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## ECONOMIC IMPACT OF THE COST OF PERSONAL PROTECTIVE EQUIPMENT TO FACE THE COVID-19 PANDEMIC: INTEGRATIVE LITERATURE REVIEW

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### ABSTRACT

The COVID-19 disease was detected in Wuhan-China in December 2019; in March 2020, it was declared a pandemic. Due to the high transmissibility, there was a need to adapt protocols for the use of Personal Protective Equipment (PPE) to provide health care, substantially increasing its use. However, increased demand and production shortages culminated in rising costs. The aim of this study was to analyze the economic impact on the cost of acquiring PPE in the face of the COVID-19 pandemic. An integrative literature review was performed in PubMed, LILACS and CINAHL databases. Global PPE inventories are insufficient, with increasing demand prices are rising, reaching up to 15 times the usual price. Considering the limited revenue of health institutions, opportunistic control of the increase in the prices of these inputs is necessary to maintain patient care.

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## INTRODUCTION

COVID-19 disease, caused by the novel coronavirus (SARS-CoV-2), was initially detected in Wuhan, China, in December 2019. On January 30, 2020, the WHO Director-General stated that the outbreak of disease was considered a public health emergency of international importance<sup>1</sup>, and on March 11, 2020 it was declared as a pandemic<sup>2</sup>. Due to the rapid and easy spread of the virus, the need for intensive care and the use of technologies specific to an intensive care environment for a portion of the affected people, there have been changes in the workflow, health care protocols and expenses with consumables, especially with Personal Protective Equipment (PPE)<sup>3</sup>. Based on existing evidence, the COVID-19 virus is transmitted between people through close contact and droplets. People most at risk of developing the infection are those who come into close contact with a COVID-19 patient or who care for COVID-19 patients<sup>1</sup>.

According to evidence, SARS-CoV-2 mainly spreads between people when an infected person is in close contact with another. The virus can spread through an infected person's mouth or nose in tiny liquid particles that range from larger 'respiratory droplets' to smaller 'aerosols' when the person coughs, sneezes, sings, breathes heavily or talks. Close contact can result in inhalation or inoculation of the virus through the mouth, nose or eyes<sup>4</sup>. This implies the use of gloves, lab coat, face protection and masks for all encounters involving a suspected case and enhanced precautions for aerosol generating procedures<sup>5</sup>. Growing global demand caused not only by the number of COVID-19 cases, but also by the misinformation and panic leading to the purchase and stockpiling of the product - will cause even greater shortages of PPE worldwide<sup>1</sup>. In addition to loss of life and the collapse of the healthcare system, fighting the COVID-19 outbreak has also posed economic challenges for many countries<sup>6</sup>. Given the difficult access, high prices, and dubious quality of some

PPE, buyers need to evaluate the device they are planning to purchase, the manufacturer, third-party intermediaries (if applicable) and contract terms before deciding to purchase<sup>3</sup>. For the adequacy of health care to COVID-19 cases and the incorporation of new recommended biosafety practices, there was a need to increase the demand for PPE to guarantee the safety of professionals, with this, health systems have raised some concerns regarding the high demand for increasing existing capacity and financial support, healthcare systems that do not have extra capacity may experience increases in operating costs<sup>7</sup>. Shortages of essential supplies can drive up costs as suppliers can raise prices and charge higher amounts, with the coronavirus outbreak creating unprecedented demand for medical supplies and equipment, New York state has paid about 15 times the usual price<sup>8</sup>. In view of the above, the need to ensure safe conditions for the performance of health care in the advent of COVID-19, guarantee and optimize the supply of inputs and availability of PPE in an adequate manner considering the scarcity of these products due to the increase in demand and rising costs, the study is necessary. The objective of this study is to analyze the economic impact on the cost of acquiring personal protective equipment in the face of the COVID-19 pandemic.

## METHODOLOGY

The present study is an integrative literature review, which seeks answers in science to solve practical problems, being in line with Evidence-Based Practice (EBP). Trimming to the best evidence to support knowledge that aids decision making<sup>9</sup>. Having as a delimiting question, he had elaborated through the PICo strategy: What is the economic impact on the cost of PPE to face the COVID-19 pandemic? Where P (problem) – Cost, I (interest) – PPE, Co (context) – COVID-19.

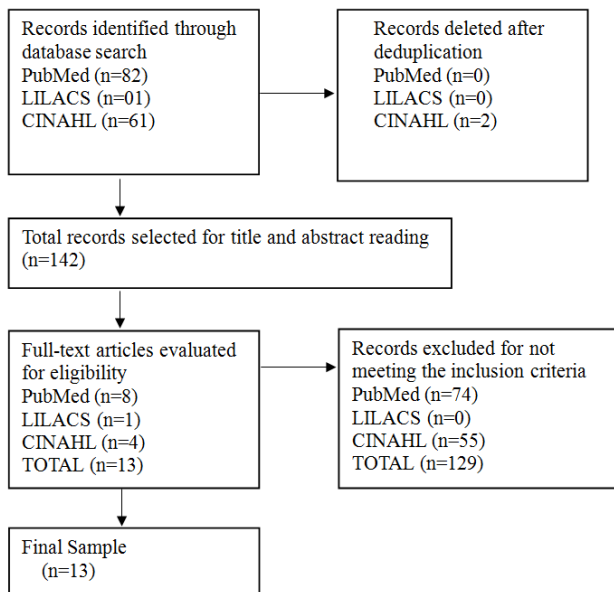


Figure 1. Sample flowchart

The steps that make up this review are identification of the topic and elaboration of the research question, search in the databases, establishment of inclusion and exclusion criteria for selected studies, search of the texts in full, evaluation of included studies, interpretation of results and knowledge synthesis<sup>9</sup>. The selection of the sample occurred through the Descriptors in Health Sciences (DeCS) and Medical Subject Headings (MeSH), their controlled synonyms and Boolean operators OR, AND. Three databases were searched: US National Library of Medicine (PubMed), Latin American and Caribbean Literature on Health Sciences (LILACS), and CINAHL. The search strategy used to reach the expected results in the PubMed and CINAHL databases was (“Costs and Cost Analysis” OR “Cost” OR “costs”) AND (“Personal Protective Equipment”) AND (“COVID-19”). For the LILACS database, the search strategy (“Costs and Cost Analysis” OR “cost”) AND

(“Individual Protection Equipment” OR “Individual Protection Equipment”) AND (“Coronavirus Infections” OR COVID-19”) was used. For inclusion of the works, the following criteria were obeyed abstract available in the databases described above, language of publication being Portuguese, English or Spanish, work available in full, and publication period from 2020. The articles that were available one more than one database were considered only once. The search was carried out in April and May 2021. After setting up the sample for analysis of the texts in full, the data synthesis was performed. The presentation of the data was carried out in a descriptive way, proceeding with the categorization of the data extracted from the selected studies.

## RESULTS

Chart 1 presents the references analyzed in this integrative literature review, where the information from the studies that made up the analysis corpus are individually synthesized, contributing to the interpretation of the results. With the advent of COVID-19 and its high power of transmissibility, to guarantee the provision of health care and guarantee the safety of workers, it was necessary to adapt the protocols and biosecurity measures, in this sense there was a growing increase in the demand for PPE. The purpose of PPE is to protect users from the spread of infectious diseases. The type and need for an isolation gown depends on the anticipated amount of contact with potentially infectious material<sup>10</sup>. Considering the need to protect health workers who are on the front lines of the fight against the COVID-19 pandemic and the problems related to the international and national shortage of PPE, the rational use of this equipment is essential in order to minimize the impacts of this crisis, especially with regard to the illness of workers<sup>3</sup>.

Current global stocks of PPE are insufficient, especially for surgical masks and respirators<sup>1</sup>. COVID-19 originated in China, with China accounting for 12.2% of total world exports, so many countries immediately lost access to vital goods once the Chinese government implemented a mandatory quarantine, unfortunately some of these goods Lost vitals included extremely important items to fight the virus, such as masks, respirators, pharmaceutical drugs and other miscellaneous raw materials<sup>11</sup>. With the growing demand for these supplies, New York State has paid \$0.20 for gloves that typically cost less than a nickel and up to \$7.50 each mask, about 15 times the usual price, these payment details provided by state authorities show how much the shortage of critical medical equipment is driving up prices<sup>8</sup>. The inadequate supply of PPE has been a constant throughout the world. This is especially true for N95 respirators and surgical masks, in some places shortages are critical, forcing healthcare workers to perform their duties in unsafe conditions, in part because of the shortage and high cost, many hospitals are finding it difficult to pay by PPE<sup>12</sup>. According to the WHO recommendation, the number of PPE units should vary according to the severity of the disease and the number of aerosol-generating procedures per patient. For each patient/day, it is recommended to use 25 units of gowns and 25 units of surgical masks<sup>13</sup>. Some specialized health services also had their costs increased with the spread of the virus, due to the recommendations of increased levels of PPE to reduce viral transmission. In a retrospective study by the Aneurim Bevan Healthboard, for maxillofacial surgery, to assess the additional cost of PPE required for care due to COVID-19, found that this cost totaled £11.50 (US\$16.23) per patient, multiplied by 2,808 patients, the total cost over a one-year period was £32,292 (US\$45,577.25)<sup>14</sup>. In a Monte Carlo simulation study for performing endoscopies based on 10,000 patients per year, 20 healthcare professionals will use 10,000 PFF2 masks, in terms of incremental cost-effectiveness ratio values, the universal pre- endoscopy combined with the use of high-risk PPE in all patients, regardless of test results, becomes cost-effective when the prevalence rate among asymptomatic individuals increases to 1% or more<sup>15</sup>. The use of masks consistently reduces the volume and degree of projected release of the virus-laden infectious biological load, providing a significant reduction in risk to users' co-workers.

**Chart 1. Characterization of the corpus of research articles according to authors, objective, type of study, results and conclusion in PubMed, LILACS and CINAHL databases**

| Title  | Objectives  | Study Type           | Results  | Conclusion   |
|--|---|----------------------|--|--|
| Economic evaluation of programs against COVID-19: A systematic review  | Summarize the cost-effectiveness of COVID-19 programs.  | Systematic review.   | Personal protective equipment was more cost-effective in the short period than no intervention.  | This study can help choose the best strategies against the COVID-19 pandemic.  |
| Impact of COVID-19 on the cost of surgical and obstetric care: experience from a Nigerian teaching hospital and a review of the Nigerian situation   | Assessing the impact of the COVID-19 pandemic on the cost of surgical and obstetric care in Nigeria.  | Descriptive study.   | Healthcare costs remain high due to additional costs of protective equipment.  | The COVID-19 pandemic has exponentially increased the cost of surgical and obstetric care in Nigeria.  |
| Cost-effectiveness analysis of SARS-CoV-2 infection prevention strategies including pre-endoscopic virus testing and use of high risk personal protective equipment  | To analyze the cost-effectiveness of pre-endoscopy testing strategies for asymptomatic patients in a high-volume tertiary endoscopy unit.   | Descriptive study.   | Incremental cost-effectiveness ratio values were lower for routine pre-endoscopy testing along with high-risk PPE use.   | In general, routine pre-endoscopy testing combined with high-risk PPE becomes more cost-effective as COVID-19 prevalence rates increase.   |
| COVID-19 Solutions Are Climate Solutions: Lessons From Reusable Gowns  | Finding out if reusable isolation gowns are considered a first step for hospitals to save money, stay safe and transition to climate-smart healthcare practices.  | Literature review.   | Hospitals reported a 50% reduction in apron expenses after adopting reusable aprons, given a 2,000% increase in the price of disposable aprons.  | The circumstances of the pandemic have alerted us to the need to change our practices from single-use PPE to standardized reusable applications.   |
| Economic impact of COVID-19 pandemic on healthcare facilities and systems: International perspectives  | Discuss the economic impact of COVID-19 on US and international hospitals, healthcare facilities, surgeries, and surgical outcomes.   | Descriptive study.   | Even the United States was not immune to PPE shortages, nearly 15% of physicians reported that they did not have access to N95 masks, 20% did not have access to gloves, approximately 12% did not have access to face shields, and about 50% did not have access to face shields. had access to aprons. | The lack of preparation contributed greatly to the difficulties faced by health facilities around the world. In many cases, there was a lack of PPE for health professionals. Alternative strategies helped lessen the effects of the COVID-19 pandemic. |
| Risk of COVID-19 due to Shortage of Personal Protective Equipment  | Analyze the risk of COVID-19 due to the shortage of personal protective equipment.  | Descriptive study.   | Professionals are working in unsafe conditions due to a shortage of N95 masks and the high cost of equipment.  | Due to the worldwide shortage of PPE, the CDC is allowing the extended use, reuse and processing of N95 masks.   |
| Additional cost in personal protective equipment to NHS services during COVID-19: a review of the expense incurred by Aneurin Bevan Healthboards Maxillofacial unit over a one-year period to meet current clinical guidelines | Highlight the additional cost of PPE for NHS services during COVID-19.  | Descriptive study.   | The additional cost of PPE due to current COVID-19 guidelines totaled £11.50 per patient.  | The expense is necessary to reduce transmission of COVID-19 while continuing to provide surgical treatment.  |
| The monthly operating cost of an institutional COVID-19 airway response team: A financial model and sensitivity analysis based on experience at an academic medical center   | To estimate the personnel and maintenance costs of a dedicated COVID-19 team responding to the airways based on the experience of an urban academic hospital in the northeastern United States between March and June 2020. | Descriptive study.   | We estimate that the cost of disposable equipment was \$225 by air, while the average reimbursement was \$188.46.  | The pandemic has changed the financial landscape of medicine and anesthesiology in particular across the country.  |
| Budget impact on the purchase of personal protective equipment to combat COVID-19  | Analyze the amount of personal protective equipment consumed before and during the pandemic and the budgetary impact caused by its acquisition.   | Retrospective study. | All the items analyzed showed a significant increase in the amount used and, mainly, in the purchase value, costing 525% more compared to months without a pandemic.   | The increase in costs was related to the scarcity of products both in the national and international markets. Understanding the amounts paid and establishing control over dispensing equipment favors budget planning.                                  |
| Dentists See 'Substantial' Increase in PPE Prices  | Analyze the increase in PPE prices.   | Descriptive study.   | According to research conducted by the ADA's Health Policy Institute, prices for personal protective equipment have increased substantially since the beginning of the COVID-19 pandemic.  | Nearly a third of dentists reported that prices tripled or more.   |
| Reusable respirators as personal protective equipment during ENT surgery   | To describe the collective experience, and 3 institutes, of using a reusable half-face respirator in 72 cases of head and neck surgery.   | Descriptive study.   | There is a potential savings of £150 using the reusable respirator for a month.  | The reusable respirator is an economical alternative to disposable respirators.  |
| Doing Our Part to Conserve Resources: Determining Whether All Personal Protective Equipment Is Mandatory for Closed Reduction and Percutaneous Pinning of Supracondylar Humeral Fractures                                      | To evaluate the effect, efficacy, and safety for surgeons and patients of 2 variations of semi-sterile techniques for closed-reduction and percutaneous pinning (CRPP) of supracondylar humerus fractures.                  | Retrospective study. | It is estimated that nationwide adoption of this technique in the United States could save between 18,312 to 22,162 gowns and masks with savings of \$3.7 million to \$4.4 million annually..  | We are currently facing a critical shortage of PPE due to the COVID-19 epidemic, data suggest that the semi-sterile technique is safe and that it could preserve approximately 20,000 gowns and masks in the United States over the next year.           |
| Low-cost production of handrubs and face shields in developing countries fighting the COVID-19 pandemic.   | In-house produce large-scale WHO-recommended hand compresses and indigenous face shields for use by healthcare workers in the hospital.   | Descriptive study.   | The cost of each face shield was just 15 INR Indian rupees.  | These economic preparedness measures to combat the pandemic could be taken by all health facilities around the world, to overcome the expected PPE crises and stop the outbreak.   |

Chart 2. Use of Personal Protective Equipment (PPE) according to the level of care

| Level of care  | Hand hygiene | Apron | Surgical mask | Respirator (N95 or PFF2) | Eye shield or face shield | Gloves |
|--|--------------|-------|---------------|--------------------------|---------------------------|--------|
| Screening  | X            |       | X             |                          |                           |        |
| Collection of samples for laboratory diagnosis   | X            | X     |               | X                        | X                         | X      |
| Suspected or confirmed case of COVID-19 requiring admission to a healthcare facility WITHOUT an aerosol generating procedure | X            | X     | X             |                          | X                         | X      |
| Suspected or confirmed case of COVID-19 requiring hospitalization in a health unit WITH aerosol-generating procedure         | X            | X     |               | X                        | X                         | X      |

Source: WHO. Requirements and technical specifications of personal protective equipment (PPE) for the novel coronavirus (2019-ncov) in healthcare settings.

The personal benefit of masks stems from their barrier function, preventing unconscious hand movements from reaching the mucous membranes of the mouth and droplets of others, N95 masks provide the best protection against airborne COVID-19<sup>11</sup>. The increase in surgical and obstetric care brought about by the pandemic was mainly due to the additional burden of ensuring the use of adequate PPE during patient care as a disease containment measure and such equipment is not readily available in public hospitals in Nigeria and, therefore, the financial burden of acquiring these supplies for use by the healthcare professional is being passed on to the patient<sup>16</sup>. A study by the Obafemi Awolowo University Teaching Hospitals Complex (OAUTHC) found that patients scheduled for a cesarean section currently incur an additional cost of about ₦15,000 (US\$39.4) for four surgical gowns, ₦6,800 (US\$17.9) for 8 N95 masks, ₦5,000 (US\$13.1) for PPE for the sonographer, totaling an additional cost of about ₦26,800 (US\$70), almost the price of a cesarean section which is between ₦30,000 to 35,000 (US\$79 to 92), with the Nigerian minimum wage being ₦30,000 (US\$79)<sup>16</sup>. In a study carried out in a quaternary-level public hospital in the interior of the state of São Paulo, it was identified that the average daily consumption of triple mask was 767 units in the first two months of 2020 (before the pandemic) and 1284 units in the second two months of 2020. (during the pandemic) and N95/PFF2 respirators of 39 units and 106 units respectively. Regarding aprons, the daily average was 1621 units before the pandemic and 1906 during the pandemic. Regarding the financial values, the acquisition of the triple mask showed an increase of 2,888% in unit costs and 331% for the N95/PFF2 respirator. Costs related to the purchase of aprons were high, from R\$1.70/unit to R\$6.70/unit, an increase of 394%<sup>17</sup>. Considering the daily average of distributed inputs, the current values of the product market and the change in care activities, there was a 525% increase in the total cost of PPE during the months of March and April, the beginning of the pandemic, from R\$ 162,348.30/month to BRL 852,438.00/month<sup>17</sup>. Changes in biosafety protocols during the COVID-19 pandemic significantly increased the costs of dental appointments. It was observed that the costs of a dental appointment increased 19.05 times, based on the changes between the pre and post COVID-19 protocols. The annual cost of oral care has increased 9.5 times. The increase in the number of PPE explains the increase in the price per period and, consequently, the greater impact on the budget<sup>6</sup>.

According to a November survey by the ADA's Health Policy Institute, prices for personal protective equipment have increased substantially since the start of the COVID-19 pandemic, with nearly a third of dentists reporting prices tripling or more<sup>18</sup>. Following a review of the guidelines for COVID-19 airway responses published by the European Society of Anesthesiologists, the American Society of Anesthesiologists, and the Difficult Airway Society, a list of necessary supplies used by the airway team for each intubation procedure was compiled (PPE, disposable laryngoscope blade and medication), it was estimated that the cost of disposable equipment was US\$ 225 by air, however the reimbursement for this procedure was US\$ 188.46, with the institution having a net expense of approximately \$34<sup>19</sup>. According to the American Hospital Association, the pandemic has created a loss of \$202 billion across the entire healthcare industry, forcing healthcare systems to lay off employees and making hospitals scramble to minimize supply chain costs, however, as demand for PPE grows, hospitals have sacrificed sustainable solutions for disposable options<sup>10</sup>. To minimize the financial impact of the increased demand and costs of PPE, some

institutions have studied alternative strategies to the use of disposable equipment for reusable ones. Otolaryngologists and head and neck surgeons are at high risk of contagion from respiratory diseases, including COVID-19, the Sundstrom SR 100 respirator is a reusable facial device, mainly used in industrial environments to filter gas and vapor particles, the SR 510 P3 filter and the accompanying SR 221 pre-filter allow the capture of particles equivalent to the PFF3 mask. The cost per unit of a reusable respirator supplied with an appropriate filter is approximately £34 (US\$47.87), as an alternative to disposable PFF3 masks, which cost £3.40 (US\$4.79) per unit, potential savings of £150 (US\$211.19) are estimated using the reusable respirator for one month, and the acquisition cost is recouped after it is used for 10 patients<sup>20</sup>. Limiting the use of PPE where it is safe for the patient and physician should be prioritized. A study conducted to assess the effect, efficacy, and safety for surgeons and patients of 2 variations of semi-sterile (no gowns and traditional drapes) closed reduction and percutaneous pinning (CRPP) techniques of supracondylar humerus fractures. Institutional costs for a standard drape package are \$94, \$2 per gown and \$0.10 per mask, savings of 1 drape, 2 gowns, and 2 masks have been accounted for total savings of \$US 98.20 per case and preservation of PPE in the semi-sterile technique, considering that there are between 9,306 to 11,081 patients undergoing CRPP for humerus fractures annually in the United States, using the semi-sterile technique, savings are estimated between US\$ 913,849 to US\$ 1,088,154<sup>21</sup>. This moment of pandemic crisis requires the judicious and proper use of PPE, so the Infection Control Team of the JPNA Trauma Center, AIIMS, Nova Delphi, took measures such as the in-house production of hand compresses and face shields. The in-house made face shields were prepared with available materials such as foam, transparency sheets and elastic bands, the cost of each unit was ₹15 (Indian Rupees) US\$0.20<sup>22</sup>. These economic measures to combat the pandemic can be taken by health institutions to overcome PPE shortages and stop the outbreak. The COVID-19 pandemic has become a public health emergency and has raised global concerns due to limited capacity to treat the disease, COVID-19 has spurred the urgent search for effective interventions, and there is little information about the monetary value of treatments<sup>23</sup>.

## FINAL CONSIDERATIONS

The COVID-19 pandemic brought with it a change in biosafety needs with the implementation of new protocols requiring a greater need for the use of PPE; however, the increase in demand generated a shortage of these inputs and a consequent increase in prices directly impacting the budget costs of institutions of health. This gets worse as the pandemic progresses and the production of this equipment does not keep up. There was a need for some institutions to adapt, looking for alternative solutions to meet their needs. Opportunistic control of the increase in the prices of these inputs is necessary, since the need to make PPE available is fundamental to maintain the provision of health care by professionals who struggle to maintain the lives of patients in the already limited income of health institutions. health.

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