# Effect of COVID-19 on essential medicines order quantities and prices for Mulago national referral hospital; a mixed methods study

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## SUPERVISORS APPROVAL

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SUPERVISOR: RAJAB KALIDI SIGNATURE:  DATE: 25 APRIL 2023

CO-SUPERVISOR: WINNIE NAMBATYA SIGNATURE:  DATE:25 APRIL 2023

## DEDICATION

This work is dedicated to my husband Nelson in appreciation of his unwavering support and encouragement throughout my journey in pursuing the Masters in Health Supply Chain course and conducting this study. I want you to know that I do not take it for granted and May God bless you.

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## ABSTRACT

**Background:** Mulago national referral hospital (NRH) housed Uganda's largest COVID-19 treatment unit, and managed patients with moderate, severe and critical disease severities. Clinical management of these patients required a considerable amount of essential medicines (EM) whose demand surged with patient numbers. EM orders were adjusted including, through emergency orders, to procure COVID-19-leaning EM. EM prices too increased with demand. Increase of COVID-19-leaning EM order quantities was curtailed by budget constraints.

**General objective:** This study assessed the effect of COVID-19 on EM order quantities and prices at Mulago NRH.

**Methods:** A concurrent mixed methods study was conducted at Mulago NRH. The study included 142 EM and 9 key informants (KIs). EM selected for the study were those listed in Mulago's orders of March 2018 to March 2022 and within the essential medicines and health supplies list of Uganda 2016. KIs were purposively selected. Pre-tested data collection tools (EpiData Manager V4.6 and key informant guide) were used to collect data on EM order quantities and prices, and coping mechanisms deployed by Mulago. Data was analysed using SPSS v22.0 and ATLAS.ti v8.

**Results:** Out of the 237 medicines ordered during the study period, 142 (59.9%) were EM. Of these, 89 (62.7%) were COVID-19-leaning. In response to EM needs, emergency order numbers increased 10-fold, over the first two years of the pandemic from the two years just before. COVID-19-leaning and non-COVID-19-leaning EM order quantities are correlated to severity and patient numbers, with correlation coefficients of 0.45 and -0.02 respectively. COVID-19-leaning and non-COVID-19-leaning EM prices are correlated to severity and patient numbers, with correlation coefficients of 0.13 and 0.23 respectively. KIIs revealed that Mulago NRH coped with EM demands through emergency ordering, order quantity adjustments, inter-institutional redistribution of EM, procurement of donations and cost-sharing with patients.

**Conclusion:** There was a moderate positive a very weak negative correlation between COVID-19-leaning EM order quantities and non-COVID-19-leaning EM respectively, and COVID-19 patient numbers. There was a very weak positive and a weak positive correlation between COVID-19-leaning and non-COVID-19-leaning EM prices respectively and

COVID-19 patient numbers. Mulago NRH applied a multipronged approach of coping mechanisms to meet the emerged EM demands that arose due to COVID-19.

## LIST OF ACRONYMS

| | |
|---|---|
| API | Active Pharmaceutical Ingredient |
| COVID-19 | Corona Virus Disease 2019 |
| CTU | COVID-19 Treatment Unit |
| EAC VIHSCM | East African Community Regional Center of Excellence for Vaccines, Immunization and Health Supply Chain Management |
| EM | Essential Medicines |
| EMHS | Essential Medicines and Health Supplies |
| EMHS CLB | Essential Medicines and Health Supplies Credit Line Budget |
| EMHSLU | Essential Medicines and Health Supplies List of Uganda |
| FY | Financial Year |
| GOU | Government of Uganda |
| HDU | High Dependence Unit |
| HIV | Human Immunodeficiency Virus |
| HSC | Health Supply Chain |
| ICU | Intensive Care Unit |
| KI | Key Informant |
| KII | Key Informant Interview |
| MTC | Medicines and Therapeutics Committee |
| NGMC | National Guidelines for Management of COVID-19 |
| NMS | National Medical Stores |
| NRH | National Referral Hospital |
| PRHs | Public Referral Hospitals |
| REC | Research and Ethics Committee |
| SARS-CoV-2 | Severe Acute Respiratory Syndrome Coronavirus 2 |
| SCC | Supply Chain Collaboration |

| | |
|---|---|
| SCR | Supply Chain Redundancy |
| SCV | Supply Chain Visibility |
| SDP | Service Delivery Point |
| UOM | Unit of Measure |
| UK | United Kingdom |
| VEN | Vital, Essential and Necessary |
| WHO | World Health Organization |

## OPERATIONAL DEFINITIONS

**Essential medicines:** These are medicines required to meet the priority healthcare needs of a population. They should be available and accessible at all times, in the right dosage forms, right quality and affordable [1]. In this study, EM were those within the essential medicines and health supplies (EMHS) orders of Mulago NRH and listed in the essential medicines and health supplies list of Uganda (EMHSLU), 2016 [2].

**Essential medicines and health supplies orders**: These are reviewed, approved, and costed requirements lists with cost commitment sent out to Uganda's central medical stores national medical stores (NMS) to trigger supply of ordered-for items according to annual published NMS order/delivery schedules [3]. In Uganda, these orders are generated based on corresponding financial year (FY) procurement plans and are detailed by items (including EM), item quantities, and item prices. Routine EMHS orders for Mulago NRH are made monthly. Additionally, emergency orders may also be made, when the need arises. For this study, EMHS orders constituted those that correspond to the period of March 2018 to March 2022.

**Essential medicines order quantities:** These are quantities of EM within EMHS orders. For this study, EM order quantities was the aggregation of all EM order quantities (routine and emergency) made in a particular month.

**Essential medicines prices:** These refer to unit prices attached to each EM. For this study, EM prices were extracted from the NMS delivery notes/ invoices. For months with several deliveries, the EM prices was the average of unit prices of all deliveries for the month under consideration.

**Coping mechanisms:** These are strategies aimed at reducing the severity and duration of negative outcomes during undesired situations. In this study the undesired situation was the Corona virus disease 2019 (COVID-19) pandemic.

**Trend:** Signifies the general direction in which something is changing. It is the upward or downward pattern in data over time [4]. For this study, the pattern in quantitative data (EM order quantities and pricing) over a four-year period from March 2018 to March 2022 was quantified and explained.

**COVID-19:** For this study COVID-19 manifested in the number of patients diagnosed with COVID-19 and with varying disease severities. Diagnosis was based on meeting the clinical criteria of the varying COVID-19 severities with a confirmed positive (severe acute

respiratory syndrome coronavirus 2) SARS-CoV-2 polymerase chain reaction test. For this study, COVID-19 was expressed as a single numerical value that integrated patient numbers and severity.

**Disease severity:** The American journal of managed care defines disease severity as "the presence and extensiveness of a disease in the body" [5]. COVID-19 presents in four disease severity categories which are mild, moderate, severe and critical disease. Mulago NRH managed moderate, severe and critical disease categories and these were the focus of the study. According to Uganda's National Guidelines for Management of COVID-19 (NGMC), patients with moderate disease presented with pneumonia without need for oxygen; patents with severe disease required oxygen therapy, and patients with critical disease presented with acute respiratory distress syndrome and with a sepsis spectrum that ranged from systemic inflammatory response syndrome to severe sepsis and septic shock with multi organ damage, requiring intensive care unit (ICU) services [6].

**COVID-19-leaning essential medicines:** These connote medicines that are used in the clinical management of COVID-19 and associated co-morbidities (underlying health conditions) such as chronic obstructive pulmonary disease, hypertension, diabetes [7][8].

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# CHAPTER 1. INTRODUCTION

This study assessed the effect of the Coronavirus disease 2019 (COVID-19) on essential medicines (EM) order quantities and prices at Mulago NRH in Kampala, Uganda. In this study, COVID-19 (the independent variable) was conceived to manifest as patient numbers of three disease severities, namely moderate, severe, and critical while EM order quantities and prices were the dependent variables. COVID-19 was quantified by numerical values integrating COVID-19 patient numbers and severity, while EM order quantities and prices were quantified by integrated numerical values of EM order quantities for COVID-19-leaning EM and non-COVID-19-leaning EM, and integrated numerical values of EM prices for COVID-19-leaning EM and non-COVID-19-leaning EM, respectively.

This chapter presents the study's context, background, problem statement, purpose, objectives, research questions, significance, delimitations and limitations.

## 1.1 Context

The health supply chain (HSC) comprises stakeholders, systems, and procedures that ensure that high-quality essential medicines (EM) to support patient care at service delivery points (SDPs) are available, accessible, acceptable and affordable [9]. The Corona virus disease 2019 (COVID-19) pandemic however disrupted global and national HSCs. These disruptions included: shutdown of active pharmaceutical ingredient (API) factories for example China, the major global source of APIs [10]; regulation and restriction of some medicines exports for example by India, the world’s leading pharmaceutical exporter of generic medicines [11]; transportation and logistics difficulties such as cargo backlog at key container ports, cancelled air and maritime shipments, and travel restrictions that led to truck driver scarcity [12][13]. Additionally, there was an exponential growth in demand for medicines to support COVID-19 clinical management arising from high morbidity and hospital admissions [14].

COVID-19 caused worldwide severe shortages of medical commodities including EM [15]. The pandemic similarly uncovered health system weaknesses in several countries across the world [16][17]. Before the COVID-19 pandemic, Uganda’s HSC lacked agility and flexibility among other bottlenecks. Additionally, the essential medicines and health supplies (EMHS) budget was constrained [18]. COVID-19 pandemic disruptions coupled with high demand, especially for medicines used in COVID-19 clinical management (COVID-19-leaning EM) caused price escalations for medicines [13][19].

Consequently, hospitals in Uganda that managed COVID-19 patients adopted various coping mechanisms such as adjustment of EMHS orders, to facilitate uninterrupted access to required medicines within unadjusted and also inadequate budgetary provisions. EMHS orders adjustments included increase in COVID-19-leaning EM order quantities, as well as inclusion of non-planned EM, and consequent reduction in non-COVID-19-leaning EM.

Against this background, the study assessed the effect of COVID-19 on EM order quantities and prices at Mulago NRH in Kampala.

### 1.2 Background

The COVID-19 pandemic originated in Wuhan, China towards the end of 2019. However, due to its severity, the World Health Organization (WHO) declared it a pandemic of international emergency in March 2020 [20]. By 20 April 2023 over 763 million individuals had already been infected, with a death toll of over 6.9 million worldwide [21][22]. In Uganda, the first case was reported on 20 March 2020, with the first death recorded on 23 July 2020 [23]. By 20 April 2023, 170,634 cumulated cases and 3,632 deaths had been registered [24].

To combat the disease spread, governments worldwide instituted various measures such as lockdown of businesses and restrictions on movement of persons [25]. In Uganda, the government instituted measures including: lockdown on businesses; restriction of movement; closure of educational institutions, places of prayer, recreation centers; etc. [26][27]. In addition, the Government of Uganda (GoU) published the Uganda COVID-19 preparedness and response plan [28]. The plan provided for the development, update, and publication of the National Guidelines for Management of COVID-19 (NGMC) [6]. The guidelines recommended treatment options, including appropriate hospital admissions based on disease severity.

According to the guidelines, COVID-19 patients with moderate, severe, and critical disease categories were to be admitted to COVID-19 treatment units (CTUs) housed at public referral hospitals (PRHs) such as Mulago NRH. These patients required a considerable amount of EM. With the surge of COVID-19 cases, especially during the waves, demand for COVID-19-leaning EM spiraled. The instituted COVID-19 spread control measures and high morbidity also interrupted the global and national HSC. The HSC was also affected when exporters of COVID-19-leaning EM prioritized national needs and curtailed exportation at the expense of countries like Uganda. EM prices escalated partly due to the resultant demand-

supply forces. As a consequence, the surge in the demand for COVID-19-leaning EM was not met with matching supply. This required PRHs such as Mulago NRH to adopt coping mechanisms to continue delivering existing services in addition to handling COVID-19 clinical care. And for these, EM were critical.

The EM demand surge and associated price escalation resulted in high expenditure on COVID-19-leaning EM. In Uganda, this cost was borne by PRHs such as Mulago NRH utilizing their unadjusted essential medicines and health supplies credit line budget (EMHS CLB). EMHS CLBs for PRHs are funded by the GoU and development partners under Vote 116 of the National Medical Stores (NMS) [29]. However, this budgetary provision was already inadequate and incapable of meeting EMHS demands before the pandemic [30]. This necessitated adjustments to EMHS orders to accommodate COVID-19-leaning EM, and this adjustment was most pronounced during the waves.

The extent of the EM order quantity adjustments and EM price changes, as well as the existing coping mechanisms deployed by Mulago NRH to meet EM demands arising from the pandemic were not systematically investigated. Therefore, this study assessed the effect of COVID-19 on EM order quantities and prices for Mulago NRH in Kampala.

### 1.3 Problem Statement

Mulago NRH's EM orders are based on annual procurement plans with little or no deviation from the planned quantities. However, during the COVID-19 pandemic, especially during the waves, order quantities greatly varied due to significant escalation in demand for COVID-19-leaning EM. At the same time, prices especially for COVID-19- leaning EM also escalated as a result of global and national HSC disruptions. The variation in order quantities was reflected in increased number of emergency orders.

During the COVID-19 pandemic, GoU financed the health sector to enable it cope with the pandemic. This financing prioritized recurrent (salaries of recruited staff, surveillance staff allowances, and provisions of medical supplies like personal protective equipment and sanitizers) and development expenditures (purchase of ambulances, intensive care unit (ICU) beds, ventilators, and oxygen), and excluded EM [31]. This exclusion was partly attributable to lack of prior knowledge to forecast the effect of COVID-19 on related EM order quantities and prices. The inability to forecast this effect made it impractical to make contingency budgetary provisions. Therefore, PRHs such as Mulago NRH met COVID-19 EM requirements amidst escalating EM prices and HSC disruptions without corresponding

supplementary budgetary provision. Mulago NRH adjusted its EMHS orders among other coping mechanisms to accommodate COVID-19 EM requirements within the existing EMHS CLB. Moreover this budget was inadequate for EM even before the pandemic [30].GoU's intervention to better meet EM requirements during pandemic situations may take the form of contingency budgetary provisions referencing the effect of COVID-19 on EM order quantities and prices for Mulago NRH.

This study, therefore, assessed the effect of COVID-19 on EM order quantities and prices, as well as explored coping mechanism deployed by Mulago NRH in meeting EM demand.

## 1.4 Purpose of the Study

This study assessed the effect of COVID-19 on EM order quantities and prices, as well as explored existing and necessary coping mechanisms deployed by Mulago NRH in meeting EM demand arising from the COVID-19 pandemic.

## 1.5 Research Objectives

### 1.5.1 General Objective

To assess the effect of COVID-19 on essential medicines order quantities and prices for Mulago national referral hospital.

### 1.5.2 Specific Objectives

The specific objectives of this study are:

a) To assess trend of essential medicines order quantities for Mulago national referral hospital before and during the COVID-19 period.
b) To assess trend of essential medicines prices for Mulago national referral hospital before and during the COVID-19 period.
c) To explore coping mechanisms deployed by Mulago national referral hospital towards meeting emerged essential medicines demands during the COVID-19 pandemic.

## 1.6 Research Questions

The research questions of this study are:

a) What is the trend of essential medicines order quantities in relation to COVID-19 patient numbers for Mulago national referral hospital before and during COVID-19?

b) What is the trend of essential medicines prices in relation to COVID-19 patient numbers for Mulago national referral hospital before and during COVID-19?
c) What are the coping mechanisms deployed by Mulago national referral hospital towards meeting emerged essential medicines demands during the COVID-19 pandemic?

### 1.7 Significance of the Study

The extent of the effect of COVID-19 on EM order quantity adjustments and EM price changes, as well as the existing coping mechanisms deployed by Mulago NRH to meet EM demands, has been systematically investigated. The findings of this study may be used to guide stakeholders, including GoU and health development partners, to better understand and mitigate the effect of COVID-19 on EM order quantities and prices. This study provides recommendations to inform policy and interventions to ensure the adequacy of EM, control of EM prices during future pandemic situations as well as the build coping capacity for PRHs in Uganda.

### 1.8 Delimitations

The study focused only on Mulago NRH and excluded other PRHs in Uganda that managed COVID-19 patients.

The study focused only on moderate, severe, critical COVID-19 disease categories and excluded the mild category.

The study only considered the effects of COVID-19 on EM order quantities and prices during the period of March 2018 to March 2022.

The study only considered the effects of COVID-19 on EM order quantities and prices and did not consider other factors that may have affected these outcomes, such as changes in demand, changes in healthcare policies, supply chain disruptions and economic conditions.

The study used a mixed-methods approach, which limited the depth of analysis for each individual method.

The study focused on only EM listed within the Essential Medicines and Health Supplies List of Uganda (EMHSLU), 2016 excluding other critical medicines used in COVID-19 clinical management.

## 1.9 Limitations

The study focused on moderate, severe and critical disease categories, excluding the mild severity. This may have undermeasured the extent of the disease burden with the consequence of distorting the integrated measure of COVID-19 patient numbers and severity, the representative measurement of COVID-19.

The study excluded patients who lacked confirmatory laboratory test results, yet such patients were also managed and consumed the same medicines when they presented with COVID-19 symptoms. This resulted in understatement of patient numbers for the study.

The unreliability of the COVID-19 confirmatory laboratory tests resulted in false results which, for this study, could have distorted the patient sample selection.

Due to insufficient record data, some EM orders were not available nor usable to extract EM order quantities which resulted in omission of possibly result impacting data.

Some of the referenced orders were follow-up (repeat orders) arising from non-delivery and this was not discernable. This resulted in overstatement of EM order quantities.

The study investigated linear relationships while other, curved-linear or non-linear relationships may have existed and been more explanatory.

The study was limited by the mixed methods design which did not allow for comprehensive exploration of all associated factors and variables.

The study was limited to Mulago NRH and may not be generalizable to other PRHs in Uganda and other countries.

The study did not capture all factors that could affect EM order quantities and prices, such as changes in demand, supply chain disruptions and government policies.

# CHAPTER 2. LITERATURE REVIEW

In this chapter, the relevant literature regarding the COVID-19 pandemic and its impact on order quantities and prices in emergency management was reviewed. The purpose was to explore the connection between the variables under study. The review of literature (theoretical and empirical) was done in accordance with the objectives of the study to lay down a framework or identification of relevant literature, assessment, and critique of previous studies, and identification of gaps in literature that this study sought to fill. This chapter also presents the study's conceptual framework.

## 2.1 Theoretical review

Several theories and models explain and describe how medicines utilization varies including in times of emergency such as pandemics. This study was based on the theory of change. This theory provides a framework to evaluate how interventions or events lead to outcomes. In the context of this research topic, the theory of change helped identify how COVID-19 may have affected the EM order quantities and prices for Mulago NRH.

Given that this study sought to assess the trend in EM order quantities and prices for Mulago NRH just-before and during the COVID-19 pandemic, the theory helped identify and relate changes in patient numbers and, EM order quantities and prices.

By adopting the theory of change approach, the researcher gained comprehensive understanding of the direct and indirect factors that impacted EM during the pandemic with focus on patient numbers, disease severity, EM order quantities and EM prices. The study also identified potential strategies and interventions to ensure adequacy of EM and control of EM prices during future pandemics.

## 2.2 Empirical review

### 2.2.1 COVID-19 pandemic in Uganda

The COVID-19 pandemic posed significant challenges to national, regional and global capacities across different aspects [32]. Low-income countries, including Uganda, faced notable difficulties in addressing the pandemic, similar to previous outbreaks like HIV in the 1990s and Ebola in the mid-2010s [33]. The impact of the COVID-19 pandemic was multi-sectoral but more palpable in the healthcare system.

At the start of March, 2020 GoU developed a COVID-19 preparedness and response plan structured on eight pillars including case management, logistics and operations, and continuity of essential services. The case management pillar stipulated that patients with moderate to critical disease are hospitalized in PRHs such as Mulago NRH. The logistics and operations pillar ensured that supplies to deliver all planned services are quantified and procured, while the continuity of essential services pillar ensured uninterrupted essential services and sustains the response to other disease outbreaks [28]. The case management pillar was additionally tasked with development and publication of up to-date NGMC [6]. The guidelines document is a reference for health workers on appropriate clinical management of COVID-19. The clinical management is guided by disease severity categories of mild, moderate, severe and critical COVID-19. Patients with moderate disease present with pneumonia without need for oxygen and those with severe disease require oxygen therapy. Patients with critical disease exhibited symptoms such as acute respiratory distress syndrome and a range of sepsis-related conditions, including systemic inflammatory response syndrome, sepsis, severe sepsis, and septic shock, with multiple organ damage. Patients with severe disease require high dependence care while those with critical disease require intensive care [6]. At PRHs including Mulago NRH, CTUs were set up with capacity to meet healthcare needs for the moderate to critical disease categories.

The clinical care described in the NGMC informed the formulation of Uganda's COVID-19 medical countermeasures list. The list guides procurement, supply and rational use of the EMHS.

GoU's financial interventions for COVID-19 health care excluded EM [31]. PRHs including Mulago NRH financed the required EM (COVID-19-leaning EM) using the existing EMHS CLB that were not adjusted to accommodate CTU requirements. This necessitated adjustment of hospital EMHS orders to accommodate CTU requirements, including COVID-19-leaning-EM, at the expense of other health care requirements. WHO indicated that like is the case of many other countries Uganda's priority diseases were compromised when personnel and resources were diverted to COVID-19 management [34].

### 2.2.2 Essential medicines and health supplies orders for Mulago national referral hospital

EM are fundamental for GoU delivering on the national minimum health care package [35]. EM should meet certain criteria including being of high quality, easily accessible, affordable,

and used appropriately. NMS is mandated to procure, store and distribute EMHS to all public facilities including Mulago NRH [36]. EMHS orders are generated based on corresponding financial year (FY) procurement plans and comprise items (including EM), item quantities, and prices. These orders are placed routinely on monthly or bimonthly basis [3]. Routine EMHS orders for Mulago NRH are monthly. Additionally, emergency orders are made. Mulago NRH uses a pull (order-based) system to order for EMHS from NMS. These orders trigger supply of the ordered for items.

Public hospitals in Uganda including Mulago NRH develop annual EMHS procurement plans based on past consumption, morbidity levels, pre-fixed budgetary allocation, the Essential Medicines and Health Supplies List of Uganda (EMHSLU), among other factors. These plans are shared with NMS for aggregation to inform the procurement plan at national level. The procurement plans are priced to form annual procurement budgets. EMHS orders follow procurement plans with no more than 20% quantity deviation [3]. EMHS orders are designed to maintain and replenish desired stock levels, and to sustain universal access to medicines. Actual item prices are determined by NMS, and reflected at the time of delivery as indicated in the delivery notes/invoices.

The EMHSLU lists safe, efficacious, and cost-effective EMHS most appropriate for Uganda's healthcare needs. These items are categorized by level of care, and also by the Vital, Essential and Necessary (VEN) classification. The VEN classification prioritizes items according to health impact, to ensure that adequate stock levels of life-saving EMHS are maintained at SDPs [2].

The requirements for clinical care of COVID-19 necessitated deviation from the procurement plans to accommodate COVID-19-leaning EM. The deviation often exceeded the 20% quantity limit and included items not planned for [3].

### 2.2.3 Effect of the COVID-19 pandemic on essential medicines order quantities

Assuming negligible wastage and rational use, EM order quantities are inferable to utilized quantities. Order quantities are based on existing demand. Several studies on EM demand, utilization and sales, during and before the COVID-19 pandemic, have been conducted. When specific EM were considered effective and were recommended for COVID-19 treatment, their demand and utilization escalated.

For instance, a study in Germany reported increased utilization of +110% for Hydroxychloroquine and +111% for Paracetamol (Acetaminophen) at the onset of the

pandemic in March 2020. In contrast, the utilization of Azithromycin and other antibiotics decreased by 55% and 2% respectively, compared to 2019 [37].

A similar study in Italy noted that public hospitals experienced escalation in demand of various medicines used in the treatment of COVID-19. The study reported that the mean relative difference in drug demand between the COVID-19 period and the pre-COVID-19 period was highest for Hydroxychloroquine (4661.67%) and Azithromycin (195.40%) [38]. Similarly, demand for injectables such as muscle relaxants, general anesthetics, Ascorbic acid (Vitamin C) and antithrombotic agents among others escalated.

Comparably, community pharmacies in Jodhpur, India reported an increase in sales of Hydroxychloroquine, Azithromycin, Ivermectin, and Vitamin C of 25%, 25-50%, 50-75% and 75-100% respectively during the pandemic [38]. Another study in Nigeria showed a substantial escalation in the utilization of antibiotics (46.7%), Vitamins/Immune boosters (96.7%) and Hydroxychloroquine (100%) [19].

Given that there was no specific medicine approved for treatment of COVID-19, patients receive potentially effective drugs, drugs under compassionate drug use program, participate in clinical trials, or self-medicate. More so, several countries published national guidelines recommending treatment options for COVID-19. This was reflected in the differing demand trend for specific EM across different countries, and within some countries over time.

For example, at the start of the pandemic, Hydroxychloroquine (an antimalarial and a treatment of rheumatoid arthritis and systemic lupus erythematosus) was recommended as a possible medicine for COVID-19 treatment, hence increased in demand and utilization as reported in Germany, Italy, India and Nigeria. Later, demand and utilization decreased as studies showed no benefit of use as post-exposure prophylaxis or as a COVID-19 treatment [39]. A similar demand trend was reported about Azithromycin, an antibiotic with anti-inflammatory, immunomodulatory, and anti-fibrotic effects as of Hydroxychloroquine. The decrease could be attributed to the increased scrutiny and concern surrounding antimicrobial resistance [40].

A study in India reported that due to increased scrutiny of the different COVID-19 treatment options, there was no utilization of antimalarial medicines (such as Hydroxychloroquine) despite recommendations, and a decline for antibiotics such as Azithromycin as reported by 45% and 57.7% of pharmacies respectively [41].

In cases where several drugs belonged to a single therapeutic class, and one was selected over the rest, its demand and utilization increased relatively more. For example, Paracetamol was recommended in treatment of COVID- 19 related fevers and myalgia over other analgesics such as NSAIDs. NSAIDs at the start of the pandemic had been associated with an elevated risk of adverse effects in patients with acute viral respiratory infections, including COVID-19 [42].

The demand growth for muscle relaxants, general aesthetics and antithrombotics in Italy could be attributed to the high numbers of critically ill patients that required them [43].

While several studies have been conducted to understand the demand and utilization of EM and the ultimate effect it had on order quantities during the COVID-19 pandemic in different parts of the world, there is a dearth of research specific to Uganda. Given the unique context and challenges faced by healthcare facilities in low-resource settings like Uganda, it was important to study the demand, order and utilization of EM at Mulago NRH during the pandemic.

### 2.2.4 Effect of the COVID-19 pandemic on essential medicines prices

Several studies on EM pricing, during and before the COVID-19 pandemic, have been conducted. It has been generally found that EM prices increased especially for COVID-19-leaning EM.

Case in point, a study in Ecuador established that the prices of medical commodities experienced a sharp increase during the first few months of the COVID-19 pandemic. Prices for some commodities were significantly inflated compared to their typical market value. Compared with 2019, the mean price of EM such as Paracetamol (Acetaminophen) 500 mg pills had increased up to 796%. Although the prices of these commodities oscillated greatly since 2019, the increase in April and May 2020 is evidently attributable to the pandemic, given that COVID-19 disease commonly presents with a high fevers and myalgia alongside other signs and symptoms [17].

A study among selected regions in India established that over 50% of community pharmacies registered price increase for analgesics (such as Paracetamol) [44]. A similar trend in price increase for analgesics was observed in Ecuador study above.

A study in an urban population of northern Nigeria established that there was price increase of 93.3%, 96.7%, and 66.7% for antimalarials, antibiotics, and vitamins/immune boosters respectively [19].

Another study on the impact of the COVID-19 pandemic on consumers' access to essential medicines in Nigeria affirms that one of the key challenges impacting access to essential medicines was the high cost of medicines [45].

On the contrary, a study among pharmacy and drug stores in Bangladesh, reported no increase in prices in 50%, 65.3%, 54.7% and 51.8% of the stores for antimalarials, antibiotics, analgesics, and vitamins respectively [46]. This may be attributed to the fact that Bangladesh is a manufacture of generics for mentioned drugs and therefore they met growing demand and at not necessarily an increased cost [47].

Similarly, a study in Saudi Arabia indicated that 70% of the respondents reported no significant price changes for prescription drugs that were in shortage during the pandemic [48]. This was attributed to the effective exchange programs between Saudi hospitals' and the increased public healthcare spending to reduce the impact of COVID-19 on the healthcare sector.

Increase in prices of suggested medicines to treat COVID-19 was also linked to disruptions in the supply of APIs for manufacturing the EM. China, the biggest and cheapest source of APIs and the epicenter of the virus, instituted trade restrictions, curtailing supply of APIs [49], consequently increasing EM costs and prices.

In Uganda, PRHs such as Mulago NRH financed the purchase of CTU requirements off their EMHS CLB. It may be argued that dramatic price escalations of EM eventually led to reduced order quantities due to insufficient EMHS budgets. Besides, Uganda's health sector demand for EM is highly reliant on imports [50] and this may also have influenced price increases. Uganda is a free market economy [51] where the government does not control commodity pricing and this is the case for EM prices.

### 2.2.5 Coping mechanisms deployed towards meeting emerged essential medicines during the COVID-19 pandemic

Medicines are important in delivering quality health services [52], but disruptions arising from the COVID-19 pandemic have negatively affected their availability and accessibility [53]. In the event of disruptions, as those triggered by the COVID-19 pandemic, national

HSC including SDPs such as Mulago NRH deployed strategies to reduce the severity and duration of the disruptions. These strategies constitute coping mechanisms. Coping mechanisms include supply chain visibility (SCV), supply chain redundancy (SCR) and supply chain collaboration (SCC) [54] [55].

SCV entails having timely and accurate demand and inventory information across the HSC to inform demand forecast [56]. Several countries have achieved SCV, for example, in United States of America, the Food and Drug Administration and American Society of Health-System Pharmacists publish drug shortage lists consisting of COVID-19 medicines [57][58]. In Europe, the European Medicines Agency publishes a similar list [59]. In Uganda, SCV in the public sector is supported by an electronic emergency logistics management information system, a web-based tool that provides real-time data on the availability of EMHS at national, regional, district and SDP levels [60].

SCR entails having buffer stock, rationalized utilization and pre-qualification of a large pool of suppliers who are activated during disruptions, among others [61]. SCR has limitations for example, in Uganda, hospital budgets can barely afford additional stock beyond what is immediately needed. SCR during COVID-19 was observed mainly at the start of the pandemic when several countries pursed nationalistic policies that enforced export controls to maintain national buffers of health supplies [62]. Unfortunately, this limited supply of needed health commodities to other nations. The United Kingdom (UK) maintains a country buffer stock of medicines of up to six months [63]. These supplies held up UK's HSC during the pandemic, despite spikes in demand, disruption to production and freight, and export bans in some countries [63]. Another country that maintain national stockpiles is Finland where Finnish pharmaceutical companies, healthcare units and importers are required to maintain a stockpile of medications for a period of 3–10 months. The Finnish government provides compensation to cover the expenses associated with preserving such reserves [64].

Rational utilization includes measures such as transfer of case management supplies (medical equipment, supplies, and medicines) from non-essential to essential departments or units and repurposing of medical equipment, in response to COVID-19. Anesthesia machines may be repurposed to mechanical ventilators [65]. In support of global and national efforts to increase access to affordable medicines for treatment of COVID-19, WHO prequalifies manufacturers of these medicines, a list which maybe referenced by national regulatory authorities and national procurement units without having to conduct further assessment [66]. This is essential during emergency procurements as well as in situations when the national

regulatory authorities and national procurement units are constrained in evaluation of manufacturers and products.

SCC entails building mutually beneficial alliance with other supply chain stakeholders to leverage synergy as a means of attaining common supply chain objectives [67]. SCC was noted in Saudi Arabia through the country's effective medicines exchange program that mitigated COVID-19 EM unavailability [48]. In Uganda, SCC is realized through Uganda's national redistribution strategy for prevention of expiry and handling of expired medicines and health supplies[68]. The strategy guides HSC actors in the redistribution of EMHS across health facilities. This practice reduces expiries and increases availability of EMHS.

### 2.2.6 Summary

The literature review has explored the effect of COVID-19 on EM order quantities and prices for Mulago NRH. The review includes both theoretical and empirical perspectives.

The theoretical review applied the theory of change to explain the effect of the pandemic on EM order quantities and prices, and how access to EM can be sustained during pandemics.

The empirical review discussed Uganda's response to COVID-19 particularly the health sector. GoU developed a COVID-19 preparedness and response plan that stipulated varying roles of different players. Mulago NRH played a leading role in clinical management of moderate to critical COVID-19 cases. The pandemic led to adjustments in the hospital's EMHS orders, deviating from annual procurement plans, to accommodate increased demand for certain EM especially the COVID-19-leaning.

The review also explored the effect of the COVID-19 pandemic on EM order quantities. Studies conducted in different countries indicated that the demand and utilization of specific EM increased during the pandemic, particularly those recommended for COVID-19 treatment. Demand trends varied across countries and changed over time as new evidence emerged regarding the effectiveness of certain medicines.

Studies showed that prices increased during the pandemic, especially for COVID-19-leaning EM. The disruptions in the supply chain, including trade restrictions and shortages of active pharmaceutical ingredients (APIs), contributed to the price escalations. However, some countries did not experience significant price changes, possibly due to local manufacturing of generic drugs.

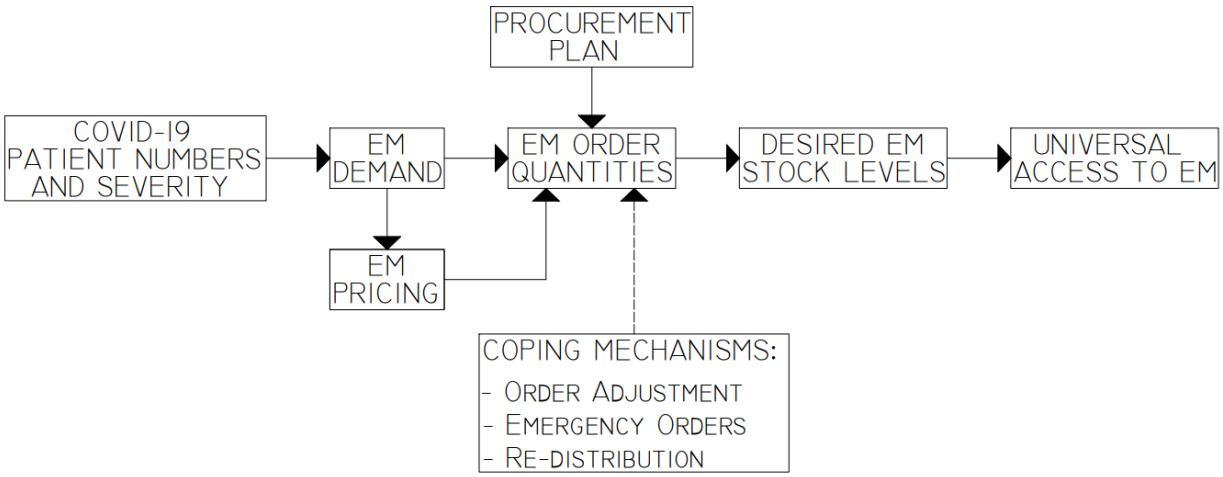
Lastly, the review discussed coping mechanisms employed to meet the demand for EM during the pandemic. These mechanisms included enhancing SCV, SCR, and SCC. Countries implemented strategies to monitor drug shortages, share information, and collaborate to mitigate disruptions and ensure availability of EM.

## 2.3 Conceptual framework

Demand for EM increases with COVID-19 patient numbers and disease severity. Disease severity is in categories of moderate, severe and critical. With increase in COVID-19 patient numbers of differing severity, demand for COVID-19-leaning EM increases [69]. Some studies indicated that increased demand for COVID-19-leaning EM with unmatched supply led to COVID-19-leaning EM price escalation [70]. In Uganda, under normal circumstances EMHS orders do not vary much from corresponding FY procurement plans. EMHS orders are structured to maintain and replenish desired stock levels, and to sustain universal access to medicines. During the pandemic, requirements for clinical management of COVID-19 necessitated deviation from procurement plans to accommodate COVID-19-leaning EM. The deviation was with consideration for prevailing prices, themselves (the prices) escalating. Accordingly, coping mechanisms were deployed to meet escalating EM demand under escalating EM prices, to generate adjusted EM order quantities.

For this study, COVID-19 (the independent variable) was conceived to manifest in form of patient numbers of three disease severities namely moderate, severe and critical. The dependent variables were EM order quantities and prices.

The conceptual framework showing the relationship between the COVID-19 pandemic and EM orders at Mulago NRH is illustrated in figure 2.1.




(*Illustration developed by researcher from literature)*

**Figure 2.1 Conceptual framework illustrating the effect of the COVID-19 pandemic on essential medicines order quantities and prices**

# CHAPTER 3. METHODOLOGY

This chapter laid down the methodology that guided the study. It presented the study design, study setting, population of study, sample size, description and selection, data sources, data collection methods and instruments, data processing, study variables, data analysis, quality assurance, ethical considerations as well as health and safety measures taken during the research.

## 3.1 Study design

A concurrent mixed methods study was conducted. The quantitative aspect involved a retrospective longitudinal review of data to assess trend of EM order quantities and prices for Mulago NRH from March 2018 to March 2022 (two years just before and the first two years of the COVID-19 pandemic). The qualitative aspect of the research was exploratory and involved investigation of coping mechanisms deployed by Mulago NRH towards meeting emerged EM demands during the COVID-19 pandemic. The mechanisms included order quantity adjustments, inter-institutional EM redistribution, procurement of donations and cost-sharing with patients.

The longitudinal study design was appropriate as it enabled identification of trend of EM order quantities and prices over the study period. The researcher was able to assess how EM order quantities and prices fluctuated before and during the pandemic giving insight to inform future planning and resource allocation.

The exploratory study design was appropriate as there was limited existing knowledge on the coping mechanisms deployed by Mulago NRH in response to the challenges posed by the COVID-19 pandemic. Through key informant interviews (KIIs), the researcher gained understanding of copying mechanisms deployed by Mulago NRH from the perspective of the informants, void of researcher bias.

The `best of both worlds' (mixed methods) approach which this study adopted enabled description and explanation of the study aspects.

## 3.2 Study setting

The study was conducted at Mulago NRH the largest public and referral hospital in Uganda. It is located in Kampala, Uganda. It is also a teaching facility of the College of Health Sciences, Makerere University [71]. The hospital accommodated the largest CTU and managed the highest number of COVID-19 patients in Uganda. As of 12$^{th}$ July 2021,

Uganda's PRHs had 1500 standard beds, 415 high dependence unit (HDU) beds and 177 ICU beds. Of these, Mulago NRH had 600 standard beds, 300 HDU beds and 27 ICU beds. The rest of the PRHs had an average of 60 standard beds, 8 HDU beds and 10 ICU beds [72]. As of 31st March 2022, Mulago NRH CTU admission records indicated 5,324 total admissions (unpublished data).

## 3.3 Study population

The study population for the quantitative data are medicines comprised in Mulago NRH's EMHS orders of March 2018 to March 2022. These orders are detailed by items including EM, item quantities and prices. And, the study population for COVID-19, are confirmed COVID-19 patients with varying disease severities managed at the Mulago CTU from the start of the pandemic to March 2022 documented in the Mulago NRH CTU in-patient report book.

The study population for the qualitative data comprised staff of Mulago NRH involved in ordering, receiving, issuing and utilizing EM, who were present during the study period and consented to participate in the study.

## 3.4 Data sources

The study collected both primary and secondary data.

### 3.4.1 Primary data sources

Primary data was collected from staff of Mulago NRH involved in ordering, receiving, issuing and utilizing EM, as key informants (KIs). Key informants included the executive director, the chairperson Medicines and Therapeutics Committee (MTC), the head CTU, clinical heads of the different directorates (internal medicine, pediatrics and child health, and surgery), pharmacists and other key persons involved in EM supply chain.

### 3.4.2 Secondary data sources

Secondary data was obtained from records of the pharmacy and stores departments, and the CTU. These records included: procurement plans for financial years 2017/2018, 2018/2019, 2019/2020, 2020/2021 and 2021/2022; EMHS orders from March 2018 to March 2022; NMS Invoice/Delivery Notes from March 2018 to March 2022 and the CTU inpatient report book. The records provided information on type of order (routine or emergency), EM monthly planned quantities, EM ordered quantities, EM prices at procurement planning, prices of EM

delivered, and daily COVID-19 patient numbers for the different disease severities of moderate, severe and critical.

### 3.5 Sample description

The quantitative component covered: all medicines comprised in Mulago NRH's EMHS orders of March 2018 to March 2022 and in the Essential Medicines and Health Supplies List of Uganda (EMHSLU), 2016 [2]; and COVID-19 patient numbers categorized by moderate, severe and critical disease severities that were managed at Mulago NRH CTU from the start of the pandemic to March 2022 as drawn from the CTU in-patient report book.

The qualitative component involved staff working in Mulago NRH with appropriate experience, knowledge and information on coping mechanisms deployed by Mulago NRH towards meeting emerged EM demands during the COVID-19 pandemic. The study considered only staff who were present during data collection for the study period and consented to participate.

### 3.6 Selection Criteria

#### 3.6.1 Inclusion criteria

For the quantitative data:

i) **EM sample:** Only medicines within Mulago NRH's EMHS orders of March 2018 to March 2022 and comprised on the EMHSLU, 2016.

ii) **COVID-19 patient numbers and severity sample:** All COVID-19 patient data for moderate, severe and critical disease severities as documented in the CTU in-patient report book, and with COVID-19 confirmatory laboratory results, from the start of the pandemic to March 2022.

For the qualitative data:

KI's for this study included the executive director, the chairperson MTC, the head CTU, pharmacists and other staff involved in EM supply chain with more than five years employment in Mulago NRH; and with appropriate experience, knowledge and information on coping mechanisms deployed by Mulago NRH towards meeting emerged EM demands during the COVID-19 pandemic, who were present during data collection for this study and consented to participate.

### 3.6.2 Exclusion Criteria

For the quantitative data:

**i) EM sample:** All vertical program EM (such as antimalarials, anti TBs and antiretrovirals) and EM with funding other than the EMHS CLB. These were excluded because they have no bearing on the hospital's EMHS CLB and the EMHS CLB has no bearing on them.

**ii) COVID-19 patient numbers and severity sample**

- All COVID-19 patients recorded in the Mulago NRH CTU in-patient report book with mild disease severity.
- All COVID-19 patients recorded in the Mulago NRH CTU in-patient report book but without record of disease severity.
- All COVID-19 patients recorded in the Mulago NRH CTU in-patient report without record of confirmatory laboratory test for COVID-19.

For qualitative data:

All members within the inclusion criteria but who were unable to complete the interview, for example, due to competing priorities or who did not consent to participate in the study.

## 3.7 Sample size determination

For the quantitative data, all EM selected from Mulago NRH's EMHS orders of March 2018 to March 2022, and all COVID-19 patient numbers categorized by disease severity that met the eligibility criteria defined in section 3.5 were studied.

For the qualitative data, nine KIs were interviewed, and to this extent, data saturation was attained.

## 3.8 Sampling Procedure

### 3.8.1 Quantitative sampling

For the quantitative EM data, sampling followed the steps below.

Step 1: Selected all medicines comprised in Mulago NRH's EMHS orders of March 2018 to March 2022.

Step 2: From the selected medicines, only medicines comprised in the EMHSLU 2016 were selected.

Figure 3.1 illustrates the quantitative sampling for EM data.

For the quantitative COVID-19 patient data, sampling followed the steps below.

Step 1: Extracted all COVID-19 patient numbers comprised in Mulago NRH CTU in-patient report book from the start of the pandemic to March 2022.

Step 2: From the above numbers, only those with disease severities of moderate, severe and critical; and with confirmed positive SARS-CoV-2 polymerase chain reaction test were considered.

Figure 3.2 illustrates the quantitative sampling for COVID-19 patient data.

### 3.8.2 Qualitative Sampling

For the qualitative data, the participants were purposively selected based on their appropriate experience, position and access to information related to the coping mechanisms deployed by Mulago NRH towards meeting emerged EM demands during the COVID-19 pandemic. Table 3.1 comprises the list of interviewed staff.

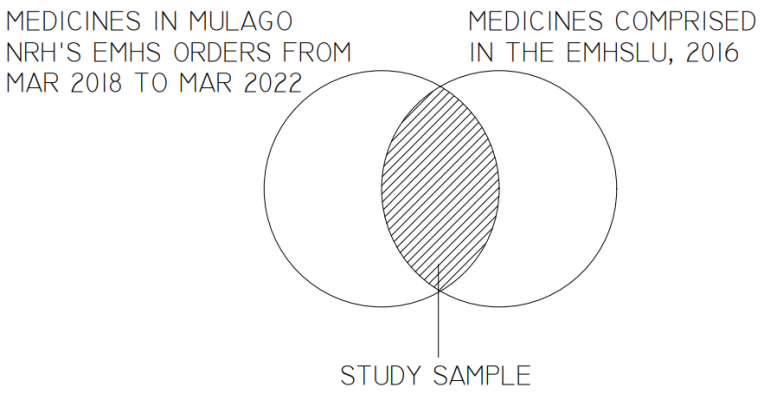



**Figure 3.1 Venn diagram illustrating the sampling of essential medicines data**

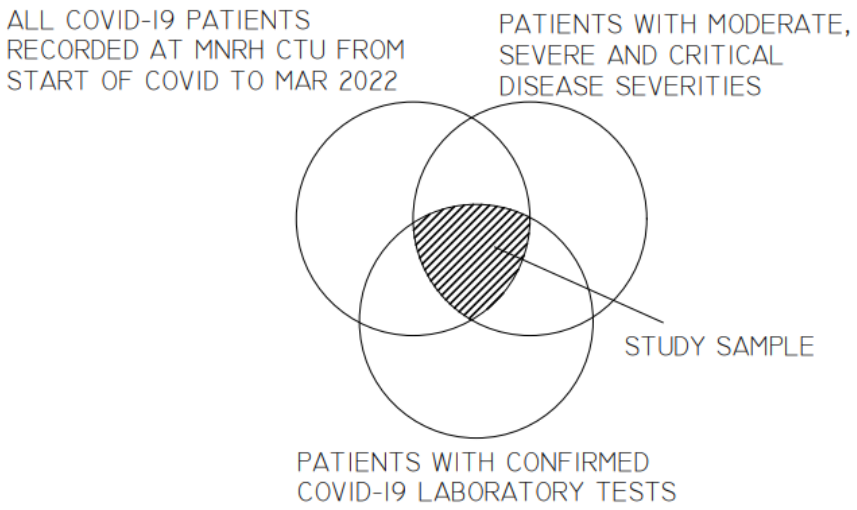



**Figure 3.2 Venn diagram illustrating the sampling of COVID-19 patient data**

**Table 3.1 A table of Key Informants (KIs)**

| No. | Individuals to be interviewed | Number to be interviewed |
|---|---|---|
| 1 | Executive Director | 1 |
| 2 | MTC Chairperson | 1 |
| 3 | Pharmacists | 2 |
| 4 | Head of stores | 1 |
| 5 | Head of CTU | 1 |
| 6 | Clinical Heads of Directorates | 3 |
| **Total** | | 9 |

### 3.9 Sample Size

For the quantitative study, sampling yielded:

- The EM sample as tabulated in Appendix A. It comprises 142 EM out of a total of 237 medicines that were ordered during the period of March 2018 to March 2022.

- COVID-19 patient statistics in form of patient numbers for moderate, severe and critical disease severities.

For the qualitative study, sampling yielded nine KIs.

## 3.10 Data collection methods and tools

### 3.10.1 Quantitative data collection methods and tools

Data applicable to specific objectives (a) and (b) of the study was collected from desk review of pharmacy and stores department records of Mulago NRH, and entered directly in online data abstraction sheets designed in EpiData Manager version 4.6 of the EpiData Association, Odense M, Denmark. The data abstraction sheets had variables including: month and year; type of order; item description; planned monthly quantity; order date; ordered quantity; delivery date and delivery note/invoice unit price; and daily patient numbers for three disease severity categories moderate, severe and critical. Data was collected by the researcher and two research assistants with a pharmacy training background. Research assistants were trained on the protocol, data collection procedures, and data entry prior to data collection. The designed abstraction sheets for quantitative data are attached in Appendix B as Annexures I and II.

### 3.10.2 Qualitative data collection methods and tools

Data applicable to objective (c) of the study was collected using a structured key informant interview (KII) guide and after signing of the consent form. The developed KII guide is attached as Annexure III of Appendix B and the consent form as Appendix C. Data was collected in the form of written field notes and audio recordings. KIIs were double audio-recorded to enable reconciliation in case of poor-quality audio. Both audio recordings and notes were used to extract the exact words, phrases and whole sentences as stated by the KIs. The duration of each interview was approximately 25 minutes. All interviews were conducted and audio recorded by the research assistants. The collected data was backed up on different flash drives.

## 3.11 Data processing

The data entered in EpiData Manager was iteratively exported to Microsoft Excel (Microsoft Office 2021, Microsoft Corporation, Redmond, Washington, USA) for entrant 1 and entrant 2 and compared to check for discrepancies to enable verification and corrections until no more discrepancies were detected. The final corrected data set was then imported into Statistical Package for the Social Sciences (SPSS) statistics version 22.0 from Microsoft Excel. In SPSS statistics version 22.0, additional variables such as the monthly average number of COVID-19 patients (discrete data), the weighted numerical value that integrates severity with number

of COVID-19 patients (continuous data), the normalized monthly order quantity deviation for each specific EM (continuous data); the integrated monthly EM order quantity representative of each of the two EM categories (continuous data), the normalized EM price deviation for each specific EM (continuous data), and the integrated monthly price of all EM in each EM category.

The recorded KIIs data was transcribed into Microsoft Word by the two research assistants independently. The transcripts were proofread by two experts independently before importing them into ATLAS.ti version 8, a qualitative data analysis software. The process started with uploading three randomly selected transcripts to develop coding (sub-themes). On this basis, the rest of the transcripts were coded. Further coding yielded themes. The themes were validated to make sure no themes had been left out. A report was generated.

### 3.12 Variables

The quantitative study variables are presented in table 3.2.

**Table 3.2 Quantitative study variables**

| **Independent variable (s)** | **Dependent variables** |
|---|---|
| Objective (a) To assess trend of essential medicines order quantities for Mulago national referral hospital before and during the COVID-19 period (of March 2018 to March 2022). | |
| 1. COVID-19 patient numbers (discrete data)<br>2. COVID-19 severity category (ordinal data) | Monthly EM ordered quantities (discrete data) |
| Objective (b) To assess trend of essential medicines prices for Mulago national referral hospital before and during the COVID-19 period (of March 2018 to March 2022). | |
| 1. COVID-19 patient numbers (discrete data)<br>2. COVID-19 severity category (ordinal data) | EM prices on monthly delivery notes/invoices (continuous data) |

Qualitative data comprised verbatim responses and demeanour.

### 3.13 Data analysis

#### 3.13.1 Quantitative data analysis

In order to determine the effect of COVID-19 on EM order quantities and prices, interrupted time series analysis for the period March 2018 to March 2022 (two years just before and during the first two years of the COVID-19 pandemic) was performed, and the data analyzed using SPSS statistics version 22.0.

***Descriptive statistics***

Descriptive statistics included:

- Comparison of sample size with population size as a percentage.
- Stratification of EM by relevance to treatment of COVID-19 and co-morbidities resulting in classification into categories of COVID-19-leaning and non-COVID-19-leaning, described in form of counts and percentage as illustrated in table 3.3.

**Table 3.3 Descriptive statistics of EM relevance to COVID-19 treatment**

| Therapeutic classification | Number of EM | Percentage EM |
|---|---|---|
| COVID-leaning | | |
| Non-COVID-leaning | | |

- Emergency orders as a proportion of the total orders for respective months. This has been presented as a graphical plot of the proportion of the number of emergency orders to the total number of orders for respective months against time in months, as illustrated in figure 3.4.

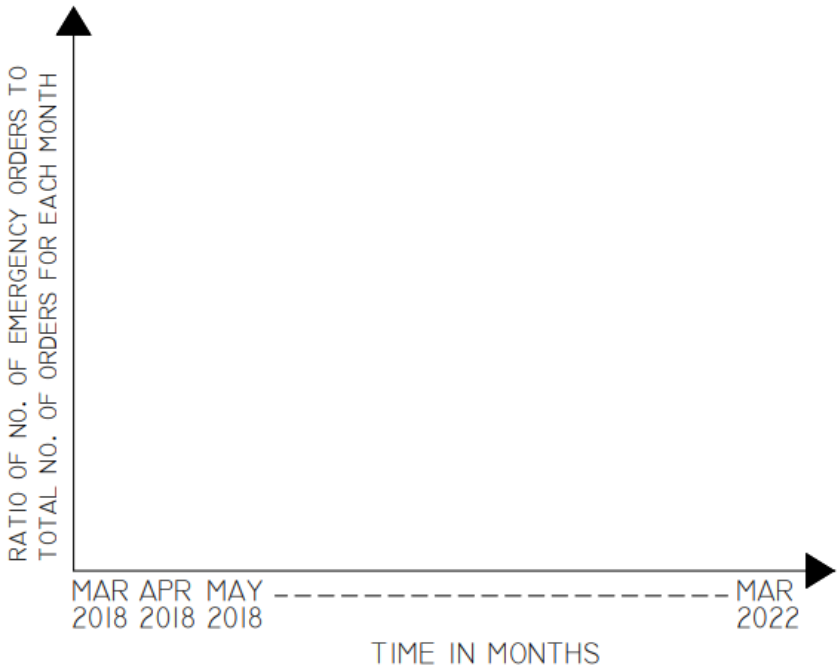



**Figure 3.3 Graphical plot of the ratio of number of emergency orders to total number of orders for respective months against time**

This has also been presented as an aggregated proportion of number of emergency orders to the total number of emergency orders over the two-year periods just before and during COVID-19, as illustrated in table 3.4.

**Table 3.4 Illustration of descriptive statistics for emergency orders**

| | | | |
|---|---|---|---|
| Total number of emergency orders in the two years just before COVID | | Total number of emergency orders in the first two years of COVID | |
| Total number of Orders in the two years just before COVID | | Total number of orders in the first two years of COVID | |
| Ratio of total number of emergency orders in the two years just before COVID-19 to total number of orders in the two years just before COVID | | Ratio of total number of emergency orders in the first two years of COVID to total number of orders in the first two years of COVID | |

Figure 3.4 and table 3.4 were processed from orders data in table 4.3.

***Analysis for objectives (a) and (b)***

For objective (a) To assess trend of essential medicines order quantities for Mulago national referral hospital before and during the COVID-19 period (of March 2018 to March 2022), analysis was done as detailed below.

**Preliminary analysis**

Preliminary analysis was conducted to visualize the trend of EM order quantity deviations before and during the COVID-19 pandemic. The visualization was achieved by plotting super imposed trends of the representative numerical values of COVID-19 and EM order quantities in each of the two EM categories over the study period (March 2018 to March 2022).

COVID-19 was quantified by allocating and computing numerical values integrating COVID-19 patient numbers and severity. This was computed as explained below.

COVID-19 manifests in form of severity where severity for this study took on moderate, severe and critical disease categories. The other category was mild severity but this was excluded from analysis because whereas these cases were admitted at the start of the pandemic, they were later turned away to focus on the other categories as guided by the Uganda COVID-19 preparedness and response plan [28].

The monthly average number of COVID-19 patients was computed for each of the three severities using equation 3.1.

$$P = \sum_{x=1}^{x=n} P_x * \frac{1}{n}$$ ..... *Equation 3.1*

Where, $P$ is the monthly average number of COVID-19 for a specific severity

$P_x$ is the daily number of patients for the specific severity

*n* is the number of days in the month

The monthly average number of COVID-19 for each EM category has been tabulated in Appendix E.

Weighted numerical values that integrate severity with number of COVID-19 patients were computed using equations 3.2 to 3.6.

$$C = S_m * P_m + S_s * P_s + S_c * P_c$$ ……. *Equation 3.2*

Where, $C$ is the weighted numerical value that integrates severity with monthly average number of COVID-19 patients

$S_m$ is the weight associated with moderate disease

$S_s$ is the weight associated with severe disease

$S_c$ is the weight associated with critical illness

$P_m$ is the monthly average number of COVID-19 patients with moderate disease

$P_s$ is the monthly average number of COVID-19 patients with severe disease

$P_c$ is the monthly average number of COVID-19 patients with critical disease

Based on a study in Kenya that examined COVID-19 management costs, the cost per patient per day for management of patients with moderate, severe and critical COVID-19 disease in hospital was $63.70, $124.53 and $599.51 respectively [73]. By ratios, the three weights associated with disease severity were computed in equations 3.3 to 3.6.

$$S_m = \frac{63.70}{63.70 + 124.53 + 599.51} = 0.081$$ …….. *Equation 3.3*

Where, $S_m$ is the weight associated with moderate disease

$$S_s = \frac{124.53}{63.70 + 124.53 + 599.51} = 0.158$$ ……..…… *Equation 3.4*

Where, $S_s$ is the weight associated with severe disease

$$S_c = \frac{599.51}{63.70 + 124.53 + 599.51} = 0.761$$ ……...…...….. *Equation 3.5*

Where, $S_s$ is the weight associated with critical disease

$$C = 0.081P_m + 0.158P_s + 0.761P_c$$ ……. *Equation 3.6*

COVID-19 patient data was processed Figure 3.4 and table 3.4 were processed from orders data in Appendix D.

The weighted numerical values that integrate COVID-19 patient numbers and severity for each month have been tabulated in Appendix F.

EM was quantified by allocating and computing numerical values integrating all EM order quantities in each of the two EM categories. This was computed as explained below.

***Normalization of EM order quantity deviations:*** The deviation of monthly ordered quantities from monthly planned quantities was normalized over the monthly planned quantities as computed in equation 3.7.

$$E_n = \left(\frac{E_{order} - E_{planned}}{E_{planned}}\right) \quad \text{..... Equation 3.7}$$

Where, $E_n$ is normalized monthly order quantity deviation for each specific EM

$E_{order}$ is monthly ordered quantity for each specific EM

$E_{planned}$ is monthly planned quantity for each specific EM

***Integration of EM order quantities for each EM category:*** The integrated quantity of all EM in each of the two categories was computed using equation 3.8.

$$E_{n\_category} = \sum_{x=1}^{x=n} E_{n\_x} * \frac{1}{n} \quad \text{..... Equation 3.8}$$

Where, $E_{n\_category}$ is the integrated EM order quantity representative of each of the two EM categories

$E_{n\_x}$ is normalized monthly order quantity deviation for each specific EM as computed in equation 3.7

$n$ is total number of EM in each of the two EM categories

Note: The monthly EM planned quantities were the annual procurement plan quantities for the FYs 2018/2019, 2019/2020 and 2020/2021. For the FY 2021/2022, we referred to the previous FY (2020/2021) because the planned quantities for EM for FY 2021/2022 were adjusted to accommodate COVID-19 EM demands, making the latter plan unsuitable for reference.

Assumptions made included:

1) Items with no planned quantities for the respective FY but with ordered quantities were allocated the maximum normalized value in their respective months.
2) Items with no planned quantities for the respective FY, and not ordered, were omitted from analysis in those respective months.

***Data presentation (Graphical aids):*** The integrated EM order quantity representative of each of the two EM categories and the weighted numerical value that integrates severity with monthly average number of COVID-19 patients was plotted against time in months (over the 4-year period, March 2018 to March 2022) as illustrated in figure 3.2. This displays the trends of EM order quantity deviations from the planned over the study period for the two EM categories.

**Further analysis**

Further analysis was conducted to determine the relationship between COVID-19 (patient numbers and severity) and EM order quantities. This was achieved by a scatter plot of the monthly integrated numerical value that integrates severity with number of COVID-19 patients and the integrated monthly value that integrates EM order quantities for each EM category over the period of COVID-19 (March 2020 to March 2022). Lines of best fit were derived to describe the relationship. The scatter plots are illustrated in figures 3.3 and 3.4.

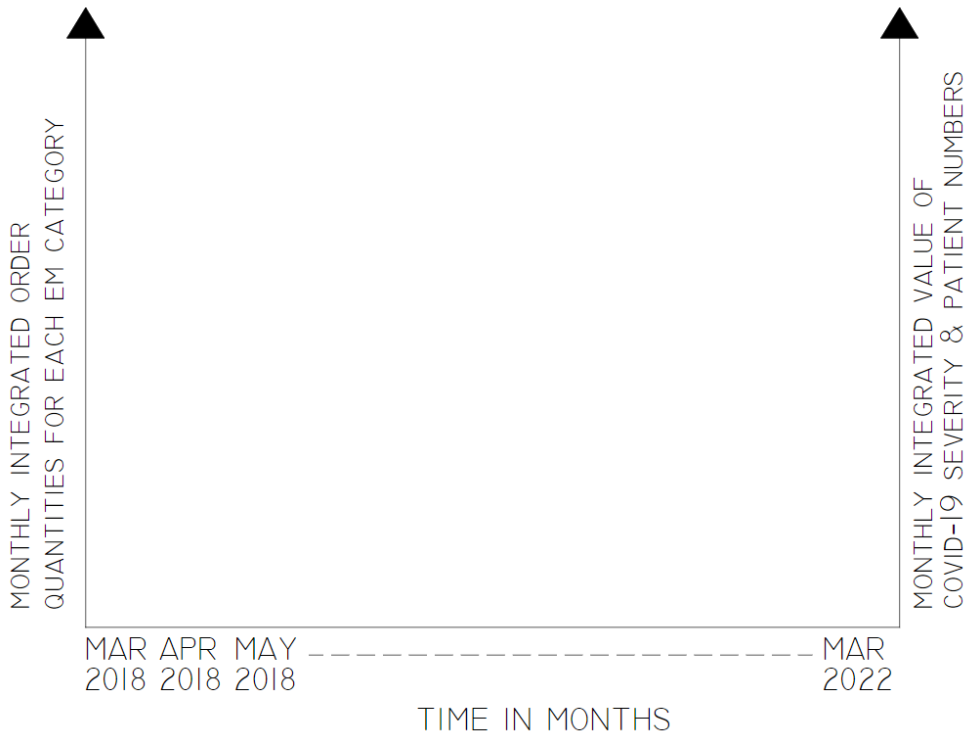



**Figure 3.4 Trends of COVID-19 and essential medicines order quantities for each essential medicines' category**

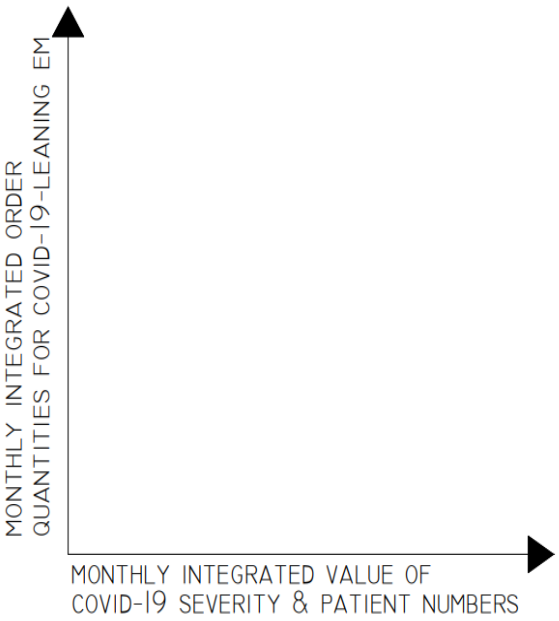



**Figure 3.5 Relationship between COVID-19 and order quantities for COVID-19-leaning essential medicines**

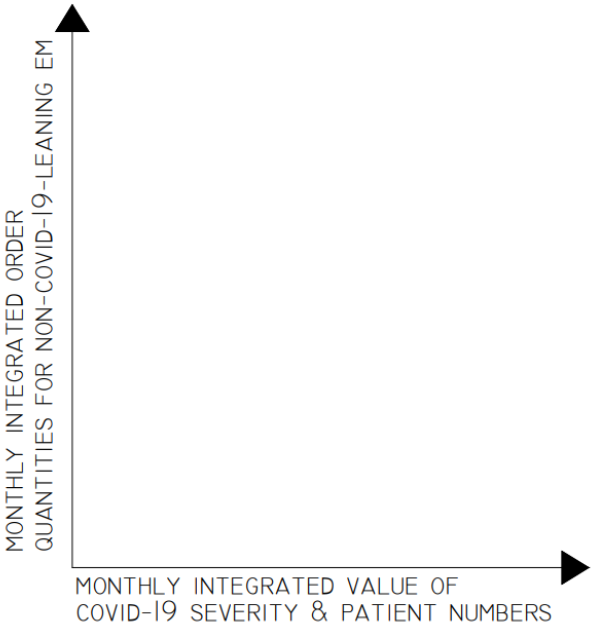



**Figure 3.6 Relationship between COVID-19 and order quantities for non-COVID-19-leaning essential medicines**

For objective (b) To assess trend of essential medicines prices for Mulago national referral hospital before and during the COVID-19 period (of March 2018 to March 2022), analysis was done as detailed below.

Analysis was conducted to visualize the trend of EM price deviations before and during the COVID-19 pandemic. The visualization was achieved by plotting super imposed trends of the representative numerical values of COVID-19 and numerical values of EM prices in each of the two EM categories over the study period (March 2018 to March 2022).

EM prices were determined by allocating and computing numerical values integrating all EM prices in each of the two EM categories. This was computed as explained below.

***Normalization of EM price deviations:*** The deviation of monthly delivery note/invoice EM prices from the annual procurement plan prices was normalized over the annual procurement plan prices as computed in equation 3.9.

$$P_{norm} = \left(\frac{P_{order} - P_{planned}}{P_{planned}}\right) \quad \text{…….. } \textit{Equation 3.9}$$

Where, $P_{norm}$ is normalized EM price deviation for each specific EM

$P_{order}$ is monthly delivery note/invoice EM prices for each specific EM

$P_{planned}$ is annual procurement plan prices for each specific EM

***Integration of EM prices for each EM category:*** The integrated price of all EM in each of the two EM categories was computed using equation 3.10.

$$P_{EM} = \frac{\sum_{x=1}^{x=n}(Q_x * P_{norm\_x})}{\sum_{x=1}^{x=n} Q_x} \quad \text{…..…… } \textit{Equation 3.10}$$

Where, $P_{EM}$ is EM price for each EM category

$P_{norm}$ is the EM price for EM x belonging to a particular EM category

$Q_x$ is total monthly order quantity for EM x

**Note:** The procurement plan EM price was the unit price as per the procurement plan for respective financial years. For the FY 2021/2022, we referred to the previous FY (2020/2021) because the planned quantities for EM for FY 2021/2022 were adjusted to accommodate COVID-19 EM demands, making the latter plan unsuitable for reference. EM items not priced in respective procurement plans and EM items not delivered/not ordered were excluded from analysis.

Items with no planned prices for the respective FY but with delivery note/invoice prices were omitted from analysis in those respective months.

***Data presentation (Graphical aids):*** The integrated EM prices representative of each of the two EM categories and the weighted numerical value that integrates severity with monthly average number of COVID-19 patients were plotted against time in months (over the 4-year period, March 2018 to March 2022) as illustrated in figure 3.5. This was displayed by plotted trends of EM price deviations from the planned over the study period for the two EM categories.

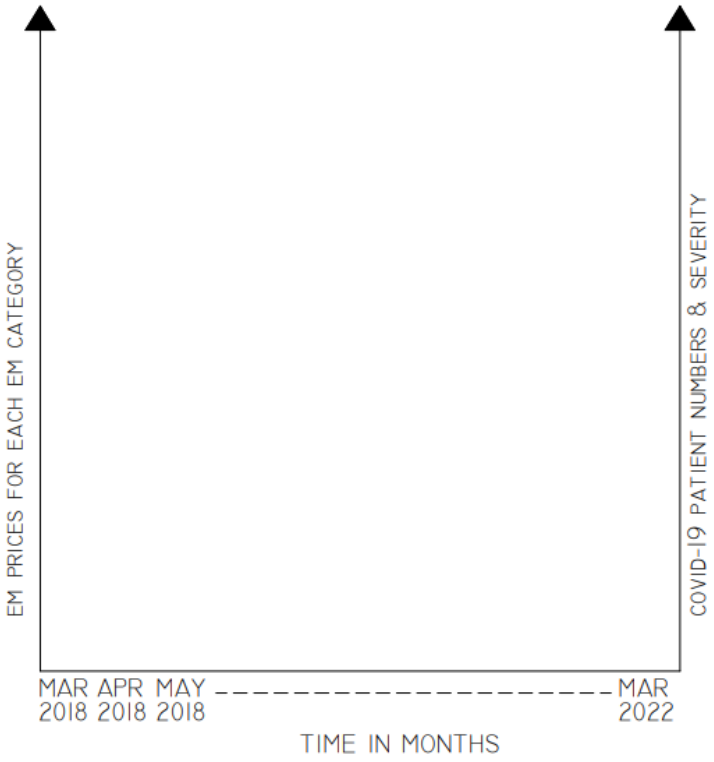



**Figure 3.7 Trends of COVID-19 and essential medicines prices for each essential medicines' category**

**Further analysis**

Further analysis was conducted to determine the relationship between COVID-19 (patient numbers and severity) and EM prices. This was achieved by a scatter plot of the weighted numerical value that integrates severity with number of COVID-19 patients and the numerical value that integrates EM prices for each EM category over the period of COVID-19 (March 2020 to March 2022). Lines of best fit were derived to describe the relationship. The scatter plots are illustrated in figures 3.6 and 3.7.

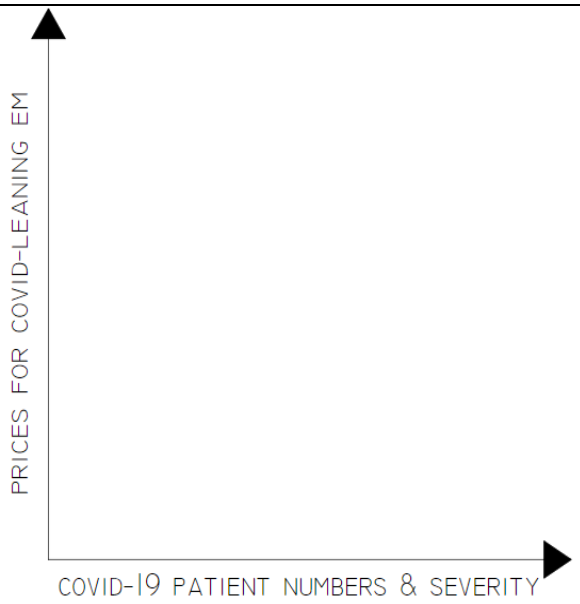



**Figure 3.8 Relationship between COVID-19 and Prices for COVID-19-leaning essential medicines**

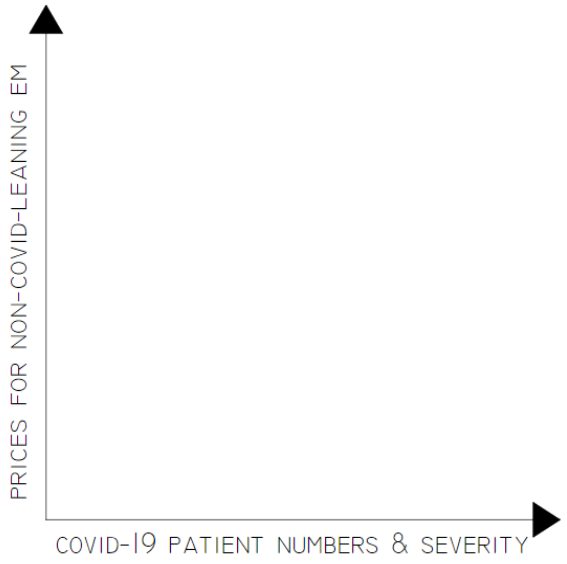



**Figure 3.9 Relationship between COVID-19 and order quantities for non-COVID-19-leaning essential medicines**

### 3.13.2 Qualitative data analysis

To analyze the qualitative data obtained through KII, all codes generated from ATLAS.ti version 8 were downloaded into Microsoft Excel (Microsoft Office 2021, Microsoft Corporation, Redmond, Washington, USA). The codes were arranged according to themes and then a report was generated. Qualitative results were presented as narratives and quotes.

Both the results from the quantitative and qualitative were triangulated with a conceptual link.

## 3.14 Quality assurance

### 3.14.1 Quality assurance for quantitative data

Quantitative data was collected by two research assistants with a pharmacy training background. Research assistants were trained on the protocol, data collection procedures, and data entry prior to data collection. Double-entry of data was done by the research assistants to enable detection and elimination of discrepancies. A pretest of the data abstraction sheet was done using 20 item entries of February 2018, that were not be included in the analysis.

### 3.14.2 Quality assurance for qualitative data

The qualitative aspect of the study focused on trustworthiness. Trustworthiness supports the rationale for accepting research findings as a basis of further research, public policy formulation and, community and individual actions [74]. Trustworthiness relies on credibility, transferability, dependability and confirmability [75].

**Credibility**

For this study credibility was promoted through triangulation of qualitative data. The researcher conducted KIIs. At the end of each interview, the researcher's interpretation of the respondents' interview was told to the respondent to enable verification of interpretation. The researcher transcribed the interview responses.

Two independent research assistants with experience in qualitative research separately read the written field notes and transcripts and, listened to audio recordings. The researcher and research assistants thereafter met to discuss areas of agreement and disagreement, including formulation of themes.

**Transferability**

The researcher provided a detailed description of the context in which the research was carried out, the study period, the setting, sampling strategy, sample size, sample, interview procedure and topics and excerpts from the interview guides [75].

**Dependability**

Raw data (that is audio recordings, field notes from interviews and transcripts) and conceived themes were peer reviewed by the research supervisor, research co-supervisor and the Research and Ethics Committee (REC) of University of Rwanda.

**Confirmability**

For this study confirmability was ensured by having a structured KII guide with no leading questions.

## 3.15 Ethical considerations

The researcher sought approval from University of Rwanda REC, ethical approval from the Mulago institutional review board (their REC), and administrative clearance from the Executive Director Mulago NRH before the study could start.

It was anticipated that there would be no harm to the participants except for the risk of contracting COVID-19 during data collection. Therefore, a COVID-19 mitigation plan was developed.

During data extraction and KIIs, identifying information was avoided as much as possible. Written consent was obtained from the KIs after explaining the purpose and procedures of the study. Only the participants who provided informed consent were interviewed.

Privacy and confidentiality of data was ensured by masking personal identifiers like names and title. Participants were free to accept or refuse participation in the study. They were informed of their right to withdraw from the study at any point in time.

### 3.16 COVID-19 mitigation plan

Cognizant of the challenges posed by the COVID-19 pandemic on field research, several mitigation strategies were put in place to ensure that study plans are implemented on schedule with minimal risk to both researchers and study participants (KIs).

a) The researcher and research assistants wore medical masks all the time they were in public and during interaction with the KIs.

b) The researcher and research assistants strictly observed two meters distance between themselves and the study participants during interviews as recommended by current COVID-19 preventive measures for the country.

c) Field staff strictly sprayed their hands with sanitizer before and immediately after each interview.

d) Field staff were trained in both COVID-19 preventive measures and responsible conduct of research before commencement of fieldwork.

e) All other COVID-19 behavioral measures such as no handshakes, no hugging and no spitting in public were adhered to.

f) The researcher and research assistants were encouraged to take COVID-19 vaccination before field work.

g) Research assistants with COVID-19 like signs and symptoms were excused from fieldwork.

h) The researcher and research assistants abided by all the COVID-19 prevention protocols of the study sites.

# CHAPTER 4. PRESENTATION OF RESULTS

This chapter presents the results of this study. The quantitative aspect of the study analyzed the effect of COVID-19 on EM order quantities and prices by interrupted time series analysis for the period March 2018 to March 2022 using SPSS statistics version 22.0. And, the qualitative aspect of the study analyzed data obtained through KII, using ATLAS.ti version 8.

## 4.1 Classification of EM by relevance to COVID-19 clinical management

Out of the 237 medicines ordered during the period of March 2018 to March 2022, 142 (59.9%) were EM. The study stratified the EM into COVID-19-leaning and non-COVID-19-leaning, of which 89 (62.7%) were COVID-19-leaning as presented in table 4.1. The EM classified under the categories of COVID-19-leaning and non-COVID-19 leaning are tabulated in Appendix F and Appendix G respectively.

**Table 4.1 Classification of EM by relevance to COVID-19 clinical management**

| Therapeutic classification | Number of EM (N=142) | Percentage EM (%) |
|---|---|---|
| COVID-leaning | 89 | 62.7 |
| Non-COVID-leaning | 53 | 37.3 |

## 4.2 Trend of essential medicines order quantities over the four-year study period (March 2018 to March 2022)

### 4.2.1 Trend of number of emergency orders and, COVID-19 severity and patient numbers over the four-year study period (March 2018 to March 2022)

Data on the monthly number of orders (routine and emergency), and the monthly number of emergency orders as a proportion of the total monthly number of orders over the four-year study period (March 2018 to March 2022), has been presented in Appendix H. This proportion indicates that of the total orders made by Mulago NRH over the two-year period before COVID-19, only 4% were of emergency nature. This increased to 38% over the first two years during the pandemic.

**Table 4.2 Proportion of emergency orders before (March 2018 to February 2020) and during (March 2020 to March 2022) the COVID-19 pandemic**

| | Total number of emergency orders | Total number of orders | Proportion of total number of emergency orders to total number of orders |
|---|---|---|---|
| Before COVID-19 (Mar 2018 -Feb 2020) | 1 | 25 | 4% |
| During COVID-19 (Mar 2020-Mar 2022) | 19 | 50 | 38% |

Data of the monthly COVID-19 patient numbers in form of an integrated value of severity and patient numbers over the four-year study period (March 2018 to March 2022), has been presented in Appendix I.

Data of the monthly number of emergency orders as a proportion of the total monthly number of orders together with the monthly integrated value for COVID-19 severity and patient numbers over the four-year study period (March 2018 to March 2022), has been presented as a graphical plot in figure 4.1. This graph indicates that the number of emergency orders varied with patient severity and numbers. More emergency orders were noticed after March 2020 when the CTU was opened at Mulago NRH, and the number of these orders increased as COVID-19 severity and patient numbers peaked. This may imply that there is positive relationship between COVID-19 (severity and patient numbers), and number of emergency orders.

### 4.2.2 Trend of essential medicines order quantities and, COVID-19 severity and patient numbers over the four-year study period (March 2018 to March 2022)

Data on the monthly integrated EM order quantities for each EM category over the four-year study period (March 2018 to March 2022), has been presented in Appendix J. This data has been presented as a combinational graphical plot of: the monthly integrated EM order quantities values for COVID-19-leaning; and the monthly integrated EM order quantities values for COVID-19-leaning EM; monthly integrated values for COVID-19 severity and patient numbers, plotted against time in months, in figure 4.2. The graph indicates that COVID-19-leaning EM follows a closely similar trend with COVID-19 severity and patient numbers. As patient severity and numbers increase, so does COVID-19-leaning EM. This is not nearly the case for non-COVID-19-leaning EM, with the observation of a decline in order quantities over the first year of the pandemic (where the biggest patient severity and numbers

was recorded) and an increase in the second year during the decline of the pandemic (where patient severity and numbers recorded was lowest).

### 4.2.3 Relationship between COVID-19 severity and patient numbers, and EM order quantities

The relationship between COVID-19 severity and patient numbers, and EM order quantities is presented as a scatter plot of the weighted numerical values that integrate COVID-19 severity and patient numbers, and the numerical values that integrate EM order quantities for each EM category, as presented in figures 4.3 and 4.4.

The relationship between the COVID-19-leaning EM order quantities, and COVID-19 severity and patient numbers (figure 4.3) is defined to be of a linear nature. The line of best fit extracted from the scatter plot is of the equation, $y = 0.0545x + 0.5717$ with the coefficient of determination, R-squared = 0.2027. The correlation coefficient for this plot was computed using the excel function of CORREL (data range 1, data range 2) and a value of 0.45 was obtained which indicates a moderate positive correlation between COVID-19-leaning EM order quantities, and COVID-19 severity and patient numbers.

The positive correlation is most emphasized in selected EM including Enoxaparin 80mg (an anticoagulant), Azithromycin, and Ceftriaxone whose order quantities increased by 1692.2% 149.2% and 24% respectively over the first two years of the pandemic compared to the two years just before.

The relationship between the non-COVID-19-leaning EM order quantities, and COVID-19 severity and patient numbers (figure 4.4) is defined to be of a linear nature. The line of best fit extracted from the scatter plot is of the equation, $y = -0.001x + 0.2171$ with the coefficient of determination, R-squared = 0.0004. The correlation coefficient for this plot was computed using the excel function of CORREL (data range 1, data range 2) and a value of -0.02 was obtained which indicates a very weak negative correlation between non-COVID-19-leaning EM order quantities, and COVID-19 severity and patient numbers.

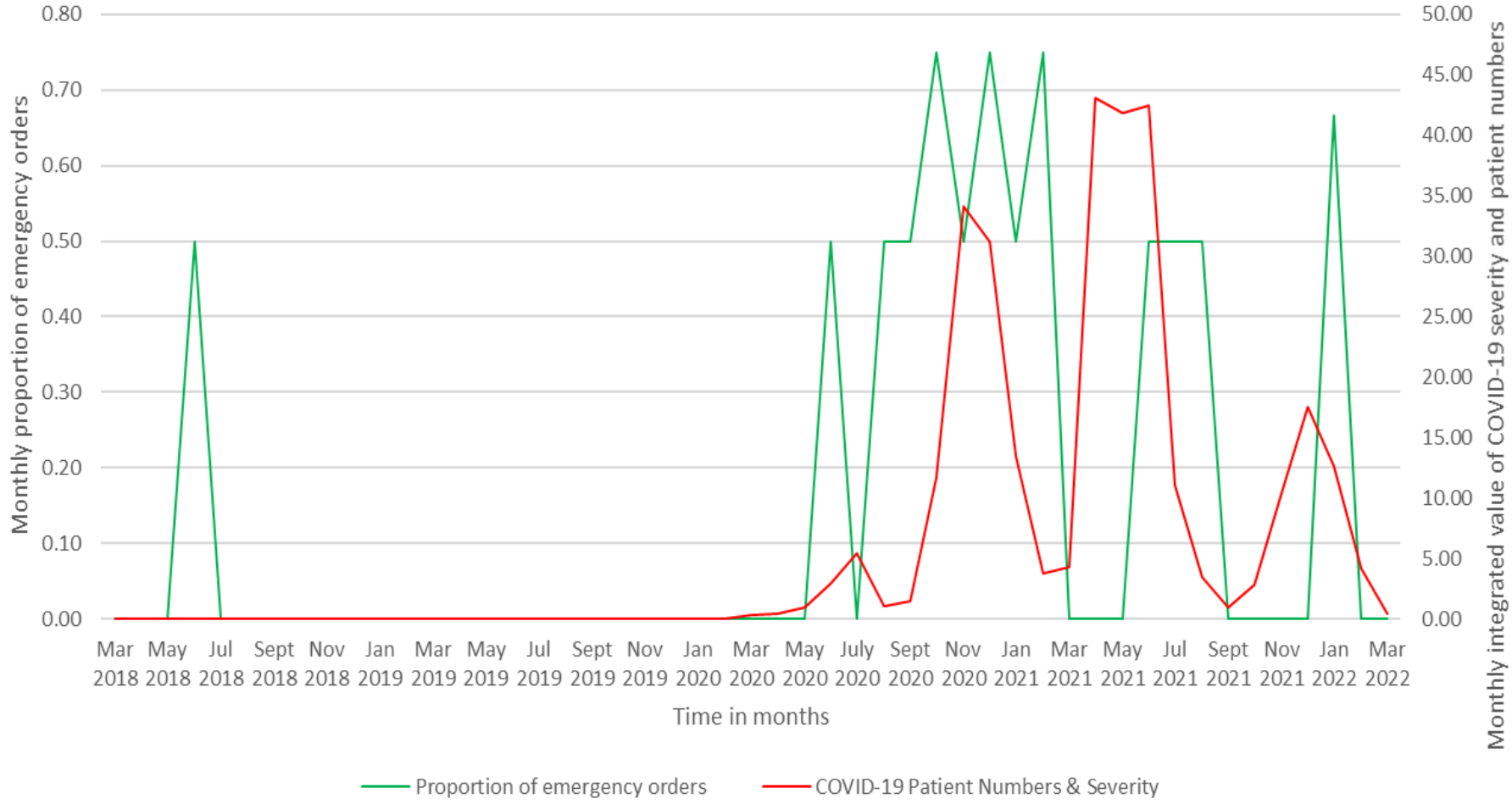



**Figure 4.1 Graphical plot of monthly proportion of emergency orders and integrated COVID-19 severity and patient numbers over the study period**

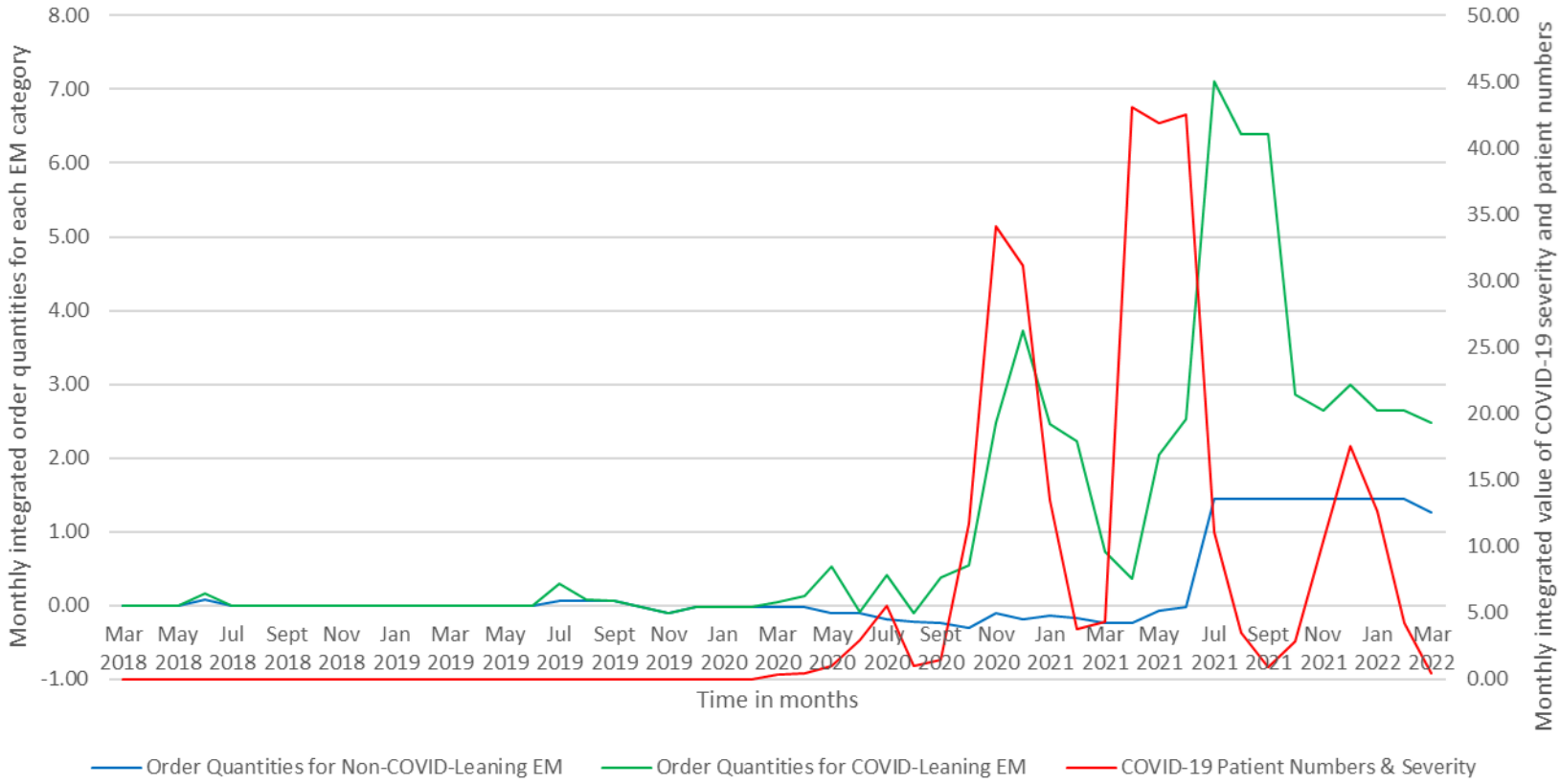



**Figure 4.2 Graphical plot of monthly integrated COVID-19 severity and patient numbers, and monthly integrated essential medicines order quantities for the two essential medicines categories over the study period**

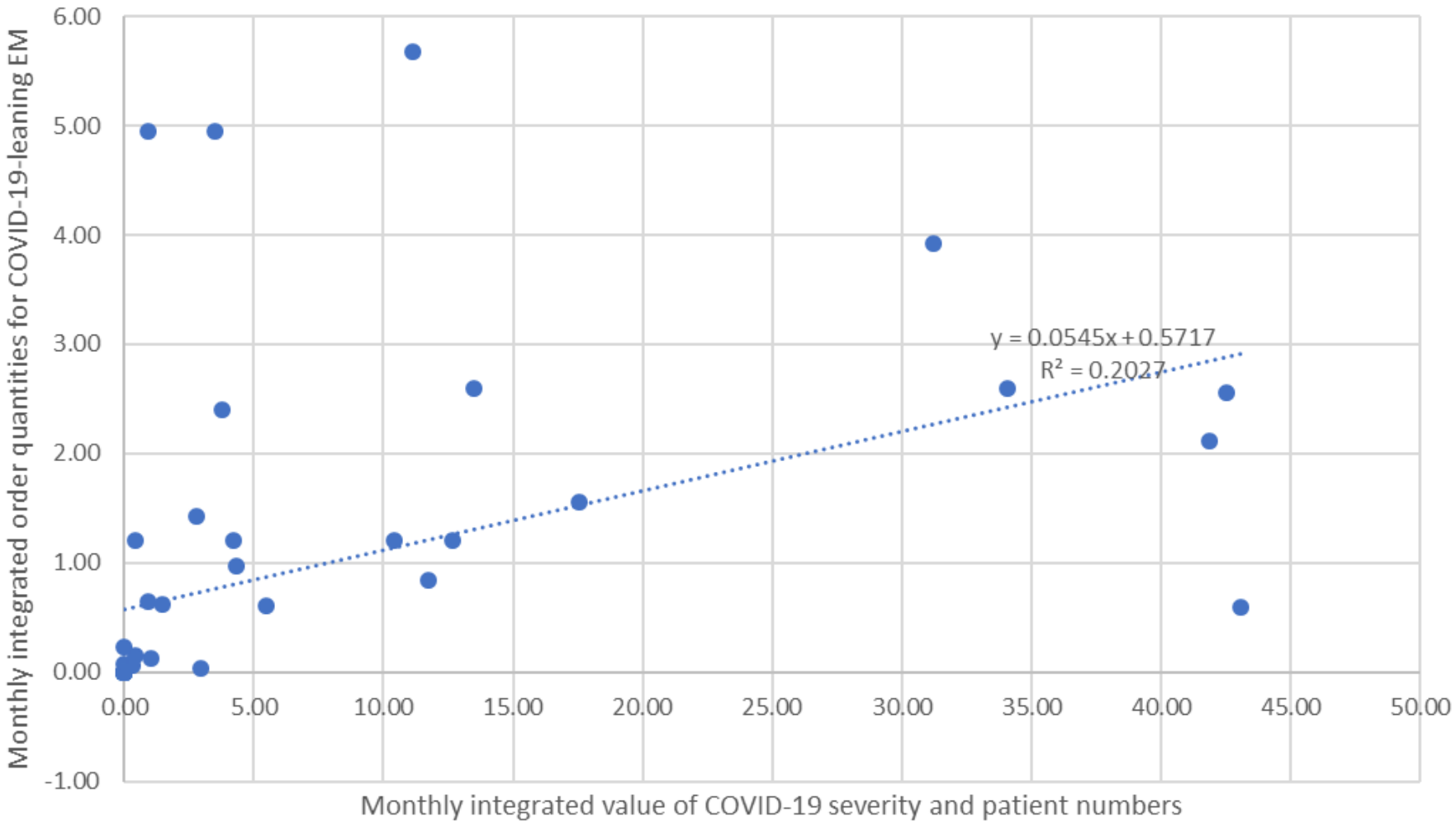



**Figure 4.3 Scatter plot of monthly integrated order quantities for COVID-19-leaning EM and integrated value of COVID-19 severity and patient numbers**

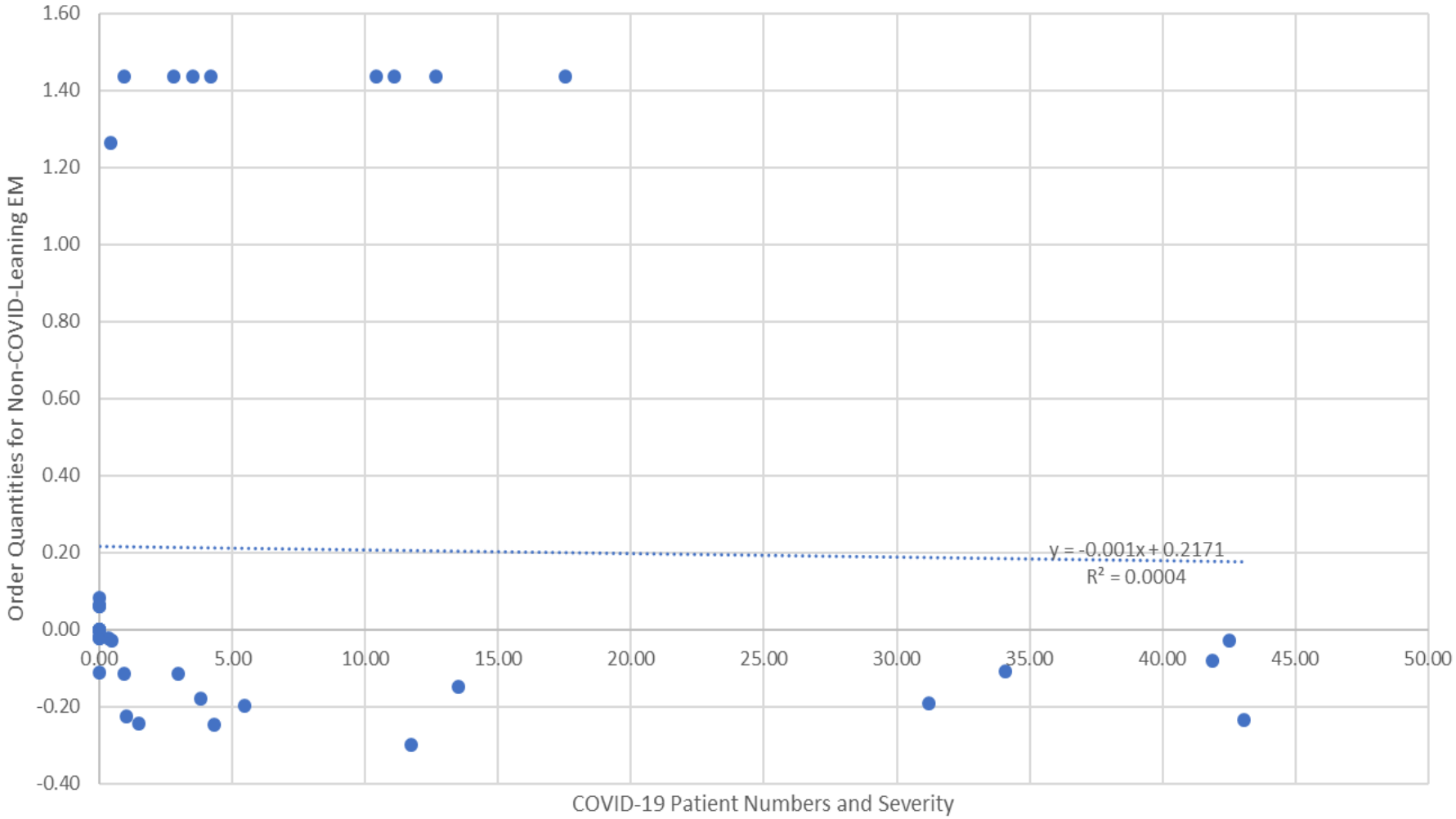



**Figure 4.4 Scatter plot of monthly integrated order quantities for non-COVID-19-leaning EM and integrated value of COVID-19 severity and patient numbers**

### 4.2.4 Qualitative analysis of the effect of COVID-19 on essential medicines order quantities

This section presents the outcome of the KIIs concerning the effect of COVID-19 on EM order quantities.

Most of the participants stated that the hospital faced the challenge of inadequacy of EM due to escalated demand for medicines used in COVID-19 clinical management, arising from increased COVID-19 patients admitted at the CTU.

One participant stated that:

> *"The effect was….it resulted in inadequacy, because this was a situation that was not planned for. It encroached on the planned medicines for the general needs for hospital. So, when you bring in these large numbers of COVID, it meant that these essential medicines were depleted very rapidly actually."* (KII 008, Female participant)

Most participants reported insufficiency of COVID-19-leaning EM with unmatched increase in supply. The examples of antibiotics (Ceftriaxone, Azithromycin), intravenous fluids, sedatives used in ICU, Enoxaparin, and Paracetamol were given.

One participant stated:

> *"At the start of the first wave, it seemed, we were at our normal lacking but when it came to the second wave, then the third where we started meeting patients with severe, critical disease categories, there was deepening , there was that severe inadequacy because now, most of the items that we needed actually already were not sufficient and yet the demand was extremely very high because we had a lot of admissions. The stock outs were quite very eminent and they were severely out of the normal. There was extensive need that would not be easily met by the little supplies that we had"* (KII 004, Male participant)

Another participant stated:

> *"We managed different degrees of severity, for the critical cases they were managed at ICU and ICU requires a lot of medicines to bring these patients to a state they need to be in like*

*sedatives, the drugs for induction when they are being intubated for ventilatory support, all those were in short supply"* (KII 008, Female participant)

Another participant stated:

*"while other key commodities that were needed in COVID-19 management like Enoxaparin, Azithromycin, Vitamin C, assorted medicines for ICU were insufficient. So, they were inadequate"* (KII 006, Male participant).

Another participant stated:

*"I think when COVID happened, it took the country by storm and we saw a drastic increase in demand for commodities such as medicines. The drastic raise was especially for those medicines that were used to manage COVID. Such as Azithromycin, Ceftriaxone, Paracetamol, and some other essential medicines that were meant for ICU care drastically increased"* (KII 007, Female participant)

Another participant stated:

*"then we had also intravenous fluids, because these were also on high demand and we had many of those, antipyretics, the Paracetamols which were excessively used"* (KII 003, Male participant)

On the other hand, some of the participants reported reduced demand for medicines not used in COVID-19 clinical management due to reduced numbers of patients seeking care at the hospital especially at the start of the pandemic. Such cases included accident victims, tuberculosis, ear, nose and throat, eye.

One participant stated that:

*"Well, I would look at it in two ways, it caused a stock out of some key commodities that were needed on the COVID side while on the other hand some other commodities ended up being over stocked because patients were not coming to especially areas like outpatients, at the start of the pandemic. We would look at commodities like antimalarials they were on a high side of the stock"* (KII 006, Male participant).

Another participant stated that:

*"Yes, the number of patients coming in with other ailments may have gone down at the start of the pandemic with the lock down, there were less accidents and accident victims consume a lot of medicines and medical supplies"* (KII 001, Female participant).

Another participant stated that:

*"then there was a decline at least during the time there was the lockdown for those items that were not used in the management of COVID. Services and clinics such as TB, ENT, eye, - those supplies declined"* (KII 002, Female participant).

Another participant stated that:

"*while on the other hand some other commodities ended up being over stocked because patients were not coming to especially areas like outpatient, at the start of the pandemic. We would look at commodities like antimalarials they were on a high side of the stock*" (KII 006, Male participant).

Although demand for COVID-19-leaning EM escalated with COVID-19, order quantities for the EM could not entirely match this demand due to budgetary constraints. Some of the participants reported that the hospital budget didn't change and that they had to procure EM within budgetary constraints.

One participant stated that:

*"It was inadequate because some of the medicines like anticoagulants are quite expensive and the shear volumes of the needed essential drugs would overwhelm the demands. For example, every patient needed a blood glucose test every day. If you just can't meet the cost of blood glucose strips , you just can't meet the cost of the insulin as most of these patients were on dexamethasone which definitely made them hyperglycemic and they required to be on regular blood glucose of course monitoring and all the effects really were direct effects of the COVID-19 disease that wouldn't have been there normally"* (KII 001, Female participant)

Another participant stated that:

*"The budget for EMHS was not enough, the hospital management to some extent prioritized CTU needs. Orders were placed and exceeded the allocated budget, by the end of the FY*

*2020/21, the annual budget had been exceeded by over 1billion UGX. Meaning that the following FY 2021/22 started off with less the allocated budget*" (KII 002, Female participant)

## 4.3 Trend of essential medicines prices over the four-year study period (March 2018 to March 2022)

### 4.3.1 Trend of essential medicines prices and, COVID-19 severity and patient numbers over the four-year study period (March 2018 to March 2022)

The monthly integrated EM prices for each EM category over the four-year study period (March 2018 to March 2022), have been presented in Appendix K. This data has been presented as a combinational graphical plot of: the monthly integrated EM prices for COVID-19-leaning; and the monthly integrated EM prices for non-COVID-19-leaning EM; monthly integrated values for COVID-19 severity and patient numbers, plotted against time in months, in figure 4.5.

The graph indicates that COVID-19-leaning EM prices follow a closely similar trend throughout the pandemic period of two years. Much earlier, almost two-years before the pandemic, a sharp price increase was observed, attributable to other factors other than the pandemic. Almost nine months to the pandemic prices returned to normal perhaps. On the other hand, non-COVID-19-leaning EM prices remained almost constant with a slight drop as the pandemic peaked. In the final six months of the study period, prices for non-COVID-19-leaning EM followed the same trend as the pandemic.

### 4.3.2 Relationship between COVID-19 severity and patient numbers, and EM prices

The relationship between COVID-19 and EM prices is presented as scatter plot of the weighted numerical value that integrates COVID-19 severity and patient numbers, and the numerical value that integrates EM prices for each EM category as presented in figure 4.6 and figure 4.7.

The relationship between the COVID-19-leaning EM prices, and COVID-19 severity and patient numbers may be defined to be of a linear nature. The line of best fit extracted from the scatter plot is of the equation, $y=0.0004x+0.0257$ with the coefficient of determination, R-squared = 0.0166. The correlation coefficient for this plot was computed using the excel function of CORREL (data range 1, data range 2) and a value of 0.13 was obtained which indicates a very weak positive correlation between COVID-19-leaning EM prices, and COVID-19 severity and patient numbers.

The relationship between the non-COVID-19-leaning EM prices, and COVID-19 severity and patient numbers may be defined to be of a linear nature. The line of best fit extracted from the scatter plot is of the equation, y= 0.001x+0.0415 with the coefficient of determination, R-squared = 0.0514. The correlation coefficient for this plot was computed using the excel function of CORREL (data range 1, data range 2) and a value of 0.23 was obtained which indicates a weak positive correlation between COVID-19-leaning EM order quantities, and COVID-19 severity and patient numbers.

### 4.3.3 Qualitative analysis of the effect of COVID-19 on essential medicines prices

This section presents the outcome of the KIIs concerning the effect of COVID-19 on EM prices.

The hospital faced challenges of price escalation for EM required for clinical management of COVID-19. Such medicines included enoxaparin, dexamethasone. This increase was partly attributable to opportunistic hoarding of medicines especially those required in COVID-19 clinical management, and to escalated demand that exceeded available supply.

One participant stated:

> *"Even some of suppliers started running out of stock and we see that if the stock is inadequate and the demand is very high……is that people raise prices. I think even other order drugs like dexamethasone which we used to buy cheaply rose to very expensive…almost 10 times or nearly. Even these normal antibiotics, something that used to go up to 2500 went up to around 4000 -5000. So, some of the items actually rose up because of the high demand*." (KII 005, Male particpant)

Another participant stated:

> *"But initially people were hoarding medicines and prices sky rocketed, they eventually went down but not to the price before the pandemic"* (KII 007 Female particpant).

## 4.4 Coping mechanisms deployed by Mulago NRH during the COVID-19 pandemic

With increased prices the EMHS budget established at NMS was exhausted, hence the hospital sought support from the MoH and health implementing partners such as infectious disease institute, WHO among others. Support was secured in form of donations. Additionally, some patients contributed to purchase of their medicines.

Mulago NRH benefited from inter-institutional redistribution of EM. Through this initiative, the hospital received EM from other hospitals that either had less COVID-19 patient burden or no patients at all, and yet possessed excess of such (required) EM. This redistribution was effected at no cost to Mulago NRH, hence of no negative impact to the budget.

Routine orders had been scheduled and structured based on fixed annual procurement plans with no consideration for COVID-19. Therefore, it was necessary to incorporate emergency orders based on eventual needs of COVID-19 as they arose.

One participant stated:

> *"It was inadequate, and definitely, the budget was over stressed and what was available was not enough"* (KII 004, male participant)

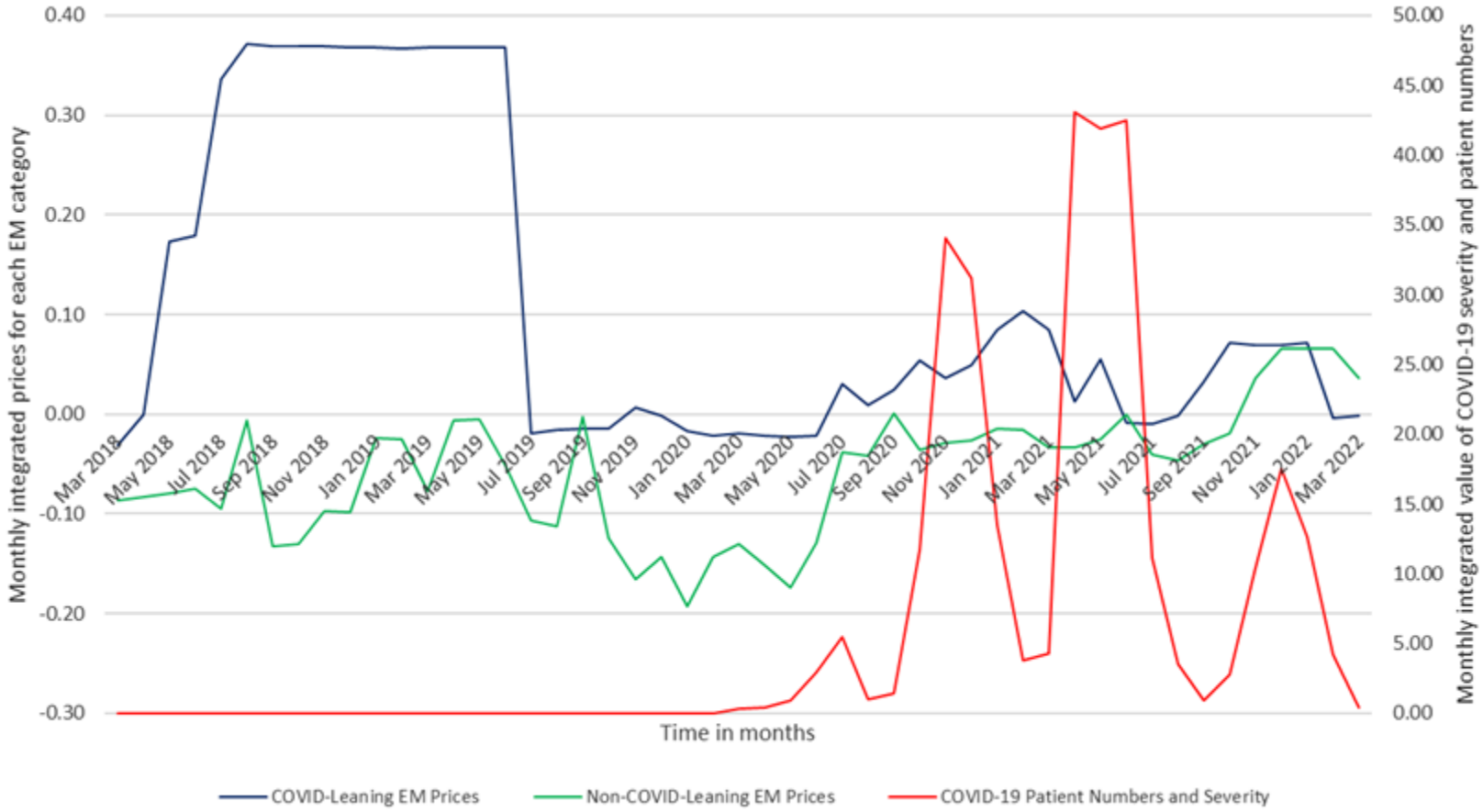



**Figure 4.5 Graphical plot of monthly integrated COVID-19 severity and patient numbers, and monthly integrated essential medicines prices for the two essential medicines categories over the study period**

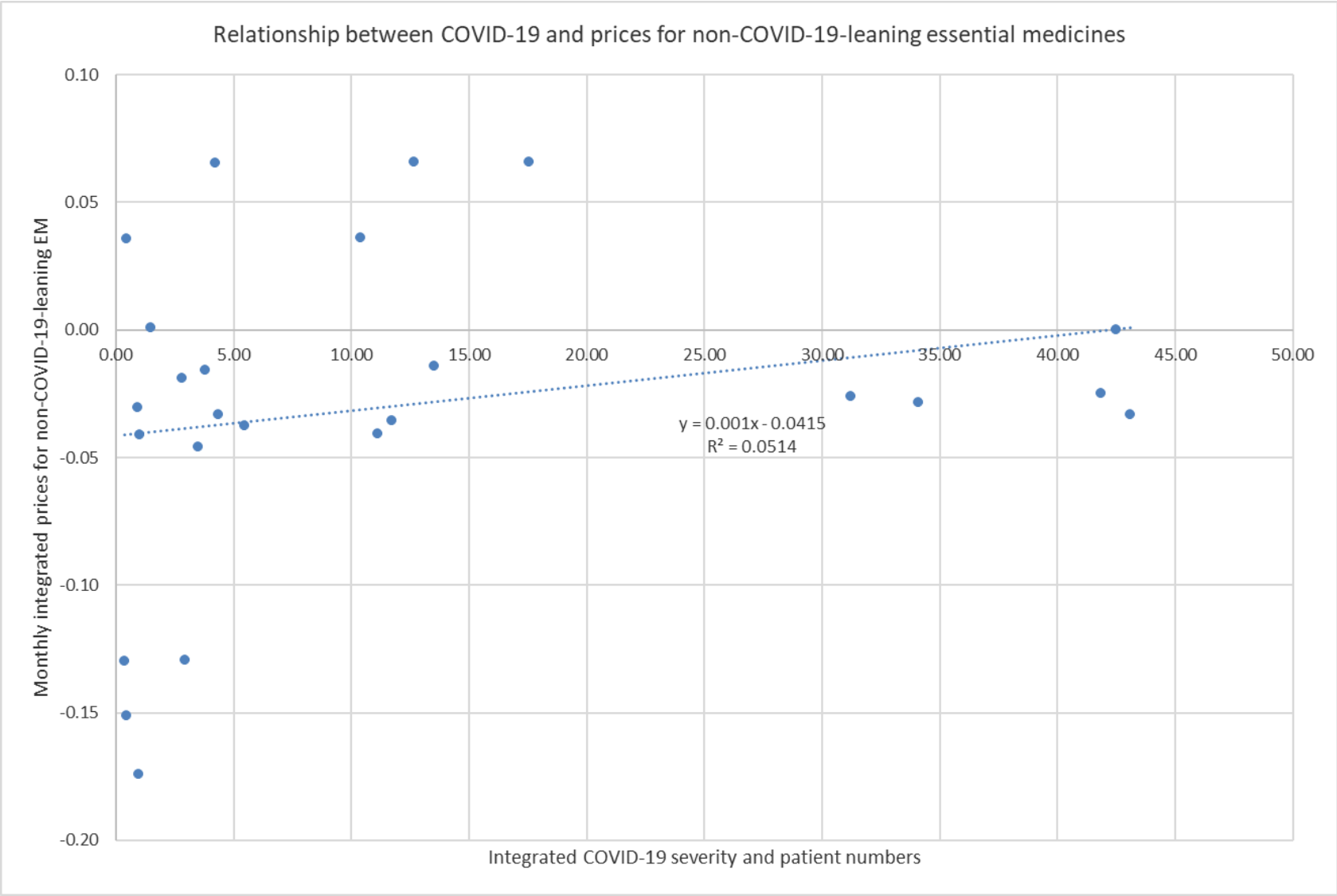



**Figure 4.6 Scatter plot of monthly integrated prices for non-COVID-19-leaning EM and integrated value of COVID-19 severity and patient numbers**

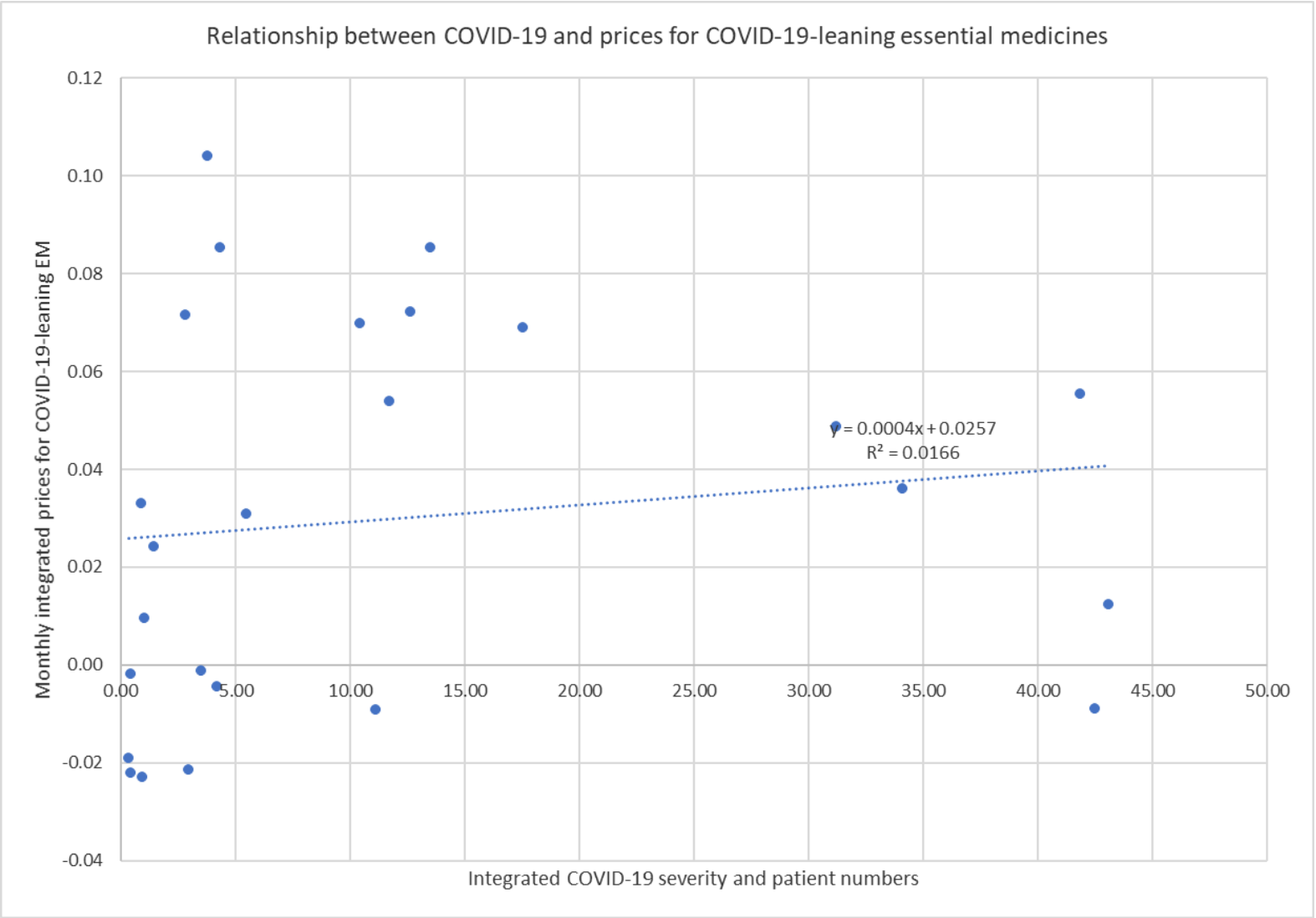



**Figure 4.7 Scatter plot of monthly integrated prices for COVID-19-leaning EM and integrated value of COVID-19 severity and patient numbers**

Another participant stated that:

> *"Cost sharing- that is because the essential drugs that were not available, patients had to purchase them on open market so that was cost sharing. Seeking for donations, seeking for help from NGOs."* (KII 005, male participant)

Another participant stated that:

> *"Emergency orders were part of the strategies that were used to get more resources of EM commodities for the management of COVID."* (KII 003, Male participant)

Another participant stated that:

> *"With budget shortage, we even reached out to NGO's and health partners for support."* (KII 001, female participant)

Another participant stated that:

> *"We embarked on looking for donations from the ministry of health and health development partners such as IDI, WHO. We also initiated redistributions from nearby hospitals. And as I earlier mentioned, we prioritized the hospital deliveries from NMS and medicines and supplies were directed towards COVID-19 patient management."* (KII 002, Male participants)

Mulago does not have contingency in its budget to cater for unforeseen needs that may arise from medical emergency situations such as pandemics, epidemics among others.

One participant stated that:

> *"Mulago does not really have a clear measure on responding to sudden increase in EM demands but usually what they try to do is to reallocate resources from the already available budget but there's nothing special they have in place to address that"* (KII 009, KII 008, Female participants)

Some participants recommended that public hospitals including Mulago NRH are provided with contingency funding towards pandemic situations.

Another participant stated that:

*"From my side, I think we need a contingency fund in place. With every pandemic medicines and other requirements change, but there should be that float available when required." (KII 009 Female participant)*

Some participants recommended that hospitals maintain buffer stocks to be able to meet surges in demand including during pandemics.

Another participant stated that:

*"We need to have some buffer stocks and regularly cross check their expiry and then having a special budget allocated towards essential drugs when a need arises"* (KII 006, Male participant)

# CHAPTER 5. DISCUSSION

Having presented the study results in the previous chapter, this chapter discusses the results to provide interpretation and analysis of the study findings.

## 5.1 Trend of essential medicines order quantities

The trend of COVID-19 patient numbers observed from the study is consistent with the national wide trend with coinciding peaks and crests. The first major surge in Uganda occurred during the last months of 2020 [76]. The study results show that the first major surge happened between December 2020 and January 2021. The second major surge in Uganda occurred in the late April 2021 [76]. The study results show the third peak between April and July 2021. The last wave in Uganda occurred between December 2021 and January 2022, and the study results show a peak in the same period[77]. The observed coincidence of peaks for Mulago NRH and the rest of the country is explained by the fact that Mulago NRH was Uganda's main CTU taking up the biggest portion of patients throughout the pandemic.

The trend of the monthly integrated value of COVID-19 severity and patient numbers, and monthly integrated value of essential medicines order quantities for COVID-19-leaning and non-COVID-19-leaning EM over the four-year study period (March 2018 to March 2022) indicates that COVID-19-leaning EM follows a closely similar trend with COVID-19 severity and patient numbers. But this is not the case for non-COVID-19-leaning EM with the observation of a decline in order quantities over the first year of the pandemic (where the biggest patient severity and numbers was recorded) and an increase in the second year during the decline of the pandemic (where patient severity and numbers recorded was lowest).

This is because as COVID-19 severity and patient numbers increased, demand for COVID-19-leaning EM and therefore order quantities for the same increased and vice versa. The highest increase in COVID-19-leaning EM was most notable in selected items including Enoxaparin 80mg (an anticoagulant), Azithromycin, and Ceftriaxone which increased by 1692.2% 149.2% and 24% respectively over the first two years of the pandemic compared to the two years just before. Most KIs reported escalated demand translating into increased EM order quantities for the following COVID-19-leaning EM: Ceftriaxone, Azithromycin, Enoxaparin, and Paracetamol among others. In comparison, a study in Italy noted that public hospitals experienced escalation in demand between the COVID-19 and pre–COVID-19 periods for Hydroxychloroquine (4661.67%) and Azithromycin (195.40%) [38].

The increase in order quantities for COVID-19-leaning-EM was effected through emergency orders that supplemented the routine monthly orders. This was evidenced by the 10-fold

increase in the number of emergency orders from the two years just before, and the first two years of the pandemic. This is because the demand surge was not envisaged during annual procurement planning and therefore had not been accommodated in routine orders.

Demand for non-COVID-19-leaning EM declined especially at the start of the pandemic due to reasons such as increased non-health seeking behaviour especially during the first year of the pandemic for reasons such as travel restrictions and fear for COVID-19 infection.

The relationship between COVID-19 and EM order quantities was further assessed through linear regression analysis. The derived linear relationship was established to be of moderate positive correlation for the COVID-19-leaning EM and a very weak negative correlation for the non-COVID-19-leaning EM.

### 5.2 Trend of essential medicines prices

Study results show that monthly integrated prices for COVID-19-leaning EM and the monthly integrated COVID-19 severity and patient numbers follow a closely similar trend. On the other hand, prices for the non-COVID-19-leaning EM remained almost unaffected, which may be attributable to effort to sell off stock of medicines whose demand had declined. The sharp rise of prices, the sustained relatively higher prices, and the eventual sharp decline of prices that was observed for COVID-19-leaning EM before the COVID-19 pandemic may be attributable to the then hiked importation verification costs by National Drug Authority in the effort to promote the build Uganda buy Uganda (BUBU) policy (to promote local manufacturing and discourage importation). Other causes for escalated import prices included increase global demand for the same commodities with unmatched supply and increased logistical costs. The decline then may be attributable to the importers reducing their profit margins to remain competitive and maintain sales.

The relationship between COVID-19 and EM prices was further assessed through linear regression analysis. The derived linear relation was established to be of very weak positive correlation for the COVID-19-leaning EM and a weak positive correlation for the non-COVID-19-leaning EM. Causes for the price increase other than COVID-19 severity and patient numbers, may have included COVID-19 related HSC disruptions. Such disruptions included global and national travel restrictions, verification of imports was interrupted, remote working, industrial activity suspension including for medicines, speculative and opportunistic hoarding of medicines among others.

### 5.3 Coping mechanisms deployed by Mulago NRH

Study results indicated that Mulago NRH's budget for EMHS was constrained and the hospital was faced with a situation of insufficient supply to meet escalated demand and utilization of EM even before the pandemic. The hospital devised to seek support from the MoH and health implementing partners such as infectious disease institute, WHO among others. This effort was largely successful as substantial support was secured in form of donations. The hospital was therefore able to significantly meet its healthcare mandate by clinically managing COVID-19 patients while continuing to offer other health services.

COVID-19 patients were of varied financial capability and many were financially capable to purchase their medicines. This too alleviated the budgetary constraint of the hospital.

Mulago NRH also benefited from inter-institutional redistribution of EM. Through this initiative, the hospital received EM from other hospitals that either had less COVID-19 patient burden or no patients at all, and yet possessed excess of such (required) EM. This redistribution was effected at no cost to Mulago NRH, hence of no negative impact to the budget. This was similarly observed in Saudi Arabia through the country's effective medicines exchange program that mitigated COVID-19 EM unavailability.

Emergency orders additionally helped address the limitations of routine orders since the latter had been structured with no consideration for COVID-19. This enabled procurement of EM for clinical management of COVID-19 as demand arose.

# CHAPTER 6. CONCLUSION AND RECOMMENDATIONS

This chapter presents the conclusion and recommendations of this study.

## 6.1 Conclusions

The trend of COVID-19-leaning EM order quantities closely followed that of COVID-19 patient numbers unlike that for the non-COVID-19-leaning EM.

Further analysis revealed a moderate positive correlation between COVID-19-leaning EM order quantities and COVID-19 patient numbers. There is a very weak negative correlation between non-COVID-19-leaning EM and patient numbers.

The trend of COVID-19-leaning EM prices closely followed the trend for COVID-19 patient numbers unlike for the non-COVID-19-leaning EM prices that remained relatively constant even with the increase in COVID-19 patient numbers. There is a very weak positive correlation between COVID-19-leaning EM prices and COVID-19 patient numbers, and a weak positive correlation between non-COVID-19-leaning EM prices and patient numbers.

The coping mechanisms deployed by Mulago NRH to meet the emerged EM demands included order quantity adjustments, inter-institutional redistribution of EM, procurement of donations, and cost-sharing with patients.

## 6.2 Recommendations

In respect to policy and practice it is recommended that:

The Government intervenes to stabilize medicine prices in emergency situations such as during pandemics through: tax waivers; subsidies; clamping down on opportunistic hoarding among other measures.

At national level, medical counter measures initiatives are developed, implemented, maintained and improved to minimize morbidity and mortality in the event of public health emergencies such as may arise from pandemics.

The national level, the EM supply chain resilience be enhanced to better withstand disruptions caused by pandemic situation by establishing backup suppliers and diversifying supply sources.

At institutional level, buffer stock is established and maintained to enable institutions cope with surges that may arise from situations such during pandemics.

Allowance is made for contingency in annual budgeting for public hospitals to enable readiness for emergency situations that may arise such during pandemics.

GoU to promote and invest in local production of EM to reduce dependency on international suppliers and mitigate supply chain disruptions. This may be achieved through incentives, subsidies, and partnerships with local pharmaceutical manufacturers.

GoU to allocate resources and invest in healthcare infrastructure, including storage facilities, transportation networks, and information systems, to support efficient and timely distribution of EM during emergency situations.

In respect to further research, it is recommended that:

Factors that influenced the increase in EM order quantities, other than COVID-19 severity and patient numbers, are further investigated. Findings will further inform mitigation and coping measures.

Conduct a comparative analysis of the effect of COVID-19 on EM order quantities and prices for other PRHs in the region. Findings will provide a broader understanding of the effect of the pandemic on medicines procurement and pricing across different healthcare settings.

Analyze the factors contributing to changes in EM prices for the public sector during the pandemic. Investigate if global supply chain disruptions, increased demand, or other factors influenced pricing, and identify potential strategies to mitigate price fluctuations.

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## APPENDICES

### Appendix A: Essential medicines in the study sample

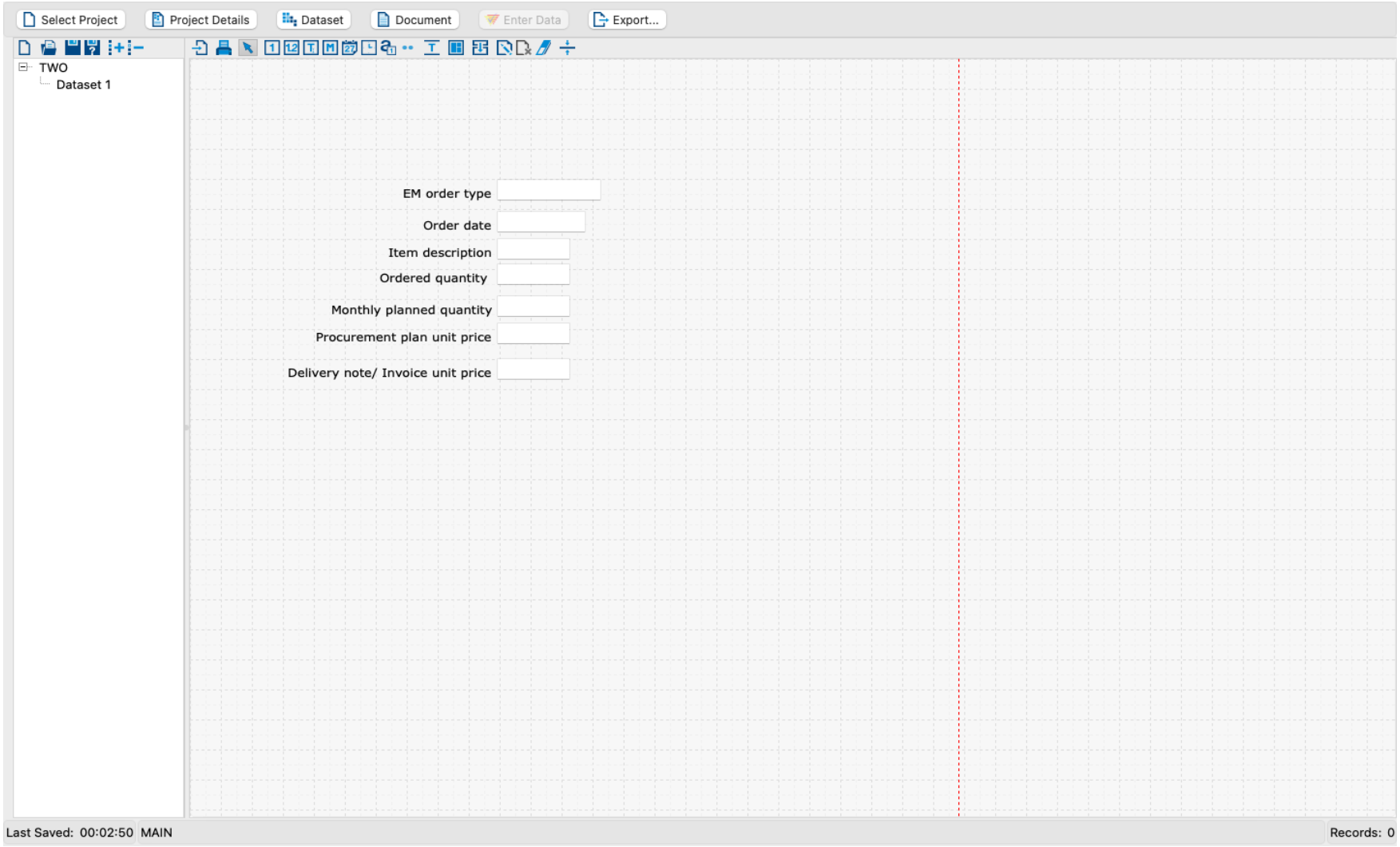
| S/N | Item description | UOM |
|---|---|---|
| 1 | Acetazolamide 250 mg tablets | 100 |
| 2 | Acetylsalicylic acid 75mg SR tablets | 100 |
| 3 | Aciclovir 200mg tablets | 100 |
| 4 | Adenosine injection 3mg/ml-2ml vial | 1 |
| 5 | Albendazole 400mg tablets | 500 |
| 6 | Allopurinol 100mg tablets | 28 |
| 7 | Amethocaine (Tetracaine) hydrochloride eye drops 0.5%, 0.5ml dose units | 1 |
| 8 | Aminophylline 250mg/10ml inj. Slow iv infusion | 1 |
| 9 | Amiodarone HCl 50mg/ml, 3ml | 6 |
| 10 | Amitriptyline 25mg tablets | 1000 |
| 11 | Amoxicillin 250mg capsules | 1000 |
| 12 | Amoxicillin dispersible tablets 250mg | 100 |
| 13 | Amphotericin b 50mg vial | 1 |
| 14 | Ampicillin 500mg powder for reconstitution IV/IM/infusion | 100 |
| 15 | Atropine 1% eye drops, 10ml | 1 |
| 16 | Atropine 1mg/1ml IV/IM | 100 |
| 17 | Azithromycin 500mg tablets | 3 |
| 18 | Beclomethasone inhaler 50mcg/dose 200 doses | 1 |
| 19 | Betamethasone+Neomycin 0.1%+0.5% eye drops, 10ml | 1 |
| 20 | Bisacodyl 5mg tablets | 100 |
| 21 | Bupivacaine HCl 0.5% in dextrose 8.0% injection solution, 4ml ampoule, spinal | 20 |
| 22 | Calcium chloride 10%/ 10ml ampoule | 1 |
| 23 | Calcium gluconate injection, 10%, 10ml vial | 1 |
| 24 | Captopril 25 mg tablets | 100 |
| 25 | Carbamazepine 200mg tablets | 1000 |
| 26 | Carbimazole 5mg tablets | 100 |
| 27 | Carvedilol 6.25mg tablets | 30 |
| 28 | Ceftriaxone sodium 1g powder for injection | 1 |
| 29 | Cetrizine tablet 10mg | 100 |
| 30 | Chloramphenicol 0.5% eye drops, 10ml | 1 |
| 31 | Chloramphenicol 5% ear drops, 10ml | 1 |
| 32 | Chlorpromazine 100mg tablets | 1000 |
| 33 | Chlorpromazine HCl 50mg/2ml deep IM | 100 |
| 34 | Ciprofloxacin 0.3% eye drops, 10ml | 1 |
| 35 | Ciprofloxacin 500mg tablets | 100 |
| 36 | Ciprofloxacin iv 200mg/100ml vial | 1 |
| 37 | Cis-atracurium injection 2mg/ml 10ml vial | 5 |
| 38 | Clonazepam 2mg tablets | 30 |

| | | |
|---|---|---|
| 39 | Codeine phosphate 30mg tablets | 100 |
| 40 | Dexamethasone 0.5mg tablets | 1000 |
| 41 | Dexamethasone 4mg/ml ,2ml ampoule | 100 |
| 42 | Diazepam 10mg/2ml IM/slow IV/IV infusion | 100 |
| 43 | Diazepam 2.5mg suppositories | 5 |
| 44 | Diclofenac sodium 50mg enteric coated tablets | 100 |
| 45 | Digoxin 250mcg tablets | 1000 |
| 46 | Digoxin injection 0.25 mg/ml 2ml | 100 |
| 47 | Dobutamine iv 25mg/2ml ampoule | 1 |
| 48 | Domperidone 10mg tablets | 100 |
| 49 | Enoxaparin 40mg/0.4ml,0.4ml Vol., pre-filled syringe | 2 |
| 50 | Enoxaparin 60mg/0.6ml vol prefilled syringe | 2 |
| 51 | Enoxaparin 80mg/0.8ml,1ml syringe | 1 |
| 52 | Ephedrine 30mg/ml 1 ml ampoule | 10 |
| 53 | Epinephrine (adrenaline) 1mg/ml IV/IM/SC | 100 |
| 54 | Etomidate 2mg/ml, 20ml vial | 1 |
| 55 | Fentanyl citrate 50mcg/ml 2ml ampoule | 10 |
| 56 | Fluoxetine capsules 20mg | 100 |
| 57 | Fluphenazine 25mg/ml injection | 10 |
| 58 | Folic acid 5mg tablets | 1000 |
| 59 | Furosemide 20mg/2ml IM/slow IV/IV | 100 |
| 60 | Furosemide 40mg tablets | 1000 |
| 61 | Gentamicin 0.3% eye/ear drops, 10ml | 1 |
| 62 | Glibenclamide tablets 5mg tablets | 100 |
| 63 | Glucose (dextrose) 5% infusion 500ml | 24 |
| 64 | Glucose 50% injection 100ml | 1 |
| 65 | Glycopyrrolate 0.2mg/ml injection | 1 |
| 66 | Griseofulvin 500mg tablets | 100 |
| 67 | Haloperidol 5mg/1ml injection | 1 |
| 68 | Haloperidol tablets 10mg | 100 |
| 69 | Hydralazine injection 20mg/ml | 5 |
| 70 | Hydrocortisone sodium phosphate 100mg injection | 50 |
| 71 | Hydroxyurea 500mg capsules | 100 |
| 72 | Ibuprofen 200mg tablets | 1000 |
| 73 | Imipramine 25 mg tablets | 1000 |
| 74 | Insulin Isophane human 100iu/ml Inj. SC | 1 |
| 75 | Insulin Mixtard human 100iu/ml Inj.SC | 1 |
| 76 | Insulin Soluble, neutral, human 100iu/ml Inj.SC | 1 |
| 77 | Isoflurane inhalation 100%, 250ml vial | 1 |
| 78 | Isosorbide dinitrate 20mg tablets | 56 |
| 79 | Ketamine 500mg/10ml injection IV/IM | 5 |
| 80 | Labetalol 5mg/ml 20ml vial | 1 |
| 81 | Lactulose 10g/15ml syrup, 100ml bottle | 1 |
| 82 | Lidocaine HCl 2% injection | 1 |
| 83 | Lisinopril tablets 10mg | 100 |
| 84 | Magnesium sulphate 50%, 10ml | 1 |

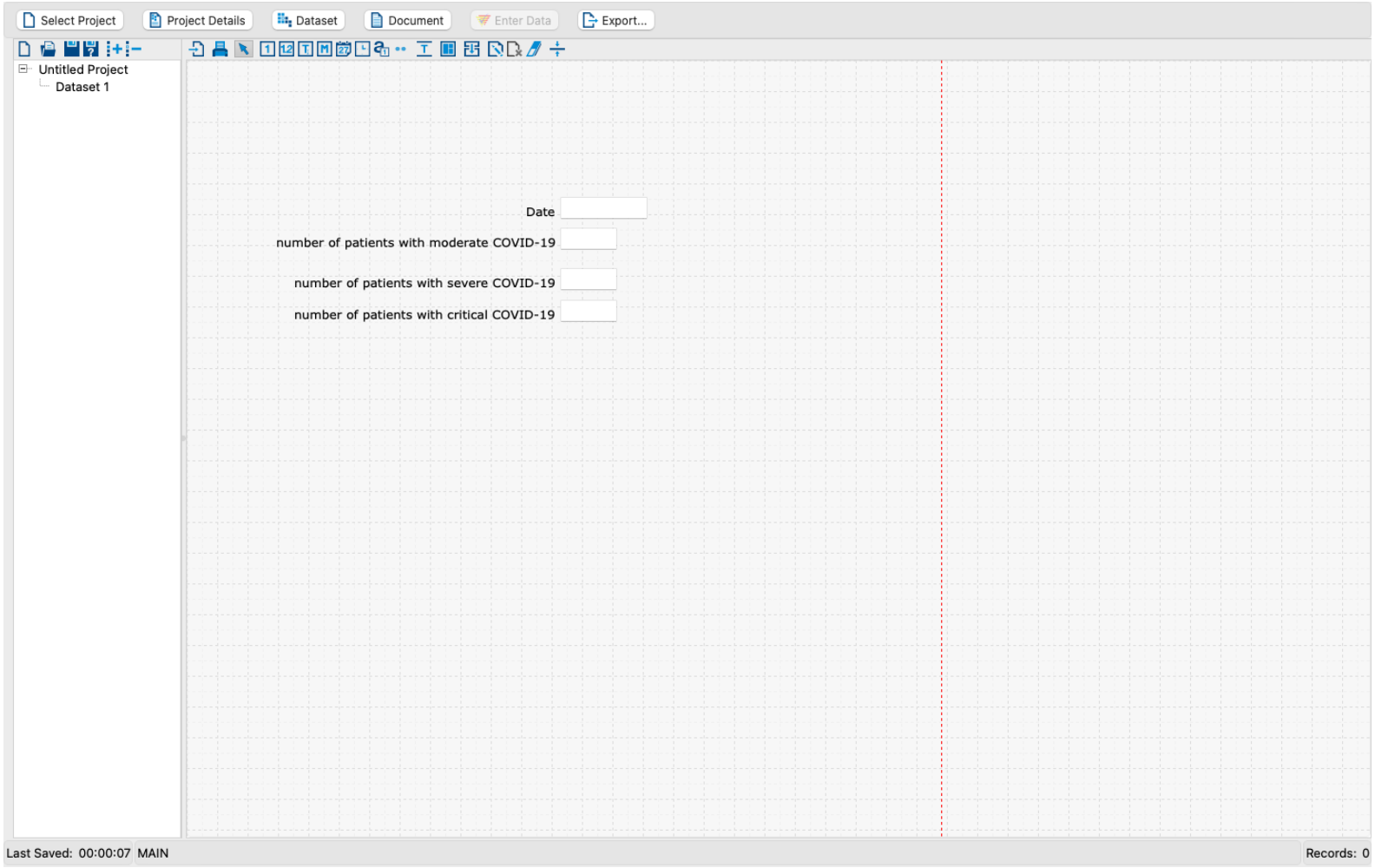
| | | |
|---|---|---|
| 85 | Magnesium trisilicate comp 250mg+120mg tablets | 1000 |
| 86 | Mannitol 20% 100ml infusion | 1 |
| 87 | Meropenem 500mg vial | 1 |
| 88 | Metformin HCl 500mg tablets | 100 |
| 89 | Methyl prednisolone sodium succinate 500mg, dry powder injectable | 1 |
| 90 | Metoclopramide 10mg/2ml injection | 100 |
| 91 | Metronidazole 200mg tablets | 1000 |
| 92 | Metronidazole 500mg/100ml infusion | 1 |
| 93 | Miconazole 2% cream, 20g tube | 1 |
| 94 | Miconazole 2% oral gel 20g tubes | 1 |
| 95 | Midazolam 5mg/ml 3ml ampoule | 5 |
| 96 | Morphine sulphate 10mg/ml IV/IM/SC | 10 |
| 97 | Naloxone 0.4mg/ml 1ml ampoule | 10 |
| 98 | Nifedipine retard 20mg tablets | 100 |
| 99 | Olanzapine tablets 10mg | 100 |
| 100 | Omeprazole 200mg capsules | 100 |
| 101 | Omeprazole 40mg injection | 1 |
| 102 | Oral rehydration salts for 1lt | 25 |
| 103 | Paracetamol 125mg suppositories | 10 |
| 104 | Paracetamol 500mg tablets | 1000 |
| 105 | Penicillin, benzathine benzyl 2.4mu/1.44g ampoule | 10 |
| 106 | Pethidine 100mg/2ml IV/IM/SC | 10 |
| 107 | Phenobarbital 30mg tablets | 1000 |
| 108 | Phenoxymethylpenicillin 250mg tablets | 1000 |
| 109 | Phenylephrine eye drops 10%, 5ml | 1 |
| 110 | Phenytoin sodium 100mg tablets | 1000 |
| 111 | Phenytoin sodium 50mg/ml injection 5ml | 1 |
| 112 | Potassium chloride 15% vial | 1 |
| 113 | Prednisolone 5mg tablets | 1000 |
| 114 | Propofol 10 mg/ml, 50ml vial | 1 |
| 115 | Pyrimethamine 25mg+sulfadoxine 500mg tablets | 1000 |
| 116 | Rabeprazole sodium injection 20mg/5ml, 5ml vial | 1 |
| 117 | Rabies vaccine + solvent 0.5ml, 1 dose | 1 |
| 118 | Risperidone 1mg tablets | 100 |
| 119 | Rocuronium bromide 10mg/ml 5ml ampoule | 1 |
| 120 | Salbutamol inhalation 100mcg/dose, 200 doses | 1 |
| 121 | Salbutamol nebuliser 5mg/2.5ml vial | 1 |
| 122 | Sevoflurane inhalation 100%, 250ml vial | 1 |
| 123 | Silver sulphadiazine cream 1% 20g tube | 1 |
| 124 | Sodium (Ringers) lactate compound infusion | 24 |
| 125 | Sodium chloride/Normal saline 0.9% infusion | 24 |
| 126 | Sodium valproate 500mg tablets | 100 |
| 127 | Spironolactone 50mg tablets | 1000 |
| 128 | Suxamethonium chloride 100mg/2ml injection | 100 |
| 129 | Tetracycline 1% eye ointment, 3.5g tube | 1 |

| | | |
|---|---|---|
| 130 | Thiamine IV injection 100mg/ml-2ml | 1 |
| 131 | Thiopental sodium 500mg ampoules | 50 |
| 132 | Timolol maleate 0.5% eye drops, 5ml | 1 |
| 133 | Tramadol 50mg capsules | 100 |
| 134 | Tramadol injection 100mg/2ml ampoules | 5 |
| 135 | Trifluoperazine 5mg tablets | 1000 |
| 136 | Vancomycin 500mg injection | 1 |
| 137 | Vecuronium 10mg powder for reconstitution | 1 |
| 138 | Vitamin b complex tablets | 1000 |
| 139 | Vitamin K1 (phytomenadione) 10mg/ml IM | 1 |
| 140 | Warfarin 5mg tablets | 28 |
| 141 | Water for injection 10ml | 100 |
| 142 | Zinc sulphate 20mg tablets | 100 |

## Appendix B: EpiData 4.6 data abstraction sheet to collect EM order quantities and prices related data



Appendix C: EpiData 4.6 data abstraction sheet to collect COVID-19 patient data



**Appendix D: Key informant interview guide**

**Effect of COVID-19 on essential medicines order quantities and prices for Mulago national referral hospital; a mixed methods study**

**Key Informant Interview Guide for participants**

**Part A: Demographic**

1. Designation
2. Work experience in Mulago NRH (in years)
3. Gender

**Part B: Questions**

1. In your opinion, what was the effect of COVID-19 on adequacy of essential medicines (EM) at Mulago NRH?
2. Which EM were most affected by COVID-19 and to what extent?
3. What was the effect of COVID-19 on EM prices at Mulago NRH?
4. Which EM were most affected by COVID-19 and to what extent?
5. How adequate were Mulago NRH's EMHS budget in meeting the effects above?
6. If the EMHS budget was inadequate, what measures did Mulago NRH take to meet EM needs?
7. What measures has Mulago NRH put in place to respond to sudden increases in EM demands under unusual situations such as epidemics, pandemics etc.?
8. What measures do you recommend to be put in place to enable public referral hospitals such as Mulago NRH to cope with EM needs incase of epidemics, pandemics etc.?

**END. Thank you.**

**Appendix E: Consent form for key informants**

**Part I: Introduction**

My name is _____ (Interviewer). I am part of the research team that is conducting a study titled "**Effect of COVID-19 on essential medicines order quantities and prices for Mulago national referral hospital; a mixed methods study**."

The lead researcher for this study is Nyombi Vicky Richardova Babirye (Telephone: +256773335393 and E-mail: nyombi.vicky@yahoo.com), working in the pharmacy department, Mulago national referral hospital (NRH), Kampala, Uganda and also a student undertaking a masters' in health supply chain with the University of Rwanda, Kigali, Rwanda.

The other contact person for this study is Kalidi Rajab (Telephone: +256776798978 and E-mail: rkalidi@gmail.com) the main supervisor of this research project from the pharmacy department, school of medicine, college of health sciences, Makerere university, Kampala, Uganda.

This form gives you information to help you decide whether to or not to participate as a key informant in this study. Being in the study is voluntary. Please read this form carefully. You may ask any questions about the study, and then decide whether to or not to participate.

**Part II: Information sheet**

The COVID-19 pandemic has affected the health supply chain systems of many public health facilities in Uganda. The most affected are public referral hospitals (such as Mulago NRH as they house COVID-19 treatment units that admit and manage COVID-19 patients with moderate, severe, and critical disease. Patients with these categories of disease require significant expenditure on essential medicines. To meet these emerged essential medicines demands under no additional budgetary provision amidst high essential medicines prices, the public referral hospitals have adopted a number of coping mechanisms. We therefore, want to understand the different coping mechanisms instituted by Mulago NRH during the COVID-19 pandemic to meet the high essential medicines demands of the COVID-19 treatment unit. The information collected will inform government and stakeholder response for how to protecting health facilities housing COVID-19 treatment units from adverse essential medicines shortages with recurrent waves of the pandemic.

**Study procedure**

If you agree to participate in this study as a key informant, the interview will take place in a convenient space at Mulago National Referral Hospital. The interview will be guided by

questions within a key informant guide and last about 25-30 minutes. The interviewer will ask you questions including personal identifying information such as your names, designation, number of years worked at Mulago NRH, and roles and responsibilities in regards to Mulago's essential medicines orders and the health supply chain; and the different essential medicines related coping mechanisms instituted by Mulago NRH during the COVID-19 pandemic.

**Costs**

You will not be charged for any of the study activities, for this engagement with you, we will only ask you questions as earlier mentioned.

**Compensation**

You will be compensated with Uganda shillings twenty thousand (UGX 20,000) for your time and this will be given at the end of the key informant interview.

**Risks and Benefits**

There are no physical risks to participating in this study, as no samples will be taken from you or medicines administered.

However, since we are asking you to share with us some personal information and work-related information, some questions may make you uncomfortable. To minimize this risk, we stress that:

1. You may refuse to answer any question or excuse yourself from the study anytime you feel uncomfortable.
2. All information obtained during the key informant interview will remain confidential.

Before starting the key informant interview, we shall ensure that the following are in place to mitigate the risk of COVID-19 infection.

1. The facilitator of the key informant interview will be wearing a face mask. You shall also be request you to wear one. If you do not have one at the time, the research team will provide you with one.
2. The facilitator will have hand sanitizer to use in-between handling things like pens and consent forms, and on surfaces of where the key informant interview will take place.
3. To the extent possible, we shall ensue that the distance between the facilitator and the key informant is at least 2 meters in a room that is well ventilated.

**Benefits of the study**

Although this study will not benefit you directly, but Mulago national referral hospital will get the final report and be able to identify which areas they need to improve according to your views.

We also hope that information from the study will inform government budget allocation in respect to the EM component to public hospitals housing treatment units, especially during pandemics situations.

**Voluntary Participation**

Your participation in this study is voluntary. You may refuse to participate or to answer any question that you do not want to answer, and you can end your participation at any time for any reason. Refusing to participate will not involve any penalty or loss of benefits to which you are otherwise entitled such as your job, or benefits that come with your job.

**Anonymity**

All of your responses will be anonymous, and none of the information you give will be traced back to you. A study number rather than your name will be used.

**Questions**

If you have any questions, comments or concerns about this study now or any time during the study, you may contact Nyombi Vicky Richardova Babirye on Tel: +256773335393 and e-mail: nyombi.vicky@yahoo.com.

**Rights of the participant**

If you have any questions about your rights as a research participant or want to contact people other than the research team members, you should contact Dr. Fredrick Nakwagala (Chair-Mulago National Referral Hospital Research and Ethics Committee.) on Tel 0772325869 and e-mail: nakwagala@yahoo.com.

It is your choice whether to or not to take part in this research. If you chose to take part, you may change your mind and eave the study at any time without punishment. Refusing to participate will not affect you or your job in any way. In case you are unhappy with any of the research procedures, please contact any of the study team members (the lead researcher and the supervisor).

This study has been approved by the Mulago NRH and University of Rwanda Research and Ethics Committees. These organizations are responsible for ensuring that research is conducted according to current guidelines on research in human participants and that your rights are protected.

**Funding for the project:**

The funding for this study is from the lead investigator (Nyombi Vicky Richardova Babirye).

**Certificate of Consent:**

I have read and understood the information above, and I have had the opportunity to ask questions about it and all questions that I have asked have been answered to my satisfaction. I consent voluntarily to participate as a key informant in this research.

Name of key informant: _____

Signature of key informant: _____ Date: _____

**Part III: Statement of the researcher**

I confirm that the participant was given an opportunity to ask questions about the study, and all the questions asked by the participant have been answered correctly and to the best of my ability. I confirm that the individual has not been coerced into giving consent, and the consent has been given freely and voluntarily.

Name of Interviewer: _____

Signature of Interviewer: _____ Date: _____

**Appendix F: Essential medicines classified as COVID-19-leaning**

| S/N | Item description | UOM |
|---|---|---|
| 1 | Beclomethasone inhaler 50mcg/dose 200 doses | 1 |
| 2 | Salbutamol inhalation 100mcg/dose, 200 doses | 1 |
| 3 | Acetylsalicylic acid 75mg SR tablets | 100 |
| 4 | Amitriptyline 25mg tablets | 1000 |
| 5 | Amoxicillin dispersible tablets 250mg | 100 |
| 6 | Azithromycin 500mg tablets | 3 |
| 7 | Captopril 25 mg tablets | 100 |
| 8 | Carvedilol 6.25mg tabletss | 30 |
| 9 | Cetrizine tablet 10mg | 100 |
| 10 | Chlorpromazine 100mg tablets | 1000 |
| 11 | Clonazepam 2mg tablets | 30 |
| 12 | Dexamethasone 0.5mg tablets | 1000 |
| 13 | Digoxin 250mcg tablets | 1000 |
| 14 | Fluoxetine capsules 20mg | 100 |
| 15 | Furosemide 40mg tablets | 1000 |
| 16 | Glibenclamide tablets 5mg tablets | 100 |
| 17 | Haloperidol tablets 10mg | 100 |
| 18 | Lisinopril tablets 10mg | 100 |
| 19 | Metformin HCl 500mg tablets | 100 |
| 20 | Metronidazole 200mg tablest | 1000 |
| 21 | Nifedipine retard 20mg tablets | 100 |
| 22 | Oral rehydration salts for 1lt | 25 |
| 23 | Paracetamol 500mg tablets | 1000 |
| 24 | Phenoxymethylpenicillin 250mg tablets | 1000 |
| 25 | Prednisolone 5mg tablets | 1000 |
| 26 | Spironolactone 50mg tablets | 1000 |
| 27 | Tramadol 50mg capsules | 100 |
| 28 | Warfarin 5mg tablets | 28 |
| 29 | Aminophylline 250mg/10ml inj. Slow iv infusion | 1 |
| 30 | Atropine 1mg/1ml IV/IM | 100 |
| 31 | Calcium gluconate injection, 10%, 10ml vial | 1 |
| 32 | Ceftriaxone sodium 1g powder for injection | 1 |
| 33 | Chlorpromazine HCl 50mg/2ml deep IM | 100 |
| 34 | Cis-atracurium injection 2mg/ml 10ml vial | 5 |
| 35 | Dexamethasone 4mg/ml ,2ml ampoule | 100 |
| 36 | Diazepam 10mg/2ml IM/slow IV/IV infusion | 100 |
| 37 | Digoxin injection 0.25 mg/ml 2ml | 100 |
| 38 | Enoxaparin 40mg/0.4ml,0.4ml Vol., pre-filled syringe | 2 |
| 39 | Enoxaparin 80mg/0.8ml,1ml syringe | 1 |
| 40 | Ephedrine 30mg/ml 1 ml ampoule | 10 |
| 41 | Epinephrine (adrenaline) 1mg/ml IV/IM/SC | 100 |
| 42 | Etomidate 2mg/ml, 20ml vial | 1 |
| 43 | Fentanyl citrate 50mcg/ml 2ml ampoule | 10 |
| 44 | Furosemide 20mg/2ml IM/slow IV/IV | 100 |
| 45 | Glucose (dextrose) 5% infusion 500ml | 24 |

| | | |
|---|---|---|
| 46 | Glucose 50% injection 100ml | 1 |
| 47 | Hydralazine injection 20mg/ml | 5 |
| 48 | Hydrocortisone sodium phosphate 100mg injection | 50 |
| 49 | Insulin Isophane human 100iu/ml Inj. SC | 1 |
| 50 | Insulin Mixtard human 100iu/ml Inj.SC | 1 |
| 51 | Insulin Soluble, neutral, human 100iu/ml Inj.SC | 1 |
| 52 | Ketamine 500mg/10ml injection IV/IM | 5 |
| 53 | Labetalol 5mg/ml 20ml vial | 1 |
| 54 | Meropenem 500mg vial | 1 |
| 55 | Metoclopramide 10mg/2ml injection | 100 |
| 56 | Metronidazole 500mg/100ml infusion | 1 |
| 57 | Midazolam 5mg/ml 3ml ampoule | 5 |
| 58 | Naloxone 0.4mg/ml 1ml ampoule | 10 |
| 59 | Phenytoin sodium 50mg/ml injection 5ml | 1 |
| 60 | Propofol 10 mg/ml, 50ml vial | 1 |
| 61 | Rabeprazole sodium injection 20mg/5ml, 5ml vial | 1 |
| 62 | Sodium (Ringers) lactate compound infusion | 24 |
| 63 | Sodium chloride/Normal saline 0.9% infusion | 24 |
| 64 | Suxamethonium chloride 100mg/2ml injection | 100 |
| 65 | Thiopental sodium 500mg ampoules | 50 |
| 66 | Tramadol injection 100mg/2ml ampoules | 5 |
| 67 | Vitamin k1 (phytomenadione) 10mg/ml IM | 1 |
| 68 | Water for injection 10ml | 100 |
| 69 | Diazepam 2.5mg suppositories | 5 |
| 70 | Paracetamol 125mg suppositories | 10 |
| 71 | Hydroxyurea 500mg capsules | 100 |
| 72 | Isosorbide dinitrate 20mg tablets | 56 |
| 73 | Magnesium trisilicate comp 250mg+120mg tablets | 1000 |
| 74 | Olanzapine tablets 10mg | 100 |
| 75 | Amiodarone HCl 50mg/ml, 3ml | 6 |
| 76 | Methyl prednisolone sodium succinate 500mg, dry powder injectable | 1 |
| 77 | Morphine sulphate 10mg/ml IV/IM/SC | 10 |
| 78 | Omeprazole 40mg injection | 1 |
| 79 | Rocuronium bromide 10mg/ml 5ml ampoule | 1 |
| 80 | Vancomycin 500mg injection | 1 |
| 81 | Vecuronium 10mg powder for reconstitution | 1 |
| 82 | Omeprazole 200mg capsules | 100 |
| 83 | Dobutamine iv 25mg/2ml ampoule | 1 |
| 84 | Enoxaparin 60mg/0.6ml vol prefilled syringe | 2 |
| 85 | Thiamine IV injection 100mg/ml-2ml | 1 |
| 86 | Calcium chloride 10%/ 10ml ampoule | 1 |
| 87 | Codeine phosphate 30mg tablets | 100 |
| 88 | Glycopyrrolate 0.2mg/ml injection | 1 |
| 89 | Zinc sulphate 20mg tablets | 100 |

**Appendix G: Essential medicines classified as non-COVID-19-leaning**

| S/N | Item description | UOM |
|---|---|---|
| 1 | Atropine 1% eye drops, 10ml | 1 |
| 2 | Betamethasone+Neomycin 0.1%+0.5% eye drops, 10ml | 1 |
| 3 | Phenylephrine eye drops 10%, 5ml | 1 |
| 4 | Chloramphenicol 0.5% eye drops, 10ml | 1 |
| 5 | Chloramphenicol 5% ear drops, 10ml | 1 |
| 6 | Gentamicin 0.3% eye/ear drops, 10ml | 1 |
| 7 | Tetracycline 1% eye ointment, 3.5g tube | 1 |
| 8 | Timolol maleate 0.5% eye drops, 5ml | 1 |
| 9 | Isoflurane inhalation 100%, 250ml vial | 1 |
| 10 | Sevoflurane inhalation 100%, 250ml vial | 1 |
| 11 | Aciclovir 200mg tablets | 100 |
| 12 | Albendazole 400mg tablets | 500 |
| 13 | Bisacodyl 5mg tablets | 100 |
| 14 | Carbamazepine 200mg tablets | 1000 |
| 15 | Carbimazole 5mg tablets | 100 |
| 16 | Ciprofloxacin 500mg tablets | 100 |
| 17 | Diclofenac sodium 50mg enteric coated tablets | 100 |
| 18 | Folic acid 5mg tablets | 1000 |
| 19 | Griseofulvin 500mg tablets | 100 |
| 20 | Ibuprofen 200mg tablets | 1000 |
| 21 | Imipramine 25 mg tablets | 1000 |
| 22 | Lactulose 10g/15ml syrup, 100ml bottle | 1 |
| 23 | Phenobarbital 30mg tablets | 1000 |
| 24 | Phenytoin sodium 100mg tablets | 1000 |
| 25 | Pyrimethamine 25mg+sulfadoxine 500mg tablets | 1000 |
| 26 | Sodium valproate 500mg tablets | 100 |
| 27 | Trifluoperazine 5mg tablets | 1000 |
| 28 | Vitamin b complex tablets | 1000 |
| 29 | Amphotericin b 50mg vial | 1 |
| 30 | Bupivacaine HCl 0.5% in dextrose 8.0% injection solution, 4ml ampoule, spinal | 20 |
| 31 | Ciprofloxacin iv 200mg/100ml vial | 1 |
| 32 | Fluphenazine 25mg/ml injection | 10 |
| 33 | Haloperidol 5mg/1ml injection | 1 |
| 34 | Magnesium sulphate 50%, 10ml | 1 |
| 35 | Penicillin, benzathine benzyl 2.4mu/1.44g ampoule | 10 |
| 36 | Pethidine 100mg/2ml IV/IM/SC | 10 |
| 37 | Potassium chloride 15% vial | 1 |
| 38 | Salbutamol nebuliser 5mg/2.5ml vial | 1 |
| 39 | Miconazole 2% cream, 20g tube | 1 |
| 40 | Silver sulphadiazine cream 1% 20g tube | 1 |
| 41 | Acetazolamide 250 mg tablets | 100 |
| 42 | Domperidone 10mg tablets | 100 |
| 43 | Risperidone 1mg tablets | 100 |
| 44 | Adenosine injection 3mg/ml-2ml vial | 1 |
| 45 | Ciprofloxacin 0.3% eye drops, 10ml | 1 |

| | | |
|---|---|---|
| 46 | Amethocaine (Tetracaine) hydrochloride eye drops 0.5%, 0.5ml dose units | 1 |
| 47 | Miconazole 2% oral gel 20g tubes | 1 |
| 48 | Rabies vaccine + solvent 0.5ml, 1 dose | 1 |
| 49 | Lidocaine HCl 2% injection | 1 |
| 50 | Mannitol 20% 100ml infusion | 1 |
| 51 | Ampicillin 500mg powder for reconstitution IV/IM/infusion | 100 |
| 52 | Allopurinol 100mg tablets | 28 |
| 53 | Amoxicillin 250mg capsules | 1000 |

**Appendix H: Data of number of monthly orders over the four-year study period (Mar 2018 to Mar 2022)**

| Month | Mar 2018 | Apr 2018 | May 2018 | Jun 2018 | Jul 2018 | Aug 2018 | Sept 2018 | Oct 2018 | Nov 2018 | Dec 2018 | Jan 2019 | Feb 2019 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of routine orders | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| No. of emergency orders | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total orders | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Proportion of emergency orders | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

| Month | Mar 2019 | Apr 2019 | May 2019 | Jun 2019 | Jul 2019 | Aug 2019 | Sept 2019 | Oct 2019 | Nov 2019 | Dec 2019 | Jan 2020 | Feb 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of routine orders | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| No. of emergency orders | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total orders | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Proportion of emergency orders | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

| Month | Mar 2020 | Apr 2020 | May 2020 | Jun 2020 | July 2020 | Aug 2020 | Sept 2020 | Oct 2020 | Nov 2020 | Dec 2020 | Jan 2021 | Feb 2021 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of routine orders | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| No. of emergency orders | 0 | 0 | 1 | 0 | 1 | 1 | 3 | 1 | 3 | 1 | 3 | 0 |
| Total orders | 1 | 1 | 2 | 1 | 2 | 2 | 4 | 2 | 4 | 2 | 4 | 1 |
| Proportion of emergency orders | 0.0 | 0.0 | 0.5 | 0.0 | 0.5 | 0.5 | 0.8 | 0.5 | 0.8 | 0.5 | 0.8 | 0.0 |

| Month | Mar 2021 | Apr 2021 | May 2021 | Jun 2021 | Jul 2021 | Aug 2021 | Sept 2021 | Oct 2021 | Nov 2021 | Dec 2021 | Jan 2022 | Feb 2022 | Mar 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of routine orders | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| No. of emergency orders | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| Total orders | 1 | 1 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 3 | 1 | 1 | 1 |
| Proportion of emergency orders | 0.0 | 0.0 | 0.5 | 0.5 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.7 | 0.0 | 0.0 | 0.0 |

**Appendix I: Data of the monthly integrated values of COVID-19 severity and patient numbers over the four-year study period (Mar 2018 to Mar 2022)**

| Month | Mar 2020 | Apr 2020 | May 2020 | Jun 2020 | July 2020 | Aug 2020 | Sept 2020 | Oct 2020 | Nov 2020 | Dec 2020 | Jan 2021 | Feb 2021 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Monthly integrated value for COVID-19 severity and patient numbers | 0.34 | 0.45 | 0.94 | 2.95 | 5.48 | 1.02 | 1.46 | 11.71 | 34.09 | 31.20 | 13.50 | 3.79 |

| Month | Mar 2021 | Apr 2021 | May 2021 | Jun 2021 | Jul 2021 | Aug 2021 | Sept 2021 | Oct 2021 | Nov 2021 | Dec 2021 | Jan 2022 | Feb 2022 | Mar 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Monthly integrated value for COVID-19 severity and patient numbers | 4.33 | 43.07 | 41.86 | 42.51 | 11.10 | 3.50 | 0.91 | 2.80 | 10.41 | 17.53 | 12.64 | 4.20 | 0.44 |

**Appendix J: Data of the monthly integrated values of essential medicines order quantities over the four-year study period (Mar 2018 to Mar 2022)**

| Month | Mar 2018 | Apr 2018 | May 2018 | Jun 2018 | Jul 2018 | Aug 2018 | Sept 2018 | Oct 2018 | Nov 2018 | Dec 2018 | Jan 2019 | Feb 2019 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Order Quantities for Non-COVID-19-leaning EM | 0.00 | 0.00 | 0.00 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Order Qts for COVID-19-leaning EM | 0.00 | -0.01 | 0.00 | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Integrated value for COVID-19 severity and patient numbers | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| Month | Mar 2019 | Apr 2019 | May 2019 | Jun 2019 | Jul 2019 | Aug 2019 | Sept 2019 | Oct 2019 | Nov 2019 | Dec 2019 | Jan 2020 | Feb 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Order Quantities for Non-COVID-19-leaning EM | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 | 0.06 | 0.06 | -0.02 | -0.11 | -0.02 | -0.02 | -0.02 |
| Order Qts for COVID-19-leaning EM | 0.00 | 0.00 | 0.00 | 0.00 | 0.23 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Integrated value for COVID-19 severity and patient numbers | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| Month | Mar 2020 | Apr 2020 | May 2020 | Jun 2020 | July 2020 | Aug 2020 | Sept 2020 | Oct 2020 | Nov 2020 | Dec 2020 | Jan 2021 | Feb 2021 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Order Quantities for Non-COVID-19-leaning EM | -0.02 | -0.03 | -0.11 | -0.11 | -0.20 | -0.22 | -0.24 | -0.30 | -0.11 | -0.19 | -0.15 | -0.18 |
| Order Qts for COVID-19-leaning EM | 0.06 | 0.15 | 0.64 | 0.03 | 0.60 | 0.12 | 0.62 | 0.84 | 2.59 | 3.92 | 2.60 | 2.40 |
| Integrated value for COVID-19 severity and patient numbers | 0.34 | 0.45 | 0.94 | 2.95 | 5.48 | 1.02 | 1.46 | 11.71 | 34.09 | 31.20 | 13.50 | 3.79 |

| Month | Mar 2021 | Apr 2021 | May 2021 | Jun 2021 | Jul 2021 | Aug 2021 | Sept 2021 | Oct 2021 | Nov 2021 | Dec 2021 | Jan 2022 | Feb 2022 | Mar 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Order Quantities for Non-COVID-19-leaning EM | -0.25 | -0.23 | -0.08 | -0.03 | 1.44 | 1.44 | 1.44 | 1.44 | 1.44 | 1.44 | 1.44 | 1.44 | 1.27 |
| Order Qts for COVID-19-leaning EM | 0.97 | 0.59 | 2.12 | 2.55 | 5.67 | 4.95 | 4.95 | 1.42 | 1.21 | 1.55 | 1.21 | 1.21 | 1.21 |
| Integrated value for COVID-19 severity and patient numbers | 4.33 | 43.07 | 41.86 | 42.51 | 11.10 | 3.50 | 0.91 | 2.80 | 10.41 | 17.53 | 12.64 | 4.20 | 0.44 |

**Appendix K: Data of the monthly integrated essential medicines prices over the four-year study period (Mar 2018 to Mar 2022)**

| Month | Mar 2018 | Apr 2018 | May 2018 | Jun 2018 | Jul 2018 | Aug 2018 | Sep 2018 | Oct 2018 | Nov 2018 | Dec 2018 | Jan 2019 | Feb 2019 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Monthly integrated COVID-19-Leaning EM prices | -0.03 | 0.00 | 0.17 | 0.18 | 0.34 | 0.37 | 0.37 | 0.37 | 0.37 | 0.37 | 0.37 | 0.37 |
| Monthly integrated non-COVID-19-Leaning EM prices | -0.09 | -0.08 | -0.08 | -0.08 | -0.09 | -0.01 | -0.13 | -0.13 | -0.10 | -0.10 | -0.02 | -0.03 |
| Integrated value for COVID-19 severity and patient numbers | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| Month | Mar 2019 | Apr 2019 | May 2019 | Jun 2019 | Jul 2019 | Aug 2019 | Sep 2019 | Oct 2019 | Nov 2019 | Dec 2019 | Jan 2020 | Feb 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Monthly integrated COVID-19-Leaning EM prices | 0.37 | 0.37 | 0.37 | 0.37 | -0.02 | -0.02 | -0.01 | -0.01 | 0.01 | 0.00 | -0.02 | -0.02 |
| Monthly integrated non-COVID-19-Leaning EM prices | -0.08 | -0.01 | 0.00 | -0.05 | -0.11 | -0.11 | 0.00 | -0.12 | -0.17 | -0.14 | -0.19 | -0.14 |
| Integrated value for COVID-19 severity and patient numbers | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| Month | Mar 2020 | Apr 2020 | May 2020 | Jun 2020 | Jul 2020 | Aug 2020 | Sep 2020 | Oct 2020 | Nov 2020 | Dec 2020 | Jan 2021 | Feb 2021 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Monthly integrated COVID-19-Leaning EM prices | -0.02 | -0.02 | -0.02 | -0.02 | 0.03 | 0.01 | 0.02 | 0.05 | 0.04 | 0.05 | 0.09 | 0.10 |
| Monthly integrated non-COVID-19-Leaning EM prices | -0.13 | -0.15 | -0.17 | -0.13 | -0.04 | -0.04 | 0.00 | -0.04 | -0.03 | -0.03 | -0.01 | -0.02 |
| Integrated value for COVID-19 severity and patient numbers | 0.34 | 0.45 | 0.94 | 2.95 | 5.48 | 1.02 | 1.46 | 11.71 | 34.09 | 31.20 | 13.50 | 3.79 |

| Month | Mar 2021 | Apr 2021 | May 2021 | Jun 2021 | Jul 2021 | Aug 2021 | Sep 2021 | Oct 2021 | Nov 2021 | Dec 2021 | Jan 2022 | Feb 2022 | Mar 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Monthly integrated COVID-19-Leaning EM prices | 0.09 | 0.01 | 0.06 | -0.01 | -0.01 | 0.00 | 0.03 | 0.07 | 0.07 | 0.07 | 0.07 | 0.00 | 0.00 |
| Monthly integrated non-COVID-19-Leaning EM prices | -0.03 | -0.03 | -0.02 | 0.00 | -0.04 | -0.05 | -0.03 | -0.02 | 0.04 | 0.07 | 0.07 | 0.07 | 0.04 |
| Integrated value for COVID-19 severity and patient numbers | 4.33 | 43.07 | 41.86 | 42.51 | 11.10 | 3.50 | 0.91 | 2.80 | 10.41 | 17.53 | 12.64 | 4.20 | 0.44 |