QATAR UNIVERSITY

COLLEGE OF HEALTH SCIENCES

# ASSESSMENT OF ORDERING PRACTICES AT BIOMEDICAL RESEARCH CENTER (BRC)- METABOLIC RESEARCH LABORATORY (MRL)

BY

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# ABSTRACT

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Title: Assessment of Ordering Practices at Biomedical Research Center – Metabolic Research Laboratory (MRL)

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**Background:** Assessment of the purchasing and ordering process in the Metabolic Research Laboratory (MRL) at the Biomedical Research Center (BRC) at Qatar University (QU) is a critical component of the quality management system (QMS). **Aims and objectives:** Assess and compare the contribution of price, delivery period, and items' handling parameters on choosing the ordering method by BRC staff. **Methods:** A quantitative descriptive study was conducted on 201 collected items from 2018-2020. The project was divided into two phases. In phase I, data was categorized and investigated while in phase II, data was analyzed based on three parameters: price, delivery time, and item's handling. **Results:** Prices of local suppliers were higher than online suppliers and original manufacturer prices. Amazon and Sedeer showed high percentages of on-time delivered items. In addition, all the companies showed good handling except for some orders from online suppliers. **Recommendations:** some recommendations and suggestions were illustrated to improve the purchasing and ordering process in BRC, such as creating a standard operating procedure (SOP) to follow during the purchasing process, assign finance personnel responsible for ordering processes, and create an excel sheet that contains detailed information about the received items for tracking purposes.

# DEDICATION

*This project is dedicated to my family members and friends for their continuous support and encouragement.*

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# CHAPTER 1: INTRODUCTION

## 1.1 Background

Ordering and purchasing practices should be successfully managed since it is a critical component of the quality management system (Sánchez-Rodríguez and Martínez-Lorente, 2004). Although it is challenging, purchasing and inventory processes, if adequately managed in medical laboratories, will ensure cost savings by balancing budget and spending, availability of reagents and supplies whenever needed, and the outstanding quality of equipment and supplies. There should be policies and procedures to follow in the lab to manage the ordering practices better. All supplies, reagents, and instruments should be carefully selected according to the best price from the best supplier that maintains the qualified lab work. The personnel in charge of ordering should also choose the best purchasing process to keep the work not interrupted in both diagnostic and research laboratories. It is also essential to link inventory management and the laboratory ordering system, such as getting a warning whenever the lab has a low stock item.

Regarding diagnostic labs, the management of ordering practices is highly crucial since patient results and treatment, which is the hospital's primary vision, will be affected (Alhassen,2018). For research labs, managing ordering practices has the same importance as supporting medical students' research or hospitals' and organizations' research to achieve goals that support developing the medical system and the patients' health. Ordering the items can be achieved either by direct orders from the manufacturers, indirect through local medical suppliers, or indirect through online suppliers.

In Qatar University, the Metabolic Research Laboratory (MRL), a part of the Biomedical Research Center (BRC), aims to study the biology of several diseases and find new therapeutic targets. The scope of services of (MRL) includes both molecular biology studies and in vivo studies that require using various highly sensitive biological models such as chick embryos and zebrafish. In MRL, the researchers carry out investigations on many diseases such as cardiovascular diseases, obesity, type II diabetes, cancer, and related medical outcomes. MRL as well as supports the process of education in QU. Thus, many research projects are carried out in this laboratory (BRC, n.d.).

Many materials and medical items, which are usually not available in the State of Qatar, are needed to maintain the lab's continuing work. Thus, the BRC department proceeds to request a variety of items from other countries by various local and online suppliers, considered intermediate companies between the original manufacturers and the end-users. The BRC department deals with numerous local suppliers in Qatar, such as Sedeer, Atlantic, Qatar Scientific, Beamed Trading, Medicare, UTECH Products, Key Solutions, Power 2 Group, and Decon. The department also deals with some online suppliers such as Amazon, Pipette, eBay, and Bioactiva Diagnostica to diversify the purchasing options. In the BRC department, to keep the procurement process moving smoothly and minimize the risk of problems or service interruption, the process should be assessed continuously to find the problems, give solutions, and change in the process if needed. Many indicators can be monitored and evaluated to check the process. This study will discuss and assess three primary parameters relevant to orders: price, delivery period, and items handling in the BRC department, focusing on the mainly practice at MRL.

### 1.1.1 Price

Usually, the price is the first indicator that the buyer looks at, but it should not be the only indicator for making the decision (Alhassen, 2018). Prices of the same items differ according to the way of ordering; for example: buying an item directly from the manufacturer will sometimes be much cheaper than buying the same item from a supplier or vendor (Nichols, 2018). The expert lab end-user should study each case separately from all aspects and make the best decision.

### 1.1.2 Delivery period

It is critical for the orders to be delivered in the specified period, so the workflow will not be interrupted. The delivery period should not be very long in order to be able to complete the research and studies on their specified times. Also, in diagnostics labs, the supplies' speedy delivery is crucial since it affects patients' tests' follow up (Alhassen, 2018).

### 1.1.3 Handling of items

Quality of the receiving items is a significant factor that should be considered during purchasing. Quality refers to the degree of end-user satisfaction with the received item since the products should meet or exceed end-user's expectations (Perreault and McCarthy, 2002). After paying and waiting to get the items, the buyer will expect receiving these items in good condition. The condition of the received items depends on shipment handling since some items have specific conditions for shipping. Some lab items can be shipped at room temperature, while others should be shipped in a temperature control either 2-8℃, -20℃, or in dry ice (-80℃). Also, some items are fragile and breakable, so they need gentle handling during shipping. The lab does not accept any shipment received in bad condition since this can affect the work and results.

## 1.2 Research Centers in Qatar

Recently Qatar established many research centers seeking development and innovation in all fields, including the medical field, such as Qatar Biomedical Research Institute (QBRI), Research Department at Weill Cornell Medicine - Qatar (WCM-Q), and Biomedical Research Center (BRC) in Qatar University (QU).

### 1.2.1 Qatar Biomedical Research Institute (QBRI)

In Qatar Foundation, Qatar Biomedical Research Institute (QBRI) is under the umbrella of Hamad bin Khalifa University (HBKU), which aims to develop the healthcare field (Specialized Research Institutes, n.d.). QBRI was established in 2012 to develop healthcare in Qatar concerning prevention, diagnosis, and treatment (QBRI, n.d.). The institute is concerned about research that studies many diseases and disorders highly significant to Qatari populations, such as cancer, neurological disorders, and diabetes (QBRI, n.d.). The ordering system in QBRI starts with preparing a list of the items to be ordered then requests for quotations from biomedical products' local distributors to have an idea about the prices and choose the proper one. After that, they fill a Material Requisition (MR) form and raise it to the procurement officer, who will open tendering for all the local distributors based on the MR form. The procurement department then sends the quotations to end-users for technical evaluation. Finally, they will prepare the purchase order (PO) for the distributor, providing the best price. The items' delivery usually takes from two to four months or sometimes more according to the date of delivery provided by the distributor previously (QBRI, n.d.). Since QBRI is a research institute; and it is essential to process the research during a specific period, they face a problem with a long time to deliver the items. However, recently they are ordering and receiving some items from Weill Cornell University research laboratory, which is much faster.

### 1.2.2 Research Department at Weill Cornell Medicine - Qatar

The Research Department at Weill Cornell Medicine - Qatar (WCM-Q), on the other hand, provides continuous developments in the medical field that specifically have an impact on complex diseases such as diabetes (Machaca, n.d.). This biomedical research program will undoubtedly need ordering items and materials to move on in all research. According to the manager of the procurement and logistics department at WCM-Q (H. Jaber, personal communication, Sep 09, 2020), the research department is using German software for items ordering called SAP software. The process depends on the items needed; each type of item has a specific ordering policy. End users follow the ordering policies, usually prepare three quotations, and then choose a vendor, which provides the best price with a suitable delivery time. The manager emphasized that the procurement department must know well about the country rules of importing and exporting processes; in addition, research centers should create a clear plan for importing and exporting before launching. Besides that, politics is an influencing factor because the delivery of items depends on the manufacturer's country and its relationship with Qatar.

Another problem that WCM-Q is suffering from; is the condition of the received frozen items, which will be affected by the atmosphere if they are not appropriately handled. The price is a significant issue because each lab has its fund and has to manage using it to receive the needed items and achieve significant results. Therefore, the price, delivery time, and the items' condition are very remarkable factors that may affect the WCM-Q ordering system. WCM-Q research department is working on solving ordering problems, and they found that making an account that has a list of the required number of items with agreed price list and delivery times valid for one year will help in receiving these items faster without the need for quotations. This

method helped them a lot in managing delivery time and price parameters.

### 1.2.3 Biomedical Research Center in Qatar University

Biomedical Research Center (BRC) at Qatar University (QU) is another center interested in research related to metabolic diseases, infectious diseases, and genomics. The center was established in September 2014 as a support for the biomedical sciences program in QU. It is dedicated to developing research and training of students besides collaborating with other organizations, such as Hamad Medical Corporation (HMC), QBRI, WCM-Q, Ministry of public health, Sidra Medical and Research Center, and Anti-Doping Lab Qatar (BRC, n.d.). After BRC establishing, there was a need to get some materials and items to start holding research and training. Therefore, they created policies and procedures for items ordering and procurement. The procurement policy in BRC sets that if the requisitions are below 50,000 QR, they will request three different suppliers' quotations. The quotations will then be evaluated by preparing a "quotation evaluation form", and the purchasing order will be created after choosing the best supplier. If the requisitions are more than 50,000 QR, on the other hand, the process will need more approvals and steps to be done. The end-users should send a detailed bill for the procurement department; then, the buyer will prepare the tender documents. After that, tender documents should be approved by the legal office and tender committee. The tender documents will be presented to receive offers for not less than 21 days. The offers will then be evaluated technically by filling the "technical evaluation form" and commercially by filling the "commercial evaluation form" by the end-users, who will choose the recommended supplier. Finally, the buyer will issue the purchasing order to the approved supplier (H. Yalcin, personal communication, Jan, 2020). Figure 1 illustrates the flowchart of the procurement process in BRC department. BRC, just the same as QBRI and WCM-Q, also has some

ordering practice problems and needs new suggestions and recommendations to have a more flexible and productive ordering system. BRC suffers from late items delivery and receiving the items in poor condition sometimes; this affects the workflow and the research progress since research has a specific period to be completed. In some cases, if the staff and the students managed to fix the delivery time and condition parameters, then the price of the items would be very high.

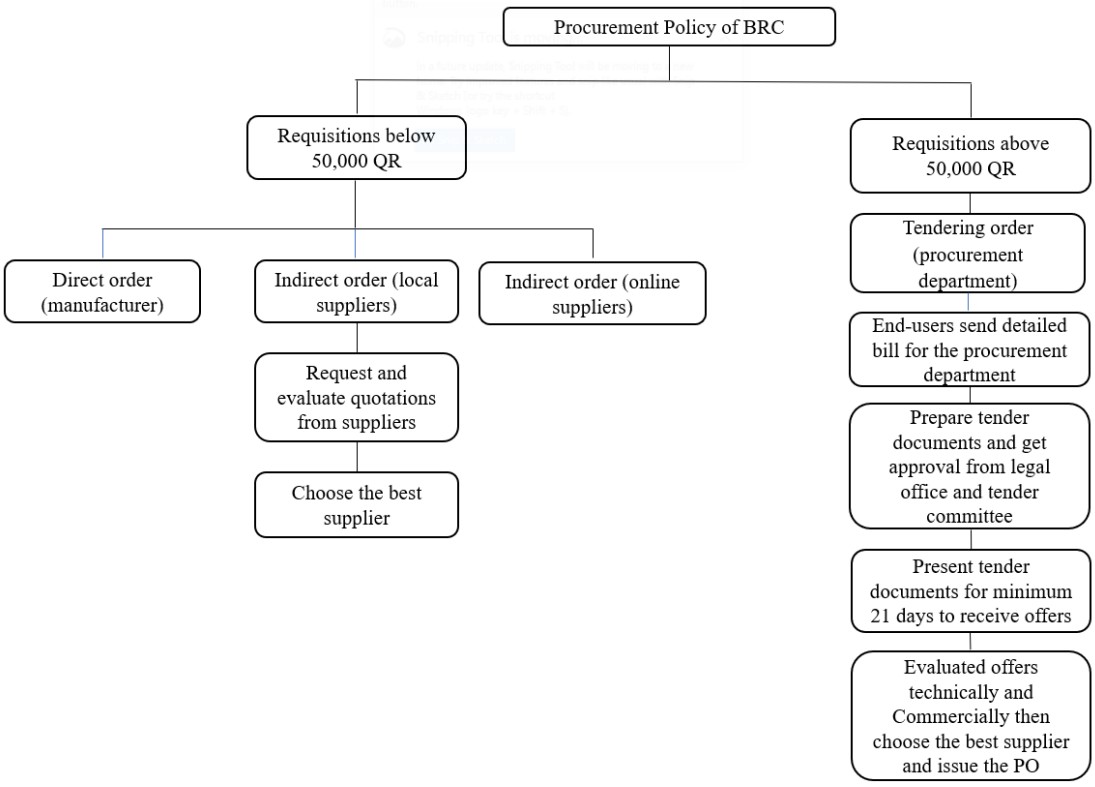


Figure 1: Flow chart of the procurement process in BRC department.

Regarding the BRC budget, every year, there is a budget located for BRC administration, which is divided into three types of expenses: capital expenses (CAPEX), operational expenses (OPEX), and human resources expenses (HR). CAPEX is the major expense that the organization pays for long-term use assets, such as property, computers, building improvements, or equipment. In contrast, OPEX is

the day-to-day expenses needed for an organization's operations, such as consumables, kits, or overhead costs (Verbrugge et al., 2006). In addition, the HR budget is located for the employees' salaries. After subtracting these expenses from the budget, the remaining will be divided into the BRC three principal investigators (PIs): Dr. Hadi Yassine, Dr. Huseyin Yalcin, and Dr. Mohamed Elrayess. Each PI can spend the budget on the interest projects compatible with the research proposal and objectives. PIs also can submit proposals to get grants to finance projects; the grant can be either internal from QU or external from any other entity such as Qatar National Research Fund (QNRF) or even abroad entities. The PI can use the grant within the research purpose, such as purchasing materials, equipment, or hiring temporary staff to work on the project. In addition, QU gives the PI a "student grant" to work on graduation projects for both under and postgraduates. The PI will not be allowed to get more than one grant simultaneously, except for student grants (QU BRC, 2017).

Regarding the expenditures, the requested materials or equipment to be purchased will be checked if listed and approved in the budget, and no personal electronics will be approved, such as laptops, computers, or printers. If the required items' price is more than 50,000 QR, it will be directed to tendering and competitive offers, while if it is less than 50,000 QR, the PI can ask for advances cash payment to use on project purchases then provide the invoices and the proof of payment to reconcile the advanced cash amount with the actual spending. The PI also can pay the project expenses and ask for reimbursement after providing the original invoices (QU BRC, 2017). In some cases, the procurement department will take over payment (direct payment) after getting the quotation from the PI. Moreover, each PI will have a P-card with a specific amount and can be used for purchasing if the items required are less than 15,000QR. Since orders exceeding 50,000 QR are going directly to

tendering, we limit this study to consumables and small orders, allowing us to study multiple ordering methods.

### 1.3 Problem statement

The diversity of research activities at MRL increases and creates many challenges relevant to ordering equipment and supplies. According to current practice, there are several ordering methods, such as direct order from the manufacturer, indirect order through local or online companies, or tendering. Each of these has advantages and disadvantages. In some cases, BRC is suffering from shipments that are received late or in an unacceptable condition, which delays the labs' work. Moreover, if the department managed the delivery time and items' handling problems, it suffers from high costs. Therefore, the researchers consume a lot of their working time to follow up on the purchasing process and choosing the best product with the best price that agrees with the budget of BRC. There is a strong need to assess the MRL's current ordering practice to ensure the continuation of the ongoing projects and availability of all items, supplies, and reagents for researchers and maintain sustainability and continuity of research work without interruption.

### 1.4 Research objective

This project's main objective is to assess and compare the contribution of price, delivery period, and items' handling parameters on choosing the ordering method by BRC staff to support the BRC department at QU in enhancing purchasing and ordering practices.

### 1.4.1 Research specific objectives

This project sought to achieve the following specific objectives:

1. To Compare and investigate price parameter through the different ordering systems.
2. To Compare and investigate delivery period parameter through the different ordering systems.
3. To Compare and investigate items' handling parameter through the different ordering systems.

## 1.5 Significance of the Study

This study will suggest recommendations to be implemented in the lab, improving the purchasing and ordering practices. These recommendations will maintain the desired research on time without interruption by having a smooth ordering system that ensures the required medical items' availability in proper condition.

# CHAPTER 2: LITERATURE REVIEW

## 2.1 Background

Several studies discussed the procurement process in many organizations including healthcare organizations. Some of these studies illustrate the effects of the parameters mentioned in the above chapter on achieving high-level quality service and improve the current practices in the organizations. This chapter will present a literature review of some research relevant to the topic to gain knowledge about the procurement process, the impact of the parameters on the purchasing decision, and the different procurement methods.

## 2.2 Process of laboratory items procurement

Laboratories need items and equipment orders continuously. If the lab is new, so equipment and items must be ordered to start the service; on the other hand, if it is an existing lab, the ordering may be to introduce a new test, start new research, replace non-functioning equipment, or improve an existing test. It is highly essential to follow a correct and precise process during procurement because this will lead to accurate and timely results that greatly value clinical decision making. Besides, choosing the best way of ordering helps in processing research and projects on time. Therefore, making an accurate purchasing decision has a big impact on the organization's finance by reducing the expenses and increasing the revenues, as well as, the huge impact on the quality of the ordered products (Kruk et al., 2007). There are many challenges in this process since there are several products from many companies besides many medical vendors, so it is crucial to study all the options and plan carefully before ordering. Planning the process carefully will help in achieving the objective of increasing satisfaction and profits of all the supply chain parties: manufacturer, supplier, and customer (Lee et al., 2001). The procurement personnel should consider

multiple factors when placing the order: end-user need, financial issues, national guidelines and regulations, proper handling, and availability of appropriate storage for the items (WHO, 2013). According to WHO (2000 and 2013), critical steps should be followed during procurement to ensure the workflow will continue smoothly. These steps are discussed in the following points.

### 2.2.1 Procurement planning

In all organizations, well-advanced planning for items and materials procurement is required to ensure the work is not interrupted and achieve the desired outcomes. This stage is considered critical during which both parties agree on some terms that should be followed during the process. This agreement will state the common objectives of the collaboration between both parties (Cassivi, 2006). The first step is assessing the needs by determining the lab requirements. As we mentioned before, it is beneficial to link inventory management and ordering system, so all the lab requirements will be automatically provided, and no items will be missed. The end-user or the stakeholders should be engaged in the planning step by asking them about their needs and giving them the chance to participate in item and supplier selection. This step will help in the procurement process since they are involved more than management in the workflow. The plan should discuss the items needed to be procured, when and where the delivery should occur, who will do this process, and how it will be conducted (WHO, 2000 and 2013). After selecting a suitable product that meets all standards, the staff should estimate the quantity needed from each item. This estimation can be done annually by forecasting the future need for reagents and supplies according to the previous consumption, since exchanging the forecasting information between end-users and suppliers is an essential step of planning the supply chain (Cassivi, 2006). Determining the quantities is challenging since it should

be accurate to minimize the risk of reagents and supplies shortage or waste.

### 2.2.2 Implementation

In this stage, the laboratory should state the requirements written covering technical and commercial data, which will result in the satisfaction with the product. The procurement personnel should then approach several suppliers, vendors, or manufacturers to get the best offer. The suppliers should submit quotations according to the specifications identified previously. After that, the quotations must be evaluated to choose the best offer according to the price, delivery period, shipping condition, maintenance, and service (in case of equipment), and any other specifications required. It would be better if the laboratory end-user is the one who is evaluating the quotations and narrowing the selection rather than an administrator since the laboratory end user is going to compare the offers by looking into all the aspects and choose the most suitable offer depending on the test or the project that will be conducted. After choosing the best offer, the buyer should find out more about the supplier, especially if it is the first time dealing with this vendor. The buyer should inquire about its reliability, reputation, how long the company is in business, and following any accredited standards. The buyer should not decide quickly or be forced to choose any company; the lab can also contact other labs that have dealt with this company before to ask about their reputation. When the lab is sure about the decision, then there should be a written contract (purchase order) between the buyer and the supplier, which has exacted and full details about the price, delivery, shipping, warranty, installment, training, maintenance, and any important details to avoid any problems or misunderstandings in the future (WHO, 2000 and 2013).

### 2.2.3 Monitoring and evaluation

The procurement process should be routinely monitored and evaluated to check its effectiveness; this includes some indicators such as: choosing the correct product, checking the consumption, forecasting, and inventory management. The buyer should also evaluate the supplier's performance by continuously collecting data related to the product's delivery time and condition, balancing the price with the product, service quality, and the company's response speed. Moreover, the lab end-user has to continuously evaluate the product quality by performing quality assurance measures such as checking the rate of invalid runs or out-of-range quality control results and performing proficiency testing (WHO, 2000 and 2013).

## 2.3 Impact of the Parameters on Purchasing Decision

### 2.3.1 Price

As mentioned before, price is the most motivating factor for decision-making to purchase an item, use a service, or choose a supplier, but it should not be the only factor assessed. The customer should assess all the parameters at the same time and balance the pros and cons of each option. In a previous quantitative study done in (2016) by Al-Azzam, he surveyed a group of tourist patients visiting Jordan for treatment and he found that there is a significant relationship between the hospitals' services' prices and the attraction of the patients. This agrees with Alfred's study in 2013 in which he found that the influence of the prices of mobile phones affects the purchasing decisions of the customers. Also, Alhassan in 2018 concluded that the price is the most parameter that has a contribution to the purchasing decision of laboratory supplies by an average of (52%). It has been found that optimizing the costs of the operations conducted in Al Zahrawi Medical in U.A.E. is one of the factors that will help the company to change the purchasing decision of the customers and increase its profits as well (Lenin, 2014). In addition, a study conducted in the Czech Republic

about the factors influencing consumer behavior showed that the price factor has an influence on the purchasing decision (Stávková et al., 2008). In Iraq as well the researchers found that price is one of the factors that have a strong influence on the consumer's behavior (Furaiji et al., 2012). From the previous studies, the important contribution of price parameter in affecting the purchasing decision can be concluded. Therefore, the assessment of price parameter is highly important to choose the best purchasing method.

### 2.3.2 Delivery Period

It is crucial for every organization and customer to receive the ordered items on time. This will ensure the continuity of the work in organizations, increase the satisfaction of the customers, and positively impact their behavior and purchasing decisions. In Alhassan's (2018) study, he found that the speed of delivering the laboratory supplies has an average of (12.5%) in the contribution of purchasing decision, however, it was the lowest contribution compared to other parameters. The delivery period was the second parameter with the price that can help Al Zahrawi Medical to optimize the operations, improve the weaknesses, and get more profits according to Lenin's (2014) study. This is because delivering the medical supplies on time will change the customers' perceptions regarding Al Zahrawi company since it is an essential factor. Thus, choosing a purchasing method that ensures receiving the supplies on time is essential, since it will keep the work uninterrupted.

### 2.3.3 Items' Handling

Receiving supplies of good quality is another essential factor that affects the purchasing decision of the customers. It is highly important regarding laboratories to get the items valid to use, shipped in the compatible temperature, and in a good condition. Receiving a good quality service is also essential as confirmed in Al-Azzam's (2016) study when he found that the quality of the Jordanian hospitals'

service has a significant relationship with the attraction of the tourist patients to get the treatment in Jordan besides the price. Alfred (2013) as well, found that the quality of the products influences the buying decisions with the price. Also, the quality of the received laboratory supplies had an average of (13.3%) in the contribution of purchasing decision in Alhassan's (2018) study. Stávková et al. (2008) found that the quality of products is the most important factor in influencing purchasing decisions. Receiving the items in an acceptable condition and valid to be used is essential to keep the work continuity and choose the best purchasing method.

## 2.4 Procurement Methods

There are four main methods used in BRC for items ordering; each method has its advantages and disadvantages.

### 2.4.1 Direct Orders

These are the orders done directly from the manufacturer without the need for a supplier or vendor. Low costs characterize this ordering method because the buyer directly orders from the factory without intermediary involvement. Therefore, this will save the buyer's money due to finance overhead costs avoidance (McCrea, 2020). In addition, ordering directly from the manufacturer increases the linkage and the good relationships between the manufacturer and the buyer; this will help in the future in case the buyer needs to make any modifications to the products so that it can be done quickly due to the direct contact with the manufacturer. Speedy delivery is one of the advantages as well. Besides, the delivery of the items in good condition since the manufacturer is aware of each item's specific detail (McCrea, 2020). The manufacturer knows the shipment process and condition for every product precisely because some products need special conditions during shipping, such as temperature control for items that need to be shipped on wet (2-8℃) or dry ice (less than -20℃).

### 2.4.2 Indirect Local Suppliers' Orders

Ordering through local suppliers includes ordered and delivered products by an intermediate local company (supplier or vendor). Ordering through a vendor takes a longer time to deliver the items (sometimes more than two months). It is also relatively more expensive due to the finance overhead costs since suppliers usually charge the lab around 5-15% of their service costs; however, suppliers still can get the best price offers from the manufacturer due to their direct relationship (WHO, 2000). Ordering through a local supplier, on the other hand, will ensure receiving the items in good condition since the company is specialized in medical products' handling and will be fully responsible for the shipping and maintaining the shipment in the desired condition. It also has an advantage by saving the effort to search for a manufacturer and delivery method for the required items.

An organization can follow either single or multiple sourcing strategies. Single sourcing strategy (sole sourcing) means that the organization depends on one supplier to deliver a particular product. In contrast, multiple sourcing strategies (dual sourcing) means that the organization can get this product from multiple suppliers simultaneously (Costantino and Pellegrino, 2010). In a single sourcing strategy, the buyer and supplier can make a partnership and share benefits. There will be a lower risk of opportunistic behavior and a significant commitment from the supplier. However, it is precarious for the buyer to be depending only on one supplier since the supply may be interrupted.

Regarding multiple sourcing, on the other hand, the buyer will have alternative sources for the products in case of any interruption of the supply. Besides, having a competition between the suppliers gives the buyer the best quality, price, delivery, and negotiation power. In some cases, multiple sourcing will have some drawbacks: the risk of information sharing, consuming money and time to deal with more than one supplier,

and less response from suppliers with less interest in the organization (Costantino and Pellegrino, 2010; Moglix Business, 2018).

### 2.4.3 Indirect Online Suppliers' Orders

These are indirect orders done through online suppliers (intermediates) to deliver the items to the end-user. The significant advantage of online suppliers is the low prices compared to local suppliers (Bakos, 2001). The most disadvantage of online suppliers is shipping problems (Jain, 2008). Sometimes the online suppliers deliver the products by the courier companies, which are not fully aware of the medical items' proper handling. Therefore, the products may be received in poor condition and cannot be used, such as cells that need to be delivered in dry ice or products that need to be shipped at 2-8℃ temperature. Another disadvantage of online ordering that the buyer has to follow up and take full responsibility for the order until it is received in the lab, which is the opposite of ordering through a local supplier. Regarding the delivery time, some online suppliers deliver the items on-time, while in some cases, a delay can occur; this differs from one supplier to another.

### 2.4.4 Tendering

When orders are more than 50,000 QR, the tendering process will be used through the procurement department at BRC (H. Yalcin, personal communication, Jan, 2020). Tendering is used to drive competition between the suppliers to call for their bids to give the best offer. It is a very long process with many forms, steps to be done (such as technical evaluation and price evaluation), and the items take a long time to be delivered. However, an advantage of tendering is that it saves the technical staff time and effort from following up with the companies or the suppliers since this will be the procurement department's responsibility.

## 2.5 Situation of the Study in the Field

As mentioned above, various studies show the link between the three parameters (price, delivery period, and handling of items) and the purchasing decision from the customer. However, limited studies are showing the effect of these parameters on choosing the best medical laboratories' items ordering method, especially in Qatar. From reviewing the literature, medical laboratories in Qatar and especially the MRL had no previous researches that studied their purchasing and ordering system. In this study, the MRL system will be assessed by comparing the three parameters between different ordering methods to study the link between these parameters and choosing the purchasing method by BRC staff.

# CHAPTER 3: METHODOLOGIES

## 3.1 Background

The Metabolic Research Laboratory (MRL) is a part of the Biomedical Research Center (BRC) at Qatar University (QU) that conducts several kinds of biomedical research with a high-level target. Thus, many medical materials and products need to be ordered. This chapter will discuss the study design and the method that has been used for data collection and analysis.

## 3.2 Study design

In this project, a quantitative descriptive study was conducted from February 2020 to October 2020 to assess the MRL's items ordering practices. The sample has been collected using a simple random sampling method, since all small items that have been ordered between 2018-2020 using direct or indirect methods such as laboratory consumables and clinical kits) had the same probability to be selected in this study. Big equipment orders, which are ordered through the tendering method, on the other hand, have been excluded from the study. A total of (201) items has been analyzed in the study.

## 3.3 Data collection

An approval to access the lab facility and service was obtained from Ms. Naiema Al-Meer, BRC Technical Manager. The study does not require accessing personal data, doing interviews, using questionnaires, or using human or animal samples. Therefore, there was no need for ethical approval to conduct the project. The study only needs to review previously placed orders. The BRC staff provided the researcher with purchase orders, delivery notes, and invoices for the medical items requested from many different suppliers by the BRC department from 2018 to 2020.

## 3.4 Methods

The work of this project is conducted in two main phases: phase I and phase II. In the first phase, the collected data is investigated and categorized, while in the second phase, the data is analyzed based on the three interest parameters. This section is discussing the two phases in detail.

### 3.4.1 Phase I

In the first phase of this project, the available orders of lab consumables, specific biological kits, or small equipment placed in the last two years have been identified, and all the relevant documents have been collected, including purchase orders, invoices, or delivery notes. The researcher investigated all the documents and collected a total number of 201 items. After that, information regarding these orders have been entered into an excel sheet such as Items' names, Items' catalog number, ordering date, receiving date, quantity ordered and received, condition of the received items, type and name of the supplier, name of the manufacturer, cost of the item, the shipping and storing temperature.

The items were categorized into groups according to the storage temperature: items that can be stored and shipped at room temperature, items that need to be stored and shipped within 2-8℃ degrees using wet ice during shipping, or frozen items that need to be stored and shipped in a temperature less than -20℃ on dry ice.

Orders were also categorized according to the ordering method: indirect orders through local suppliers, indirect orders through online suppliers, or items that has quotations from local suppliers as shown in Table 1. Based on collected data, the department of BRC deals with some local suppliers such as Sedeer, Atlantic, Qatar Scientific, Beamed Trading, Medicare, UTECH Products, Key Solutions, power 2 Group, and Decon. The department also orders through some online suppliers such as

Amazon, Pipette, Bioactiva Diagnostica, and eBay.

Table 1: Descriptive Statistics of Collected Data

| **Storage temperature** | **Room temperature** | **2-8℃ (cold)** | **<-20℃ (frozen)** |
|---|---|---|---|
| **Number of items** | 146 | 21 | 34 |
| **Percentage (%)** | 72.6 | 10.5 | 16.9 |
| **Ordering method** | **Local supplier** | **Online supplier** | **Quotations from local suppliers** |
| **Number of items** | 171 | 18 | 12 |
| **Percentage (%)** | 85 | 9 | 6 |

### 3.4.2 Phase II

In the second phase of the study, efficiency assessment is conducted for each ordered item based on the parameters that affect the purchasing and ordering practices: price, delivery time, and proper handling of the shipments.

**Price:** Regarding the price analysis, the first parameter, a comparison between the original price (manufacturer price) and the price of ordered items from suppliers, will be considered first to find if the prices of items when ordering through suppliers differ from the original prices of the items in the manufacture. The suppliers' prices have been taken from the available data from BRC, while the original manufacturers' prices have been collected from the manufacturers' websites with converting the currency into Qatari Riyal to be compatible with suppliers' prices. Some descriptive statistics measurements are calculated, such as price difference and percentage of difference in the price.

The price difference for each item is calculated as follows:

$$\text{price difference} = \text{supplier price} - \text{orginal price}$$

Where supplier price is the price of the item via a supplier, and the original price is the price of the item in the original manufacture.

The difference percentage in the price of each item is also calculated and given as

$$\text{difference percentage} = \frac{\text{price difference}}{\text{orginal price}} \times 100$$

Then find the average percentage of the items ordered from each supplier.

Testing hypothesis: To test if there is a significant difference between the suppliers' groups, the normality test Kolmogorov-Smirnov test will be conducted to check if the items' prices for each supplier group follow normal distribution. If the price is normally distributed one-way ANOVA test will be conducted, while if the price is not normally distributed Kruskal-Wallis test will be conducted. If the test showed a difference between the groups, Dunn's multiple comparisons test is computed to check the most significant difference.

Secondly, a comparison between local and online suppliers' prices will be conducted to help the BRC department make the purchase decision before proceeding with the purchasing process. Therefore, the researcher will compare the prices of specific items provided by some local suppliers through quotations with the corresponding items' prices from online suppliers.

**Delivery time:** is the second parameter that is affected by ordering practices in BRC besides the price. The researcher will analyze this parameter by checking the items' ordering and delivery dates, then comparing between percentages of on-time and late delivery of items. Based on the researcher's working experience in Molecular

Genetics Laboratory at Hamad Medical Corporation in Doha – Qatar, a period of 6-8 weeks from the date of ordering until receiving the items is considered on-time delivery; otherwise, it is late delivery.

**Items' handling:** is the third parameter that is affected by the ordering practices in BRC. This parameter will be analyzed by checking the provided information about the received items. The way of handling of the items will be assessed based on the following: item's condition (good/bad), item's shipment temperature (controlled/uncontrolled), and validity of using the items (valid/invalid). Figure 2 illustrates the flow chart of the study design.

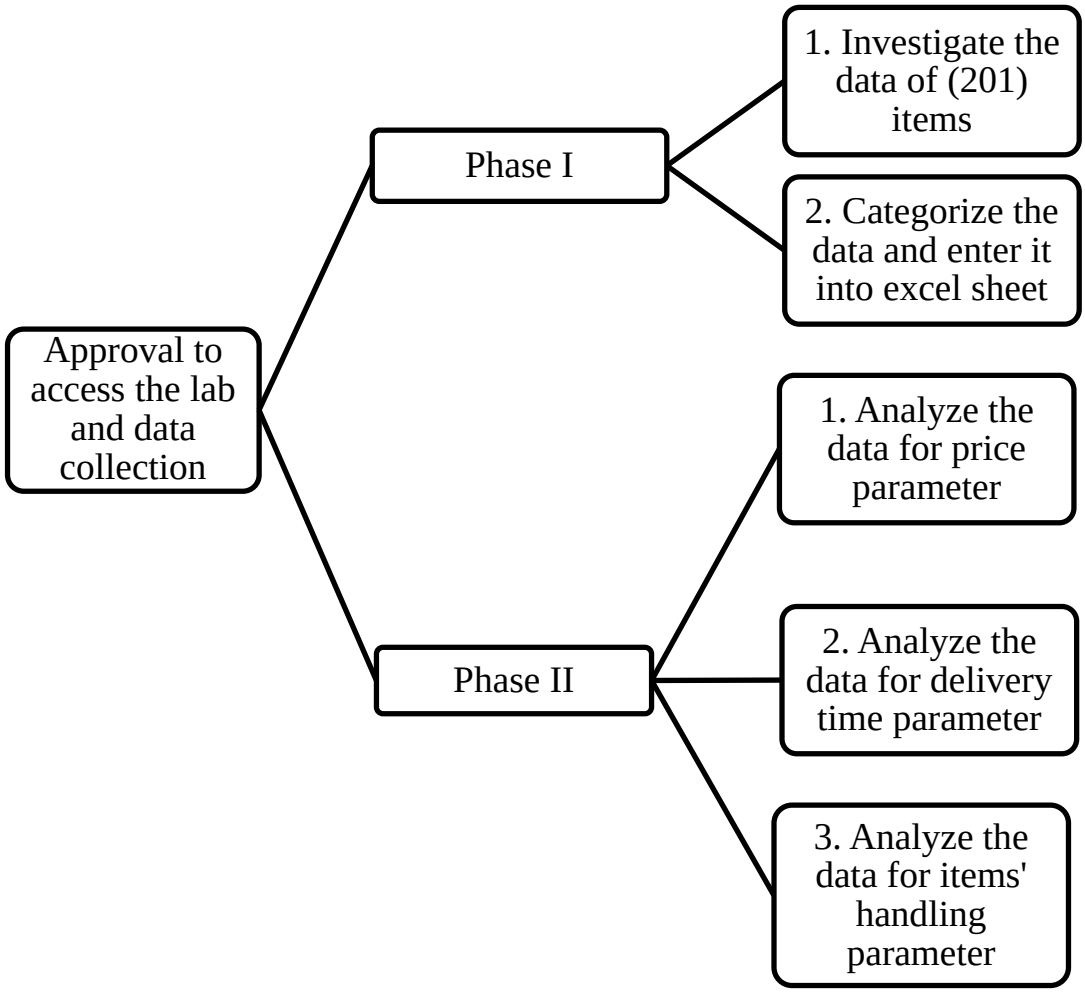


Figure 2: Flow chart of the study design.

# CHAPTER 4: RESULTS

## 4.1 Background

This chapter displays the results of comparisons of purchasing and ordering practices for 201 items ordered by the BRC department in QU during the period between 2018 and 2020. The results will be compared based on the following parameters: price, delivery time, and items handling.

## 4.2 Price

This section will analyze the first parameter that is affected by ordering practices, which is the price. A comparison will be provided between the items ordered through local and online suppliers, but first, a comparison between suppliers' prices and the original manufacturer prices is considered by finding the percentage of differences between the prices. Therefore, the researcher student has collected the original manufacturer prices of the items from their websites.

### 4.2.1 Suppliers' prices versus manufacturers' prices

As stated above, suppliers are divided into two groups, either local or online suppliers. The researcher observed that items ordered from Amazon and Pipette online suppliers are the most frequent based on the collected data. Thus, their prices are chosen to be compared with the original manufacturers' prices. The prices' difference percentages for the items ordered through online suppliers are decreased by an average of (20%) compared to the original manufacturers' prices.

Generally, from the available data, it is observed that the prices for almost all of the items ordered from local suppliers are higher than their original prices from the manufacturer as expected, considering the profit for local vendors. However, the researcher decided to focus on items with a more than 50% increase in prices during

2018-2020 because this can affect the purchasing decision, which is highly related to the budget of BRC, as shown in Table 2. The results also show that the prices of items from local suppliers (ordering price) are remarkably higher than those of manufacturer prices (original price).

With regards to local suppliers, the results in Table 2 show that Beamed Trading company has the highest percentage of the increase in the prices compared to the original prices from the manufacturer with an average of (257%), followed by Sedeer that has an average of (108%). Atlantic and Qatar Scientific (QS) companies, on the other hand, have a lower average of (88%) and (82%) respectively. Figure 3 conducted by excel software illustrates the graphical presentation for the average of the prices' increasing percentage for each local supplier. Items' names and catalog numbers are available in APPENDIX A.

Table 2: Original Manufacturers' Prices and Local Suppliers' Prices

| Item | Catalog number | Manuf. | Supplier | Original price | Ordering price | Diff. | Percentage increase (%) |
|---|---|---|---|---|---|---|---|
| MiSeq Reagent Kit v2 (300 cycles) | MS-102-2001 | Illumina | Beamed | 4012 | 12240 | 8228 | 205 |
| MiSeq Reagent Kit v2 (300 cycles) | MS-102-2002 | Illumina | QS | 4012 | 7776 | 3764 | 94 |
| Nextera XT Index Kit v2 Set A (96 indexes, 384 samples) | FC-131-2001 | Illumina | QS | 3720 | 7147 | 3427 | 92 |
| PhiX Control v3-Illumina | FC-110-3001 | Illumina | QS | 620 | 971 | 351 | 57 |
| Nextera XT DNA Library Preparation Kit (96 samples)-Illumina | FC-131-1096 | Illumina | QS | 11926 | 19118 | 7192 | 60 |
| Biosensor / Ni-NTA (NTA) Tray | 18-5101 | Fortebio | Sedeer | 2349 | 5400 | 3051 | 130 |

| Item | Catalog number | Manuf. | Supplier | Original price | Ordering price | Diff. | Percentage increase (%) |
|---|---|---|---|---|---|---|---|
| Biosensor/ Amine Reactive 2nd Generation (AR2G) Tray | 18-5092 | Fortebio | Sedeer | 2349 | 3920 | 1571 | 67 |
| Reagent / Amine Coupling 2nd Generation Reagent Kit | 18-5095 | Fortebio | Sedeer | 3381 | 5910 | 2529 | 75 |
| FHC | RL-1831 | ATCC | Sedeer | 1414 | 11,985 | 10571 | 748 |
| Caco2 | HTB-37 | ATCC | Sedeer | 1414 | 5080 | 3666 | 259 |
| Primary Bronchial / Tracheal Epithelial cells | PCS-300-010 | ATCC | Sedeer | 3327 | 5080 | 1753 | 53 |
| Falcon Polystyrene Microplates | 353043 | Falcon | Atlantic | 514.6135 | 1230 | 715.3865 | 139 |
| Merk Durapore PVDF Membrane Filters | GVWP01300 | Merk | Atlantic | 389.382 | 640 | 250.618 | 64 |
| Corning Round Ice Bucket with Lid | 432123 | Corning | Atlantic | 322.1125 | 610 | 287.8875 | 89 |
| Sureone filter Tip Reload Pipette Tips:10ul | 11907724 | Fisherbrand | Atlantic | 205.6775 | 400 | 194.3225 | 94 |
| Falcon 15ml Conical Centrifuge Tubes | 352095 | Falcon | Atlantic | 572.32 | 970 | 397.68 | 69 |
| Sodium hydroxide | SO04251000 | SCHARLAB | Atlantic | 128.626 | 450 | 321.374 | 250 |
| FG-Microplate | 4346906 | Thermofisher scientefic | Sedeer | 386.9 | 615 | 228.1 | 59 |
| Ethilon Nylon Non-absorbable suture | 7718G | Ethicon | Sedeer | 1923.185 | 5775 | 3851.815 | 200 |
| 8-strip PCR tubes+caps | AM12230 | Thermofisher scientefic | Sedeer | 740.95 | 1205 | 464.05 | 63 |
| Falcon 50ml Conical Centrifuge Tubes | 352070 | Falcon | Atlantic | 717.371 | 1200 | 482.629 | 67 |
| Fisherbrand™ Sterile Polystyrene Disposable Serological Pipets with Magnifier Stripe | 11869181 | Fisherbrand | Atlantic | 148.92 | 240 | 91.08 | 61 |

| Item | Catalog number | Manuf. | Supplier | Original price | Ordering price | Diff. | Percentage increase (%) |
|---|---|---|---|---|---|---|---|
| Falcon™ Tissue Culture Treated Flasks | 353018 | Falcon | Atlantic | 619.551 | 1220 | 600.449 | 97 |
| Fisherbrand™ SureOne™ Filter Tip Reload Pipette Tips 0.1-10 | 11907724 | Fisherbrand | Atlantic | 250.39 | 400 | 149.61 | 60 |
| Fisherbrand™ SureOne™ Filter Tip Reload Pipette Tips 10-100 | 11947724 | Fisherbrand | Atlantic | 259.515 | 420 | 160.485 | 62 |
| Fisherbrand™ SureOne™ Filter Tip Reload Pipette Tips 20-200uL | 11957724 | Fisherbrand | Atlantic | 250.39 | 400 | 149.61 | 60 |
| Fisherbrand™ Polypropylene Clear Autoclave Bags | 11553342 | Fisherbrand | Atlantic | 82.125 | 130 | 47.875 | 58 |
| Corning® 25 mm Diameter Syringe Filters, 0.2 µm Pore NY Membrane, Sterile, Individually Packaged, 50/Case | 431224 | Corning | Atlantic | 559.91 | 1070 | 510.09 | 91 |
| Whatman™ 3030-861 Grade 3MM CHR Cellulose Western Blotting Paper Sheet, 20 x 20cm, Thickness: 0.34mm (Pack of 100) | 3030-861 | GE | Atlantic | 223.745 | 490 | 266.255 | 119 |
| Pyrex® Reagent bottles, round bottom with reusable screw caps | 1515/08D | Pyrex | Atlantic | 404.055 | 750 | 345.945 | 86 |
| Falcon® 12-well Clear Flat Bottom TC-treated Multiwell Cell Culture Plate, with Lid, Individually Wrapped | 353043 | Falcon | Atlantic | 726.1675 | 1230 | 503.8325 | 69 |

| Item | Catalog number | Manuf. | Supplier | Original price | Ordering price | Diff. | Percentage increase (%) |
|---|---|---|---|---|---|---|---|
| Durapore® Membrane Filter, 0.22 µm | GVWP01300 | Merck | Atlantic | 389.382 | 640 | 250.618 | 64 |
| Corning® Ice Bucket with Lid, Round, 4L | 432123 | Corning | Atlantic | 375.95 | 610 | 234.05 | 62 |
| Pyrex® Reagent bottles, round bottom with reusable screw caps | 1515/04D | Pyrex | Atlantic | 284.7 | 570 | 285.3 | 100 |
| Pyrex® Reagent bottles, round bottom with reusable screw caps | 1515/08D | Pyrex | Atlantic | 404.055 | 750 | 345.945 | 86 |
| Nutri-Fly® BF, 10 x 1L Packets | 66-112 | Genesee Scientific | QS | 383.25 | 666 | 282.75 | 74 |
| Isolated 12-bit Voltage Output Phidget | OUT1001_0 | Phidgets | QS | 109.5 | 217 | 107.5 | 98 |
| 4x Isolated Solid-state Relay Phidget | REL1100_0 | Phidgets | QS | 91.25 | 181 | 89.75 | 98 |
| Acrylic Enclosure for the 1002 | 3800_2 | Phidgets | QS | 25.55 | 49 | 23.45 | 92 |
| Potassium Ferricyanide (ACS) | C995H04 | GFS Chemicals | Beamed Trading | 143.81 | 500 | 356.19 | 248 |
| Eppendorf epT.I.P.S. | 7732C09 | ep T.I.P.S. | Beamed Trading | 423.035 | 700 | 276.965 | 65 |
| Agarose | A9539-250G | Millipore Sigma | Beamed Trading | 1221.29 | 2423 | 1201.71 | 98 |
| 100ml Graduated Cylinder, Class A Serialized Glass | 1204Q99 | United Scientific Supplies | Beamed Trading | 178.85 | 350 | 171.15 | 96 |
| Erlenmeyer Flasks, Set of 5 | 1217C65 | United Scientific Supplies | Beamed Trading | 164.25 | 490 | 325.75 | 198 |
| 250ml Glass Beaker, Low Form Pk/12 | 1204P90 | Thomas | Beamed Trading | 175.2 | 850 | 674.8 | 385 |
| 500ml Glass Beaker, Low Form Pk/6 | 1204P92 | United Scientific Supplies | Beamed Trading | 111.69 | 550 | 438.31 | 392 |
| 1000ml Glass Beaker, Low Form Pk/6 | 1204P95 | United Scientific Supplies | Beamed Trading | 247.47 | 2250 | 2002.53 | 809 |
| Dissecting Set - 20 instruments | 1177L67 | Eisco | Beamed Trading | 105.85 | 822 | 716.15 | 677 |
| Parafilm® 4"x250ft (100mm x 75m) | 1222K01 | Heathrow | Beamed Trading | 262.8 | 419 | 156.2 | 59 |

| Item | Catalog number | Manuf. | Supplier | Original price | Ordering price | Diff. | Percentage increase (%) |
|---|---|---|---|---|---|---|---|
| RNaseZap™ RNase Decontamination Solution | AM9782 | Thermofisher scientefic | Sedeer | 1321.3 | 2075 | 753.7 | 57 |
| Tubes and Ultra Clear Caps, strips of 8 | AM12230 | Thermofisher scientefic | Sedeer | 740.95 | 1205 | 464.05 | 63 |
| Novex™ Reversible Membrane Protein Stain Kit | IB7710 | Thermofisher scientefic | Sedeer | 448.95 | 695 | 246.05 | 55 |
| MicroAmp™ Fast Optical 96-Well Reaction Plate with Barcode, 0.1 mL | 4346906 | Thermofisher scientefic | Sedeer | 386.9 | 615 | 228.1 | 59 |
| MicroAmp™ Optical Adhesive Film | 4311971 | Thermofisher scientefic | Sedeer | 985.5 | 1580 | 594.5 | 60 |
| UltraPure™ Tris Buffer (powder format) | 15504020 | Thermofisher scientefic | Sedeer | 459.9 | 825 | 365.1 | 79 |
| SuperSignal™ West Pico PLUS Chemiluminescent Substrate | 34580 | Thermofisher scientefic | Sedeer | 1043.9 | 1780 | 736.1 | 71 |
| MicroAmp™ Fast Optical 96-Well Reaction Plate with Barcode, 0.1 mL | 4346906 | Thermofisher scientefic | Sedeer | 386.9 | 635 | 248.1 | 64 |
| 10010 - PBS, pH 7.4 | 10010015 | Thermofisher scientefic | Sedeer | 51.1 | 130 | 78.9 | 154 |
| SIGMA Sodium chloride BioUltra, for molecular biology, >=99.5% (AT) | C922N28 | Millipore Sigma | Beamed Trading | 379.6 | 600 | 220.4 | 58 |
| MicroAmp™ Fast Optical 96-Well Reaction Plate with Barcode, 0.1 mL | 4346906 | Thermofisher scientefic | Sedeer | 386.9 | 595 | 208.1 | 54 |
| MicroAmp™ Optical Adhesive Film | 4360954 | Thermofisher scientefic | Sedeer | 302.95 | 490 | 187.05 | 62 |
| Agarose I (Molecular Biology Grade) | 17852 | Thermofisher scientefic | Sedeer | 1076.75 | 3020 | 1943.25 | 180 |

| Item | Catalog number | Manuf. | Supplier | Original price | Ordering price | Diff. | Percentage increase (%) |
|---|---|---|---|---|---|---|---|
| Calcein, AM, cell-permeant dye | C1430 | Thermofisher scientefic | Sedeer | 1040.25 | 1700 | 659.75 | 63 |
| DMEM | 31966021 | Thermofisher scientefic | Sedeer | 79.57 | 130 | 50.43 | 63 |
| Nutrient Mix Kaighns Mod | 21127022 | Thermofisher scientefic | Sedeer | 107.748 | 180 | 72.252 | 67 |
| Collagen I Rat Protein | A1048301 | Thermofisher scientefic | Sedeer | 773.8 | 1215 | 441.2 | 57 |
| GTXMU FITC F(AB')2 0.5 MG | A24513 | Thermofisher scientefic | Sedeer | 351.3125 | 595 | 243.6875 | 69 |
| Aristolochic acid I | A5512-100mg | Sigma | Sedeer | 627.8 | 2235 | 1607.2 | 256 |
| Goat anti-Mouse IgG (H+L) Cross-Adsorbed Secondary Antibody, Alexa Fluor 568 | A11004 | Thermofisher scientefic | QS | 715.4 | 1455 | 739.6 | 103 |
| cOmplete™, EDTA-free Protease Inhibitor Cocktail | 5056489001 | Millipore Sigma | Beamed Trading | 3666.425 | 5792 | 2125.575 | 58 |
| Acrylamide/Bis 19:1, 40% (w/v) solution | AM9022 | Thermofisher scientefic | Sedeer | 474.5 | 780 | 305.5 | 64 |
| BRIP1 TaqMan Assays | 4351372 | Thermofisher scientefic | Sedeer | 1054.85 | 1750 | 695.15 | 66 |
| Ponceau S | ab146313 | Abcam | Sedeer | 146 | 220 | 74 | 51 |
| CellTracker™ CM-DiI Dye | C7001 | Thermofisher scientefic | Sedeer | 1014.7 | 1545 | 530.3 | 52 |
| Antibiotic-Antimycotic (100X) | 15240062 | Thermofisher scientefic | Sedeer | 146 | 235 | 89 | 61 |
| Monoclonal Anti-β-Actin antibody produced in mouse | A2228-100UL | Sigma | Sedeer | 1792.15 | 3370 | 1577.85 | 88 |
| Canagliflozin-50mg | 11575 | Cayman Europe | Atlantic | 1069.45 | 2100 | 1030.55 | 96 |
| Empagliflozin-100mg | 17375 | Cayman Europe | Atlantic | 996.45 | 1900 | 903.55 | 91 |
| GFP Polyclonal Antibody | A-6455 | Thermofisher scientefic | QS | 1109.6 | 2022 | 912.4 | 82 |
| Anti-Serotonin Antibody, clone YC5/45 | MAB352 | Merck Millipore | QS | 1265.82 | 1940 | 674.18 | 53 |

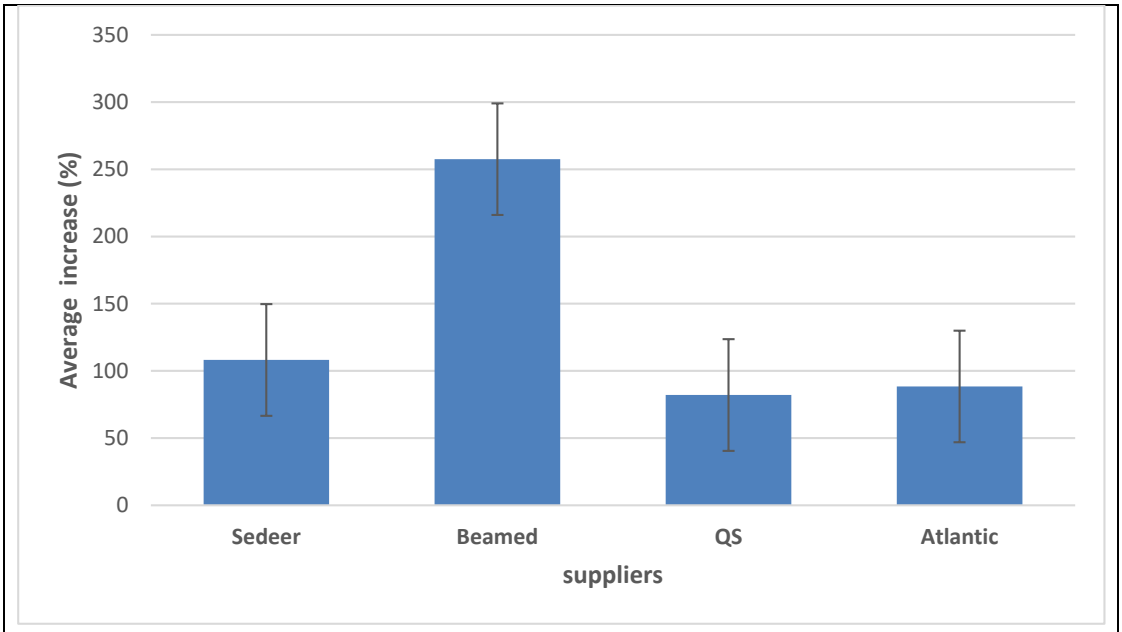


Figure 3: Plots of the bar chart of average of prices' increasing percentage for each local supplier.

Prism 6 Software has been used for statistical analysis. Table 3 shows the Kolmogorov-Smirnov test for the suppliers' groups. This normality test is conducted to check if the items' prices for each supplier group follow normal distribution and it has been chosen because it is the most common normality test.

Table 3: Kolmogorov-Smirnov Normality Test

| Suppliers | Sedeer | Beamed | Qatar Scientific | Atlantic |
|---|---|---|---|---|
| KS normality test | 0.3504 | 0.209 | 0.2524 | 0.2586 |
| P-Value | < 0.0001 | 0.1262 | 0.0485 | 0.0003 |

From Table 3 it is observed that the P-values of Sedeer, Qatar Scientific, and Atlantic are less than 0.10, so the data is not normally distributed. Thus, the Non-parametric Kruskal-Wallis test is computed to test the differences between the four suppliers' groups as shown in Table 4.

Table 4: Kruskal-Wallis Test

| | |
|---|---|
| Kruskal-Wallis statistic | 7.758 |
| P value | 0.0513 |

The significant level is 0.10

From Table 4, the P-value (0.0513) is less than the significant level (0.10), we conclude that there is a significant difference between the four suppliers' groups. Therefore, the Dunn's multiple comparisons test is computed to check the significant differences. The bar chart in Figure 4 conducted by Prism 6 software shows that there are differences between Beamed and all other groups, while the difference between Sedeer and Beamed is the most significant since its P value (0.036) is less than (0.10). This significant difference between Sedeer and Beamed can be explained in Table 5, where it can be noticed that Sedeer prices mean rank is less than Beamed by 20.91. This difference between Sedeer and Beamed is the largest compared with other groups. The graphical presentation of this significant difference is shown in Figure 4.

Table 5: Dunn's Multiple Comparisons Test

| | Mean rank 1 | Mean rank 2 | Mean rank diff. | n1 | n2 | P Value |
|---|---|---|---|---|---|---|
| Sedeer vs. Beamed | 33.59 | 54.5 | -20.91* | 33 | 13 | 0.036 |
| Sedeer vs. Qatar Scientific | 33.59 | 41.68 | -8.091 | 33 | 11 | > 0.9999 |
| Sedeer vs. Atlantic | 33.59 | 41.93 | -8.344 | 33 | 23 | > 0.9999 |
| Beamed vs. Qatar Scientific | 54.5 | 41.68 | 12.82 | 13 | 11 | > 0.9999 |
| Beamed vs. Atlantic | 54.5 | 41.93 | 12.57 | 13 | 23 | 0.7145 |
| Qatar Scientific vs. Atlantic | 41.68 | 41.93 | -0.253 | 11 | 23 | > 0.9999 |

The significant level is 0.10

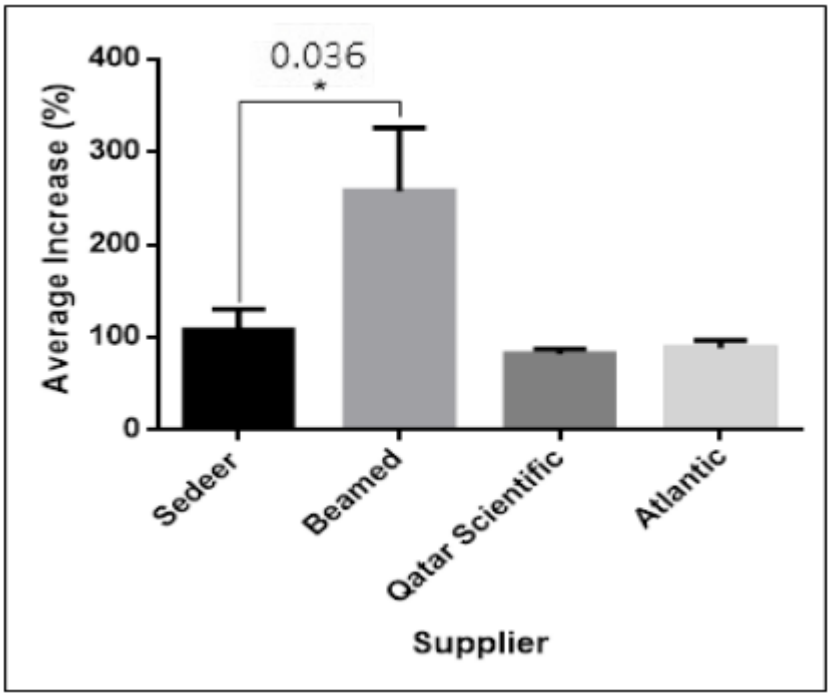


Figure 4: The differences comparison between suppliers' groups by Dunn's multiple comparisons test

### 4.2.2 Online suppliers versus local suppliers' prices

To improve the purchase decision before proceeding with the purchasing process, some local suppliers provide quotations that give details about the required items' prices. Since BRC depends only on one method to order each item, there were no items in the collected data that have online and local suppliers' prices at the same time. However, only some items (cryogenic storage boxes, 96-well PCR tube racks, Hot Plate Stirrer, and 8- channels pipette 30-300ul) have been ordered through online suppliers and have quotations received from local suppliers at the same time. Therefore, these items' prices from local and online suppliers were chosen and able to be compared in this section. Table 6 shows the prices of items from local and online suppliers. As shown, the price of cryogenic storage boxes is (117.78 QR) from Amazon online supplier, while its provided price from Beamed Trading local supplier

is (329 QR). In addition, the Beamed company has provided two types of 96-well PCR tube racks product from Heathrow and Bio Plas with prices (161 QR) and (282 QR), respectively, while the price of the same product is (61.64 QR) from Amazon.

Regarding the Hot Plate Stirrer item provided by Sedeer local supplier, the price is (4000 QR), whereas Amazon's price is (968 QR). Deacon from two manufacturers provided 8-channels pipette 30-300ul item: Eppendorf and Finnpipette with prices of (4,220 QR) and (4,370 QR) respectively, where Qatar Scientific offers it with a price of (7,328 QR). On the other hand, the German Bioactiva diagnostica online supplier offered the same item with a price of (3,091 QR). Overall, the results of Table 6 indicate that all online suppliers' prices are lower than those of local suppliers; thus, all the end users (staff of BRC) decided to purchase from the online suppliers, which supports the budget of the BRC department at QU. Figure 5 conducted by excel software illustrates the graphical presentation of the prices of items from local and online suppliers.

Table 6: Prices of Items from Online and Local Suppliers

| Item | Catalog number | Type of order | supplier price (QR) | Purchase decision |
|---|---|---|---|---|
| Argos R3130 Translucent Polypropylene 100 Place Microcentrifuge Tube Cryogenic Storage Box (Pack of 5) | ARG-R3130 | Amazon (online supplier) | 117.78 | Amazon |
| Celltreat Scientific Storage Box, CF Cryogenic Vial, 100 Place, Polycarbonate, Non-Sterile, (5/CS) | 1177Z25 | Beamed trading (local supplier) | 329 | |
| Heathrow 96-Well PCR Rack, 0.2mL, Assorted, (5/PK) | 1222K04 | Beamed trading (local supplier) | 161 | Amazon |
| Bio Plas 96 Well Microcentrifuge Tube Rack, Assorted, (5/PK) | 1212K89 | Beamed trading (local supplier) | 282 | |
| PUL FACTORY Plastic 96-Well PCR Rack for 0.2ml Micro Centrifuge tube, Pack of 5 | BHBUKPPAZINH1724 | Amazon (online supplier) | 61.64 | |

| Item | Catalog number | Type of order | supplier price (QR) | Purchase decision |
|---|---|---|---|---|
| Analog Hot Plate Stirrer, 120V, BNW | D0320 | Amazon (online supplier) | 968 | Amazon |
| Thermo Scientific RT Touch Series Magnetic Stirrer | 88880014 | Sedeer (local supplier) | 4,000 | |
| Eppendorf Research plus 8 channel pipette, 30-300 uL | 3125000052 | Qatar Scientific (local supplier) | 7,328 | Bioactiva diagnostica |
| 8 Channel Eppendorf Research Plus pipette 30-300ul | E3125000052 | Deacon (local supplier) | 4,220 | |
| Finnpipette F1 30-300uL 8 Channel Multichannel | PIP4962 | Deacon (local supplier) | 4,370 | |
| 8-Channel Research plus Pipette 30-300µL | 3125000052 | Bioactiva diagnostica (online supplier) | 3,091 | |

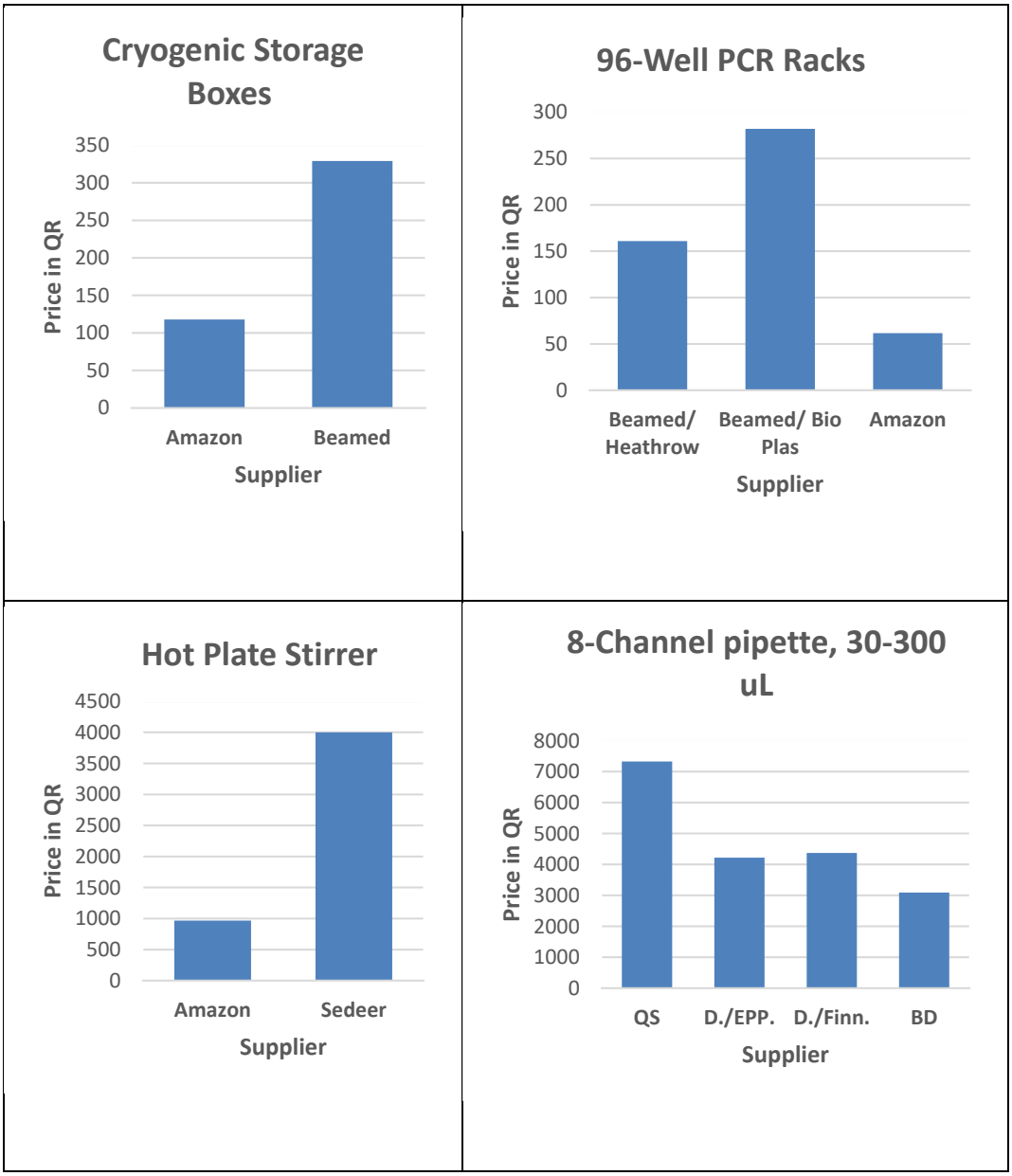


Figure 5: Plots of the bar chart for price of local and online suppliers

*QS: Qatar Scientific, D. /EPP. Deacon/Eppendorf, D./Finn.: Deacon/Finnpipette, BD: Bioactiva Diagnostic

### 4.3 Delivery time

This section will analyze the second parameter affected by ordering practices, which is the delivery time. A period of more than two months from the date of ordering until receiving is considered a late delivery. Based on the collected data, the date of ordering or receiving is not available for most indirect orders from the local suppliers (Atlantic, Qatar Scientific, Beamed Trading, Medicare, UTECH Products, Key

Solutions, Power 2 Group). Regarding indirect orders from some online suppliers (Pipette, Bioactiva Diagnostica), only a few items were ordered via BRC during 2018-2020. From Pipette, only three products were ordered, and all of them were received late; one of these orders was small equipment (stirrer), which was delayed due to the late responding from Pipette supplier and a payment issue.

While for Bioactiva Diagnostica, the date of receiving is not available. Thus, in this section, the comparison will be focused on the suppliers that have several items requested with exact dates of ordering and receiving, which are Sedeer local supplier and Amazon online supplier. Figure 6 conducted by excel software illustrates the graphical presentation of on-time and late delivered items from Sedeer and Amazon. The results show that (88 %) of items are delivered on time, while only (12 %) of items are late delivered from Sedeer. Amazon, on the other hand, has (100 %) of items are delivered on time.

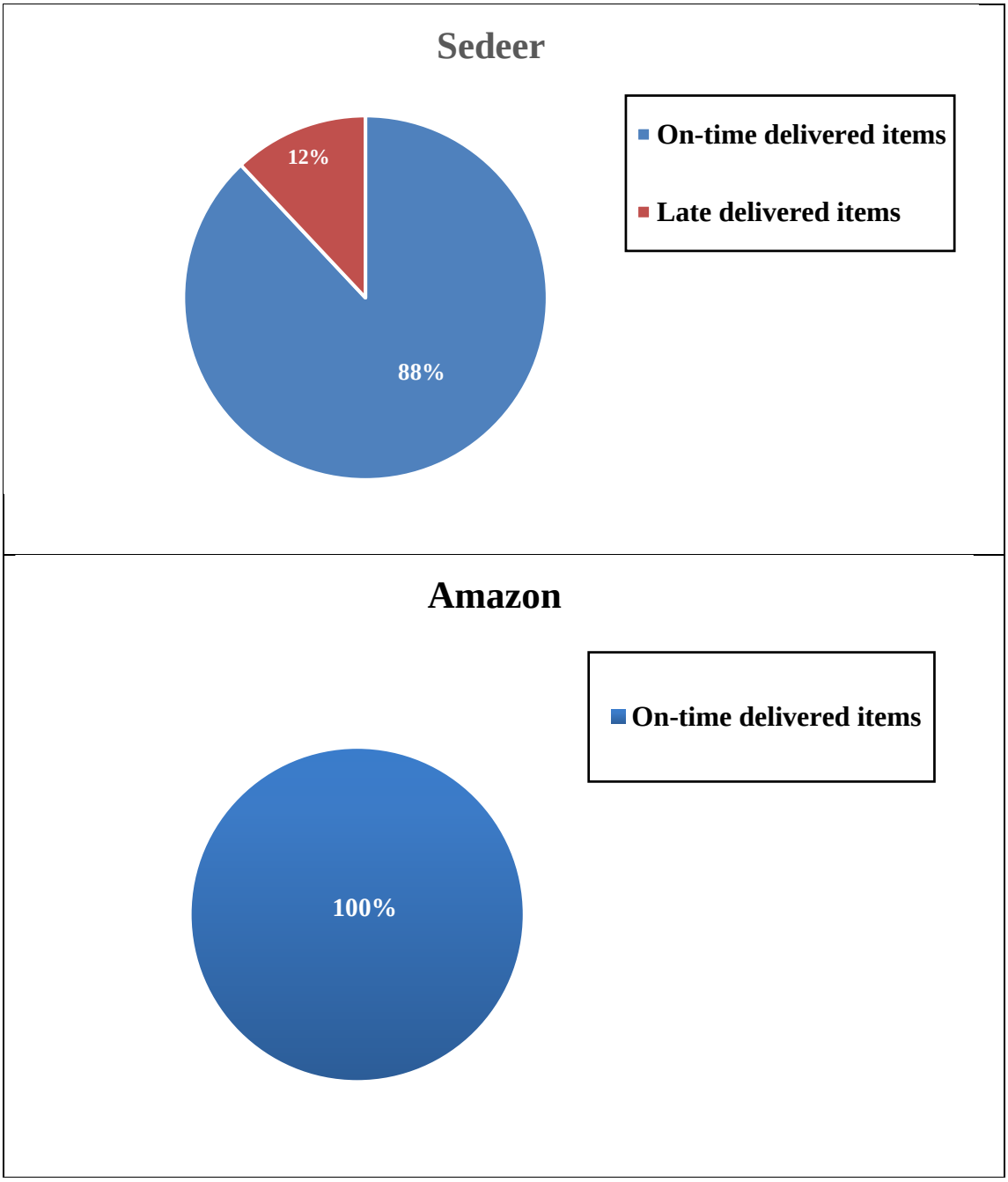


Figure 6: Plots of the pie chart of on-time and late delivered items from Sedeer and Amazon

### 4.4 Handling of Items

This section will present the third parameter that is affected by ordering practices: handling items. The comparison will be provided between orders received from local suppliers and online suppliers. Table 7 illustrates the items' handling between local and online suppliers based on the following categories: items' condition, handling atmosphere (temperature), and validity of the item.

Table 7: Handling of Local and Online Suppliers' Items

| | | Handling Categories | | |
|---|---|---|---|---|
| **Supplier's Type** | **Supplier's Name** | **Item Condition Good/Bad** | **Temperature Controlled/Uncontrolled** | **Item Validity Valid/ Invalid** |
| **Local** | **Sedeer** | Good | Controlled | Valid |
| | **Atlantic** | Good | Controlled | Valid |
| | **Qatar Scientific** | Good | Controlled | Valid |
| | **Beamed Trading** | Good | Controlled | Valid |
| | **UTECH Products** | Good | Controlled | Valid |
| | **Medicare** | Good | Controlled | Valid |
| | **Key Solutions** | Good | Controlled | Valid |
| | **Power 2 Group** | Good | Controlled | Valid |
| **online** | **Amazon** | Good | Controlled | Valid |
| | **eBay** | - | - | - |
| | **Pipette** | Good | Controlled | Invalid |
| | **Bioactiva Diagnostica** | Good | Controlled | Valid |

Based on the comparison in Table 7, it is observed that all of the items ordered through local suppliers are received in good condition, controlled temperature, and valid for use, and most of the items ordered through online suppliers are appropriately handled, except few orders from eBay and Pipette. Regarding eBay, the order hasn't been received due to improper handling and miscommunication from the courier company. For Pipette, the BRC department ordered small equipment (stirrer), which is received in good condition but is invalid for use due to Qatar's incompatible electricity voltage; thus, an adapter is needed.

# CHAPTER5: DISCUSSION

## 5.1 Background

From February 2020 to October 2020, this quantitative descriptive study was conducted to evaluate the ordering system and practices in Metabolic Research Laboratory (MRL), located at Qatar University in Biomedical Research Center (BRC). The study started with collecting 201 previous orders done in BRC between 2018 and 2020. There were two main phases; the first phase was to investigate and categorize the data, whereas the second phase was for analyzing the data based on price, delivery time, and items' handling. This chapter will discuss this project's findings and highlight some main issues that may cause work interruption in the MRL due to the currently used purchasing and ordering system.

## 5.2 Price parameter

Based on final results, the prices' difference percentages for the items ordered through online suppliers were decreased by an average of (20%) compared to the original manufacturers' prices, which agrees with (Haubl and Trifts, 2000), who concluded in his study that the price of online shopping is lower than original manufacturer price. Online prices are lower than the original prices because the online suppliers provide prices competition of the needed product, which allows the end-user to choose the best price according to the available budget (Bakos, 1991). Another reason is that online suppliers can meet their customers' expectations with less operating overheads and expenses than original stores; therefore, they can decrease products' prices.

On the other hand, the results of items' prices from local suppliers were much higher compared to original manufacturer prices and online suppliers, as shown in

Tables 1 and 5, respectively. The reason for this is the high shipping fees specified from the local suppliers on the end-user, such as import, export, and clearance fees. Based on data collected from BRC, these fees differ according to the items to be shipped. For example, items shipped at room temperature (regular shipment) have lower average shipment fees than those that need controlled temperature shipping. However, if online suppliers request shipping fees, it will be much cheaper than local suppliers because usually, they are shipping items that do not need special requirements during the process, such as consumables. Although the original manufacturer prices are much less than local suppliers' prices, the BRC is not allowed to order from the direct manufacturer in some cases if they have a local supplier in Qatar.

Based on the results of the Kruskal-Wallis test shown in Table 4 there were differences between the suppliers' groups and the significant difference was located between Sedeer and Beamed suppliers as shown in Figure 4. This price difference from Beamed differ from one item to another because sometimes Beamed company needs to get quotations for the items from another supplier if they are not the distributor, which duplicates the overhead costs.

Based on price parameter analysis, the BRC staff purchasing decision is influenced by the items' prices. This can be seen from Table 6 since they have chosen online suppliers rather than local suppliers due to the lower prices of items. This matches with Al-Azzam (2016), Alfred (2013), Alhassan (2018), Lenin (2014), Stávková et al. (2008), and Furaiji et al. (2012) studies, which stated that the price has a great influence on the purchasing decision.

### 5.3 Delivery time parameter

From the observed data, there was not enough information to analyze this parameter in-depth as there many ordering and receiving dates were missing due to the lack of an organized system to document the dates of ordering and delivery in the BRC department, which still using paper documentation with many unsigned invoices and delivery notes. From the available existing data, the analysis showed that BRC suffers in some cases from the late delivery of the items, which delays the work and research. An order from Pipette company is an example, which was received late due to a payment issue and late response from the company's side. The courier company returned the order from eBay to the origin country due to miscommunication between the company and BRC. Such problems and miscommunication lead to a significant delay in the work.

Regarding Amazon, there were accurate ordering and receiving dates available. The results showed that Sedeer and Amazon had (88%) and (100%) on-time deliveries, respectively. This result is explained by Amazon's quick shipping of the items as supported by (Welch, 2015), who concluded that the speed of items delivery by Amazon is the main advantage that distinguishes it from other online suppliers.

From the collected data, it has been shown that Amazon and Sadeer are from the frequent suppliers that BRC staff are dealing with, and this matches with Alhassan (2018) and Lenin (2014) studies that concluded the impact of speed of items delivery on the customers' purchasing decision.

### 5.4 Items' handling parameter

Proper handling of the delivered items must always be considered during the ordering process; this will help receive items in good condition valid for research uses and not interrupt the work. Therefore, proper handling will help in saving extra costs, efforts, and research period.

This parameter has been analyzed by assessing items' condition, handling atmosphere (temperature), and validity of the ordered items. It is observed from Table 7 that most of the items received in good condition; however, few items have been received with problems or bad conditions that made the items invalid for use. An example of these items was small stirrer equipment received from Pipette online supplier with an electrical voltage not suitable in Qatar; this leads to a conclusion that BRC is recommended to procure items that need special handling or controlled temperature through local suppliers' method to ensure the proper handling of the items, since receiving the items in an unacceptable condition or not in good quality will reduce the customer desire of using this ordering method in the future as stated by Al-Azzam (2016), Alfred (2013), Alhassan (2018), and Stávková et al. (2008) in their studies. It is also noticed from the collected data in this study as shown in Table 1 that most of the items (85%) were ordered through local suppliers method due to their specialized items' handling and delivering the items in good condition, which concludes that items' handling parameter contributes in BRC staff purchasing method decision.

From the results, it was observed that compared to local suppliers, online suppliers' items have lower prices and can be received faster; however, there is a higher chance of receiving them in an unacceptable condition. The reason can be that online suppliers ship the items through couriers' companies that are not specialized in properly handling medical items.

# CHAPTER6: CONCLUSION, LIMITATIONS, RECOMMENDATIONS, AND FUTURE DIRECTIONS

## 6.1 Conclusion

This study assessed the ordering and purchasing practices in the MRL based on three parameters: price, delivery time, and items' handling by analyzing 201 items. It has been found that prices of ordering items through local suppliers were much higher than online suppliers and original prices in the manufacture. Kruskal-Wallis test showed that there were differences between local suppliers' prices, and Dunn's multiple comparisons test showed that the most significant difference was between Sedeer and Beamed prices. Regarding delivery time, it has been shown that Amazon and Sedeer had high percentages of on-time delivered items. For items' handling, all the companies showed good handling except a few online suppliers' orders that had some issues. Finally, it has been concluded that high prices contribute in choosing the purchase method decision of BRC staff and makes them go with ordering from online suppliers, unless the quality of the items will be affected due to the handling issues, so they go with ordering through local suppliers in these cases or directly from the manufacturer if it is possible. Delivery time, as well, contributes to choosing the ordering method, since the staff is frequently ordering from Sedeer and Amazon, which have high percentages of on-time items' delivery.

## 6.2 Limitations of the study

This study was limited due to three factors. First, there was an absence of an arranged data entry process that will help proceed with the research and track the previous orders. That consumed the researcher's time entering the data from the provided invoices and delivery notes into an excel sheet to start analyzing. Besides, there were many missing data in the provided papers, which limited the analysis of

the parameters under consideration. Second, in BRC, each item is ordered using the same method and supplier every time, which limited the ability to compare the same item's orders through different ways or different companies. Finally, during the research period, the COVID-19 pandemic started, which limited the researcher's ability to access BRC and contact the staff. Thus, the period of the project has been extended.

### 6.3 Recommendations

The assessment outcomes showed a strong need for some recommendations and suggestions to improve the purchasing and ordering practices in the BRC. The study emphasized the importance of having standards for the process. Thus, the following recommendations were suggested:

1. Improve the purchasing and ordering policy in the BRC department by creating a standard operating procedure (SOP) to follow during the purchasing process. For example, lab consumables such as tubes, tips, beakers, and storage boxes, which do not need special conditions during shipping, can be ordered from online suppliers due to the fast delivery and low price. While, for items that need special handling or controlled temperature, such as clinical kits, it is preferred to be ordered from the original manufacturer if possible because the price will be low, and the company is specialized in medical items shipping.
2. If it is not possible to order items that need special handling from the original manufacturer, they can be ordered through local suppliers specializing in shipping medical products; however, their prices are higher. A negotiation policy can be created in order to get the best price from the local suppliers.
3. For most common items needed in almost all of the projects, a contract can be conducted between BRC and supplier to be ordered only once every one or

two years and received within multiple shipments, such as every three months; this will save the researchers' staff's time and efforts and assist in completing the projects on time.

4. Assign finance personnel who will be specialized and responsible for ordering processes, following the orders, negotiating with companies, following payment issues, and organizing all financial ordering steps; this will help since all the BRC staff are scientists and have limited financial or management experience. Therefore, this step can significantly improve, arrange the process, and save the researchers' time and efforts.
5. Create an excel sheet that contains detailed information about the received items. In this sheet, the staff can enter the ordering date, receiving date, quantity ordered, quantity received, items' receiving condition, and price; this will help BRC staff track any ordered item.
6. Create a system that gives a notification to the staff whenever any item is in low stock to proceed with the ordering process at a suitable time.
7. Identify specific local suppliers for each international manufacturer to avoid high prices (such as Beamed company case).

### 6.4 Future direction

To improve the current ordering practices in the BRC it is required to implement the previous recommendations and suggestions and monitor the process to check if these changes enhanced the process.

Since this project was limited to consumables, clinical kits, and small equipment, it is recommended to apply further studies that describe and assess the tendering process for ordering large equipment, to find its advantages, disadvantages and give recommendations to make the process easy and short.

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APPENDIX A: ITEMS' NAMES AND CATALOG NUMBERS

| no. | Item | Catalog number |
|---|---|---|
| 1 | Falcon Polystyrene Microplates | 353043 |
| 2 | Merk Durapore PVDF Membrane Filters | GVWP01300 |
| 3 | Corning Round Ice Bucket with Lid | 432123 |
| 4 | Sureone filter Tip Reload Pipette Tips:10ul | 11907724 |
| 5 | Falcon 15ml Conical Centrifuge Tubes | 352095 |
| 6 | Hydrochloric acid | AC07412500 |
| 7 | Sodium hydroxide | SO04251000 |
| 8 | DMSO | D12345 |
| 9 | FG-Microplate | 4346906 |
| 10 | Ethilon Nylon Non- absorbable suture | 7718G |
| 11 | HBSS | 14025050 |
| 12 | RNASEZAP | AM9782 |
| 13 | Extra thick western blotting filter paper | 88615 |
| 14 | 8-strip PCR tubes+caps | AM12230 |
| 15 | Nunc 15ml conical sterile polypropylene centrifuge tubes sterile paking | 339650 |
| 16 | 60mm Dish nunclon sphera packed | 174944 |
| 17 | Falcon 15ml Conical Tubes | 352099 |
| 18 | Falcon 50ml Conical Centrifuge Tubes | 352070 |
| 19 | Filter tip reload pipette tips 20 to 200ul | 11957724 |
| 20 | Filter tip reload pipette tips 100-1000ul | 11973466 |
| 21 | Filter tip reload pipette tips 10-100ul | 11947724 |
| 22 | 96-well clear flat bottom polystyrene TC-treated microplates | 3596 |
| 23 | 6-well clear TC-treated multiple well plates | 3516 |
| 24 | 12-well clear TC-treated multiple well plates | 3513 |
| 25 | 10ml stripette serological pipets | 4488 |
| 26 | Fisherbrand™ Sterile Polystyrene Disposable Serological Pipets with Magnifier Stripe | 11869181 |
| 27 | Falcon™ Tissue Culture Treated Flasks | 353018 |
| 28 | Fisherbrand™ SureOne™ Filter Tip Reload Pipette Tips 0.1-10 | 11907724 |
| 29 | Fisherbrand™ SureOne™ Filter Tip Reload Pipette Tips 10-100 | 11947724 |
| 30 | Fisherbrand™ SureOne™ Filter Tip Reload Pipette Tips 20-200uL | 11957724 |
| 31 | Fisherbrand™ SureOne™ Aerosol Barrier Pipette Tips | 11973466 |

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| 32 | Fisherbrand™ Microcentrifuge Tubes with Locking Snap Cap | 15432545 |
| 33 | Fisherbrand™ Comfort Nitrile Gloves | 15632367 |
| 34 | Fisherbrand™ Comfort Nitrile Gloves | 15642367 |
| 35 | Fisherbrand™ Polypropylene Clear Autoclave Bags | 11553342 |
| 36 | BD Luer-Lok™ 1-mL syringe | BD309628 |
| 37 | Fisherbrand™ 0.2mL PCR Tube Strips | 12179770 |
| 38 | Nunc™ EasYDish™ Dishes | 150464 |
| 39 | Corning® 25 mm Diameter Syringe Filters, 0.2 µm Pore NY Membrane, Sterile, Individually Packaged, 50/Case | 431224 |
| 40 | Whatman™ 3030-861 Grade 3MM CHR Cellulose Western Blotting Paper Sheet, 20 x 20cm, Thickness: 0.34mm (Pack of 100) | 3030-861 |
| 41 | BRAND® PP beaker with spout, low form | 87816 |
| 42 | Beakers PP Low Form Cap. 1000ml | 87620 |
| 43 | Pyrex® Reagent bottles, round bottom with reusable screw caps | 1515/08D |
| 44 | Fisherbrand™ Polypropylene Cryoboxes | 11856903 |
| 45 | Fisherbrand™ Polypropylene Clear Autoclave Bags | 11553342 |
| 46 | Falcon® 12-well Clear Flat Bottom TC-treated Multiwell Cell Culture Plate, with Lid, Individually Wrapped, Sterile, 50/Case | 353043 |
| 47 | Durapore® Membrane Filter, 0.22 µm | GVWP01300 |
| 48 | Corning® Ice Bucket with Lid, Round, 4L, Blue | 432123 |
| 49 | Fisherbrand™ SureOne™ Filter Tip Reload Pipette Tips | 11907724 |
| 50 | Falcon® 15 mL Polystyrene Centrifuge Tube, Conical Bottom, with Dome Seal Screw Cap, Sterile, 50/Bag, 500/Case | 352095 |
| 51 | Pyrex® Reagent bottles, round bottom with reusable screw caps | 1515/04D |
| 52 | Pyrex® Reagent bottles, round bottom with reusable screw caps | 1515/08D |
| 53 | Pyrex® Reagent bottles, round bottom with reusable screw caps | 1515/10D |
| 54 | Fisherbrand™ Sterile Polystyrene Disposable Serological Pipets with Magnifier Stripe | 11869181 |

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| 55 | Fisherbrand™ Sterile Polystyrene Disposable Serological Pipets with Magnifier Stripe | 11517752 |
| 56 | Nutri-Fly® BF, 10 x 1L Packets | 66-112 |
| 57 | Hook-up Wire 22AWG Black | CBL4312_0 |
| 58 | Hook-up Wire 22AWG Red | CBL4311_0 |
| 59 | Isolated 12-bit Voltage Output Phidget | OUT1001_0 |
| 60 | 4x Isolated Solid-State Relay Phidget | REL1100_0 |
| 61 | Pre-Cut; Thermal Adhesive Tape for 10 mm Square LED Assemblies - (10 Piece Sheet) | LXT-R-10 |
| 62 | Acrylic Enclosure for the 1002 | 3800_2 |
| 63 | Sodium bicarbonate, ACS reagent, 99.7-100.3% | C973T11 |
| 64 | Potassium Ferricyanide (ACS) | C995H04 |
| 65 | Eppendorf epT.I.P.S. | 7732C09 |
| 66 | Eppendorf epT.I.P.S. | 7732C25 |
| 67 | LB Broth (Lennox) | L3022-6X1KG |
| 68 | Agarose | A9539-250G |
| 69 | Bacteriological agar | A5306-250G |
| 70 | 100ml Graduated Cylinder, Class A Serialized | 1204Q99 |
| 71 | 250ml Graduated Cylinder, Class A Serialized | 1204R00 |
| 72 | 500ml Graduated Cylinder, Class A Serialized | 1204R01 |
| 73 | Glass Erlenmeyer Flasks, Set of 5 | 1217C65 |
| 74 | Petri Dish, 100 x 15mm, Stackable, Sterile, Bulk, 25/500 | 1188N81 |
| 75 | 250ml Glass Beaker, Low Form Pk/12 | 1204P90 |
| 76 | 500ml Glass Beaker, Low Form Pk/6 | 1204P92 |
| 77 | 1000ml Glass Beaker, Low Form Pk/6 | 1204P95 |
| 78 | Petri Dish, 100 x 15mm, Stackable, Sterile, Bulk, 25/500 | 1188N81 |
| 79 | Disc Blank 1/2 Inch Dia | 0190H68 |
| 80 | Dissecting Set - 20 instruments | 1177L67 |
| 81 | Parafilm® 4"x250ft (100mm x 75m) | 1222K01 |
| 82 | Glucose, powder | 15023021 |
| 83 | RNaseZap™ RNase Decontamination Solution | AM9782 |
| 84 | Western Blotting Filter Paper, Extra Thick, 8 cm x 13.5 cm | 88615 |
| 85 | Tubes and Ultra Clear Caps, strips of 8 | AM12230 |
| 86 | Novex™ Reversible Membrane Protein Stain Kit | IB7710 |
| 87 | MicroAmp™ Fast Optical 96-Well Reaction Plate with Barcode, 0.1 mL | 4346906 |

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| 88 | MicroAmp™ Optical Adhesive Film | 4311971 |
| 89 | Pierce™ BCA Protein Assay Kit | 23225 |
| 90 | UltraPure™ Tris Buffer (powder format) | 15504020 |
| 91 | SuperSignal™ West Pico PLUS Chemiluminescent Substrate | 34580 |
| 92 | MicroAmp™ Fast Optical 96-Well Reaction Plate with Barcode, 0.1 mL | 4346906 |
| 93 | trans-Dehydroandrosterone, ≥99% | 4268521 |
| 94 | Dexamethasone-Water Soluble, suitable for cell culture, BioReagent, 100 mg, Each | 4268288 |
| 95 | Mr. Frosty™ Freezing Container | 5100-0001 |
| 96 | 10010 - PBS, pH 7.4 | 10010015 |
| 97 | Methylene Blue, Certified | C871X96 |
| 98 | Sodium Dodecyl Sulfate, 500 g | C995H74 |
| 99 | Ammonium persulfate reagent grade, 98% | C991U65 |
| 100 | SIGMA TWEEN® 20, viscous liquid, cell culture tested | C987C78 |
| 101 | Coomassie Brilliant Blue R-250 | C861C44 |
| 102 | SIGMA Methyl cellulose, viscosity 1,500 cP, 2 % in H2O (20 °C) (lit.) | C988Y24 |
| 103 | SIGMA Sodium chloride BioUltra, for molecular biology, >=99.5% (AT) | C922N28 |
| 104 | MicroAmp™ Fast Optical 96-Well Reaction Plate with Barcode, 0.1 mL | 4346906 |
| 105 | MicroAmp™ Optical Adhesive Film | 4360954 |
| 106 | Restore™ Western Blot Stripping Buffer | 21059 |
| 107 | Agarose I (Molecular Biology Grade) | 17852 |
| 108 | Corning® Costar® Stripette® serological pipettes, individually paper/plastic wrapped | 4488 |
| 109 | Bisphenol E | 4487 |
| 110 | Axygen® 1.5 mL MaxyClear Snaplock Microcentrifuge Tube, Polypropylene, Clear, Nonsterile, 500 Tubes/Pack, 10 Packs/Case | MCT-150-C |
| 111 | Falcon® 3 mL Transfer Pipet, Polyethylene, with Graduations, Individually Packed, Sterile, 1/Pack, 500/Case | 357575 |
| 112 | Phenol red solution | P-0290 |
| 113 | Glycine | GB0235 |
| 114 | Calcein, AM, cell-permeant dye | C1430 |

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| 115 | Argos R3130 Translucent Polypropylene 100 Place Microcentrifuge Tube Cryogenic Storage Box with Assorted Color Lids for 0.5, 1.5 and 2.0mL Microcentrifuge Tubes (Pack of 5) | ARG-R3130 |
| 116 | Parafilm M PM999 All-Purpose Laboratory Film, 4" x 250' on 1" Core | PM999 |
| 117 | Heathrow Scientific HD234525B Blue ABS Plastic Parafilm Dispenser, 120mm Width x 156mm Height x 171mm Depth | HS234525B |
| 118 | Lab Spoon, 8 Pack lab Scoops lab Spoon Micro, Stainless Steel Lab Measuring Spoon, Lab Spatulas Laboratory Sampling Spoon Mixing Spoon. | 55 |
| 119 | PUL FACTORY Plastic 96-Well PCR Rack for 0.2ml Micro Centrifuge tube, Assorted colors, Pack of 5 | BHBUKPPAZINH1724 |
| 120 | PUL FACTORY Plastic 96-Well PCR Rack for 0.2ml Micro Centrifuge tube, Assorted colors, Pack of 6 | BHBUKPPAZINH1725 |
| 121 | Celltreat 229617 Polypropylene L-Shaped Cell Spreader, Sterile, 145mm Length, Green (Case of 500) | 229617 |
| 122 | EZ BioResearch Petri Dish with Lid, 100 mm x 15 mm, Sterile, 20/pack | PD1005NS |
| 123 | Globe Scientific 110158 Polystyrene Culture Tube with Attached Dual Position Cap, Sterile, 14mL Capacity, 17mm Dia, 100mm Height (Case of 500) | 110158 |
| 124 | TotalPass B600 Biometric Fingerprint Employee Time Clock \| 100% Identity Verification on Every Punch\| Connect via USB, Network, Wi-Fi or Web\| No Monthly Fees | B600 |
| 125 | Universal Eclipse Reload System Tips, 5-200 µl Yellow tips, 96 tips/reload, 10 reloads/pack, 10 packs/case, (CASE OF 9,600 TIPS), BNW | UE-200YC |
| 126 | Analog Hot Plate Stirrer, 120V, BNW | D0320 |
| 127 | Brand Refillable Racks for 10µl/20µl/200µl pipette tips, fits Eclipse Reload System, 10 empty racks per pack, BNW | ER-200P |

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| 128 | Celltreat Scientific Storage Box, CF Cryogenic Vial, 25 Place, Polycarbonate, Non-Sterile, (5/CS). | 1177Z22 |
| 129 | Celltreat Scientific Storage Box, CF Cryogenic Vial, 100 Place, Polycarbonate, Non-Sterile, (5/CS). | 1177Z25 |
| 130 | Heathrow 96-Well PCR Rack, 0.2mL, Assorted, (5/PK). | 1222K04 |
| 131 | Bio Plas 96 Well Microcentrifuge Tube Rack, Assorted, (5/PK). | 1212K89 |
| 132 | SYBR® Safe DNA Gel Stain 400 µL | S33102 |
| 133 | Nanodrop Lite | Nanodrop Lite |
| 134 | Thermo Scientific RT Touch Series Magnetic Stirrer, Speed Range-30 to 2000rpm, Digital-Speed Control,230V,50Hz | 88880014 |
| 135 | 100 x 2ml Clear Plastic Round Bottom Centrifuge Test Tube Vial w/ Flip Cap | NA |
| 136 | Eppendorf Research plus 8 channel pipette, 30-300 uL, orange operating button, for use with 300 uL pipette tips | 3125000052 |
| 137 | Eppendorf Research Plus pipette 30-300ul 8 Channel | E3125000052 |
| 138 | Eppendorf Research Plus pipette 30-300ul 12 Channel | E3125000060 |
| 139 | Finnpipette F1 30-300uL 8 Channel Multichannel - End of Year Promotion | PIP4962 |
| 140 | Finnpipette F1 30-300uL 12 Channel Multichannel - End of Year Promotion | PIP4970 |
| 141 | 8-Channel Research plus Pipette 30-300µL | 3125000052 |
| 142 | Eppendorf research plus 8 channels 10-100µL | 3125000036 |
| 143 | DMEM | 31966021 |
| 144 | Nutrient Mix Kaighns Mod | 21127022 |
| 145 | Trypan Blue Solution | 15250061 |
| 146 | RPMI 1640 | 21875034 |
| 147 | Vybrant MTT cell proli | V13154 |
| 148 | Collagen I Rat Protein | A1048301 |
| 149 | GTXMU FITC F(AB')2 0.5 MG | A24513 |
| 150 | PowerUp™ SYBR™ Green Master Mix | A25742 |
| 151 | Pierce™ 2-Mercaptoethanol | 35602BID |
| 152 | Aristolochic acid I | A5512-100mg |
| 153 | Pronase | 10165921001 |

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| 154 | COVID-19 (SARS-CoV-2) IgG 1 Kit ELISA TESTKIT 96 TESTS exp 2021-05 | COVG0940 |
| 155 | Dengue IgG 96 wells | DENG0120 |
| 156 | Goat anti-Mouse IgG (H+L) Cross-Adsorbed Secondary Antibody, Alexa Fluor 568 | A11004 |
| 157 | Goat anti-Chicken IgY (H+L) Secondary Antibody, Alexa Fluor 488 | A11039 |
| 158 | cOmplete™, EDTA-free Protease Inhibitor Cocktail | 5056489001 |
| 159 | CyQUANT™ MTT Cell Viability Assay | V13154 |
| 160 | CyQUANT™ MTT Cell Viability Assay | V13154 |
| 161 | Acrylamide/Bis 19:1, 40% (w/v) solution | AM9022 |
| 162 | Nalgene® cryogenic vials | 5000-0020 |
| 163 | EDTA | C000R75 |
| 164 | BRIP1 TaqMan Assays | 4351372 |
| 165 | Ponceau S | ab146313 |
| 166 | CellTracker™ CM-DiI Dye | C7001 |
| 167 | PRMT5 Monoclonal Antibody (PRMT5-21) | MA 125470 |
| 168 | Cytochalasin B | 5474 |
| 169 | Trypsin (0.25%), phenol red | 25050014 |
| 170 | LIVE/DEAD™ Viability/Cytotoxicity Kit, for mammalian cells | L3224 |
| 171 | Antibiotic-Antimycotic (100X) | 15240062 |
| 172 | SuperScript™ IV VILO™ Master Mix | 11756050 |
| 173 | Monoclonal Anti-β-Actin antibody produced in mouse | A2228-100UL |
| 174 | PiNK Plus Prestained Protein Ladder | PM005-0500 |
| 175 | Canagliflozin-50mg | 11575 |
| 176 | Empagliflozin-100mg | 17375 |
| 177 | GFP Polyclonal Antibody | A-6455 |
| 178 | Anti-Serotonin Antibody, clone YC5/45 | MAB352 |
| 179 | Trypsin-EDTA (0.25%), phenol red | 25200056 |
| 180 | Fetal Bovine Serum, qualified, heat inactivated, Brazil | 10500064 |
| 181 | Anti-SGLT1 antibody | ab14686 |
| 182 | Anti-SGLT1 antibody | ab14686 |
| 183 | Anti-SGLT2 antibody | ab85626 |
| 184 | Goat Anti-Mouse IgG H&L (HRP) | ab205719 |
| 185 | Goat Anti-Rabbit IgG H&L (HRP) | ab205718 |
| 186 | Dexamethasone-Water Soluble | D2915 |

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| 187 | Cytochalasin B from Drechslera dematioidea | C6762 |
| 188 | Latrunculin B from Latruncula magnifica | L5288 |
| 189 | Anti-SGLT2 antibody | ab85626 |
| 190 | Phospho-p90RSK (Ser380) Antibody | 9341S |
| 191 | MiSeq Reagent Kit v2 (300 cycles) | MS-102- 2001 |
| 192 | MiSeq Reagent Kit v2 (300 cycles) | MS-102- 2002 |
| 193 | Nextera XT Index Kit v2 Set A (96 indexes, 384 samples) | FC-131-2001 |
| 194 | PhiX Control v3-Illumina | FC-110-3001 |
| 195 | Nextera XT DNA Library Preparation Kit (96 samples)-Illumina | FC-131-1096 |
| 196 | Biosensor / Ni-NTA (NTA) Tray | 18-5101 |
| 197 | Biosensor / Amine Reactive 2nd Generation (AR2G) Tray | 18-5092 |
| 198 | Reagent / Amine Coupling 2nd Generation Reagent Kit | 18-5095 |
| 199 | FHC | RL-1831 |
| 200 | Caco2 | HTB-37 |
| 201 | Primary Bronchial / Tracheal Epithelial cells | PCS-300-010 |