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Original Research Article

Sustainable Procurement of Medical Technologies: Equipping 85 Modular Healthcare Systems in Argentina

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ABSTRACT

Context and objectives: This article presents the planning, construction, and equipping of 85 modular healthcare systems (MHS) in Argentina as a medium-term response to the pandemic emergency. The objective is to describe the implementation and analyze the results of this large-scale national project and its investment component for the acquisition of hospital equipment, highlighting the design, outcomes, and lessons learned in the process with a focus on long-term sustainability. **Materials and methods:** Nine different phases of the implementation process of the project are described and analyzed as components of the sustainable procurement methodology. Within the framework of the planning, construction, and commissioning of the NHS, data were collected and analyzed to qualitatively and quantitatively assess the experience of planning, designing, and procuring equipment for modular health centers. Data analysis was conducted by categorizing the acquired goods into active and passive medical devices (MD), furniture, support equipment, and installation equipment. **Results:** The analysis of the equipment acquired for the 85 MHS shows that the distribution of assets aligns with specific needs and follows similar patterns across all units. Among the 19,600 medical goods purchased, over 60% of the investment was allocated to MD, reaching 87% in centers with higher critical care activity. Visits to operating MHS confirmed their general functionality and user satisfaction with the infrastructure and equipment. Strengths identified include well-designed facilities and decentralized healthcare delivery, which has reduced the burden on central hospitals. At the same time, some lessons have been learned and risks identified, such as specific shortages of specialized personnel, minor quality issues with equipment reception, and the storage of some unused or little-used devices. The need for active post-delivery management was also observed as lessons learned for future large-scale operations. **Discussion:** It was highlighted that passive MD, mainly medical furniture, while accounting for 64% of the equipment, only represents 13% of the investment. However, their appropriate selection and maintenance are crucial for patient perception and quality of care. Furthermore, the high cost of medical technology was demonstrated by an analysis of investment per square meter. **Conclusion:** The implementation of this project focused on medical technologies, analyzing design, equipment investment, outcomes, and lessons for long-term sustainability. The high cost of medical technologies confirms the opportunity to evaluate not only the purchase price but also operational, maintenance, and disposal costs. A comprehensive approach to equipment planning and management is an essential requirement for sustainability and efficiency in LMICs. Evidence-based needs analysis, crucial for sustainable acquisition and to align the equipment with intended use, and post-implementation visits, crucial for continuous quality improvement, are recommended for the implementation of future projects. The presented lessons

learned contribute to establishing a methodological base for future MD procurement projects.

Keywords—*Sustainable procurement, Medical devices, Modular hospitals, Public investment, Argentina, Results assessment, Project management, Medical device planning, Accessibility.*

INTRODUCTION

Since Brunel's resilient hospital concept, based on prefabrication and modular construction—exemplified by the Renkioi Civil Hospital built in 1855,[1] modular hospitals have significantly evolved as an architectural solution within healthcare design. They provide new or existing health facilities with the flexibility to adapt to changing medical care needs and public health emergencies. Depending on the context, modular hospital construction may serve temporary purposes, such as increasing isolation units in densely populated urban areas. In other cases, modular expansion in existing hospitals ensures uninterrupted facility operations, significantly enhancing the efficiency of medical response.[2]

In Argentina, as in many other countries, modular healthcare systems (MHS) were rapidly developed in response to the COVID-19 pandemic to provide swift solutions and prevent overcrowding at hospitals and community healthcare centers. Over time, with positive implementation experiences, MHS has become a sustainable solution[3] to strengthen healthcare systems in the medium and long term, improving medical service accessibility in vulnerable areas, including penitentiary services, and expanding coverage in strategic locations such as tourist areas and border crossings.

This report is based on the experience gained since 2020, under the "Federal Infrastructure Improvement" project. The United Nations Office for Project Services (UNOPS) was commissioned by the Secretariat of Public Works of Argentina, Ministerio de Obras Públicas (MOP), to implement 85 MHS in various locations across the country. The project scope followed a "turnkey" model, requiring UNOPS to provide infrastructure, installations, and material goods such as medical and general furniture, accessories, etc. When writing this report, 85 MHS had been awarded and constructed. Eighty out of 85 (94%) have also been equipped and are functioning. In addition, the project has equipped another 19 MHS, where the construction of the centers, installed in tourist areas, was the responsibility of government authorities in Argentina.

This study focuses on the equipment acquired for the execution of UNOPS Project 20313, detailing the procurement process, quantitative and qualitative analysis of the equipment, and post-delivery visits to assess usage and impact.[4]

GEOGRAPHIC DISTRIBUTION AND SOCIAL IMPACT

Argentina is a vast country with a surface area of 3,761,274 km² and over 46 million inhabitants.[5] However, its population distribution is unbalanced, with 92% of the population residing in urban areas and 70% concentrated in the 31 largest urban agglomerations in the country.[6]

The distribution of MHS under Project 20313 was carried out nationwide, adapting to each area of influence, their specific characteristics and needs. The number of centers correlates to the country's most densely populated regions: Buenos Aires Province (20.69 million inhabitants, including the capital) and Córdoba Province (3.84 million inhabitants). These two provinces collectively account for 53% of the national population, where 45% of the MHS were constructed. Figure 1 shows the geographical distribution of the 85 centers within Argentina highlighting the Buenos Aires and Cordova provinces.

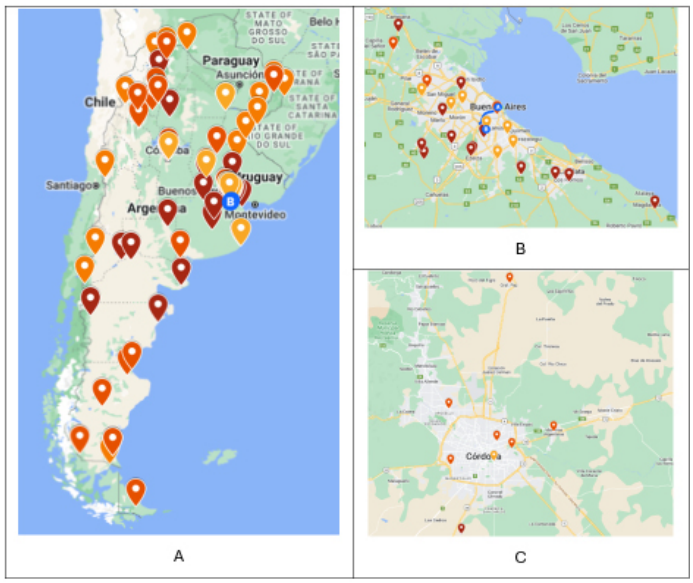

FIGURE 1. (A) Geographical distribution of the 85 MHS, detailing the centers in the provinces of (B) Buenos Aires and (C) Córdoba.

Infrastructure

Because of Argentina's diverse geographical and socioeconomic characteristics, healthcare needs vary significantly across the country. To adapt the architectural designs, infrastructure, and functional integrations of the MHS to each specific context, the MOP technical team conducted an assessment on the use of prefab solutions and a consequent needs assessment for each case. Adapting responses to particular requirements was a key element in ensuring project sustainability.[7]

Modular centers were conceived as entry points to the healthcare system in response to the COVID-19 pandemic. The different types of infrastructure provide primary, intermediate, or critical care services—either permanently or temporarily—until patients can be transferred to more complex healthcare facilities. Each modular center addresses these needs through its design and infrastructure, despite diverse site locations and contextual conditions.

Some MHS were designed to operate independently from preexisting healthcare infrastructure while still being integrated into the broader healthcare network. This was the case for centers located at border crossings and tourist areas. At first, these centers have outpatient consultation rooms, inpatient rooms, diagnostic imaging areas, and clinical laboratories.

An example of this model is the Modular Healthcare System Maldonado | HPA San Jorge | Córdoba IV, located 12 km east of Córdoba city center, as illustrated in Figure 2. It includes a shock room, observation beds, an inpatient room, an X-ray room, consultation rooms, a clinical analysis laboratory, an extraction box, a nursing station, and a pharmacy, as illustrated in Figure 3.

FIGURE 2. MHS Maldonado, HPA San Jorge, Córdoba.

Other MHS served as support areas integrated into preexisting structures and operational frameworks. These include those annexed to existing healthcare centers or those that expanded medical areas within penitentiary facilities.

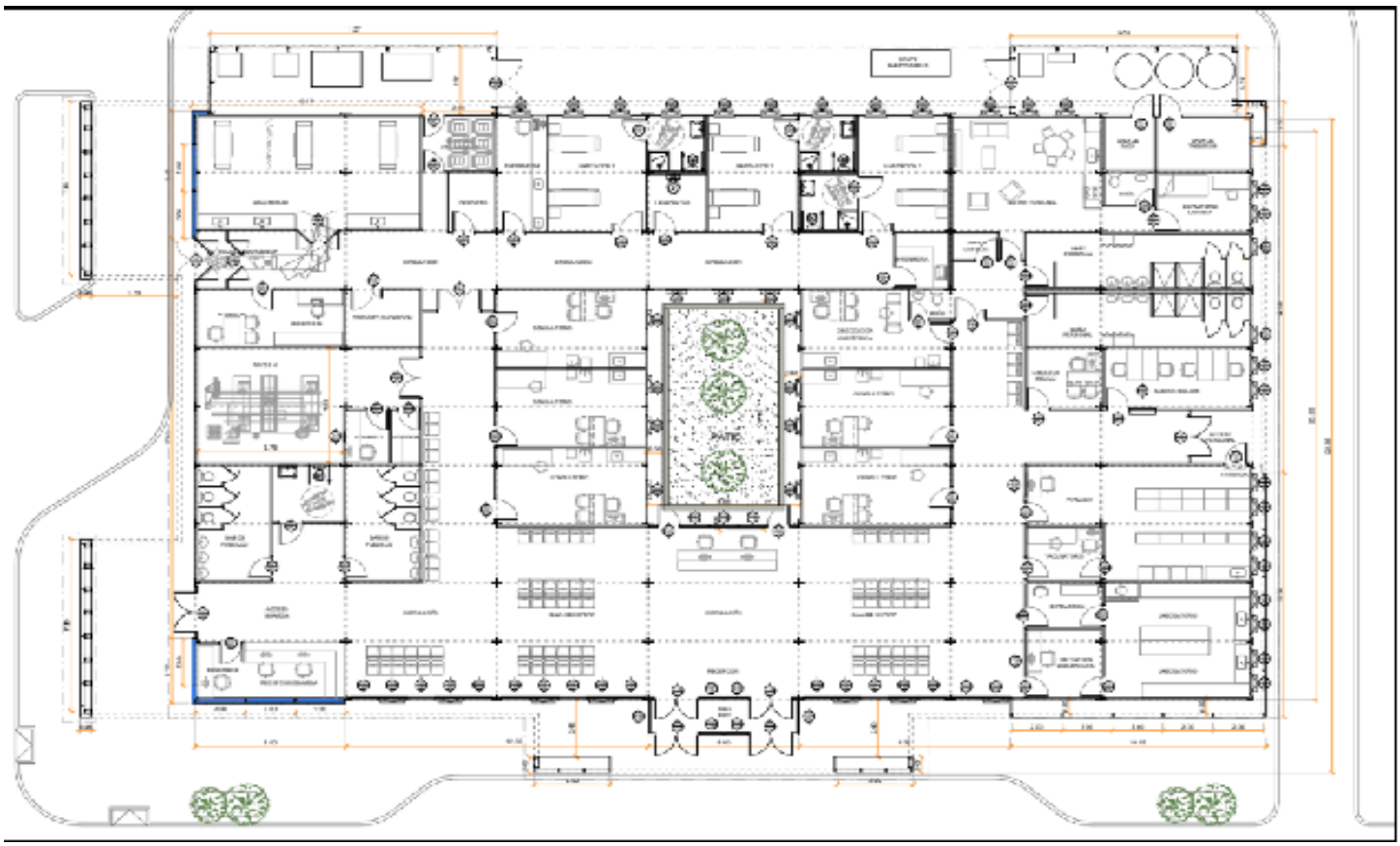

FIGURE 3. Floor plan of the MHS in Maldonado, HPA San Jorge, Córdoba.

An example of this model is the MHS at the Federal Complex Rehabilitation Center for Young Adults in Marcos Paz, Buenos Aires Province, as illustrated in Figure 4.

It includes a nursing station, pharmacy, laundry, guardroom, clinical analysis laboratory, and 12 rooms, as illustrated in Figure 5.

A third example of an MHS, in this case, complementing a preexisting healthcare center, is MHS No. 9 in Almirante Brown, Buenos Aires, which directly collaborates with the adjacent Unidad de Pronta Atención (UPA) No. 5, as illustrated in Figure 6.

It has been designed with a capacity of 76 beds for critical care and hospitalization, as illustrated in Figure 7.

FIGURE 4. MHS federal complex rehabilitation center for young adults, Marcos Paz, Buenos Aires.

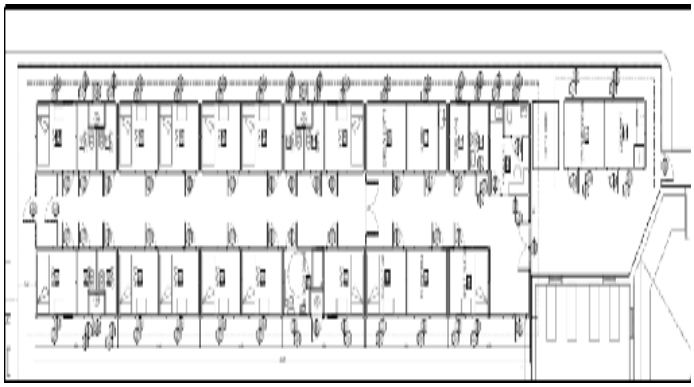

FIGURE 5. MHS federal rehabilitation complex for young adults' floor plan, Marcos Paz, Buenos Aires.

FIGURE 6. MHS No. 9, Almirante Brown, Buenos Aires. A prefab module to complement an existing center.

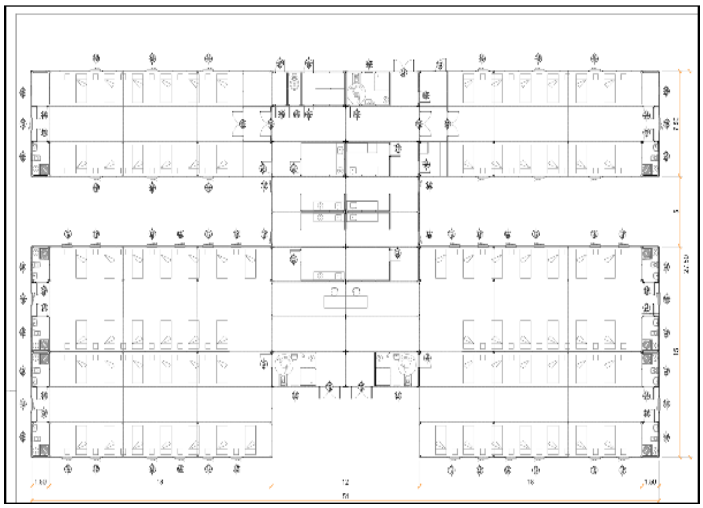

FIGURE 7. MHS No. 9, Almirante Brown, Buenos Aires. A prefab module to complement an existing center.

METHODOLOGY

Planning, designing, and procuring the equipment of the 85 MHS have been accomplished using the PRINCE2 methodology.[8] Before project closure, a phase to analyze the results has been implemented with organization visits to a few centers, as samples, several months after their commissioning, to assess the results and the impact of the project on the healthcare system.

Several months after their commissioning and before the closure of the project, a sample visit to 10 centers has been carried out to analyze the project's results.

Procurement Process

The project's implementation considered a multistep procurement methodology:

1)Grouping the procurement process for multiple MHS according to execution timelines and type. A total of nine procurement processes were conducted for the 85 MHS between 2020 and 2023, as described in Table1.

TABLE 1. Nine procurement processes carried out to equip the eighty-five health centers.

#	Process	Number of Sites	Year
1.	Modular Healthcare Systems	11	2020
2.	Modular Healthcare Systems for Penitentiary Services	6	2020
3.	Modular Healthcare Systems for Penitentiary Services	12	2020
4.	Modular Health Centers for Border	16	2020
5.	Health Isolation Centers for Penitentiary Services	10	2021
6.	Modular Healthcare Systems Phase 1	12	2021
7	Modular Healthcare Systems Phase 2 and Modular Healthcare Systems for Penitentiary Services	7	2022
8	Modular Healthcare Systems Phase 3	6	2022
9	Modular Healthcare Systems Phase 4	5	2023

Note: For the 19 MHS where UNOPS was only responsible for supplying material goods, the equipment was organized into five further procurement processes during 2020 and 2021.[9,10]

2)Determination of **requirement lists:** Based on infrastructure analysis and functional programming, using the room-by-room methodology, which designs the optimal set of equipment and furniture for each environment, considering space size and internal operational workflows.

3)Consolidation of **procurement needs:** Grouping similar or identical goods into packages according to complexity and usage characteristics, considering the local and international hospital equipment markets.

4)Definition of **technological level:** Through continuous dialogue with end users, the type of technology and complexity level of the equipment to be acquired were determined.[11]

5)Specification of **equipment requirements:** To ensure minimum acceptable quality thresholds, procurement processes followed the lowest-price principle, requiring careful assessment of local and international markets.

6)**Procurement process compliance:** Adhering to the UNOPS Procurement Manual,12 focusing on promoting local production. For Class I or A medical devices (MD) (EU and US regulations) manufactured locally in Argentina, only the local regulatory agency certification: ANMAT was required. For higher equipment of higher complexity, certifications from stringent regulatory entities such as those in the United States, Europe, Japan, Australia, and Canada were required.

7)Receipt of goods by medical units and installation of complex equipment by suppliers.

8)Certification by the national regulatory authority for fixed radiological units.

9)Analysis of procurement and installation outcomes in 10 selected centers, as a sample of the 85 centers, with different characteristics.

Equipment Requirements

- **MD and In Vitro Medical Devices (IVD)** defined according to IMRDF13 were classified as active or passive.

  - Active devices: Depend on an external energy source (other than the human body or gravity) and modify or transform that energy.

  - Passive devices: Do not require an external energy source beyond that generated by the human body or gravity.

- Support Equipment: Items not classified as MD but requiring electrical power (e.g., bedpan washers, industrial dryers, compressors, standard refrigerators, and computers).

- **Support Furniture:** Items related to general human activities or medical practice support, specifically designed for healthcare environments (e.g., dining tables, chairs, stairs, and carts).

- **Facilities-related equipment:** Supply systems supporting medical equipment and patient care (e.g., power generators and medical gas plants).

MDs, both active and passive, were classified into four functional groups:

- **Basic Care:** Equipment used in low-complexity areas, mainly for screening or primary care, such as blood pressure monitors, hospital beds, and scales. These represent 75.2% of the total medical equipment acquired for all CMS, accounting for 24.6% of the total investment.

- **Critical Care:** This category includes MDs used in critical patient care, such as ventilators, defibrillators, and infusion pumps. This group constitutes 19.2% of the medical equipment acquired and 40.2% of the total investment.

- **Sterilization:** Equipment used to eliminate pathogens from medical tools and devices, which includes hydrogen peroxide sterilizers and dry heat sterilization ovens. It represents 0.36% of MD but accounts for 5.4% of the total investment.

- **Imaging and Laboratory Diagnostics:** Internal body images for diagnostic, prognostic, and treatment purposes are generated with diagnostic imaging. Because of the nature of these healthcare centers, the acquired

equipment in this category includes fixed and mobile X-ray machines and ultrasound devices. Clinical laboratory equipment includes centrifuges for test tubes, microscopes, micropipettes, and medical refrigerators. This group accounts for 5.4% of the MD acquired but represents 29.8% of the total investment, reflecting the high cost of imaging technology.

Results and Outcome Measurement Visits

Biomedical Engineers from UNOPS personally conducted results-measuring visits to the selected 10 MHS to ensure the effectiveness of public procurement in healthcare. The results measurement phase evaluated the qualitative and quantitative impact of investment on population health while identifying lessons learned for continuous improvement.[14]

As part of this framework, site visits were planned to assess the condition and usage of delivered medical equipment and collect user feedback. A sampling methodology was used, resulting in 10 visits. At least one modular unit from each of the first eight processes outlined in the Section "The Acquired Equipment" was inspected. However, for Process 9, mentioned in Table 1, the modular units had not been equipped, making it impossible to include them in the assessment. The visits were conducted in person by one or two biomedical engineers from UNOPS.

Phase 1: Selection of Centers and Pre-Visit Planning

Before each visit, the medical coordinator of each site was contacted to ensure that the information collected at each center was representative and sufficient. This way, the visit would occur at a date and time, when the maximum number of users (e.g., X-ray technicians and ultrasound physicians) were available, and full access to all medical equipment was granted.

Phase 2: Information Gathering

Before conducting each visit, a thorough review of procurement and delivery documentation was performed. This included the examination of published procurement processes, received bids, evaluations, awarded contracts, purchase orders, and delivery receipts. All this information was organized into specific templates for each center, facilitating traceability and serving as a reference during the visits.

Phase 3: Structured Interview

A structured interview approach to ensure comparable data collection has been used. When addressing satisfaction with the proposed subjects, the referents were asked to categorize their answer using the following options: strongly disagree, disagree, neither disagree nor agree, agree, strongly agree. The structured interview comprising eight questions was submitted to the director of the visited modular unit or the person in charge during the visit, resulting in a talk of approximately half an hour.

Section a: Equipment satisfaction and suitability

1. Overall satisfaction: "The received equipment in terms of its quality, functionality, and quantity relative to your experience and expectation, is satisfactory."

2. Technology level: "The technology level of the received equipment meets the clinical needs of your patient population and the capabilities of your staff."

3. Completeness: "The equipment was delivered with all necessary accessories, components, and software required for its intended functionality and immediate use."

Section b: Personnel and training

4. Presence of personnel: "The center has sufficient and adequate staff to use the purchased medical equipment."

5. User training adequacy: "The training provided to clinical users on the operation and application of the new equipment was adequate and effective."

6. Technical training adequacy: "The training provided to technical staff (biomedical engineers and technicians) on the maintenance, troubleshooting, and repair of the new equipment was adequate and effective."

Section c: Supplier support

7. Supplier contact information: "You have clear and readily accessible information on how to contact the

supplier for warranty claims, technical support, and spare parts."

8. Warranty claim satisfaction: "If you have submitted a warranty claim, you are satisfied with the supplier's responsiveness, the speed of resolution, and the overall outcome."

Section d: Impact on healthcare infrastructure

9.Impact on higher-level facilities: "The presence of this center and its equipment has reduced the burden or demand on higher-level healthcare facilities in the province."

Phase 4: On-Site Assessment

The duration of in-person visits varied depending on the center's size, the quantity of installed medical equipment and furniture, the number of interviews conducted, and the specific operational conditions at the time of the visit. The evaluation process included:

1. Verification of serial numbers for all MDs.

2. Assessment of equipment integrity.

3. Documentation of each item's location.

4. Capturing photographic records of relevant documentation.

5. Identification of any potential issues affecting equipment usability.

6. Confirmation of appropriate user training provided for equipment operation.

7. Evaluation of supplier responsiveness in cases where technical support was requested.

The organization of the assessment tasks according to the complexity was as follows:

Type A assessments, applicable to high-complexity equipment:

- Verify the presence of the equipment.
- Check installation conditions.
- Verify the validity of the warranty and whether it has been used.
- Confirm whether the training required by the award contract has been provided.
- Ensure the presence of user manuals.
- Verify the delivery of accessories, if applicable.
- Take at least three photographs of the equipment: one showing its placement within the facility, one close-up of the equipment, and one of the serial number plate.
- Assess the equipment's functionality and gather user experience feedback.
- If possible, determine the number of patients examined or treated using the equipment.

Type B assessments, applicable to low-complexity equipment:

- At a minimum, verify the presence of the equipment, installation conditions, and warranty status.
- Take at least one close-up photograph of the equipment.

Type C assessments, applicable to medical furniture:

- Verify the presence of the furniture.
- Photograph and document any identified issues or anomalies related to its delivery.

Phase 5: Reporting and Lessons Learned

After each visit, a detailed report was compiled summarizing findings and observations. These findings were then consolidated into a final report, listing the visits chronologically and highlighting key insights for future improvements.

RESULTS

The Acquired Equipment

With the definitions explained in the methodology, the analysis of the acquired equipment and furniture allows us to demonstrate the distribution of quantity and values, as reported in Figures 8–11.

Of the goods and services directly related to medical practice and patient care, 78% correspond to MD, representing 78.9% of the investment in this category.

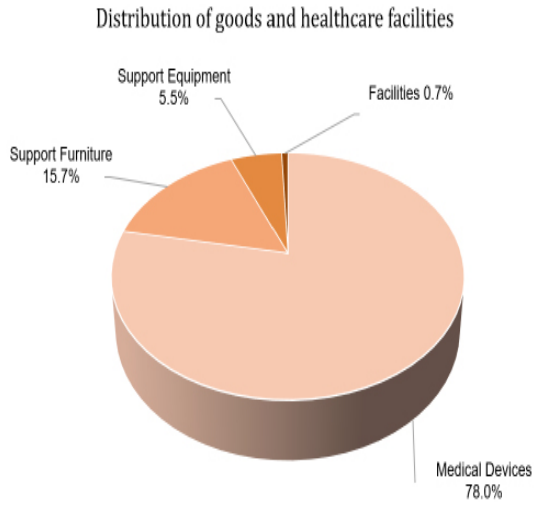

FIGURE 8. Distribution of facilities-related equipment, medical devices, support equipment, and support furniture.

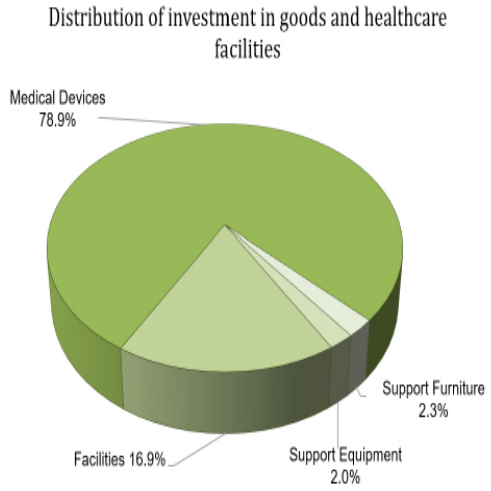

FIGURE 9. Distribution of investment in facilities-related equipment, medical devices, support equipment, and support furniture.

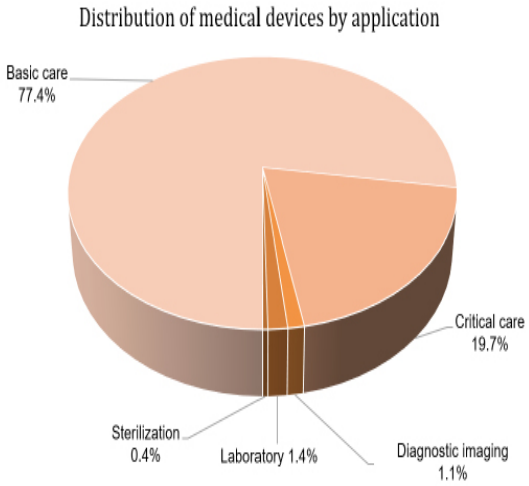

FIGURE 10. Distribution of medical devices by application.

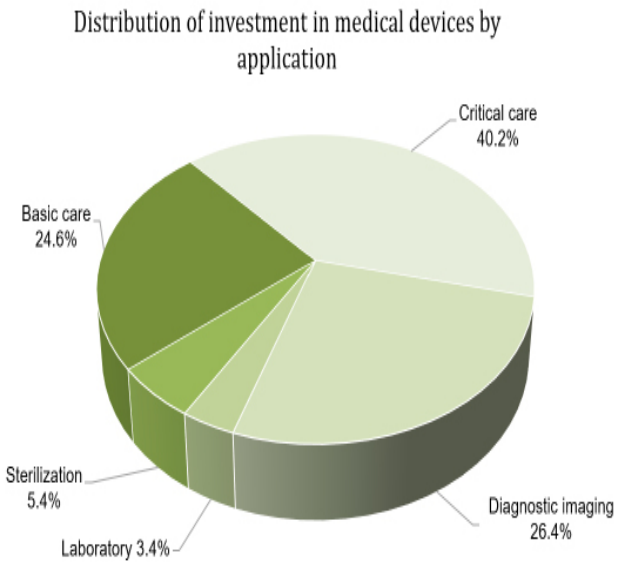

FIGURE 11. Distribution of investment in medical devices by application.

The MHS were constructed in geographical locations with dissimilar characteristics and needs; therefore, the quantity and characteristics of the assets are not homogeneous across all centers but rather respond to the epidemiological needs of each case. Nevertheless, analyzing examples from each of the MHS typologies, it is observed that their distribution follows similar patterns in all cases.

More than 60% of the investment allocated to goods directly related to medical practice, in all analyzed cases, corresponds to MD, reaching 87% in units with higher critical care activity, as higher cost devices.

Regarding MD characteristics, the largest group corresponds to basic care equipment, exceeding 62%. This is consistent with the conception of health centers as gateways to the health system. The percentage reaches 94% in Penitentiary Services Centers, where immediate and low-critical medical care is expected to be provided.

Visit Results

The objectives set for the MHS visits were met, allowing for the assessment of installed equipment conditions, its usage, and supplier responses to users. In all cases, it was possible to interview coordinators or medical officers and obtain information on current situations and future projections. The results of the structured interview carried out with the eight questions presented in "Section 2, Phase 3: Structured Interview" are presented in Table 2, as percentages of answers for each question.

TABLE 2. Results of the structured interview.

	Strongly Disagree (%) Strongly Disagree (%)	Disagree (%)	Neutral (%)	Agree (%)	Strongly Agree (%)	N/A (%)
Q1	0	40	0	10	40	10
Q2	0	10	0	60	20	10
Q3	0	0	0	30	50	20
Q4	0	25	0	25	0	50
Q5	0	30	10	10	30	20
Q6	0	10	10	0	0	80
Q7	0	30	0	10	30	30
Q8	0	0	0	0	10	90
Q9	0	0	0	10	20	70

The eight questions are presented in "Section 2, Phase 3: Structured Interview" and the results are categorized as Strongly Disagree, Disagree, Neutral or Neither Agree or Disagree, Agree, Strongly Agree, N/A: not applicable or not answered. The percentage of each answer is shown in table 2 and the statistical analysis of the answers is reported in Table 3.

Assigning numerical values from 1 to 5 allows for the calculation of mean values and standard deviations to gauge the level of agreement. Based on these metrics, the MHS

Directors' responses suggest the following:

- Technical and clinical staff training: The directors do not generally support the idea that adequate training of the technical staff has been carried out. However, they show slight support for the notion that the center has sufficient and adequately trained staff for equipment use.

- Equipment quality and support: There is some agreement among the directors regarding the quality, functionality, and quantity of the received equipment. They also agree on the availability of information for contacting the supplier when needed.

- Equipment adequacy and impact: The directors generally agree that the level of equipment is adequate for both clinical needs and staff capabilities. They also acknowledge the good condition of the equipment upon arrival and recognize that the center and its equipment have reduced the burden on higher-level healthcare facilities.

- Warranty satisfaction: In the one instance where the warranty was activated, the supplier's response was rated as very satisfactory.

TABLE 3. Statistical analysis of the results of the structured interview.

Question	Average Level of Agreement	std dev
Q6: Adequate and effective training provided to technical staff	2.5	0.7
Q4: The center has sufficient and adequate staff to use the equipment	3.5	1.4
Q5: Adequate and effective training provided to clinical users	3.5	1.4
Q1: Received equipment in terms of its quality, functionality, and quantity is satisfactory	3.6	1.5
Q7: Clear and readily accessible information on how to contact the supplier in case of need	3.6	1.5
Q2: The level of the equipment is adequate to the clinical needs and staff capabilities	4.0	0.9
Q3: The equipment was delivered in good condition for its intended functionality and use	4.3	1.0
Q9: The center has reduced the burden or demand on higher-level healthcare facilities	4.5	0.6
Q8: Supplier's responsiveness to warranty claims, satisfactory speed of resolution, and overall outcome	5.0	N/A

Note: Results below 3 show a disagreement (pink), results between 3 and 4 show a certain agreement (yellow), and results between 4 and 5 show high levels of agreement (green). N/A: not applicable. Std dev: standard deviation.

Figures 12–17 show some of the hospital areas and equipment inspected during the visits.

FIGURE 12. Equipment and facilities-related equipment installed in a critical care unit, MHS No. 9—Almirante Brown, Buenos Aires.

FIGURE 13. Equipment installed in a clinical analysis laboratory, MHS No. 28—Exaltación de la Cruz, Buenos Aires.

FIGURE 14. Equipment installed in a gynecological room, MHS No. 28—Exaltación de la Cruz, Buenos Aires.

FIGURE 15. Equipment and facilities-related equipment installed in an observation sector, MHS San Jorge, Córdoba.

FIGURE 16. Equipment and facilities-related equipment installed in a hospitalization room, MHS No. 9—Almirante Brown, Buenos Aires.

FIGURE 17. Equipment installed in an emergency office, MHS No. 28—Exaltación de la Cruz, Buenos Aires.

Although in a few cases, clinical services were found to be not operational because of a lack of clinical specialists, like cardiologists or pediatricians, end users expressed satisfaction in quality, quantity terms, and supplier responsiveness toward the available technology. They also highlight the improvements that equipment and facilities-related equipment have brought to their daily work. In addition, the new medical specialties and practices introduced in some MHS have reduced patient waiting lists in central hospitals.

The following four strengths of the implemented project were identified:

Strengths:

1. Well-designed facilities with spacious areas and adequate lighting.

2. High user satisfaction with received goods and their positive impact on daily work.

3. Reduced demand in central hospitals because of decentralized healthcare services.*

4. Properly stored and managed equipment, all of them are in good working conditions.

*Note: Reduced demand in central hospitals because of decentralized healthcare services is a qualitative finding from Question 8 of the structured interview: "To what extent has the presence of this equipment at your center reduced the burden or demand on higher-level healthcare facilities in the province?"

Lessons Learned

The following six lessons learned have been identified during the visit and an analysis of their results:

1. It is essential to establish a dedicated process ensuring sufficient personnel/specialists for MHS operation. In some cases, the absence of clinical personnel has delayed implementation and affected the warranty, since the equipment has been stored for a long time.

2. It is essential to establish a formal process to inspect the quality and integrity of each delivered equipment. In a couple of cases, the visit detected missing accessories (one wheel of one examination lamp and few shelves) and the problem was solved with the suppliers.

3. It is essential to prepare the equipment list based on the real existing or projected needs. It was observed that few equipment (about 2%), like humidifiers to support mechanical ventilation, were not used because of a lack of specific needs. The presence of some underutilized equipment may be a consequence of misalignment between the specific needs of MHS facilities-related equipment and the equipment provided as well as changing needs during a project's implementation.

4. As a result of the structured interview, it is recommended that the training process is monitored and certified. It was identified that some end users were unaware that they could request training from the equipment suppliers. In addition, they did not know how to contact the suppliers. Compounding the issue, internal training sessions were conducted by other users of similar equipment, with the risk of incorrect concepts leading to an improper use of the devices.

5. It is recommended that all the local regulatory requirements are properly managed in advance. Specifically, the necessary authorizations from the Radiological Health Authority of the Argentine Ministry of Health (Radiología Sanitaria), responsible for verifying and approving radiology rooms, were not processed from the beginning, with the risk of delays in the start-up of radiology services. In this specific case, a prompt reaction and a proactive management of this specific risk have avoided delays.

6. It is recommended to streamline the communication of the contractual conditions with the final users. In most cases, the misconception that equipment belongs to UNOPS and not to the final users prevented the possibility of its redistribution according to changing needs.

Finally, the case of MHS No. 9 in Almirante Brown, Buenos Aires Province, can be reported as a remarkable success. Originally conceived as a SARS-CoV-2 pandemic response unit, it has since been integrated into the local healthcare network, coordinating with the "Dr. Lucio Meléndez" General Acute Hospital and the adjacent "Unidad de Pronta Atención" (UPA) No. 5. It currently receives patients requiring hospitalization through the

UPA and referrals from the main hospital. During the second quarter of 2024, it recorded 695 patient admissions, with a projection of 2.800 patients/year, becoming key in relieving and decentralizing the demand for critical and intermediate care hospitalizations.

DISCUSSION

Replicability for Different Contexts

Some key parameters can be identified to help similar projects estimate budgets and workloads in the inception phase.

Within the MD acquired for all MHS, passive equipment accounts for 64% but represents only 13% of the investment in medical equipment, as shown in Figures 18 and 19.

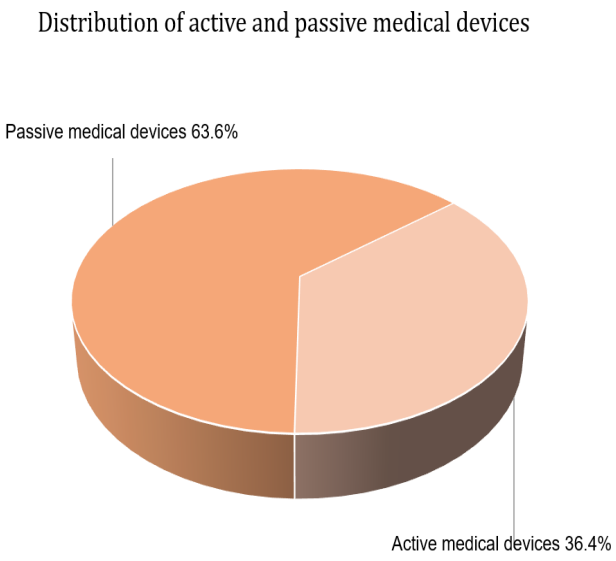

FIGURE 18. Distribution of active and passive medical devices.

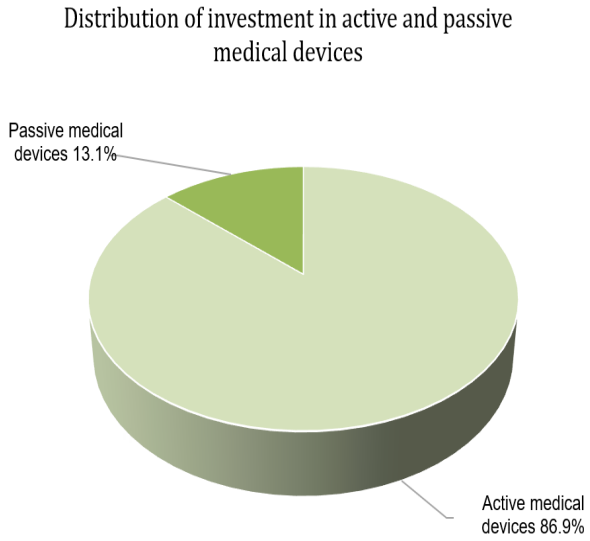

FIGURE 19. Distribution of active and passive medical devices.

The passive device group primarily consists of inpatient beds, stretchers, wheelchairs, blood pressure monitors, and stethoscopes, all of which are low-cost and low-complexity items. This could lead to underestimating the time dedicated to their evaluation and acquisition.[15] However, it is important to note that these devices are in contact with the patient for a significant portion of their stay in healthcare centers. Since the patient's perception of the environment impacts their treatment outcomes,[16–18] it is relevant to dedicate adequate human and economic resources to the selection and maintenance of these assets.

An analysis of the investment in MD, medical furniture, support equipment, and facilities-related equipment per square meter (m^2) shows that for the individual modular centers analyzed, the highest investment per m^2 corresponds to MD, followed by investment in facilities-related equipment.

Table 4 presents the MHS data for various centers with different surface areas. Four MHS typologies with different surface areas were selected to analyze the parametric cost of the equipment. These typologies range from the largest surface area (MHS #1 of 1,100 m^2) to the smallest (MHS

#4 of 285 m^2); two intermediate cases (MHS #2 and MHS #3) have also been selected.

As shown in Table 4, MHS for penitentiary services, MHS# 3 and MHS# 4, have a lower relative investment in MD in comparison with the other centers. Smaller centers of the same type have a greater relative investment in MD compared to larger ones.

TABLE 4. Investment per square meter for the different types of facilities and for four MHS, each representing different sizes and types of centers.

MHS type	# 1	# 2	# 3	# 4
Area (m^2)	1,100	990	660	285
Medical devices*	533.9	259.4	182.8	336.6
Medical furniture*	11.6	11.8	1.9	2.2
Support equipment*	6.1	0.5	22.1	25.5
Facilities-related equipment*	100.4	25.2	96.6	136.0
Total equipment investment*	**652**	**296.9**	**303.4**	**500.3**
Percentage of medical devices in total equipment cost	82%	87%	60%	67%
equipment cost				

* Investment [U$S/($m^2$)]

In table 4 MHS type #1 corresponds to MHS annexed and integrated into preexisting healthcare centers, MHS type #2 corresponds to MHS designed to operate independently from preexisting healthcare infrastructure, and MHS types #3 and #4 correspond to MHS for penitentiary services of different sizes, which respond to the size of the beneficiary population.

This evidence underscores the high cost of medical technology that is independent from the specific size and type of center and reinforces the importance of conducting a needs analysis as a starting point for the acquisition process based, among other factors, on the intended use of the assets.

Similarly, costs associated with the entire life cycle of medical technology within the healthcare center must be considered, from the initial purchase expenses to the final disposal costs. The purchase price is only the tip of the iceberg concerning associated costs. A proper medical technology cost analysis requires considering not only the purchase price but also installation, operation, financing, disposal, and other costs generated during the useful life of the device.[19]

A detailed analysis of medical technology costs throughout its life cycle will require further investigation. The Pan American Health Organization considers preventive and corrective maintenance costs to represent between 3% and 7% of the equipment's purchase cost per year when performed by the healthcare center's staff; and between 8% and 15% when external services are contracted.[20] Costs associated with the devices' operation vary depending on the technology, and their origin is very diverse. Clinical analysis laboratory equipment may have high costs in reagent consumption, while imaging equipment will have large consumption in electricity and cooling supplies. The analysis and observation of all costs associated with medical equipment during its useful life is a fundamental part of sustainable acquisition.[21]

CONCLUSION

In conclusion, as a medium-term response to the pandemic, Argentina undertook a national project to plan, construct, and equip 85 MHS. This article describes the project's implementation for the medical technologies component and analyzes its results, focusing on the design, equipment investment, outcomes, and lessons learned within the objective of long-term sustainability.

The evidence presented highlights the significant impact of MD investment on healthcare facility costs, emphasizing that the purchase price is merely the initial expense in a device's lifecycle.

Considering the significant financial implications of medical technology, as highlighted by the consistent costs across various facility types, conducting a needs analysis is a crucial first step in sustainable acquisition, ensuring that the selected equipment aligns with its intended use and the facility's long-term goals.[22]

The six identified lessons learned can serve as a valuable checklist for future healthcare infrastructure planning and medical equipment deployment, enabling hospital planners, policymakers, and health authorities to deliver effective and sustainable healthcare solutions. These lessons, when integrated with the three pillars for MD procurement—selecting equipment that meets beneficiary clinical needs, considering human resource capabilities, and assessing local infrastructure conditions, all while prioritizing the asset's lifelong use—collectively form a robust methodology for implementing future projects.

As the post-implementation visit was not included in the original project's plan and has been carried out with limited resources, to ensure continuous quality improvement process for the MD procurement implementation strategy, we recommend scheduling such visits in the design phase of future projects, including in the agreement a provisions for the regulated sharing of anonymized access data related to the project's infrastructure to measure its impact rigorously.

AUTHOR CONTRIBUTIONS

Conceptualization, V.D.V., PMC and M.A.B.; **Methodology**, V.D.V., PMC and M.A.B; **Software**, V.D.V., PMC and M.A.B; **Validation**, V.D.V., PMC and M.A.B; **Formal Analysis**, V.D.V., PMC and M.A.B; **Investigation**, V.D.V., PMC and M.A.B; **Resources**, V.D.V., P.E.G., I.L.C., PMC and M.A.B; **Data Curation**, V.D.V., P.E.G., I.L.C., PMC and M.A.B; **Writing–Original Draft Preparation**, V.D.V., PMC and M.A.B; **Writing–Review & Editing**, V.D.V., P.E.G., I.L.C., PMC and M.A.B; **Visualization**, V.D.V., PMC and M.A.B; **Supervision**, P.E.G., I.L.C.,; **Project Administration**, P.E.G., I.L.C.,; **Funding Acquisition**, P.E.G., I.L.C.

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FURTHER DISCLOSURE

Not applicable.

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