. In addition, there is the diversity of lack of standardization of the nomenclature that characterizes the SCM practices. Various forms of accounting information are, therefore, required for their effective management (Ittner *et al.*, 1999; Dekker, 2004; Dekker *et al.*, 2013). Consistent with contingency theory and conceptualizing management accounting and control systems as an organizational outcome or an aspect of organizational structure (Strauß and Zecher, 2013; Hiebl, 2014; Kalkhouran, Nedaei and Rasid, 2017), it is likely to be influenced by both internal, customer and supplier integration of the health SC to improve public health emergencies. The rest of the paper is organized as follows. Section 2 examines the definition of key concepts underpinning the study and the theoretical foundation as the dominant theoretical lens in MCS design. Section 3 provides the theoretical model for MCS design in public health emergencies and develops a set of testable hypotheses. Section 4 describes the research method whilst Section 5 summarizes results and findings. Finally, Section 6 proposes some conclusions and outlines the most important issues arising from the study.

2. Literature review

2.1 Ghana's public health emergency system

The public health system of Ghana's healthcare which manages health commodities through a three-tier system is made up of drug manufacturers, suppliers (wholesalers, distributors and retailers), the central medical stores (CMS), regional medical stores (RMS), service delivery points (SDP) and the transportation networks (Ministry of Health, 2017, Facts and Figures). Through this system, supplies and drugs, as well as contraceptives, are managed and sent to health facilities across the country. The receipt, storage and distribution of all medical supplies after procurement by the Ministry of Health (MOH) is the responsibility of the CMS. The CMS, in turn, supplies the lower levels of the tier which are financed by external financiers (Oduro *et al.*, 2020). Depending on their geographical location, health facilities (SDPs) receive their supplies from the appropriate RMS. However, the management of vaccines is slightly different from other medical supplies. These are managed through refrigerated facilities and a network of warehouses of cold storage across the regions.

The MOH exercises overall oversight control including policy formulation, evaluation and monitoring of progress in achieving set targets for the whole system (MOH, 2017, Facts and Figures; Amoako-Gyampah *et al.*, 2019). The service delivery and Teaching Hospitals are largely undertaken by the Ghana Health Service (GHS). Both of these institutions constitute the bulk of the MOH institutions under the public health system (Bamfo and Dogbe, 2017). A four-tier system made up of regional, district, sub-district and community constitute the health system delivery. Occasionally, and this is an exceptional case, the Teaching Hospitals and the Regional Hospitals procure directly from suppliers, but approval must be sought from the MOH. Thus, whilst the logistics and supply management system are centralized, the health-care delivery system is decentralized. Together with suppliers of drugs and other medical supplies at both local and international levels, pharmaceutical manufacturers, wholesalers, distributors and retailers, transportation networks and other distribution networks constitute the public health emergency system.

2.2 Management control system design in public health management

MCSs have been conceptualized from different perspectives but generally consist of formalized information systems designed and used by organizations to provide decision-making information and support for managers (Chenhall and Morris, 1986; Bouwens and Abernethy, 2000; Gerdin, 2005a; Dekker, 2016). Jermias and Gani (2004) conceptualized the MC function from two broad perspectives: product differentiation strategy (Type I MCS) and low-cost strategy (Type II MCS) based on Porter's (1985) framework for strategic priority. The former enhances the capacity of companies to differentiate their products as well as meeting the needs of customers by providing information and measures that relate to key production activities, strategic planning, customer satisfaction, quality, timely and reliable delivery of goods/services, benchmarking and employee-based measures. For companies that adopt the low-cost strategy, the latter is more appropriate as it provides information associated with activity-based costing (ABC) techniques, variance analysis and budgetary performance measures. Hoozee and Ngo (2017) note that organizations use MCSs to influence managerial behaviours such that they are directed towards attaining organizational objectives. This is because empirical evidence of a positive association among accounting information, improved decision-making and organizational performance has generally been found among management control (MC) scholars (Cooper and Kaplan, 1991). Based on Chenhall and Morris (1986), MCS is conceptualized in this study as formal systems designed for providing information for managers in health-care institutions.

In public health management, inputs such as capital, labour, materials and supplies are normally used by health centres to offer health-care services consumed by customers (patients) during their episode of care. As the services offered (including hours of nursing, testing of COVID-19 virus, ICU care, etc.), are normally associated with intermediate products, business rules and regulations that govern the generation and apportionment of costs (as it pertains in new public management) associated with intermediate products of health centres are in most health-care operations, codified in activity-based guidelines (Chapman, *et al.*, 2013). This suggests that the dimensions of SCI affect MCS design which ultimately impacts the operational performance of public health institutions. However, significant scope for improving the overall performance of the SC remains unexplored (Lega *et al.*, 2013). It has been argued that effectiveness and efficiency coexist in supply chains (Kwon *et al.*, 2016). This translates to mean that efficient management of the health SC creates a surplus in resources, which can be diverted or reinvested for the benefit of customers (patients) and other stakeholders. Information and measures are required to track operational (or production) costs of resources and other facilities (e.g. PPEs, ICU units, ventilators, testing kits, etc.), differentiate medical products at various stock (or inventory) levels and satisfy customers' (patients') needs simultaneously. In particular, information that relates to sources of inefficiency and ineffectiveness of public health operations can be revealed by MCSs through the provision of detailed information about the consumption of resources each activity undertaken by a health centre consumes (Hoozee and Ngo, 2017). Based on these decision-functional roles of the MCS, many scholars (Chenhall and Morris, 1986; Bouwens and Abernethy, 2000; Abernethy *et al.*, 2007; Hammad *et al.*, 2013; Macinati and Anessi-Pessina, 2014) have conceptualized the MCS design in public health organizations in terms of four interrelated dimensions as shown in Figure 1, namely:

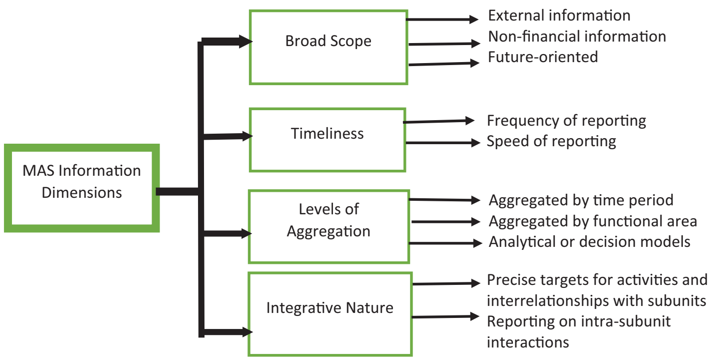
(1) Broad scope, which refers to external, non-financial and future-oriented information.
(2) Timeliness, which deals with the frequency and speed of reporting accounting information.
(3) Integration, which refers to the precise targets set for activities and the scope of variances calculation and
(4) Aggregation, which refers to various forms of aggregation such as time period and functional areas as well as analytical or decision models.

Aggregation also specifies the dimensions of cost disaggregation according to behaviour and their interrelationships within subunits.

These four attributes of the MCS design are known to be highly significant in assessing managerial decision-making in hospitals; hence, appropriately describe the MCSs designed and used in health-care organizations (Pizzini, 2006).

2.3 Supply chain integration and public health emergency

SCI refers to the degree to which an organization strategically collaborates with its SC partners and collaboratively manages intra- and inter-organization processes (Kang *et al.*, 2018). According to Flynn *et al.* (2010, p. 59), "SCI has the goal of ensuring an efficient and effective flow of products and services, information, money and decisions that will provide maximum value to the customer at high speed and at the same time at lower costs". The literature widely accepts the three dimensions of SCI (supplier and customer (or external) integration and internal integration) (Alshahrani *et al.*, 2018). External integration within the health sector focuses on the degree to which a public health organization joins with its external partners to structure inter-organizational strategies, practices and processes into collaborative, synchronized processes (Alshahrani *et al.*, 2018).



Source: Adapted from Soobaroyen and Poorundersing (2008)

Figure 1. Classification of the MCS dimensions

Internal integration, on the other hand, refers to the degree to which an organization structures its own organizational strategies, processes and practices into collaborative, synchronized processes so that customers' requirements can be fulfilled as well as interacting with suppliers in an efficient manner (Kang *et al.*, 2018). Internal integration within public health organizations requires data and information system integration that enables organizations to integrate activities within different functional areas including information sharing, collaboration and joint decision-making among the different functions (Williams *et al.*, 2013). Through collaboration and cross-functional information sharing functional goal alignment and responsiveness are facilitated by internal integration which leads to better outputs such as competitive capabilities, operational performance and overall organizational performance (Kang *et al.*, 2018). Both internal and external integration require information sharing, close collaboration, system coupling and joint decision-making with key suppliers and key customers (Wiengarten *et al.*, 2014; Huo *et al.*, 2015; Yang *et al.*, 2016). Availability of information and the support of effective tools enhance successful SCI (Taschner and Charifzadeh, 2020).

Although the SC has become a key driver that enhances overall organizational performance in contemporary organizations (Field and Meile, 2008; Maestrini *et al.*, 2017), there is evidence of underdevelopment of research that relates the specific associations between its contextual factors (Ataseven and Nair, 2017). There is an intensive requirement for public health SC management information for supplier decisions (Shah, 2004). Generally, the SC is said to constitute a series of interrelated and connected activities that involve planning, controlling and coordinating materials, parts and finished goods from the raw materials stage to end-users (Stevens, 1989). Activities of the SC are made up of sourcing and procurement, system management, inventory management, warehousing, transportation and customer service (Lambert *et al.*, 1998). Effective management of these activities enhances the performance of health-care institutions in both the public and private sector because according to Prasad and Shankar (2018), SCM is highly critical to the superior performance of health-care organizations. It has been argued that enhanced information flows and exchanges that foster operational processes such as joint investments, forecasting, production and procurement planning in innovative programmes can enhance the performance of the hospital supply chain (Tynkkynen and Vrangbæk, 2018; Prasad and Shankar, 2018; Oduro *et al.*, 2020).

The strategic collaboration of both inter-organizational and intra-organizational processes constitutes SCI (Wong *et al.*, 2011) which is normally collapsed into the supplier, customer (patient in health-care context) and internal integration (Flynn *et al.*, 2010). So, SCI involves supplier integration, customer integration and internal integration (Flynn *et al.*, 2010). According to Flynn *et al.* (2010, p. 58) "is the degree to which an organization strategically collaborates with its SC partners and collaboratively manages intra-organizational and inter-organizational processes, to achieve effective and efficient flows of products and services, information, money and decisions, to provide maximum value to the customer". Integration of these activities affects each other to enhance performance. In earlier studies, Cooper *et al.* (1997) and Lambert *et al.* (1998) described SCI as the integration of key business processes which involve end-users through suppliers and offer value-added products, services and information to customers and other stakeholders. More precisely SCI constitutes a key business process integration among a network of inter-dependent suppliers, manufacturers, distribution centres and retailers to enhance the flow of goods, services and information from suppliers to customers at relatively reduced costs.

However, there are different notions of SCs which demand different forms of accounting information at different levels of sophistication and complexities (Burritt and Scaltegger, 2014). The health SC is complex, sophisticated and more expensive to operate compared to that of mainstream discrete parts manufacturing and consumer goods (Shah, 2004). Firstly, as noted by Beier (1995), health suppliers are mission-critical to sustaining public health. Considering the rate at which the virus can spread demands diverse tools, equipment and facilities (e.g. PPEs, ventilators, ICUs) to fight it. This has resulted in diverse products that must be manufactured or produced by manufacturers and supplied to various countries and more specifically COVID-19 patients through public governance mechanisms. Hence, constant. adequate and accurate supplies of COVID-19 products and equipment are required by public health organizations to meet national demands. In contemporary public healthcare, the influence of SCI is translated and reached to just about every clinical, operational and performance area. Secondly, physician preferences underpin public health supplier selection. These are medically trained oriented, context-specific demands and experience with specific brands. As Roark (2005) points out, most often there is no link between those who make decisions regarding procurement and purchasing and those who execute the actual buying. However, with perfect alignment (or fit) of MCS information with SCI integration, this gap is bridged. Thirdly, the intensive care technology required by the pandemic calls for rapid innovative and technological processes of public health practices so that the diverse types of health-care supplies can be matched.

2.4 Operational performance of public health emergency

In relation to public health emergency response to pandemics, health SCM deals with the information, supplies and financing decisions that characterize the procurement, warehousing and distribution of COVID-19 products from suppliers to end-users with the aim of simultaneously enhancing clinical outcomes and controlling cost at minimum levels to create value. To achieve this goal, much emphasis is placed on the integration of processes which in the health-care setting refers not only to physical products such as health aids (e.g. PPEs), medical devices for COVID-19 patients (e.g. testing kits and ventilators) and pharmaceuticals but also patients related processes. Whichever the case is, the basic rationale underpinning health SCM is based on the proposition that an improved performance of the health SC is associated with intensive integration and coordination of operational processes (De Vries and Huijisman, 2011).

Although different performance indicators have been proposed to capture the multi-dimensionality measures of SC performance, the most frequently quoted model and widely applied has been that of the supply chain operations reference (SCOR) model which was originally developed in 1996 by PRTM, a management consulting firm and has been endorsed by the Supply Chain Council (Lega *et al.*, 2013). The most recent version of the framework, SCOR 12.0 which is currently a part of APICS was released in 2017 by APICS (Lima-Junior and Carpinetti, 2019) and focuses on the operational aspects of supply chain management (SCM) (Kottala and Herbert, 2020). The SCOR model which identifies five measurement criteria for SC performance assessment provides a useful framework for SC performance assessment in firms (Chen *et al.*, 2013). These metrics include cost-effectiveness, responsiveness, flexibility and speed, reliability and efficiency in asset utilization (Zanjirani *et al.*, 2009). Considering the problems (delivery delays, unavailability of PPEs, inferior or low-quality products, higher procurement cost, significant non-value adding steps, etc.) that characterized the health SC, the use of operational performance measures appropriately suits this research. To operationalize the performance effects of the variables under study and following Zanjirani *et al.* (2009), Chen *et al.* (2013) and Ataseven and Nair (2017), four facets including product or service quality, speed and flexibility of product or service delivery, cost minimization and product or service availability are used to measuring the performance of public health SC.

2.5 Contingency theory

Contingency theory suggests that there is no single MCS suitable for all organizations (Chenhall, 2003) and that the design of MCSs in organizations is highly influenced by the environment within which an organization operates. It asserts that this environment shapes the structure and processes of organizations to affect performance. Based on this basic principle, organizations should match their structures and processes to their environment to maximize performance (Burkert *et al.*, 2014). In this regard, the effectiveness of MCS design is affected by the extent to which the MCS information characteristics "fit" (or align) with contextual variables (Chenhall, 2003). The "fit" concept is the underlying principle of contingency theory which suggests that "fit" between MCS design and context variables is important for achieving high organizational performance (Otley, 2016). That is good fit implies enhanced performance whilst poor fit implies diminished performance (Chenhall, 2003). Consequently, because of compatible combinations of context and structure, it is assumed that there is the existence of both high- and low-performing organizations (Ittner and Larcker, 2001; Gerdin and Greve, 2004).

To develop an appropriate MCS framework for public health emergency response to epidemics, in the context of SCI, the current paper adopts a contingency perspective. The aim is to find the best fit between SC integration and MCS to improve hospital operational performance. To the best of the author's knowledge, no study has used the contingency framework to investigate the indirect effect of MCS design in the relationship between SCI and hospital operational performance. Therefore, the second objective of this paper is to ascertain whether there is an indirect effect of MCS design in the relationship between SCI and hospital operational performance. In the context of SCM, the paper offers valuable information by enhancing knowledge and awareness related to the role and usage of MCS in public health organizations. Contrary to contingency theory's argument that for optimum performance of the MCS variable, organizations should align their processes and structures to their environment, existing MCS-SC studies had emphasized fit in the transaction context other than fit in the organizational context (Van der Meer-Kooistra and Vosselman, 2000; Dekker, 2004; Dekker *et al.*, 2013). This is because the theoretical lens of transaction costs economics (TCE) explains how MCSs are installed in relation to the specific transaction context that arises from contracting risks between suppliers and buyers other than internal dimensions such as internal integration of the supply chain. In this regard, TCE tends to ignore the dimensions of internal fit (e.g. internal integration) of the supply chain.

From a strategic perspective, the internal fit of the supply chain represents the cross-functioning of systems and collective responsibility across functions. Collaborations across procurement, warehousing and distribution functions take place within internal integration to meet customer (patient) requirements at a low total cost (Qi *et al.*, 2017). The sharing of real-time information is facilitated through internal integration efforts and knowledge across key functions through the breakdown of functional barriers (Wong *et al.*, 2011). In addition, the actually observed patterns of MCS use and the contextual factors that underpin its design in the inter-firm exchanges domain are not fully explained by the TCE, although it provides insights on the MCS organizations should adopt to achieve fit (Anderson and Dekker, 2015). Furthermore, the adoption of the TCE is mainly based on mitigating the risk associated with the transactions in the inter-firm exchanges domain (Langfield-Smith, 2008; Dekker *et al.*, 2013). Risks associated with heightened vulnerability where there is the possibility that partners engaged in the transactions will opportunistically exploit the dependent relationship are typical examples.

2.6 Theoretical framework and hypotheses development

Figure 2 illustrates the proposed theoretical model which suggests the mediating effect of MCS information characteristics on the relationship between SCI and the operational performance of public health emergency response. SCI consists of supplier integration, customer integration and internal integration. These constructs have been theorized to have a positive influence on MCS design to jointly affect the operational performance of public health emergency response. The variables in the model comprise first and second-order latent constructs. External integration which is a second-order latent construct consists of two first-order latent constructs, namely, supplier integration and customer integration, respectively. Four first-order information characteristics comprise the MCS design which is a second-order latent construct. Finally, the operational performance of public health emergency response which is a second-order construct consists of four first-order latent constructs.

A model is provided for the mediating effect of each MCS information characteristic because under varying integration of the SC a better clarification of the distinct impacts of each MCS information characteristic mediating the relationship between SCI and the operational performance of public health emergency response can be attained. As described under hypotheses formulation in the following subsection, the link between supplier integration and MCS information characteristics implicitly tests four hypotheses (i.e. *H1a*, *H1b*, *H1c* and *H1d*) and that of customer integration and MCS information also tests four hypotheses (i.e. *H2a*, *H2b*, *H2c* and *H2d*) which are implicit. The link between internal integration and MCS information characteristics tests four hypotheses (*H3a*, *H3b*, *H3c* and *H3d*) implicitly and finally, the link between MCS information characteristics and the operational performance of public health emergency response implicitly tests 16 hypotheses (i.e. *H4a*, *H4b*, *H4c* and *H4d*), (*H5a*, *H5b*, *H5c* and *H5d*), (*H6a*, *H6b*, *H6c* and *H6d*) and (*H7a*, *H7b*, *H7c* and *H7d*).

2.6.1 Supplier (external) integration and management control system information. According to Fayard *et al.* (2012, 2014), the MCS is an essential tool or enabler for SCI

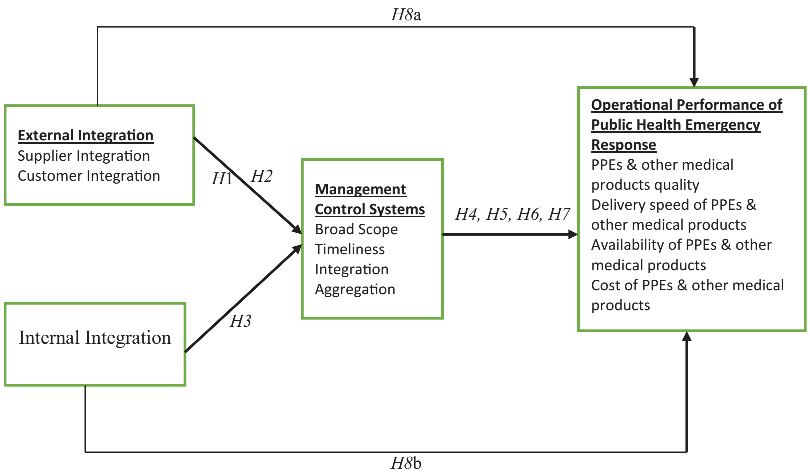


Figure 2.
Research model

because it provides accounting data on materials, services, information and capital flow of the SC. This enhances information sharing effectiveness between an organization and its suppliers (external integration). It has been argued that the wheels of SC relationships are oiled with the information provided by the MCSs with a stronger focus on logistics and information flows about corporate operational performance (Burritt and Scaltegger, 2014). Also, one of the key issues in SCM has been supplier selection and more sophistication is the approach being promoted to address SC interrelationships.

However, studies into accounting issues that relate to supplier selection are far from expected (Burritt and Scaltegger, 2014). Particularly, in the exchange with medical suppliers both within and across the country, a simpler costing system in the supplier collaborative setting would be more effective for SC performance in relation to some public health operations such as minimization of total order cost as well as low inventory cost. For example, ABC models available for purchasing often regard supplier evaluation and selection, ordering, transportation, receiving, handling, quality control and storage as a set of standardized activities carried out in a sequential fashion (Dekker and van Goor, 2000). It has been recognized that complexity is added by the global setting and this affects accounting as SC partners often extend to several logistics service providers, the supplier, the manufacturer, the retail sector and the final customer. This creates a chain of inter-organizational relationships which ultimately add to organizations' costs if not managed properly. A number of studies (Christensen and Demski, 2002; Baines and Langfield-Smith, 2003; Fayard *et al.*, 2012; Dekker, 2001) have shown that organizations that cooperate and collaborate with other firms or create inter-organizational relationships have a competitive advantage over those that do not. However, this requires the efficient sharing of MCS information about organizations' processes and activities between the partners.

In this regard, the four information characteristics (broad scope, timeliness, integration and aggregation) of the MCS have been found to play a vital role in developing collaborative activities between public health institutions and their suppliers which ultimately enhances operational performance through efficient procurement and distribution of COVID-19 supplies. For example, the broad scope dimension of the MCS provides future-oriented (forecast) information about public health projections on COVID-19 infections and the required resources and equipment that must be supplied to effectively control them. In this regard, the shortage of health supplies will be minimal as against the shortages that occurred in most parts of the world. Also, the timeliness dimension provides information on the extent and urgent supply of certain COVID-19 products (e.g. PPEs; ventilators, etc.) in some health centres which eventually results in the improvement of public health emergency response to epidemics.

Furthermore, both the integrated and aggregated dimension plays a major role by providing information for budgetary decisions on health expenditures and revenues. However, despite the ultimate goal of the MCS design in improving both financial and operational performance of the SC, empirical evidence on the positive relationship between MCS design and operational performance is relatively scarce (Burritt and Scaltegger, 2014) and is even more pronounced in health-care setting. Yet, MCSs is the gathering point for cost, time and accuracy of performance measurement and accounting classification in health-care setting (Malmmose, 2015). This is due mainly to the fact that a greater portion of MCS information benefits in service type organizations is generally qualitative and intangible in nature compared to discrete type organizations. Accounting offers a significant input to the selection of suppliers through the auditing of supplier environmental performance, reduction of waste and packaging materials and health and safety which enhance operational performance. MCSs consider the information involved with external suppliers often working together across multiple supply chains, are linked together by agreement. For example, timely cost information is not only a crucial element in strategic sourcing decisions but also influences the ongoing management of supplier relations. All these theoretical arguments and empirical evidence suggest the following hypothesis. Intensive and close coordination between hospitals and their suppliers is facilitated when the MCS information is timely and provided on a continuous basis. Timely information also enables the partners to plan, fulfill and deliver medical supplies (Chen *et al.*, 2013). In this regard, prompt response to changes in supply requirements is made through the hospital supply chain thereby minimizing the overall supply cycle time, increasing the quality of order fulfillment, reducing inventory and finally the need for *ad hoc* conflict resolution is reduced.

For example, for the measures against the spread of the COVID-19 pandemic to be effective, an adequate supply of PPEs and other mitigating resources ought to be constant. According to Cohen and Kaimenaki (2011), the availability of information that predicts future events is highly associated with the level of detail. In this regard, the extent to which MCSs are analysed for different PHERD will also depend on the level of detail of the MCS information and the appropriateness and usefulness of the information. It has been argued that the extent to which decision-making information has the appropriate level of achievement is greater when there is a higher level of detail of the MCS information. Broad scope information is highly associated with public health management decisions because it provides information related to future events such as expected requirements of medical supplies (e.g. PPEs, ventilators, etc.) and those that needed to be procured within a certain time frame, operating cost of facilities (e.g. intensive care units (ICUs)), inventory levels, the value of commodity (medical products) throughput, as well as the cost of transportation associated with the distribution and allocation of medical supplies, etc.

H1. There is a positive association between supplier integration and (a) broad scope, (b) timeliness, (c) aggregation and (d) integrated dimensions of the MCS information.

2.6.2 Customer integration and management control system information. Schoenherr and Swink (2012, p. 100) define customer integration as "the close collaborations and information sharing activities with key customers which furnish the organization with insights into market expectations and opportunities which ultimately enable a more efficient and effective response to customer needs". Decisions on patients' logistics and coordination issues are often related to the complexity and variability of demand within a hospital. For example, a typical problem that confronts designers of pharmaceutical SC has been that of striking a balance between future capacity and anticipated demands (Shah, 2004). The MCS provides customer (or patient)-related information for capacity planning and other resource acquisition decisions within a certain time frame. For example, the current pandemic outbreak (COVID-19) suggests that hospitals need to take decisions on the expansion of existing facilities such as increases in the number of beds, intensive care units, ventilators and PPEs. The MCS effectively generates this decision-making information because it plays the fundamental role of allocating resources to departments and individual sub-units. In addition, predictive information about the patronage of customers (patients) is predicted by the broad scope information dimension of the MCS.

Inputs such as capital, labour, materials and supplies are normally used by hospitals to offer health-care services consumed by customers (patients) during their episode of care. As the services offered (including hours of nursing, diagnosing and testing for COVID-19 infection, ICU care, etc.), are normally associated with intermediate products, business rules and regulations that govern the generation and apportionment of costs associated with public health's intermediate products are in most public health operations, codified in activity-based guidelines (Chapman *et al.*, 2013). The assignment of intermediate product costs to patients' hospitalization is a result of the output generated by activity-based costing (ABC) systems which is a characteristic of the four dimensions of the MCS information. Consequently, ABC systems have widely been recognized as costing system designs that provide cost reduction and better cost management information in public health operations (Cardinaels *et al.*, 2004; Sutherland, 2015). ABC systems provide more detailed costing information relating to hospital activities that yield better cost aggregation for effective decisions. Based on these arguments, the following hypothesis is formulated:

H2. There is a positive association between customer (patient) integration and (a) broad scope, (b) timeliness, (c) aggregation and (d) integrated dimensions of the MCS information.

2.6.3 Internal integration and management control system information. Conventional MCS is largely about identifying and recording inter-firm data from which are derived from external market transactions, intra-firm internal transformations and some events considered as external. To a large extent, SCM also looks at intra-supply chain processes and transactions, transformations and events including non-market interactions (Burritt and Scaltegger, 2014). Whilst consideration is given to MCSs external to the SC, inter-supply chain data from external market transactions, intra-supply chain transactions, as well as some external events of the SC, are addressed by MCS to enhance performance (Burritt and Scaltegger, 2014). For example, few SC settings for accounting arise whenever there is a preponderance for vertical integration. MCSs in SC internal integration place much emphasis on the efficient use of resources and minimization of costs to enhance performance. Inter-firm cost savings in supply chains is largely promoted by activity-based costing which is the costing system widely used in public health organizations (Schulze *et al.*, 2012; Kwon, 2016). As noted by Dekker and van Goor (2000), to internally integrate SC members, a set of MCS standards is needed. This takes a calculation of the cost of logistics for the SC which is based on a joint definition of activities and their cost drivers.

This results in the aggregation of SC activity-based costs. In this regard, cost accounting methods such as material flow cost accounting have been developed for SC accounting. Internal integration is the "cross-functional intra-firm collaborations and information sharing activities that occur via interconnected synchronized processes and systems" (Schoenherr and Swink, 2012, p. 100). It facilitates the sharing of knowledge and information of the MCS across functions and suppliers and permits better coordination of the SC to improve SC speed and flexibility. It is clear from this definition that internal integration basically measures an organization's logistics, operations, marketing and sales collaborations for the purposes of realizing overall SC objectives. Like the mainstream business organizations, all these facets of SCM integration apply to the health SC and accounting information play a significant role in providing the required and relevant information to achieving these objectives which ultimately enhances performance (Dekker, 2004; Coad and Cullen, 2006; Fayard *et al.*, 2012).

Ataseven and Nair (2017) meta-analytically examined the association between SC integration and its underlying dimensions and the operational characteristics of cost, flexibility, delivery and quality of the SC. They found a significant impact of the three dimensions of integration: supplier integration, internal integration and customer integration on the four performance attributes. It is, therefore, expected that the fit between the dimensions of MCS and public health supply integration will positively affect performance as operationalized by product service quality, speed of product or service delivery, product availability and flexibility, cost minimization. The basis of SC internal integration is to eliminate functional barriers (Flynn *et al.*, 2010) and facilitate cooperation across internal functions. SCI leads to better solutions to the cost reduction problem which the MCS provides because when the supplier and customer, as well as internal processes, are well-integrated, it results in global minimum cost compared to a series of local minimum costs. Based on this prediction the following hypotheses are formulated:

H3. There is a positive relationship between internal integration and (a) broad scope, (b) timeliness, (c) aggregation and (d) integrated dimensions of the MCS information.

2.6.4 Management control system information and supply chain performance of public health emergency. The coordination of SC relationships and use of management control mechanisms to support, plan, measure and assess SC activities and their results impact significantly on SC performance (Van der Meer-Kooistra and Vosselman, 2000). This suggests that public health emergency response to epidemics can be enhanced as the MCS information characteristics mediate the relationship between SCI and public health operational performance through information provision for the effective procurement, warehousing, distribution and transportation of COVID-19 products. For example, although it would be difficult to avoid the COVID-19 pandemic impacts on manufacturing and the SCNs of health-care institutions and related medical products, public health emergencies can still be improved through the control and prediction of health facilities and other logistics based on the MCS information. However, it has been argued that formal MCS design in public health organizations has, over the years, been problematic despite its relevance in addressing concerns from the growing regulatory and competitive pressures (Aidemark and Funck, 2009; Cardinaels and Soderstrom, 2013).

Issues bothering on goal congruence's reliance on monetary incentives, the high degree of influence over operational processes by physicians and nurses, the imposition of a wide range of priorities by stakeholders who are classified as highly influential and complex and diverse work methods and objective functions and austere budgets that generate unparalleled complexities for effective design and use of MCS, are just a few of the numerous challenges faced by public health institutions (Abernethy *et al.*, 2007). In addition, it has been reported by many studies in management accounting (Abernethy and Stoelwinder, 1995; Abernethy *et al.*, 2007) that the regular conflicts that arise from health administrators' professional objectives and that of clinicians [1] have been noted to be a hindrance to and curtailment of effective MCS design. Notwithstanding, it is strongly believed that effective design and use of MCS information enhances the identification of value-adding processes and costs across organizational boundaries, hence, investments in innovative and sophisticated cost-accounting tools and systems by health-care organizations in recent years (Cardinaels and Soderstrom, 2013).

Growing evidence suggests that as a fundamental tool for pursuing cost containment and efficiency, MCSs have increasingly gained importance within the SCM system of public health organizations (Aidemark and Funck, 2009). This is because the effective formulation, management and efficient functioning of the SC is known to be highly associated with accounting information (Seal *et al.*, 1999; Fayard *et al.*, 2012; Dekker, 2016). In particular, public health managers' use of the four dimensions comprising broad scope, timeliness, integration and aggregation of the MCS has been found to contribute to organizational performance (Abernethy and Brownell, 1999; Abernethy and Lillis, 2001; Pizzini, 2006; Abernethy *et al.*, 2007). These have subsequently been considered as critically intrinsic characteristics of the MCS designed and used in health-care settings (Pizzini, 2006). In addition, with the evolution of the new public management, the power structure of healthcare has changed making MCS more dominant in the evaluation and monitoring of clinical performance than medical skills (Malmmose, 2015).

In examining the relationship between managers' beliefs about the relevance and usefulness of cost data, cost-system functionality and actual financial performance in US hospitals, Pizzini (2006) found a positive association between the relevance and usefulness of cost accounting data as evaluated by managers and the extent of the MCS in providing detailed costing systems, classify costs according to behaviour and frequent reporting of cost data. Pizzini (2006), however, found that out of the three attributes of the MCS, only the cost detail attribute correlated positively with measures of financial performance such as cash flow, operating margin and administrative expenses. Further, a statistically insignificant relationship between cost-system design and operating expense per admission was confirmed. The conclusion drawn was that the use of accounting information has not yet been successfully applied in the management of clinical costs of the sampled hospitals. By performing an expert assessment of Vietnam's textile industry Tseng *et al.* (2018) found economic factors to have a significant impact on other aspects of SCI and those management policies involving the speed of delivery constitute the effective tools for enhancing operational performance. Based on these discussions the following hypotheses are formulated:

H4. There is a positive association between the broad scope information characteristic and (a) product/service quality, (b) speed of product/service delivery, (c) product/service availability and (d) cost minimization of the public health supply chain.

H5. There is a positive association between the information timeliness characteristic and (a) service/product quality, (b) speed of product/service delivery, (c) product/service availability and (d) cost minimization of the public health supply chain.

H6. There is a positive association between the integrated information characteristic and (a) service/service quality, (b) speed of product/service delivery, (c) product/service availability and (d) cost minimization of the public health supply chain.

H7. There is a positive association between the aggregated information characteristic and (a) product/service quality, (b) speed of product/service delivery, (c) product/service availability and (d) cost minimization of the public health supply chain.

3. Method

3.1 Data collection and sample

Our sample is taken from Public Health Institution (PHIs) in Ghana for the following reasons. Firstly, the COVID-19 pandemic is a public health emergency (Gao and Yu, 2020), hence, equipment, logistics as well as mechanisms are required to control the spread of the virus rest with the responsibility of governments. Secondly, the provision of COVID-19 equipment and other logistics to the public as well as regular updates in terms of active cases and deaths in Ghana has been the responsibility of PHIs, hence, not quite sure whether private health-care organizations are involved in tackling the pandemic. The selection of Ghana for the research site was because apart from the limited studies on SCM practices in developing countries, the supply chain of most sectors in Ghana including the public health SC has not had any investigation in terms of management practices and performance (Oduro *et al.*, 2020).

Besides, the managerial and cost information systems of public health institutions have reached a state of obsolescence and dysfunction due to evolutionary changes in the processes and procedures of health operations that have not been incorporated in their accounting systems (Nartey *et al.*, 2020). The current MCSs have little value for management decisions in the inter-firm exchanges domain as there is a limitation in the use and sophistication of cost and managerial information. Advanced accounting techniques such as activity-based costing (ABC) are, perhaps, not applied and modern costing concepts are largely unknown in most PHIs. Managerial and cost information are mostly associated with decisions on pricing rather than process improvement, performance assessment or cost reduction strategies (Nartey *et al.*, 2020). The managerial and cost information systems seemed to have become outdated and no longer support the strategic direction of PHIs though the systems are perfectly adequate for financial reporting purposes.

There are also illogical relations among operating cost of facilities, the value of commodity throughput and populations served at various levels. Neither commodity throughput nor service population appears to drive costs as they should be in an efficient and rationally operating system (Manso *et al.*, 2013). Non-connection between costs and cost drivers – clear indication of non-linkage between budgeting process and both commodity throughput and service populations (WHO, 2009; Denkyira, 2015). Currently, there is the unconventional occurrence of public sector prices for highly subsidized commodities being higher than private-sector prices (Asamoah *et al.*, 2011; Manso *et al.*, 2013). However, Kelle *et al.* (2012) noted that by paying attention to the three dimensions of SCI (supplier, customer and internal integration) in the inter-organizational linkages and their alignment with accounting information characteristics, a PHI can improve its performance through the performance of other organizations in the SC.

To test the contingency model, we collected survey data about SCI, MCS information characteristics and SC performance of public health emergency from management accountants and health SC managers from 214 public PHIs in Ghana. The list of all PHIs (hospitals, polyclinics, clinics) on a regional, district and town basis are available at the GHS database. In this regard, the population was determined by referring to a sampling frame which was obtained from the Ministry of Health's (MOH) database. The sampling frame comprised the list of all PHIs in Ghana. The PHIs sampled include public hospitals, polyclinics, medical research centres, teaching hospitals and psychiatric hospitals across 10 out of the 16 regions in Ghana. Given that there are currently 391 PHIs in Ghana (Facts and Figures), an initial sample size of 250 was drawn across 10 out of the 16 regions using the cluster sampling technique. This sampling technique was used because the population is geographically dispersed across the regions.

The initial 250 sample size was based on the fact that PHIs are not equally distributed across the 16 regions in Ghana. More than 70% of the total are located within the Greater Accra, Ashanti, Eastern, Western and Central regions. Besides, the six regions that were excluded from the survey were just recently created (3 years ago) and are yet to have a regional hospital. Furthermore, four of the 10 regions included in the survey are in the Northern Zone and have very few PHIs compared to the other six regions in the Southern zone. Based on these facts it is believed that a sample drawn from the 10 regions will be representative of all PHIs in Ghana. The initial sample of 250 was based on Hoyle (2015) at a significance level of 5% with 0.05 maximum permissible error. The collection of the sample took place between May and July 2020 when the ban on movement was lifted.

A breakdown of the samples from the 10 regions is shown in Table 1. The regions include the Greater Accra Region, Ashanti region, Western region, Eastern region, Central region, Oti Region, Upper East, Upper West, Volta and Northern regions. To address the challenges associated with questionnaire administration due to the pandemic and the observance of safety protocols to prevent the spread of the virus, the mailing and online systems were mostly used. A scale-response questionnaire (Appendix) with a covering letter that explains the purpose/objectives of the study as well as providing assurance of anonymity of responses was distributed to 232 public hospitals, 3 teaching hospitals, 10 polyclinics 2 medical research centres and 3 psychiatric hospitals giving a total of 250 questionnaires distributed. Because of the geographical distribution of public hospitals, we used the cluster sampling technique to draw the sample from these institutions. Apart from public hospitals, the total number of all other PHIs is less than 20 so much of the sample was drawn from hospitals.

Prior to the actual data collection, a pilot study involving 20 public hospitals, 1 teaching hospital, 1 medical research centre and 3 polyclinics within the Greater Accra Region was conducted to develop and validate the questionnaire. Out of the 250 questionnaires that were distributed to public hospitals, 221 responded representing a response rate of 88.4%. However, 7 of the questionnaires were either not completed or lacked certain information so were excluded from the sample resulting in 214 valid questionnaires representing an 85.6% response rate. This approach is consistent with Maiga *et al.* (2013), Chen *et al.* (2013) and Macinati and Anessi-Pessina (2014). For the other PHIs, all the three teaching hospitals responded with no error. Also, all the three psychiatric hospitals and the two medical research centres responded with no error whilst valid responses from 9 out of 10 polyclinics were received. In all, we had a sample of 214 valid questionnaires out of the 250 questionnaires sent out giving an overall response rate of 85.6%. The distribution of the sample from public health institutions is summarized in Table 2.

3.2 Scales and measures

Typically, a measurement scale is used when the constructs involved in a study have no direct observable measures. In this regard, the unobservable constructs and their

Table 1. Distribution of samples by the 10 regions

Region	Population	Sample
Gt. Accra	43	34
Ashanti	57	42
Eastern	42	27
Central	24	20
Western	28	22
Oti	32	21
Northern	14	23
Volta	23	19
Upper East	6	4
Upper West	4	2
Total	*993*	*214*

Table 2. Distribution of sample sizes

Public health organization	Population	Sample
Public hospitals	258	197
Teaching hospitals	3	3
Polyclinics	10	9
Medical research centres	2	2
Psychiatric hospitals	3	3
Total	*276*	*214*

dimensions were measured indirectly through measurement scales of several items (or questions) in which participants' responses to the measurement scale questions (or items) determine the measured value for each construct (Table 4). The scales (or instruments) used in this study consisted of those developed and used in prior literature, and hence not only ensure consistency but also the reliability and validity of the measures are guaranteed. To initiate the scale development process, the guidelines of Jarvis *et al.* (2003), as well as Bisbe *et al.* (2007) on reflective and formative constructs which have been used in many management accounting literature (Fayard *et al.*, 2012; Dekker *et al.*, 2013), was followed. Whether each of the modelled constructs is conceptually reflective or formative was initially ascertained using the guidelines. For a reflective construct, participants' responses are assumed to reflect the conditions of the latent construct. In this case changes in the responses are caused by changes in the constructs. On the other hand, a linear combination of participants' responses on a given scale type of modelling reflects formative constructs. Based on these guidelines, a reflective measurement model in which the manifest item values are a function of underlying latent construct value was specified for all the constructs before administering to respondents.

3.2.1 External (supplier) integration. This was measured following Flynn *et al.* (2010), Wong *et al.* (2011), Chen *et al.* (2013), Behesti *et al.* (2014) and Ataseven and Nair (2017). This was achieved by requesting respondents to indicate on a scale of 1 (strongly disagree) to 7 (strongly agree) the importance suppliers attach to the supply of public health medical products during emergencies.

3.2.2 External (customer) integration. This was measured based on Flynn *et al.* (2010) and Ataseven and Nair (2017) by asking respondents to indicate on a seven-point Likert scale of 1 (strongly disagree) to 7 (strongly agree) the importance the public health institution play in decisions on patients' logistics and coordination issues and the extent to which they are often related to the complexity and variability of demand within a public health emergency.

3.2.3 Internal integration. This was measured based on Flynn *et al.* (2010), Wong *et al.* (2011), Behesti *et al.* (2014) and Ataseven and Nair (2017) by requesting respondents to indicate on a seven-point Likert scale of 1 (strongly disagree) to 7 (strongly agree) the extent of the coordination used by units, sections or departments within their respective public health institutions in enhancing the use of resources to ensure cost minimization to improve operational performance.

3.2.4 Management control system design. This was based on four MCS information characteristics measured by 21 indicators (broad scope 5, timeliness 7, integration 4 and aggregation 5) developed by Chenhall and Morris (1986). The scale was subsequently used by Bouwens and Abernethy (2000), Soobaroyen and Poorundersing (2008) Hammad *et al.* (2013) and Macinati and Anessi-Pessina (2014). Like SCI, MCS was also measured on a seven-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree).

3.2.5 Supply chain operation performance. This was measured based on Chen *et al.* (2013), Behesti *et al.* (2014) and Ataseven and Nair (2017). Respondents were asked to indicate on a seven-point Likert scale 1 (strongly disagree) to 7 (strongly agree) the importance their public health attached to the quality, speed of delivery, availability and cost of medical products procured for emergencies.

3.3 Estimation technique

Our model was estimated using covariance-based structural equations modelling (CB-SEM). This approach has the notable advantage of controlling for measurement errors and simultaneously testing multiple relationships among latent exogenous and endogenous variables. Also, the CB-SEM rather than the partial least squares (PLS) was selected because the constructs exhibit a reflective measure, which can effectively be estimated via the CB-SEM model. Another reason for using the CB-SEM was to estimate the parameters of the model (loadings and path values) to minimize the difference between the sample covariances and those predicted by the theoretical model. In this case, the parameter estimation process tries to reproduce the covariance matrix of the observed measures, overall goodness of fit measures to see how well the hypothesized model fits the sample data. Secondly, unlike PLS, CB-SEM emphasizes the overall model fit, that is, this approach is oriented towards testing a strong theory.

Therefore, CB-SEM is more suitable for confirmatory research whilst the PLS is more appropriate for prediction of the dependent variables (both latent and manifest) which is achieved by maximizing the explained variance R^2 of the dependent variables. Thus, in PLS, parameter estimates are obtained based on the ability to minimize the residual variances of dependent variables. Finally, as the paper tests variables based on contingency theory, which is a dominant theory in management accounting research, we focused on the CB-SEM to confirm the existence of this theory. Compared to CB-SEM, PLS is more appropriate for theory building (exploratory analysis) although it can also be used for theory confirmation (confirmatory analysis). A summary of the analysis procedure is presented in Table 3.

4. Results

4.1 Measurement model

Table 4 summarizes the results of the measurement model which was analysed using confirmatory factor analysis (CFA). The results suggest that the key fit indices, namely, the root mean square error of approximation (RMSEA) and the comparative fit index (CFI) values of the sample data are all above the recommended cut-off value of 0.90 and within the recommended value of 0.08, respectively (Fornell and Larcker, 1981). Also, the Tucker-Lewis index (TLI) and the incremental fit index recorded values above the recommended threshold of 0.90. Based on these results, the values for the Cronbach alpha and composite reliability were ascertained to assess the reliability of all the constructs and their respective items. As summarized in Table 3, the results suggest adequate reliability of the measurement scale, as all the constructs recorded values above 0.70 (Fornell and Larcker, 1981). Moreover, the convergent validity of each measurement scale was evaluated using the maximum likelihood method.

As indicated in Table 4, all indicators in their respective constructs have statistically significant factor loadings between 0.50 and 0.90 (p-value < 0.05) which is indicative of convergent validity of the theoretical constructs. Fornell and Larcker (1981) and Hair *et al.* (2015) have asserted that discriminant validity is established if firstly, the loadings of items on their respective constructs are stronger than any other constructs in the model (or most appropriately zero loadings) and secondly, the inter-construct correlations are lower than the square of the average variance extracted (AVE). In this regard and following these guidelines, evidence of discriminant validity of the constructs in the model was confirmed by a comparison of the squared correlations of two constructs with their individual AVE. The results as summarized in Table 5 indicate that the AVE of the latent constructs is higher than the squared correlations. Furthermore, the AVE and composite reliability estimates for each construct fall beyond the acceptable threshold. Based on these overall findings, the analysis proceeded with the structural model specification and subsequent evaluation to test the hypotheses.

Table 3. Summary of the analysis procedure

Analysis procedure	Stage (of the analysis)	Description	Statistical tool	Rationale
Data coding	Stage 1	All data were assigned a code	Data coding sheets and SPSS	This step was necessary for avoiding the data of error items
Data screening	Stage 2	Data were explored to remove unwanted items and outliers	Descriptive statistics	This could visualize missing items and potentially unwanted items. Mean scores and standard deviation give clues about the presence of outliers
		The distribution of the data was examined to establish acceptable skewness	Z-score	This was used because it provides benchmarks for understanding the distribution of the data
Normality test	Stage 2	Univariate normality of data was verified and confirmed	Shapiro-Wilk's test	Shapiro-Wilk's is the most appropriate tool when the number of data points (*n*) is not more than (Byrne, 2010)
		Multivariate normality of data was verified and confirmed	Mahalanobis test	This is a gold standard provided in CFA (Byrne, 2010)
Assumptions test	Stage 2	To ensure that the data came from a normally distributed population	Shapiro-Wilk's test and Mahalanobis test	Recommended in the literature (Byrne, 2010)
		To verify whether error terms of all predictors are independent of each other	Durbin-Watson statistic	Recommended in the literature (Burkert *et al.*, 2014)
		To verify homoscedasticity	Variance inflation factor value	Recommended in the literature (Maiga *et al.*, 2013)
Scale validation	Stage 2	To compute the reliability and validity statistics of the measurement scales	CFA	This approach is the most robust way to estimate both the reliability and validity statistics (Macinati and Anessi-Pessina, 2014)
Hypotheses testing	Stage 3	To test the structural CFA model or the seven hypotheses of the study, including the mediation test	CFA	This approach is the most robust way to test structural hypotheses or models to minimize Type II error (Maiga *et al.*, 2013)

Source: Researcher's own construct

Indicator	n	Standardized regression weights	t-value
Supplier integration (α = 0.76; RMSEA = 0.068; SRMR = 0.066; GFI = 0.87; CFI = 0.94, df = 253, x^2 = 356, p-value < 0.01, composite reliability = 0.78, AVE = 0.65)	214	0.914	12.035
High level of strategic relations with suppliers	214	0.725	3.288
Participation of suppliers in the procurement process	214	0.759	6.808
Quick ordering systems with suppliers	214	0.719	6.188
Forecast and replenish collaboratively with suppliers	214	0.650	7.512
Involve suppliers in planning and goal-setting process	214	0.771	11.761
Inventory management/consignment stock with suppliers	214	0.789	8.887
Customer (patient) integration (α = 0.87; RMSEA = 0.076; SRMR = 0.072; GFI = 0.78; CFI = 0.89, df = 187, x^2 = 213, p-value < 0.01)	214	0.866	10.899
The level of linkage with our patients is high	214	0.766	7.89
The level of communication with our patients is high	214	0.887	11.21
Patients' information is kept confidential	214	0.807	10.78
Our emergency response plans are shared with patients	214	0.706	12.09
Demand forecasts of PPEs and other products are shared with patients	214	0.921	14.08
Patients have accessibility to PPEs and other medical products	214	0.687	6.12
Patients always receive the required PPEs/other products	214	0.698	8.11
Our health institution always responds promptly to patient's needs	214	0.733	12.76
Internal integration (α = 0.67; RMSEA = 0.065; SRMR = 0.071; GFI = 0.72; CFI = 0.89, df = 218, x^2 = 267.87, p-value < 0.01)	214	0.947	12.76
Closely coordinated inter-organizational activities	214	0.761	12.81
Well-integrated logistic activities with suppliers	214	0.815	7.88
Excellent distribution, transportation and warehousing	214	0.872	10.49
Inbound and outbound distribution with hospital suppliers	214	0.881	6.80
Integrated software applications with suppliers	214	0.746	11.92
Integrates purchasing of health products into planning	214	0.764	12.92
Scope of accounting information (α = 0.82; RMSEA = 0.061; SRMR = 0.079; GFI = 0.84; CFI = 0.91, df = 417, x^2 = 208.71, p-value < 0.01)	214	0.968	14.28
Information that relates to future possible events	214	0.730	8.44
Quantify the likelihood of future events occurring	214	0.767	11.11
Non-economic information	214	0.721	12.27
Information on broad factors external to hospital	214	0.809	13.21
Timeliness of accounting information (α = 0.77; RMSEA = 0.075; SRMR = 0.073; GFI = 0.82; CFI = 0.91, df = 488, x^2 = 267.87, p-value < 0.01)	214	0.919	12.49
Immediate arrival of information upon request	214	0.769	12.29
Automatic supply of information to users	214	0.740	11.76
Frequent and systematic provision of reports	214	0.793	12.66
No delay between the event and relevant information	214	0.766	8.14
Accounting information integration (α = 0.81;RMSEA = 0.055; SRMR = 0.078; GFI = 0.88; CFI = 0.93, df = 324, x^2 = 247.81, p-value < 0.01)	214	0.857	10.42
Impact of information on individual decisions	214	0.820	11.41
Influence of individual's decision on responsibility	214	0.907	12.56

(*continued*)

Table 4.
Factor loadings of variables and items

Indicator	n	Standardized regression weights	t-value
Information on precise targets for all activities	214	0.844	11.69
Impact of information on decisions on performance	214	0.784	10.01
Accounting information aggregation (α = 0.84;RMSEA = 0.066; SRMR = 0.063; GFI = 0.79; CFI = 0.88, df = 372, x^2 = 120.34, p-value < 0.01)	214	0.989	12.70
Information on functional areas in your hospital	214	0.790	12.10
Information on the effect of events on time periods	214	0.810	12.79
Processed information to influence different events	214	0.927	14.39
Information on summary reports for the hospital	214	0.726	13.34
Cost minimization (α = 0.81; RMSEA = 0.068; SRMR = 0.077; GFI = 0.89; CFI = 0.94, df = 176, x^2 = 117.45, p-value < 0.01)	214	0.794	12.78
Cost of order fulfillment in our health centre reducing over the past 6 months	214	0.681	11.46
Reduction in order fulfillment cost in our health centre has improved over the past 6 months	214	0.714	14.21
Cost of order fulfillment in our health centre has been cost-efficient over the past 6 months	214	0.709	13.69
Purchasing costs our health centre has reduced over the past 6 months	214	0.871	17.18
Operating costs in our health centre have reduced over the past 6 months	214	0.867	16.23
Inventory costs in our health centre have reduced over the past 6 months	214	0.853	8.86
Speed of product/service delivery (α = 0.88; RMSEA = 0.058; SRMR = 0.064; GFI = 0.85; CFI = 0.97, df = 211, x^2 = 247.92, p-value < 0.01)	214	0.717	5.65
Requested medical products are delivered promptly as compared to the past 6 months	214	0.736	5.95
Requested medical services are offered promptly as compared to the past 6 months	214	0.741	5.93
Requested COVID-19 products are delivered promptly	214	0.844	6.15
Requested services for COVID-19 are offered promptly	214	0.920	7.99
In our health centre supply of COVID-19 products has improved over the past 6 months	214	0.678	5.92
In our health centre response to COVID-19 services has improved over the past 6 months	214	0.709	10.55
Product/service availability and flexibility (α = 0.87; RMSEA = 0.062; SRMR = 0.066; GFI = 0.83; CFI = 0.94, df = 376, x^2 = 208.21, p-value < 0.01)	214	0.969	15.20
Flexibility of order fulfillment process getting better	214	0.871	17.90
Improvement in the order fulfillment process	214	0.850	15.69
Improvement in the cycle time of the ordering process	214	0.853	10.89
Product/service quality (α = 0.70; RMSEA = 0.065; SRMR = 0.067; GFI = 0.90; CFI = 0.87, df = 343, x^2 = 126.07, p-value < 0.01)	214	0.886	13.31
Quality of order fulfillment process getting better	214	0.932	18.56
Improvement in the order fulfillment process	214	0.812	14.94
On-time delivery of medical suppliers from supplier	214	0.819	12.09

Table 4.

Table 5.
Descriptive statistics of variables

Variable	Min	Max	Mean	S.D	Skewness	Kurtosis
Supply chain integration						
Supplier integration	1.00	7.00	5.14	1.287	3.023	0.090
Customer integration	1.00	7.00	4.82	1.370	−6.877	0.053
Internal integration	1.00	7.00	4.96	1.348	5.184	0.122
Management control system						
Broad scope information	1.00	7.00	3.67	0.821	8.257	0.872
Information timeliness	1.00	7.00	5.24	1.553	12.027	−0.539
Integrated information	2.00	7.00	4.50	1.230	14.709	0.285
Aggregated information	1.00	7.00	4.73	1.117	12.875	0.046
Public health supply chain performance						
PPEs and other medical products quality	1.00	7.00	5.48	1.148	4.451	−0.505
Delivery speed of PPEs and other medical products	2.00	7.00	4.63	1.170	−7.916	−0.176
PPEs and other medical products availability	1.00	7.00	5.25	1.544	−8.009	0.716
Cost of PPEs and other medical products	1.00	7.00	5.27	1.432	15.781	0.084

4.2 Descriptive statistics

The descriptive statistics concerning means and standard deviations are presented in Table 5 whilst the correlation matrix is in Table 6. The means for supplier integration, customer integration and internal integration were recorded 5.14, 4.82 and 4.96, respectively, with standard deviations 1.287, 1.370 and 1.348 on a scale of 1 to 7 where 1 = strongly disagree and 7 = strongly agree. Also, 3.67, 5.24, 4.50 and 4.73 were, respectively, recorded for broad scope information, information timeliness, integrated information and aggregated information with standard deviation 0.821, 1.553, 1.230 and 1.117. Finally, product or service quality, product or service delivery, availability and cost minimization recorded average values of 5.48, 4.63, 5.25 and 5.27, with standard deviation 1.148, 1.170, 1.544, 1.432, respectively. The results suggest that the observed data is highly represented by the calculated means as the deviations are relatively small compared to the mean values which is an indication that the data points are close to the means. Also, the minimum and maximum scores were within the acceptable scale which suggests that the instrument is highly reliable and does not open errors. A review of the standardized estimates for the constructs revealed the highest correlation value of 0.61 indicating the absence of multicollinearity among the variables. However, their statistical significance indicates strong relations among the constructs which in contingency theory applications measures the strength rather than a form of relationship among variables. The presence of multicollinearity signifies that the correlation between two or more variables is so high that essentially, they are represented by the same underlying construct. In this case, the presence of a correlation of value close to 1 or more is indicative of inadmissible.

Solution, which is a signal of model misspecification. This situation was, however, not found in the correlation matrix produced in Table 5.

4.3 Structural model estimate

Table 7 summarizes the results of the paths linking the constructs in the structural model whilst the AMOS output of the structural model is shown in Figures 3 and 4, respectively. To test the mediating role of MCS information characteristics on SCI and PHSCOP we follow the procedure of Baron and Kenny (1986). Firstly, the direct impacts of supplier integration, customer integration and internal integration on the operational performance of public health emergency response were tested to establish whether a direct relationship exists.

Table 6. Correlations, Cronbach's alpha, AVE and composite reliability

Variable/construct	1	2	3	4	5	6	7	8	9	10	11
EIS 1	0.94										
EIC 2	0.26***	0.87									
NIT 3	−0.21**	0.20***	0.85								
BSC 4	0.06*	−0.13**	0.53***	0.91							
TIM 5	0.18**	0.22***	0.15**	0.58***	0.94						
ITN 6	−0.14**	0.15***	0.05	0.47***	0.06	0.88					
AGG 7	0.33***	−0.02	0.51***	0.29***	0.19***	0.16***	0.91				
QTY 8	−0.31**	−0.22**	−0.09	−0.11*	0.01	0.13*	0.14**	0.97			
AVA 9	0.11**	0.37***	0.09*	0.12**	0.40***	−0.03	0.13*	0.18**	0.83		
FLX 10	0.45***	0.34***	0.54***	−0.09*	0.49***	−0.19**	0.33***	0.12**	0.37***	0.87	
COS 11	−0.27**	−0.03	0.55***	0.24***	−0.26**	0.38***	0.51***	−0.18*	0.03	0.17**	0.81
Cronbach Alpha	0.72	0.86	0.83	0.86	0.79	0.87	0.86	0.84	0.91	0.94	0.89
AVE	0.88	0.76	0.73	0.82	0.89	0.78	0.80	0.69	0.77	0.88	0.84
COR	0.73	0.66	0.81	0.76	0.67	0.79	0.84	0.89	0.75	0.69	0.77

Notes: *** < 0.01 significant at 1%; ** < 0.05 significant at 5%; * < 0.1 significant at 10%. EIS – supplier integration; EIC – customer integration; NIT – internal integration; BSC – broad scope information; TIM – information timeliness; ITN – information integration; AGG – aggregated information; QTY – PPEs/other product quality; AVA – PPEs/other products availability; FLX – flexibility and delivery speed of PPES/other products; COS – cost of PPEs/other products; AVE – average variance extracted; COR – composite reliability

Path	Standardized regression coefficient	t-statistics	p-value	Hypothesis	Decision
BSC ← EIS	0.25	2.89***	0.000	*H1a*	Supported
TIM ← EIS	0.68	4.43***	0.000	*H1b*	Supported
ITN ← EIS	0.16	3.08***	0.000	*H1c*	Supported
AGG ←EIS	0.51	4.77***	0.000	*H1d*	Supported
BSC ← EIC	0.22	2.68**	0.025	*H2a*	Supported
TIM ← EIC	0.43	7.12***	0.000	*H2b*	Supported
ITN ← EIC	0.03	1.87	0.671	*H2c*	Not supported
AGG ← EIC	0.12	3.80***	0.000	*H2d*	Supported
BSC ← NIT	0.40	2.66**	0.022	*H3a*	Supported
TIM ← NIT	0.23	5.36***	0.000	*H3b*	Supported
ITN ← NIT	0.45	3.99***	0.000	*H3c*	Supported
AGG ← NIT	0.32	6.01***	0.000	*H3d*	Supported
QTY ← BSC	0.14	2.05**	0.037	*H4a*	Not supported
AVA ← BSC	0.17	2.12**	0.047	*H4b*	Supported
FLX ← BSC	0.02	0.98	0.978	*H4c*	Not supported
COS ← BSC	0.26	4.77***	0.000	*H4d*	Supported
QTY ← TIM	0.11	2.33**	0.022	*H5a*	Supported
AVA ← TIM	0.07	3.09***	0.000	*H5b*	Supported
FLX ← TIM	0.41	8.27***	0.000	*H5c*	Supported
COC ← TIM	0.33	7.17***	0.000	*H5d*	Supported
QTY ←ITG	0.21	6.08***	0.000	*H6a*	Supported
AVA ← ITG	0.17	4.44***	0.000	*H6b*	Supported
FLX ← ITG	0.37	2.67**	0.031	*H6c*	Supported
CMT ←ITG	0.18	8.23***	0.000	*H6d*	Supported
PSQ ← AGG	0.31	5.57***	0.000	*H7a*	Supported
AVA ← AGG	0.22	2.76**	0.024	*H7b*	Supported
FLX ← AGG	0.13	1.77	0.817	*H7c*	Not supported
COS ← AGG	0.04	5.87***	0.000	*H7d*	Supported

Notes: *** <0.01 = significant at 1%; ** <0.05 = significant at 5%, * <0.1 = significant at 10%. EIS – supplier integration; EIC – customer integration; NIT – internal integration; BSC – broad scope information; TIM – information timeliness; ITG – information integration; AGG – aggregated information; QTY – PPEs/other products quality; AVA – PPEs/other products availability; FLX – flexibility and delivery speed of PPEs/other products; delivery speed; COS – PPEs/other products cost

Table 7.
Structural model estimate

This is because the mediating effect of the MCS cannot be established if there is no direct relationship between the exogenous and endogenous variables. This tested *H8a* and *H8b* and was found to be statistically significant (t = 3.75, p-value = 0.000 < 0.01) and (t = 5.88, p-value = 0.000 < 0.01) for *H8a* and *H8b*, respectively.

Secondly, tests of the mediating effects of the MCS information characteristics on the SCI-operational performance relationship were undertaken. Supplier (external) integration recorded a statistically significant positive effect on all the four dimensions of the MCS at the 1% significance level for broad scope information (t = 2.89, p-value = 0.000 < 0.01); information timeliness (t = 4.43, p-value = 0.000 < 0.01); integrated information (t = 3.08, p-value = 0.000 < 0.01); and aggregated information (t = 4.77, p-value = 0.000 < 0.01). Thus, hypotheses *H1a*, *H1b*, *H1c* and *H1d* are supported. Also, a statistically significant positive impact of customer integration on broad scope information, timeliness and aggregation at the 5% and 1% significant levels was recorded; broad scope (t = 2.68, p-value = 0.025 < 0.05); timeliness (t = 7.12, p-value = 0.000 < 0.01); and aggregation (t = 3.80, p-value = 0.000 < 0.01). The effect of customer integration on the integrated dimension of the MCS was, however, found to be

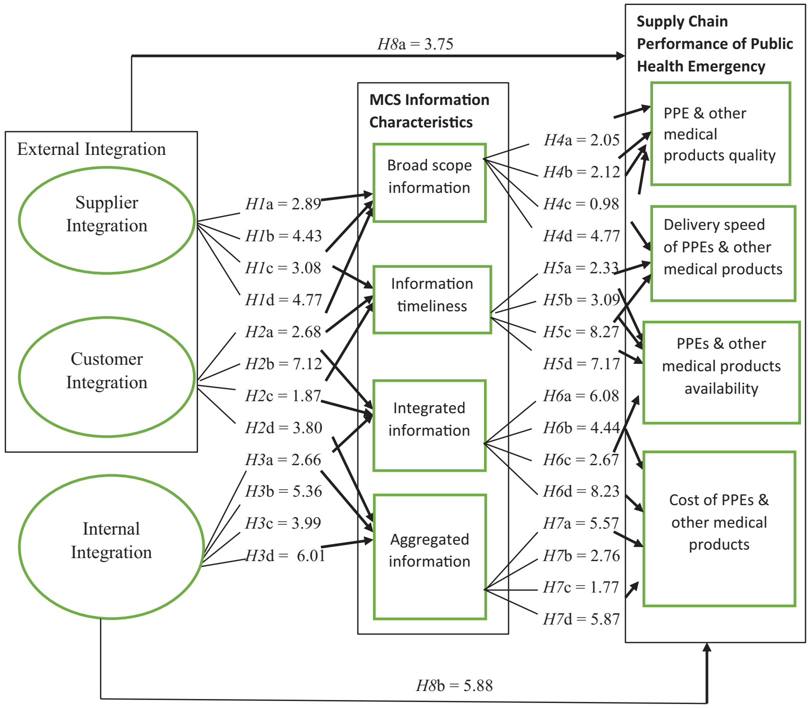
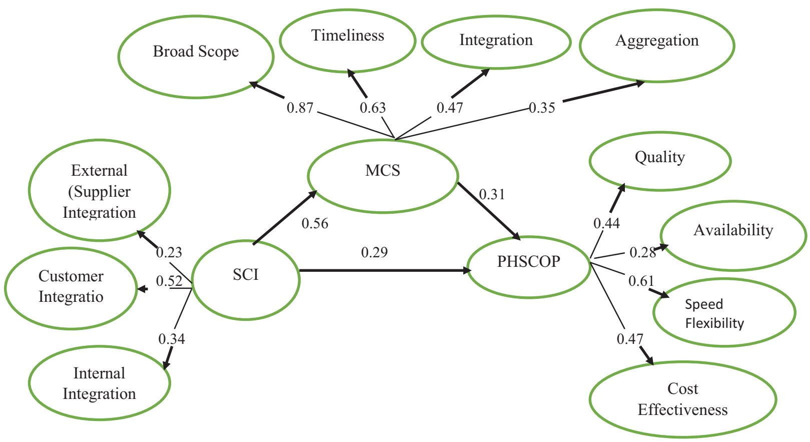


Figure 3.
Structural model output



Note: SCI – supply chain integration; MCS – management control systems; PHSCOP – public health supply chain operational performance

Figure 4.
Structural output with main constructs as second order

statistically insignificant (t = 1.87, p-value = 0.671 > 0.05). Thus *H2a*, *H2b* and *H2d* were supported but *H2c* was not supported. Finally, internal integration had a statistically positive effect on broad scope information (t = 2.66, p-value = 0.022 < 0.05), timeliness (t = 5.36, p-value = 0.000 < 0.01), integrated information (t = 3.99, p-value = 0.000 < 0.01) and aggregated information (t = 6.01, p-value = 0.000 < 0.01). Hence, hypotheses *H3a*, *H3b*, *H3c* and *H3d* are supported.

The second part of the test involved ascertaining the impact of the MCS information characteristics (broad scope, timeliness, integration and aggregation) on each of the four dimensions (quality, speed of delivery, availability and cost) of the supply chain performance of public health emergency response. In this test, the broad scope information characteristic of the MCS recorded a statistically significant positive effect on three of the four performance variables at the 5% and 1% significance levels. product quality (t = 2.05, p-value = 0.037 < 0.05); delivery speed (t = 2.12, p-value = 0.047 < 0.05); product cost (t = 4.77, p-value = 0.000 < 0.01). The relationship between broad scope information and product availability was statistically insignificant (t = 0.98, p-value = 0.978 > 0.05). Hypotheses *H4a*, *H4b* and *H4d* are supported but *H4c* is not supported. The timeliness information also recorded a statistically positive significant effect on all the supply chain performance variables at the 1% level of significance: product quality (t = 2.33, p-value = 0.022 < 0.05), product delivery speed (t = 3.09, p-value = 000 < 0.01), product availability (p = 8.27, p-value = 0.000 < 0.01) and product cost (t = 7.17, p-value = 0.000 < 0.01). Thus, hypotheses *H5a*, *H5b*, *H5c* and *H5d* were supported. The integrated information characteristic recorded a statistically significant positive effect on all the performance variables at 1% and 5% significance levels; product quality (t = 6.08, p-value = 0.000 < 0.01); the speed of delivery (t = 4.44, p-value = 0.000 < 0.01); product availability (t = 2.67, p-value = 0.031 < 0.05) and product cost (t = 8.23, p-value = 0.000 < 0.01). Hypotheses *H6a*, *H6b*, *H6c* and *H6d* are supported. Finally, the aggregated information recorded a statistically positive impact on product quality (t = 5.37, p-value = 0.000 < 0.01), speed of delivery (t = 2.76, p-value = 0.024 < 9.95) and product cost (t = 5.87, p-value = 0.000 < 0.01). In this case hypotheses *H7a*, *H7b* and *H7d* were supported. That of product availability was, however, not significant (t = 1.77, p-value = 0.817 > 0.05), hence, hypothesis *H7c* was not supported.

5. Discussion and conclusions

This paper provides preliminary empirical evidence of the mediating effect of MCS information characteristics on SCI and operational performance of public health emergency to epidemics. The results indicate that the sample data fits well in this research space of MCS information characteristics, SCI and SC performance of public health emergency response. By using SEM, this paper provides new insights into the conceptualization of the relationship between these variables in the context of a developing economy. This approach provides a theoretical contribution to the literature on empirical findings on the extent to which the MCS information characteristics facilitate public health supply chain performance during a pandemic outbreak. The importance of MCS information in enhancing the dimensions of SCI in a public health environment is, therefore, not only depicted by this paper but also the relevance and usefulness of contingency theory are fit concepts to linking SCI and MCS information in an unprecedented epidemic. This interaction has hardly been investigated not only in the literature but also in developing countries. Given that the COVID-19 pandemic spreads internationally and possesses a boundary-spanning characteristic, the findings can be extended to public health institutions in countries across the world. In other words, the four dimensions of the MCS (broad scope, timeliness, integration and aggregation) facilitate the production and distribution decisions of public health emergency products. This paper, therefore, contributes to the contingency-based management accounting literature by filling a gap that relates to the application of contingency theory in facilitating public health SC performance in a pandemic environment.

5.1 Theoretical implications

A widespread public health incident such as an epidemic or pandemic can have a substantial negative impact on businesses and SCs, including reducing their operational efficiency and performance and propagating disruptions across the SCs (Chowdhury *et al.*, 2021; Guan *et al.*, 2020; Ivanov, 2020a, Ivanov and Das, 2020). Commencing with the claim by contingency theory that the product of the relevant contextual dimensions of SCI and the MCS information characteristics determine effective organizational performance (Otley, 2016; Chenhall, 2003; Burkert *et al.*, 2014), this paper examined the mediating effect of MCS information characteristics on the relationship between external integration, internal integration, customer integration and the quality, delivery speed, availability and cost of PPEs and other medical products in a pandemic environment. The findings were based on tests conducted in four separate scenarios (Baron and Kenny, 1986):

- testing the direct link between SCI and SC performance of public health emergency response;
- testing the effect of SCI on each of the MCS information characteristics; and
- testing the joint impact of SCI and MCS information characteristics on the SC performance.

In the first test, each of the three dimensions of SCI (external or supplier integration, internal integration and customer integration) was tested against four dimensions (broad scope, timeliness, integration and aggregation) of the MCS. The positive results in this test suggest that public health institutions that adopt the four MCS information characteristics are likely to improve (or have strong) supplier and customer relationships as well as enhancing the internal dimensions (e.g. product availability, quality, etc.) of the supply chain. That is, the broad scope dimension of the MCS is likely to provide future-oriented information about production rate, stock levels and available channels of distribution which public health institutions can rely on to render emergency response services to pandemics. Theoretically, whilst effective SCM has critical implications for most industries, inconsistency or limited supplies through the public health SC system can jeopardize patient safety and overall health quality and flexibility through high logistical cost (Friday *et al.*, 2021). In the context of a pandemic such as the COVID-19, this issue is more visible and urgent (Queiroz *et al.*, 2020; Ivanov, 2020a; Ivanov and Das, 2020; Friday *et al.*, 2021). For example, the demand for necessary items such as PPE, ventilators and dried and other COVID-19 equipment has increased in recent times (Chowdhury *et al.*, 2021). Meanwhile, supplies, transportation and manufacturing face numerous challenges that reduce their capacities (Chowdhury *et al.*, 2021). These include border closures, lockdown in the supply market, interruption in vehicle movements and international trade, labor shortage and the maintenance of physical distance in manufacturing facilities (Chowdhury *et al.*, 2021; Paul and Chowdhury, 2020; Amankwah-Amoah, 2020).

5.2 Managerial implication

Whilst the MCS information characteristics facilitate decision-making in managing these facilities through the integration of the SC and MCS dimensions, the broad scope, integration, timeliness and aggregated information characteristic are expected to facilitate decisions on the procurement and distribution of PPEs and other medical products by public health institutions that adopt MCS information to manage emergencies. A test between the timeliness information characteristic recorded a positive significant effect on SC quality, delivery speed, availability and cost. This finding suggests that timeliness play important role in enhancing the supply chain performance of public health institutions during emergency response to pandemics. Prompt and immediate information about the quality, delivery time, availability and cost of PPEs and other medical products are likely to be obtained by public health institutions that install and implement MCS information characteristics. The integrated dimension recorded a statistically positive effect on quality, delivery speed and cost of products. This suggests that the information characteristics of the MCS strongly play a mediating role between external, internal and customer integration and product quality, delivery speed, availability as well as minimizing costs of public health SC. In this case, product quality enhancement, increase in speed of delivery and other operational metrics provide accessibility to products and incur the least procurement and distribution cost. Based on these findings, this paper aligns with the call by Bal *et al.* (2020) for research into public health emergency response and decision-making structures and practices, the performance implications of public health systems and their underlying values, mediatization of the COVID-19 pandemic and the role of expertise. The public health supply chain seems to be of crucial importance to the development of control and preventive measures against the current pandemic and the information requirements of product quality, delivery speed, availability and cost. Perhaps, this paper is the first to provide empirical evidence on the interaction between organizational design and SC performance of public health emergencies.

5.3 Robustness check

To determine the robustness of our model we use second-order SEM to examine whether the main constructs (SCI, MCS and PHSCOP) are statistically significant. This is shown in the structural output in Figure 3. The results show a positive relationship between SCI and MCS (t = 4.78, p-value = 0.000 $<$ 0.01), SCI and PHSCOP (t = 3.39, p-value = 0.000 $<$ 0.01) and between MCS and PHSCOP (t = 3.48, p-value = 0.000 $<$ 0.01) which confirm the previous findings. This confirms the results of our initial first-order model. Based on these findings, we argue that the four dimensions of the MCS fit well in the management of public health SCs to the pandemic response.

6. Conclusion

In conclusion, this paper developed and empirically tested a contingency model involving MCS information characteristics (broad scope, timeliness, integration and aggregation), SCI (external integration, internal integration and customer integration) and supply chain operational performance (quality, delivery, availability and cost) of public health emergency response to epidemics. Thus, the paper develops a novel theoretical model and approach to explaining the complex associations among the dimensions of MCSs and the performance impacts of public health SCM decisions on emergency response to a pandemic outbreak. The approach used in this paper clearly differentiates the performance mechanisms of the four dimensions of the MCS with respect to the performance impacts of the SCM decisions of public health emergency response decisions. Additionally, the paper explains why and how the impacts of certain MCS information characteristics on the SC performance impacts of public health emergency response can be improved. Such an enhanced knowledge and understanding has implications for procurement managers when responding to public health emergencies.

The value of the four dimensions of the MCS to the explanation of the contexts to which it is effective can then be justified and further be progressed. Judging from the findings as well as the theory underpinning this paper, public health SCM can possibly be stipulated by MCS information characteristics to which an appropriate dimension of the MCS would have a positive impact on the operational performance of public health emergency response decisions to epidemics. From an inter-organizational viewpoint, this study finds a statistically significant connection between MCS information characteristics, SCI and public health SC performance. Although there are many other SCM variables that contribute to enhancing the operational performance of public health responses to emergencies, the findings suggest the need for public health managers to target these four variables as appropriate in responding to public health emergencies. Furthermore, the results suggest that by focusing on the interaction of the four information characteristics of the MCS and SCI, the identified dimensions (quality, delivery, availability and cost) of the operational performance of public health response to emergencies can be improved through the mediating role of the MCS dimensions with which they are associated. Thus, this paper recommends the rebuilding of the public health SC information mechanism to align with the four dimensions of the MCS.

Like any empirical work, several limitations characterizing this study can be acknowledged. These limitations provide several avenues for future research. Firstly, this study examined SCI, MCS and SC performance characteristics (quality, speed, availability and cost), without controlling for any confounding variables (e.g. location, size, etc.). Such confounding variables, according to Chen *et al.* (2013), can influence public health operational performance. Future studies can control for these variables in relation to public health emergency response to epidemics to see whether the results will vary. Secondly, not all the public health SC emergency response variables were examined. For example, SC flexibility, sustainability, reliability, etc., are important dimensions of performance impacts of the operational performance of public health emergency response to epidemics, hence, their exclusion from the study could be an important shortcoming given especially the role they play in enhancing public health supply chain performance. Empirical evidence on the contingency theory's application in the MCS-SCI field can be extended to include these other equally important dimensions of public health practices. Thirdly, the empirical results are based on sample data relating to only one developing country (Ghana). However, this pandemic outbreak affects all countries across the world, hence, given that there are about 195 countries and different public health systems, possible generalization of the findings to include other countries is limited. Notwithstanding, the results can be generalized within the Ghanaian context and other countries in the sub-Saharan African region. Fourthly, this work has focused exclusively on four informational characteristics of the MCS in a pandemic environment, other numerous dimensions of the MCS design (long-term planning, budgeting, variances, decision support systems, etc.) that have been used in prior research can be examined. For example, the MCS information characteristics can be categorized under decision support systems, budgeting, long-term planning, financial and non-financial information and others. Finally, the search for appropriate contingency frameworks especially in service-oriented organizations is, however, still at its infancy stage. Future studies can look at other service organizations.

Note

1. Are in dominance when it comes to core operations of hospitals, but the implicit assumption is that they can be controlled through hospital strategies.

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Appendix. Research instrument

Supplier Integration	1	2	3	4	5	6	7
Our health facility maintains a high level of strategic relations with key suppliers of COVID-19 products							
We encourage a high level of suppliers' of COVID-19 products to participate in our procurement processes							
Our health facility establishes quick ordering of COVID-19 products with key vendors/suppliers							
Our health facility solves logistic problems jointly with key vendors/suppliers of COVID-19 products							
We include our key vendors/suppliers of COVID-19 products in our planning and goal-setting activities							
Our heath facility on frequent basis, arrange for delivery of COVID-19 products with vendors/suppliers							
We undertake vendor inventory management or consignment stock of COVID-19 products with suppliers							
We plan, forecast and replenish collaboratively of COVID-19 products with key vendors/suppliers							
Our health facility dedicates capacity for key vendors/suppliers of COVID-19 products							
Customer Integration							
The level of linkage with our COVID-19 patients is high							
The level of communication with our COVID-19 patients is high							
COVID-19 patients' information is kept confidential							
Our emergency response plans are shared with COVID-19 patients							
Demand forecast of PPEs and other products are shared with COVID-19 patients							
COVID-19 patients have accessibility to PPEs and other medical products							
COVID-19 patients always receive the required PPEs/other products							
Our health institution always responds promptly to the needs of COVID-19 patients							
Internal Integration							
Closely coordinated inter-organizational activities toward the control of COVID-19 pandemic							
Well-integrated logistic activities with COVID-19 products suppliers							
Excellent distribution, transportation, and warehousing of COVID-19 products							
Inbound and outbound distribution of COVID-19 products with health suppliers							
Integrated software applications with suppliers of COVID-19 products							
Integrates purchasing of health products into planning							
Broad Scope Accounting Information							
In our health facility the accounting information relates to future possible events							
The accounting information quantifies the likelihood of future events occurring							
In our health facility the accounting information captures non-economic information							
Our accounting system generates information on broad factors external to our health facility							
Accounting Information Timeliness							
In our health facility there is immediate arrival of information upon request							
Our accounting system automatically supply information to users							
Our accounting system frequently and systematically provides accounting reports							
There is no delay between event and relevant information in our accounting system							
Integrated Information							
Impact of information on individual decisions by our accounting system							
Influence of individual's decision on responsibility by our accounting system							
Information on precise targets for all activities by our accounting system							
Impact of information on decisions on performance by our accounting system							
Aggregated Information							
Our accounting system provides information on functional areas in your health facility							
Our accounting system generates information on the effect of events on time periods							
Our accounting system processes information to influence different events							
Our accounting system provides information on summary reports for our health centre							
Cost Effectiveness							
Cost of order fulfillment in our health center reducing over the last 6 months							
Reduction in order fulfillment cost in our health center has improved over the last 6 months							
Cost of order fulfillment in our health center has been cost efficient over the past 6 months							
Purchasing costs our health center has reduced over the past 6 months							
Operating costs in our health center have reduced over the past 6 months							
Inventory costs in our health center have reduced over the past 6 months							
Speed of Delivery of COVID-19 Products							
Requested medical products are delivered promptly as compared to the past 6 months							
Requested medical services are offered promptly as compared to the past 6 months							
Requested COVID-19 products are delivered promptly							
Requested services for COVID-19 are offered promptly							
In our health center supply of COVID-19 products has improved over the last 6 months							
In our health center response to COVID-19 services has improved over the last 6 months							
Product/Service Availability and Flexibility							
Flexibility of order fulfillment process getting better							
Improvement in the order fulfillment process							
Improvement in the cycle time of ordering process							
Quality of COVID-19 products							
Quality of order fulfillment process getting better							
Improvement in the order fulfillment process							
On-time delivery of medical suppliers from supplier							