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Pharma.Aero Bedrijvenzone Machelen Cargo 706B, 1830 Machelen

WHITE PAPER

LEAN LOGISTICS FOR VACCINES - A SUCCESS CASE IN URUGUAY: FROM THE AIRPORT TO THE PATIENT

SEPTEMBER 2021

Uruguay was the only country in the world to store, prepare and distribute vaccines directly from the airport to the vaccination centers and was able to vaccinate its population at a very fast rate.

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Contribution and support:
- Raúl Bianchi
- Marcel Barceló

For Pharma.Aero:
- Bruno Guella
- Trevor Caswell
- Frank Van Gelder
- Sara Van Lerberghe

"It was a wise move to choose the airport for the storage and handling in ultra-cold conditions. It allowed for quick implementation and avoided chain failures."

Dr. Daniel Salinas, Minister of Public Health

"The flexibility of the design helped us to adapt the plan as new challenges arouse. In addition, the inter-institutional collaboration was pivotal in reducing inefficiencies, margin of error and lead times. This was key to the success of the vaccination plan"

Lic. Jose Luis Satdjian, Vice-Minister of Public Health

1. Executive summary

Uruguay has a successful tradition of mass vaccination plans. However, the Covid-19 pandemic created an unprecedented challenge. The vaccine delivery system had to be modified in order to significantly exceed historical vaccination rates under much more demanding circumstances. It also had to use a new network of vaccination centers so as not to affect the rest of the vaccination plans.

The strategy of the distribution system was designed to be able to leverage the best practices of a logistics operation, based on the Theory of Constraints, in order to optimize time and resources. To that end, a last-mile distribution model was adopted, involving the preparation of unit orders and direct delivery from the airport to the vaccination centers, shortening the supply chain and improving the lead times within the value chain of the vaccines. This was a key factor in Uruguay's successful strategy to reduce time and risk throughout the logistics chain.

2. Status and Challenges

Covid-19 raised challenges globally, both for healthcare systems and for vaccine development at unprecedented rates to end the pandemic, which, as of early July 2021, had already caused nearly four million deaths.

The distribution of vaccines has been the greatest logistical challenge in history: all countries simultaneously had the same urgency to receive them; while the availability of international flights was substantially reduced due to the pandemic; and to ensure safety, traceability and cold chain requirements had to be maintained along the supply chain.

Moreover, the vaccine supply chain remained very uncertain, while pharmaceutical companies were still in the midst of vaccine development.

In Uruguay, at the end of 2020, it was not known yet what type of vaccines would arrive, nor how many, nor when, or the requirements for their storage and transportation. The only certainty was that they would be arriving through its International Airport.

Being aware of this, the cargo terminal at the international Airport of Montevideo, Uruguay (TCU - MVD Free Airport), launched in October 2020 the project "Acercar Vacunas" (Bringing Vaccines Closer). Based on its experience in pharmaceutical logistics, the company decided to take a leading role in the design of fast, safe and efficient logistics, anticipating the challenges and leaving nothing to chance. The government, based on the country's successful tradition of mass vaccination plans, had also been working on the definition of the vaccine distribution system. However, until now, the need to vaccinate more than 70% of the population with two doses in less than six months had never arisen; an objective that the plan originally designed by the government could not achieve.

The studies carried out by the government had already warned of the difficulty of distributing, throughout the country, a vaccine that requires a demanding cold chain, such as the one developed by Pfizer. In Uruguay there were no ultra-cold freezers available as part of usual vaccination plans, nor were there calibrated devices to control and monitor such low temperatures. On the other hand, the use of dry ice implied a complex and costly operation.

The experiences of other countries also provide insight and background, by the information gathered by Pharma.Aero on vaccine logistics at the international level, as well as the experience in the development of vaccination plans, which was accessed through government contacts.

Finally, in early January 2021, these efforts converged in a cooperative multi-task team integrated by the public and private sectors, comprising representatives of TCU - MVD Free Airport, the Ministry of Public Health (MSP), the National Emergency System (Sinae), Calmette laboratory[1] and the company va-Q-tec, all under the overall coordination of the Presidency of the Republic.

"It is important to highlight the inter-institutional collaboration. Together with the Ministry of Health, many organizations contributed in a coordinated approach, including: the Ministry of Social Development, the Association of State Medical Services, the National Emergency System, as well as many actors in the private sector. This was pivotal in reducing inefficiencies, margin of error and lead times."

Lic. Jose Luis Satdjian, Vice-Minister of Health

For the Covid-19 vaccination campaign, Uruguay decided to use vaccines from Sinovac, Pfizer and AstraZeneca. This document describes the operational solution used for the Pfizer vaccines, as it required more sophisticated logistics and shorter delivery times.

1 State laboratory responsible for the planning and execution of all vaccination plans at the national level.

3. The Solution

3.1 Strategy

The strategy for designing the National Vaccination Plan solution was based on the Theory of Constraints TOC. This is an organizational management tool developed by the Israeli physicist Eliyahu Goldratt[2].

The core idea of this methodology is that the maximum performance that can be achieved by any system is determined by very few elements, in most cases only one: the constraint (Fig 1).

Based on this approach, a strategic and tactical roadmap was established for the continuous improvement of the processes involved in the implementation of the vaccination plan in Uruguay:

- Identify the constraint in the system that defines the maximum number of people that can be vaccinated per week. In this case, the rate at which vaccines would arrive in the country.
- Ensure that the constraint operates at maximum capacity. This implies avoiding the loss of any vaccine doses and sizing the rest of the components of the distribution system (ultra-cold freezers, vaccination centers, refrigerated boxes, means of transport, etc.) with a capacity that exceeds the rate of arrival of vaccines.

Fig 1

In this way, the pressure for greater performance relied on the Executive Branch, which negotiated with the laboratories the quantities and frequency of deliveries.

In the event a significant increase in the rate of arrival of vaccines was achieved and this was no longer the limiting factor in the rate of vaccination, the review cycle would begin again to identify the new constraint and subordinate the operation of the rest of the distribution system.

3.2 Tactics

The implementation of the defined strategy involved the development of two key concepts: avoiding the loss of doses and ensuring protective capacity throughout the logistics system. Based on Pfizer specifications, training needs were identified to ensure vials would only be handled by fully qualified personnel.

3.2.1 Avoiding Losses

The first concept was reflected in the following design criteria:

- Minimize handling operations to reduce risks by eliminating non-value-adding activities.
- Strictly comply with Pfizer's standard operating procedures for storage, handling and distribution activities.
- Centralize vaccine storage in one location: the dedicated pharmaceutical warehouse at the airport.
- Create a scheduling system so that every patient is previously registered in the government health database. This allowed for proper segmentation and prioritization (exposure risk, ages, comorbidities, etc.)
- Based on the agenda previously defined, prepare orders on a daily basis and ship them overnight from the airport directly to every vaccination center in the country, with the exact amount of vaccines for the people scheduled for the next day, plus 5% for contingencies.
- Ensure that only qualified personnel are involved in the process of preparing and packing the vials (small glass vials containing the vaccine doses)
- Use only validated containers for distribution with temperature recorders and tracking & tracing systems. Optimize reverse logistics of containers, ensuring availability for future shipments.
- Not maintaining safety stock at the vaccination centers to avoid reverse logistics and transfers between vaccination centers. This simplifies handling activities and minimizes the risk of doses being lost.
- Monitor the program through daily inventory checks of each vaccination center.

2 https://goldrattgroup.com/

3.2.2 Protective Capacity

This concept refers to the fact that the infrastructure and the capacity of the required processes, from the reception of the vaccine to its application, must be sized based on the possible peaks of demand and not on the average.

Given the uncertainty that existed in January 2021 as to what vaccines would be available in Uruguay, in what quantities and when they would arrive, efforts were made to create a protective capacity throughout the supply chain, airport, distribution center and vaccine centers that would be able to adapt quickly to different scenarios.

Storage capacity at -70°C had to be sized for the most demanding scenario. The delivery time for ultra-cold freezers was approximately two months. One to two weeks are required for installation and validation testing, so it was not possible to quickly install new equipment in case of an increase in the number of vaccines received.

In another sense, vaccination teams could be designed in a **flexible** manner and adapted to the pace of vaccination. Multidisciplinary teams were defined with work contracts that ensured payment for availability, which made it possible to increase or decrease the number of vaccinators without significantly affecting their salaries. This way of organizing human resources, together with a weekly planning horizon with daily reviews, made it possible to maintain a continuous flow of inoculation.

This last concept, the **continuous flow concept**, was very important to ensure the use of each dose and reduce the risk of losses. The guidelines initially established by Pfizer indicated that the shelf life of the vaccines, once thawed and shipped to the point of inoculation, was less than five days. Therefore, in order to avoid stopping the operation in the vaccination centers and restarting days later, thereby generating vaccine balances that would not be used the following day, it was sometimes decided not to use all the available capacity, but only the capacity necessary to maintain a continuous flow of vaccination.

Therefore, it was not necessary to appeal to social networks or other means to quickly recruit people to be inoculated before the doses expired, as happened in other countries.

Based on these concepts, it was possible to install a vaccination capacity that ensured a daily minimum of 1% of the population with the possibility of rapidly doubling it. This flexibility ensured that the limitation of the system was always fixed in the amount of vaccines arriving in Uruguay.

3.3 Operations

3.3.1 Demand Management

In order to ensure a constant flow of vaccination, avoid waiting lines and take advantage of the facilities, a system was developed to register all persons willing to be vaccinated. The system then allocated quotas according to the priorities set by the commission of vaccine experts, the amount of vaccines available in the country and the capacity of each vaccination center.

3.3.2 Supply Frequency

To ensure that each vaccination center had only enough vaccines to cover the daily demand and to avoid the risk of stock-out, a daily replenishment frequency was defined and a maximum time of 12 hours from the time a vial was thawed until delivery to the vaccination center.

Once the demand for each vaccination center was confirmed, the orders were prepared overnight at the airport facilities and shipped the following morning directly to their destination.

3.3.3 Storage

Given a high degree of uncertainty and many open questions during the planning stage, the design and sizing of the vaccine storage system had to be able to accommodate different scenarios, such as handling varying sizes of the batches arriving in Uruguay and the availability or lack of ultra-cold freezers.

At the beginning of January 2021, supply agreements with Pfizer had not yet been finalized, so there was no precise information on the quantities and dates of arrival of the vaccines in Uruguay, and there was a lack of suitable equipment for storing vaccines between -80°C and -60°C in the country.

From this starting point, parallel progress was made along two paths:

- Obtain ultra-cold freezers or other equipment capable of storing vaccines between 80°C and -60°C as soon as possible.
- Design a storage system that would include the use of dry ice.

In Uruguay there was little availability of ultra-cold freezers and the maximum capacity of vaccines that could be stored was unknown. In addition, there was a high demand for this type of ultra-cold freezer equipment worldwide.

The government contacted institutions and suppliers that could provide this equipment in the short term. As a result, a local representative initially delivered two ultra-cold freezers on loan while the purchase and delivery of two new ones was being negotiated. In addition, four additional pieces of equipment were purchased and transported from the U.S. by the Uruguayan Air Force to ensure their immediate installation at the airport in Montevideo.

These ultra-cold freezers were installed and calibrated at the airport prior to the arrival of the first batch of vaccines, creating a total storage capacity of 800,000 doses. This capacity not only exceeded the largest batch of vaccines that could arrive in the country simultaneously, but also provided backup capacity in case there was any equipment failure.

The other option was to periodically replenish the dry ice in the original boxes received from Pfizer, keeping them in a chamber at -20°C to minimize thermal loss. According to Pfizer's initial specifications, this would allow the vaccines to be stored for a maximum of 30 days, so the vaccine batches had to be small and received as often as possible.

In Uruguay there are two suppliers of dry ice and only one of them can produce it in flakes, which is the preferred requirement to replenish the boxes. It was also necessary to consider the generation of CO2 inside the cold chamber and to define a safe operation mode for the staff. Although this mode of storage was ultimately not implemented, the work carried out was useful to have an alternative in the event of an extreme case.

When the arrival of the first ultra-cold freezer was confirmed, TCU - MVD Free Airport adapted the installation site of the equipment and ensured the supply of electrical power by adopting redundant infrastructures as a back-up. The staff had previously been trained under the "Bring Vaccines Closer" project to operate safely with materials at -80°C through theoretical instruction and operational simulations.

3.3.4 Distribution

The size and topography of the Uruguayan territory does not present major challenges for vaccine distribution, since it is possible to cross the country by land in about eight hours with good road conditions. The following map shows the number of vaccination posts by department (Fig 2).

However, delivery times and schedules, the particularities of Pfizer's vaccine, as well as the characteristics of the distribution to the vaccination centers, required some challenges to be solved.

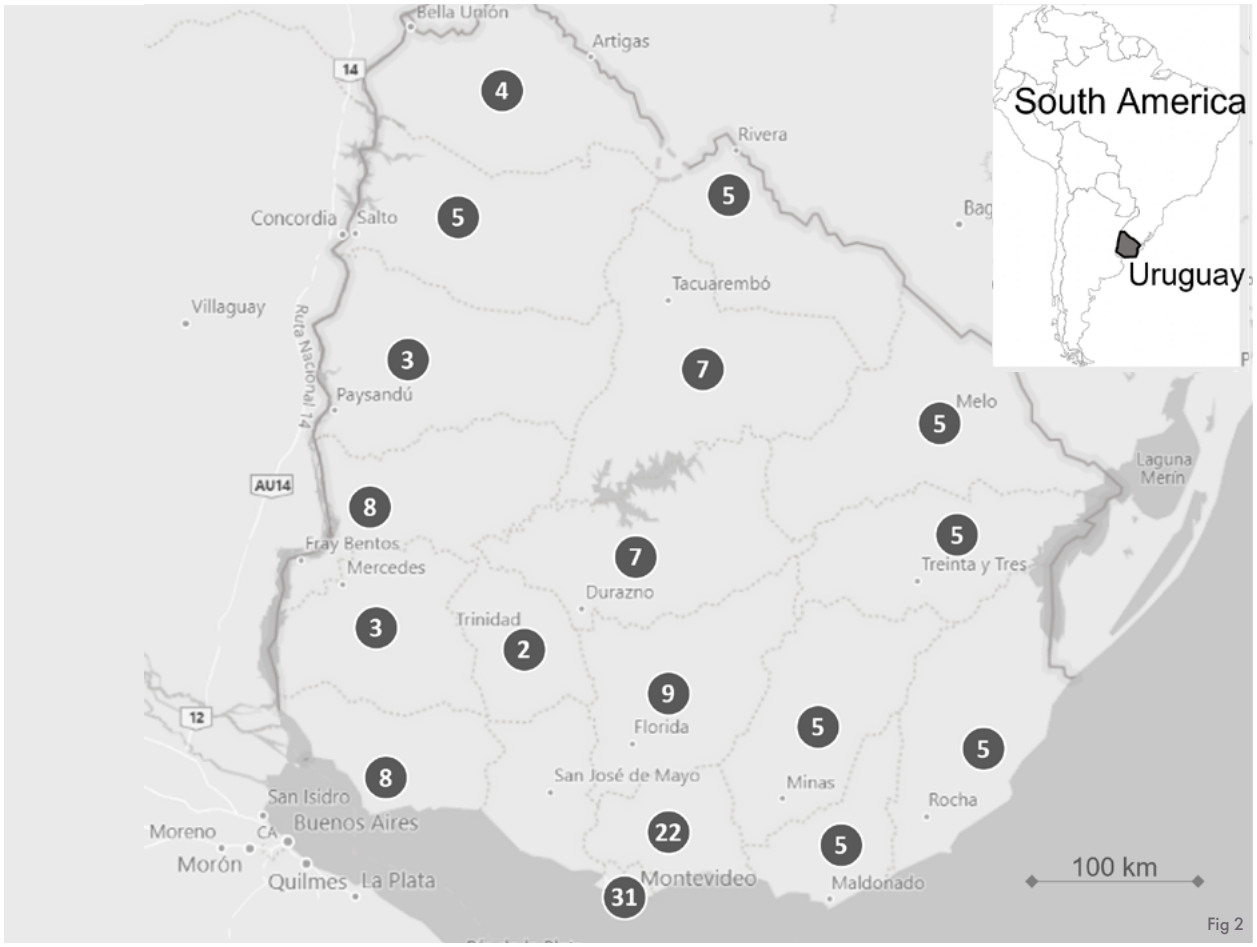


Fig 2

In order to achieve daily deliveries to each vaccination center and not to exceed 12 hours from the preparation to the delivery, the Ministry of Health made an agreement with DAC, a private company with vast experience in vaccine distribution, for deliveries in Montevideo and the metropolitan area. The rest of the country was covered by the Air Force and the Army (Fig 3).

Thus, at 4:00 a.m., the thermal boxes with vaccines were delivered to the Air Force, which departed with its planes and helicopters from the Montevideo airport to the different locations in the countryside, from where the Army continued with the distribution to the vaccination centers.

From 6:00 a.m. onwards, the vehicles of the private transportation company DAC collected the thermal boxes with vaccines to arrive before 8:00 a.m. at each vaccination center in the capital city and nearby areas.

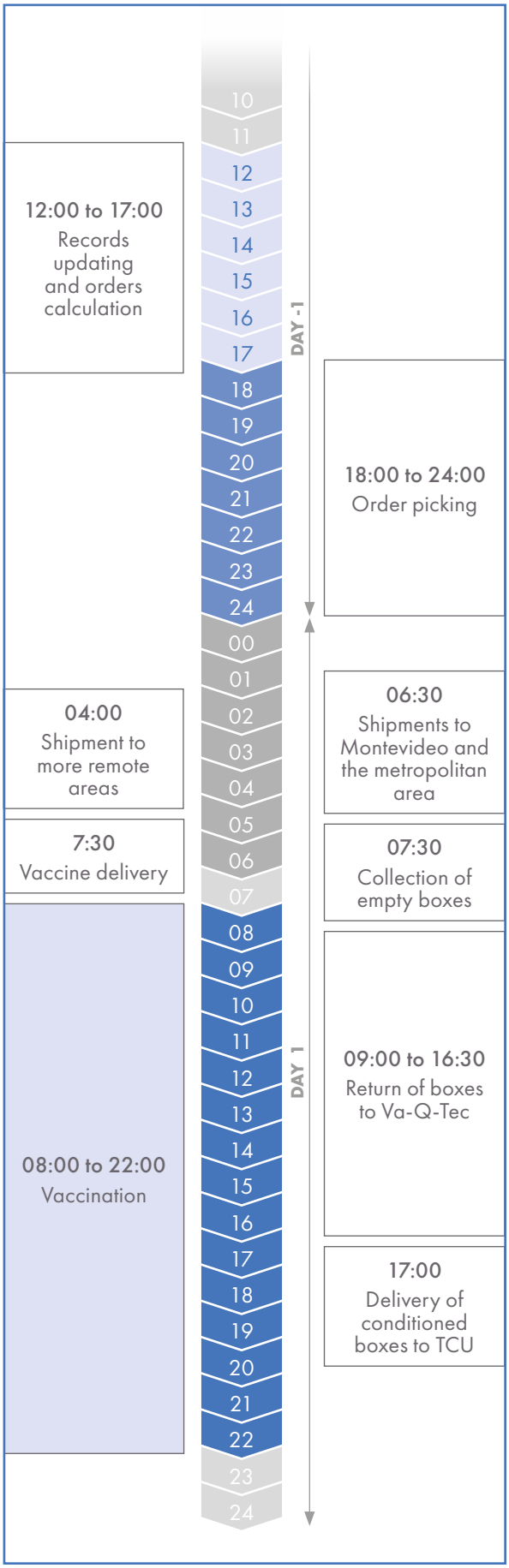
Alejandro Méndez, Country Manager of DAC, highlighted the integration work that TCU - MVD Free Airport was able to do in record time, providing visibility to the process from the moment of arrival of the vaccines, the availability of stock, the preparation of the orders, to the delivery of the vaccines.

He mentioned as one of the main challenges for this integration the participation of multiple public and private players. "We had never worked with an integration in which our carriers ended up being the Air Force with its airplanes and the Army. We had to develop a training plan for the use of the tools, the processes, our technology and that of TCU - MVD Free Airport and thus be able to have all the information centralized for the different reports".

"The system for the logistics of the thermal boxes was a bit complex at the beginning, but then it flowed perfectly. The thermal boxes have been permanently monitored by the system and none of them were misplaced."

Edgardo Ipar, Director of va-Q-tec Latin America

PROCESS STAGES Fig 3



At the same time, police custody was initially assigned to accompany the ground transportation vehicles, considering the high level of attention that the distribution of the vaccines had attracted, which represented a risk of sabotage that had never been considered in previous vaccination plans.

"Our company transports all vaccines, but we had never had these safety devices before. It was something very new, we didn't know if anything could happen during the transportation."

Alejandro Méndez, Country Manager of DAC

3.3.5 Cold chain and Traceability

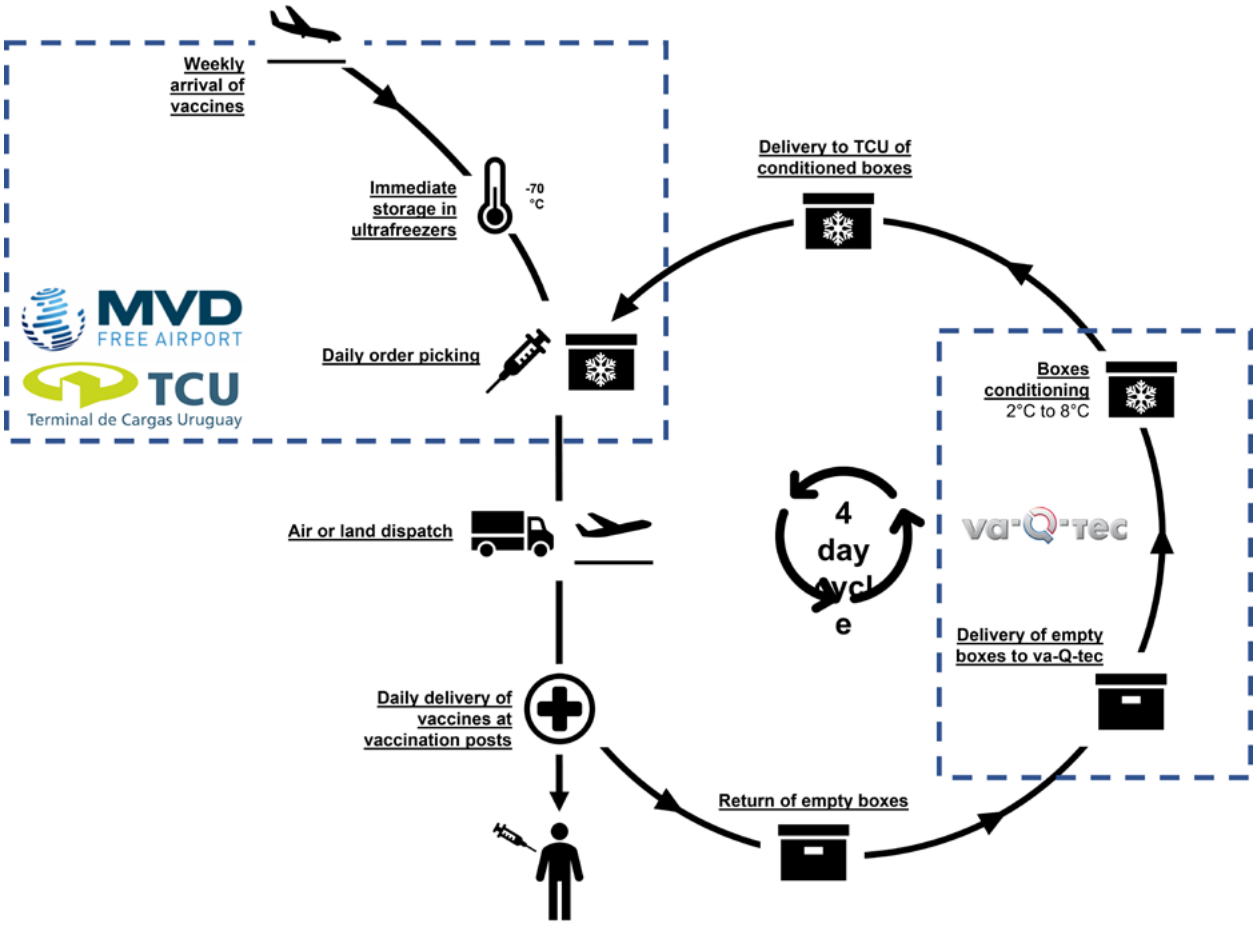
The maintenance of adequate storage and distribution conditions throughout the logistics chain was the key to guarantee the safety and efficacy of the vaccines. Given Uruguay's long and successful experience in the implementation of vaccination plans, the procedures and equipment necessary to ensure these conditions were already familiar (Fig 4).

The vaccines arrived at the airport in the boxes provided by Pfizer, including a temperature datalogger in each box. The information in every single datalogger was transmitted to Pfizer headquarters, where the Quality Assurance team analyzed the information of the shipment and released each box. This ensured that the vaccines were kept at the proper temperature throughout the international transport, from the factories in Europe and the United States to their arrival at the airport in Montevideo.

In addition, the ultra-cold freezers have a permanent temperature register and alarms to warn of any change outside the established range, and there is a procedure for opening and closing the equipment to ensure that the stored vaccines are kept at the proper temperature.

At the end of the day the government planning team sent the information to the airport to prepare the orders. TCU - MVD Free Airport staff removed the original Pfizer trays containing 195 vials from the ultra–cold freezers and immediately transferred them to a conditioned chamber between 2°C and 8°C. To avoid handling frozen vials, the total amount of orders to be prepared for each vaccinator was rounded to a multiple of 195 vials.

MATERIALS FLOW Fig 4



Inside the cold chamber, and after the necessary time for the vials to be safely handled, the individual orders were prepared with the exact quantities defined for each vaccination center, which sometimes meant having to split the Pfizer trays and prepare smaller quantities. This required designing new trays tailored to Pfizer's vials, as well as appropriate clamping mechanisms to ensure that these trays did not move inside the va-Q-tec boxes during transport. Each box was then closed and coded to facilitate traceability, allowing real-time distribution monitoring.

Traditionally, polystyrene boxes refrigerated with cooling gels were used for vaccine transportation in Uruguay. However, the lack of experience worldwide regarding the stability of mRNA vaccines made it necessary to use the best available technology. This was made possible thanks to the support of va-Q-tec, whose Latin American headquarters are located in Uruguay.

The company specializes in temperature-controlled product transport solutions. For this case, the va-Q-med 21 box was selected, designed for "last-mile distribution" of pharmaceutical products, which has phase-change exchangers, ensuring temperature maintenance for at least 48 hours.

In addition, these thermal boxes have a temperature recording device that can be read from the outside using a QR code. In this way, before opening the thermal boxes at the vaccination center, the temperature records could be analyzed to ensure that the vaccines arrived in good conditions.

The va-Q-tec boxes were also used to store the vials during the vaccination days. At the end of each day, the leftovers were stored in the refrigerators installed in each vaccination center, which were controlled by calibrated temperature sensors.

"The key elements to ensure traceability were that the thermal box is integrated in the vaQtec planning system, which allows us to know where the thermal box is from the moment the operation starts until it ends, and having used what we call va-Q-nection, which is the state-of-the-art thermograph that is activated by light. This is what has allowed the thermograph to be activated from the moment the box is opened to place the vaccine, and that is when the process begins."

Edgardo Ipar, Director of va-Q-tec Latin America

The next day, with the delivery of the new vaccines, the va-Q-med boxes used the day before were removed for reuse. At the va-Q-tec operations center, the boxes were inspected, sanitized and conditioned to the specified temperature for transportation. On a daily basis, specially conditioned thermal boxes validated by va-Q-tec were sent to the airport to prepare new orders and start another four-day cycle: conditioning, preparation of the order, distribution and vaccination, and reverse logistics.

3.3.6 Information System

The logistics chain design criteria for vaccines imposed short lead times from the time demand was identified at each vaccination station until the vaccines were delivered.

Meeting these criteria required managing the information in an agile and secure manner, avoiding errors and delays. In this sense, the flow of information from the vaccination schedules, the vaccine inventories at each station, the track and trace system of the distribution company and the warehouse management system of TCU - MVD Free Airport were integrated.

The objective was to use a single source of information, eliminating retyping of data and monitoring the progress of the process throughout all its stages (Fig 5).

The demand at each vaccination center was registered in the scheduling system of the Ministry of Public Health. Those interested in getting vaccinated could register through three channels: telephone, WhatsApp and website, and the system would schedule the day, time and place of inoculation for each one of the two doses to be applied.

This information was transferred to the supply management system which, integrated with the inventory of each vaccination center, calculated the orders to be shipped.

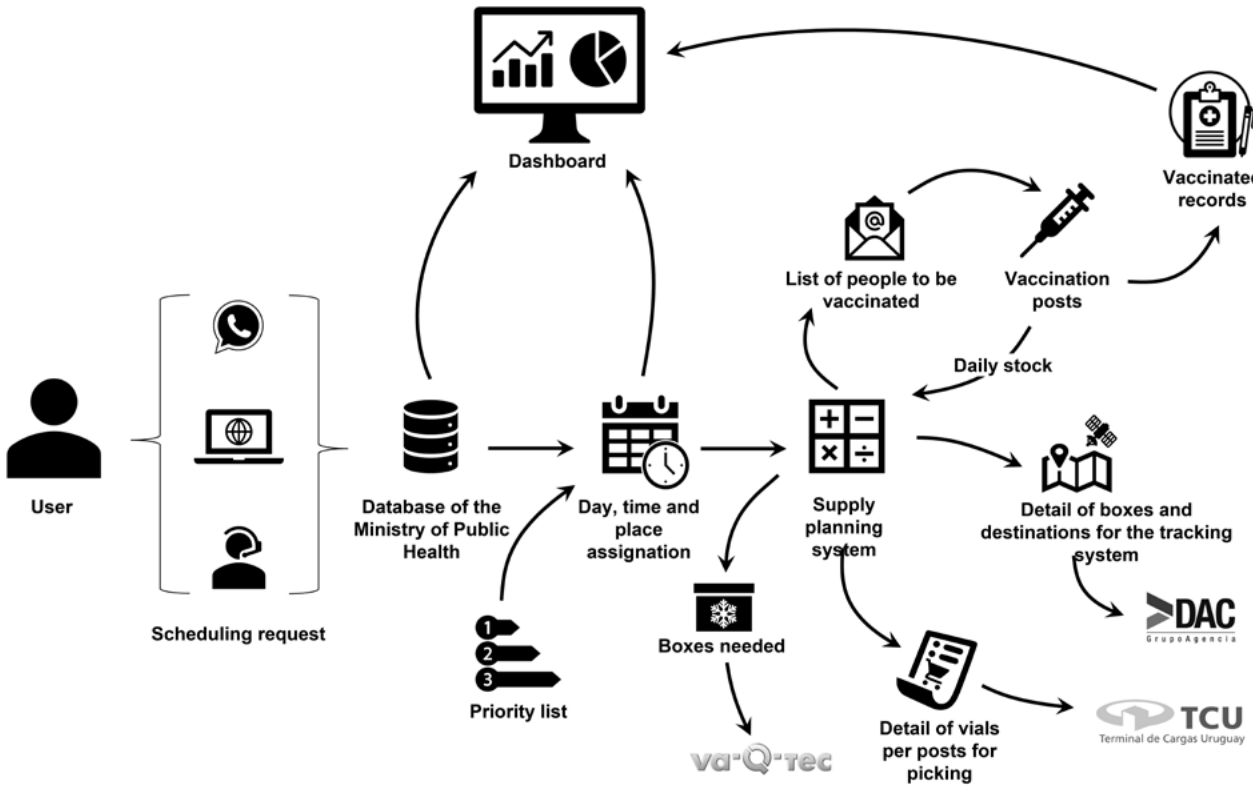
The orders were sent electronically to the distribution company and to TCU - MVD Free Airport in the appropriate formats so that they could be automatically uploaded to their systems. In this way, labels were printed that allowed the registration and tracking of each stage of the distribution, and the operators at TCU - MVD Free Airport received in their mobile terminals the details of the orders to be prepared.

The lists of people scheduled were also generated and sent automatically, via e-mail, to each vaccination center.

"TCU - MVD Free Airport was able to do all the integrations and make all the processes work seamlessly. Our own operation was fully integrated from when the vaccines arrived and when they were in stock to when we had them delivered."

Cr. Alejandro Méndez, Country Manager of DAC

INFORMATION FLOW Fig 5



le each of the main players in the Ministry of Public Health, DAC and TCU - MVD Free Airport distribution had their own management information systems, they were originally not integrated or designed to share data with each other. The available deadlines did not allow the development of an integration between systems, so the exchange of flat files and automation and calculations based on Excel spreadsheets and macros had to be implemented. Although the solution could be considered rudimentary, it turned out to be very secure and effective.

In addition, to follow up the entire process, a Balanced Scorecard was developed to analyze the allocation of vaccination quotas, the record of vaccination events by post and geographic area, and the percentage of coverage by target population and by risk priority group (Fig 6 & 7).

"The flexibility of the design enabled us to adapt our policies: for example, swiftly implement pregnant women prioritization, the creation of new vaccination centers throughout the entire Uruguayan territory as well as the implementation of mobile vaccination centers that reached each remote town and underprivileged neighborhoods in an organized and agile fashion"

Lic. Jose Luis Satdjian, Vice-Minister of Health

BALANCED SCORECARD

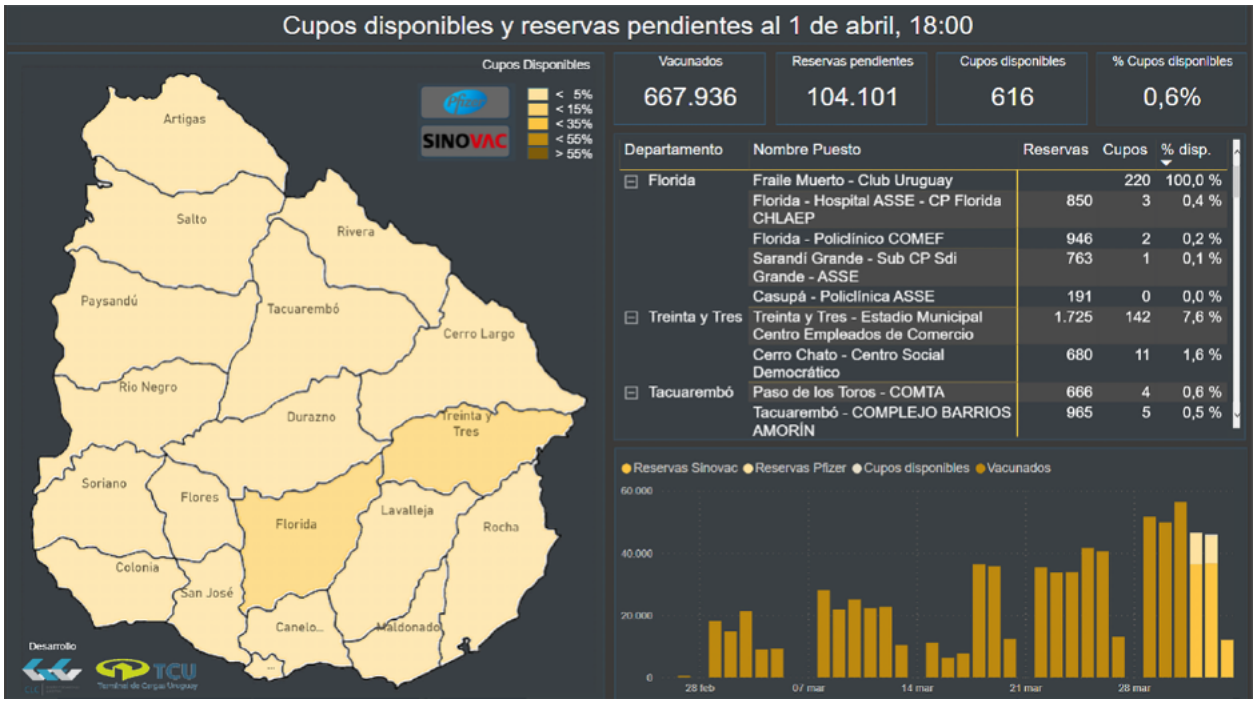


Fig 6

Fig 7

4. Results

Uruguay is among the countries with the highest percentage of its population vaccinated, despite having started vaccination several months later than the first countries to do so (Fig 8 & 9).

"The vaccination plan was successful, exhaustively elaborated, taking into account supply restrictions and preserving the cold and ultra-cold chain."

Dr. Daniel Salinas, Minister of Public Health

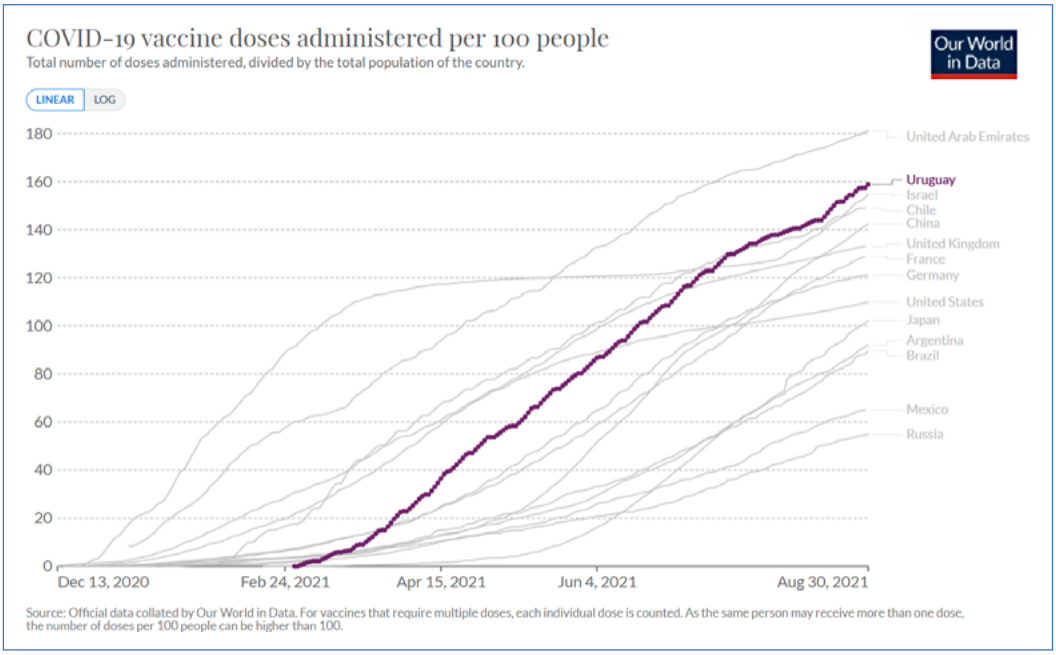


Fig 8

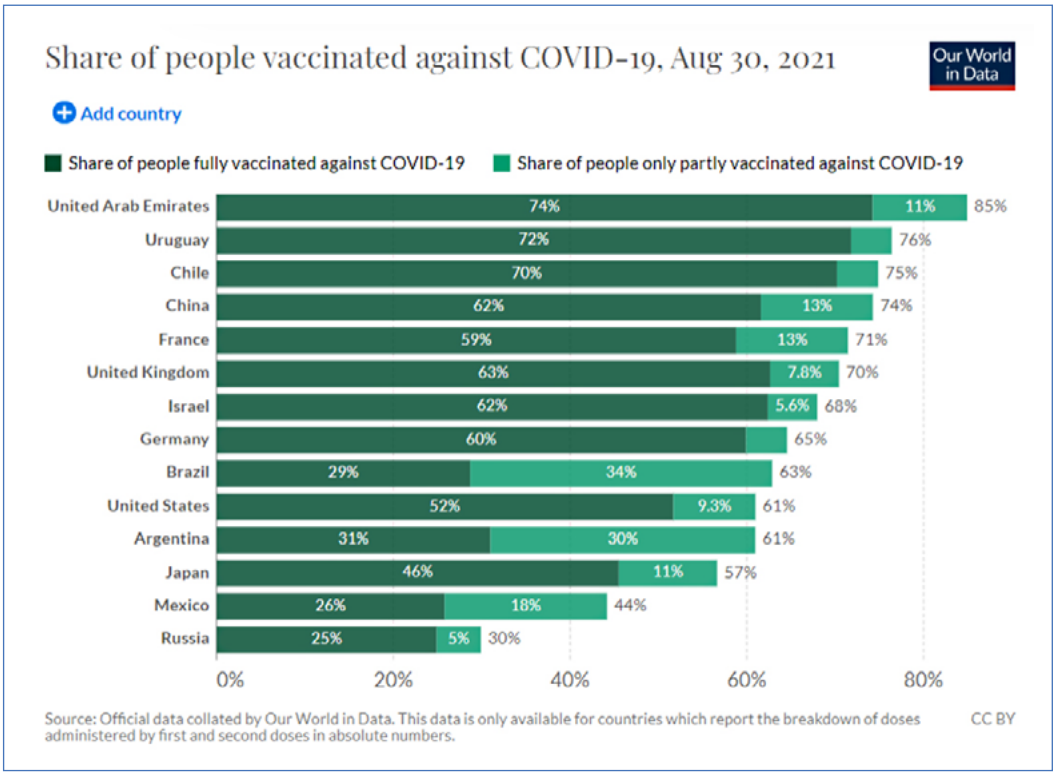


Fig 9

"Although we had the know-how of many years of experience in handling vaccine logistics throughout the country, we did not have the infrastructure. TCU - MVD Free Airport provided us with the infrastructure and human resources to undertake a campaign that, in three months, distributed much more than what is distributed in a year in the National Vaccination Plan. And that allowed us to start as quickly as we did and to carry this forward. That was very important."

Marina Monteiro, Technical Director of Calmette Laboratory

The following graph shows the weekly progress of vaccination (Fig 10). The valleys observed at the beginning and in weeks 18 and 19 correspond to low availability (decrease in vaccine supply from abroad), and the peaks occurring in weeks 14 to 16 and 20 to 23 are due to increased vaccine availability. This reflects the success of the strategy: when there were enough vaccines, the maximum capacity could be used, vaccinating daily more than 1.3% of the total population in a sustained manner, and when there were few vaccines, the vaccination rate was lowered to ensure continuity of the flow while the next batches of vaccines were arriving.

As of August 30th, (six months after starting vaccination) Uruguay had vaccinated 72% of its total population (almost 85% of the population over 12 years old) with two doses, thus far exceeding the target of vaccinating 70% of its target population in less than 6 months.

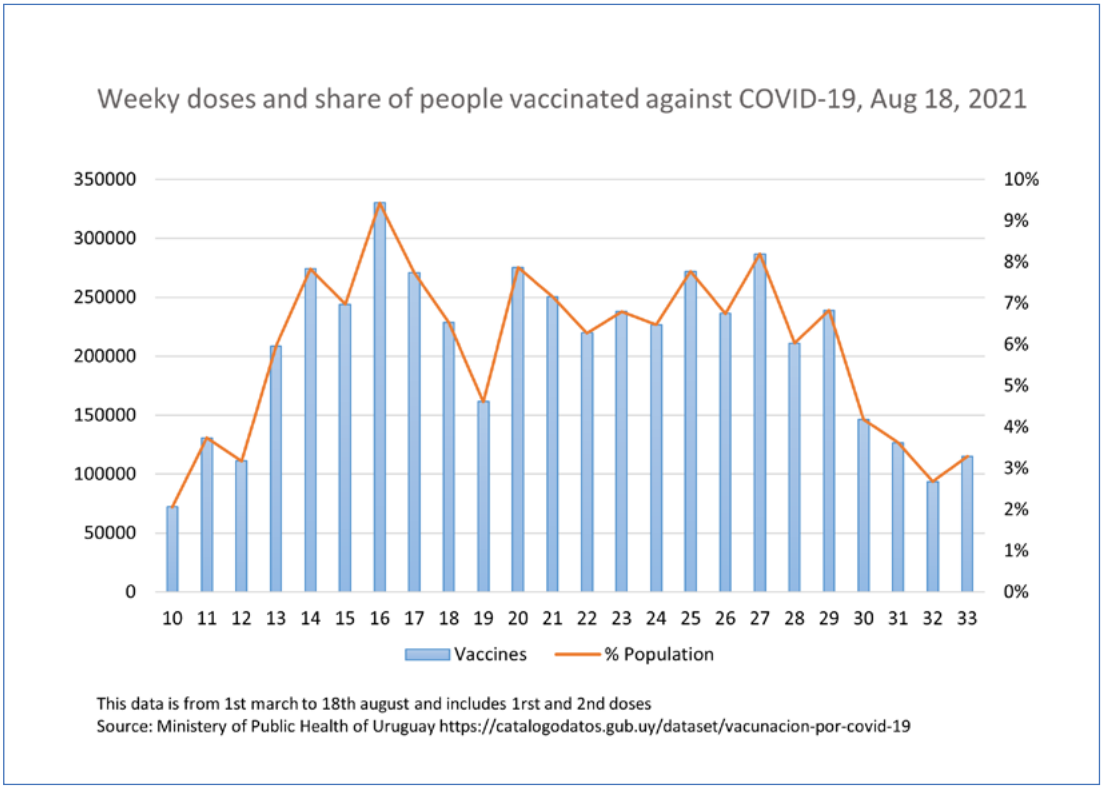


Fig 10

By the end of August 2021, 2633 boxes of Q med 21 had been shipped, with no cases of cold chain breakage reported. The figure below shows one of the documents used by va-Q-tec: the temperature report (Fig 11).

"The whole process was very positive. We were able to have traceability of the entire system, despite some emergencies. Having foreseen that there could be emergencies also helped us."

Edgardo Ipar, Director of va-Q-tec Latin America

The distribution of Pfizer's vaccines amounted to around 6,000 km per day, including air and ground transportation. By the end of June 2021, only one event had occurred: on March 25, a mechanical failure caused a helicopter to crash and a few doses were lost. The pilots were unharmed. The contingency plan ensured that new vaccines were delivered to the destination points, without causing delays in the vaccination on that day.

va-Q-tec ALWAYS THE RIGHT TEMPERATURE

Temperature report

va-Q-nection® A va-Q-tec TempChain Solution

Reference

Order:	F00027524
Box ID:	101BC0004660000809

Shipment OK ✔

Shipment Summary

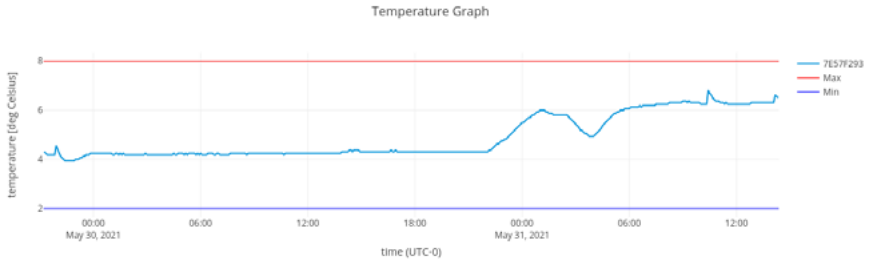
Start: 2021-05-29 21:12 (UTC-0) [Loaded] End: 2021-05-31 14:22 (UTC-0) [Received]

Temperature results

Number of datapoints:	494	Duration:	1 day(s), 17 Hour(s), 9 Minutes
Lowest temperature:	3.94°C	TimeStamp Lowest:	2021-05-29 22:24 (UTC-0)
Highest temperature:	6.81°C	TimeStamp Highest:	2021-05-31 10:24 (UTC-0)
Average temperature:	4.89°C	Standard deviation:	± 0.87°C
Mean kinetic temperature:	4.94°C	Activation energy used:	83.144 [kJ/mol]

Temperature Zone Table

Zone	Above (>)	Below (<)	Samples in Zone	Time in Zone	Degree Minutes
Above maximum	8.00°C		0.0 %	0.00 [h]	0 [°Cmin]
Within Limits	2.00°C	8.00°C	100.0 %	41.17 [h]	
Below minimum		2.00°C	0.0 %	0.00 [h]	0 [°Cmin]



va-Q-nection Configuration

Sensor ID:	7E57F293	Box ID:	101BC0004660000809
Min limit:	2.00°C	Measurement interval:	5 [min]
Time allowed < Min	30 [min]	Max limit:	8.00°C
		Time allowed > Max	30 [min]

Start and End

Box Loaded:	2021-05-29 21:12 (UTC-0)	by:	va-Q-nection Light sensor
Box Received:	2021-05-31 14:22 (UTC-0)	by:	EX002 Sarandí del Yí
	2021-05-31 11:22 (UYT,-0300)		Montevideo (Laboratorio Calmette)

Open and Close Events

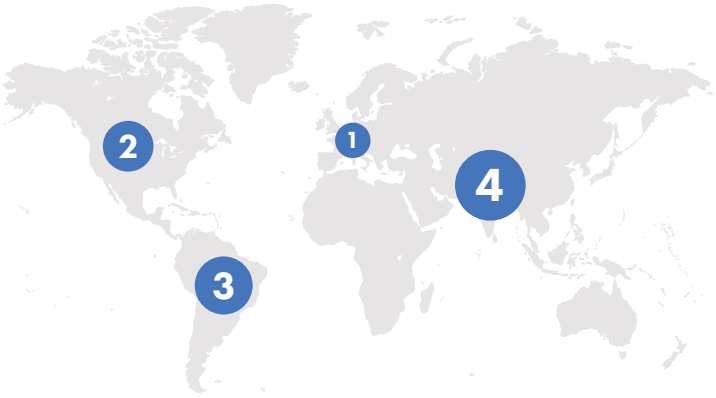
#	Open	Close	Duration [min]
1	2021-05-29 21:12 (UTC-0)	2021-05-29 21:12 (UTC-0)	1
2	2021-05-29 21:49 (UTC-0)	2021-05-29 21:51 (UTC-0)	2
3	2021-05-31 14:05 (UTC-0)	2021-05-31 14:05 (UTC-0)	1

Fig 11

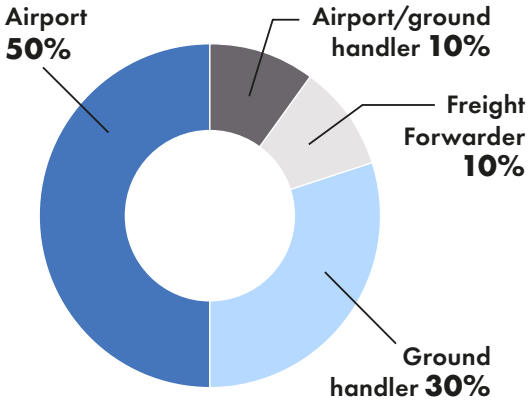
5. Benchmark towards other airports and countries

To learn about the type of operations that have been carried out in other countries and the infrastructure and procedures dedicated to the management of vaccines, Pharma.Aero conducted a survey among its partners. Ten responses were received from airports, ground handlers and freight forwarders from Asia, Latin America, North America and Europe (Fig 12 & 13). The results obtained show the uniqueness and sophistication of the solution developed in Uruguay.

NUMBER OF ANSWERS RECEIVED Fig 12



TYPE OF COMPANY Fig 13



First, we asked about the role of the airport in the vaccine logistics chain. Most of the participants received vaccines from abroad and shipped them in transit to other airports or to distribution centers in their countries, just as they received them, with no further added value (Fig 14).

Uruguay is the only case where the airport operated as a last-mile distribution center, preparing unit orders to be shipped directly to the distribution centers.

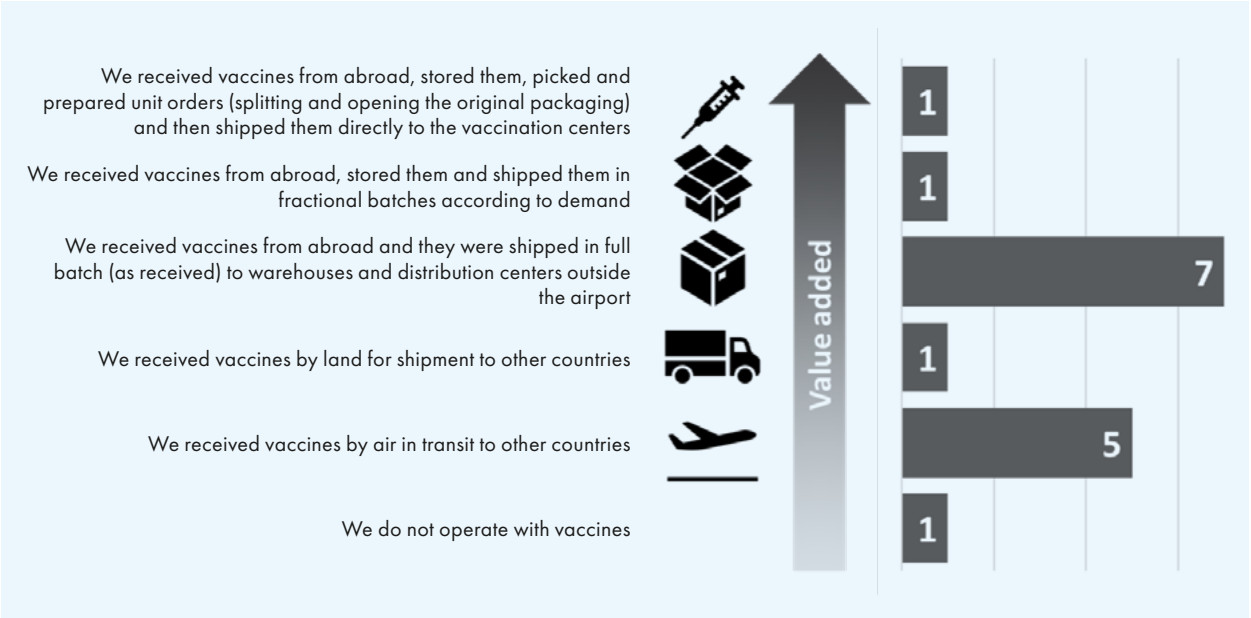


Fig 14

Regarding the type of infrastructure and equipment available to operate with vaccines, most of them had cold chambers, but only 2 out of 10 respondents had ultra-cold freezers for storing vaccines at -60°C.

- 9 — Cold rooms between 2°c to 8°C authorized by the competent authority for the storage of pharmaceutical products
- 7 — Freezer chambers between -25°C to -15°C authorized by the competent authority for the storage of pharmaceutical products
- 2 — Ultra-freezers between -80°C to -60°C
- 7 — Calibrated sensors for temperature recording and traceability
- 7 — Alarm systems in case of out-of-range temperatures
- 4 — High availability power systems (backup generators)

In order to know if they had to train their staff to operate with vaccines, they were asked the following questions:

Was a specific training conducted to comply with SOPs and other specific guidelines defined by vaccine manufacturers? (They could choose more than one answer)

The answers were as follows:

- 6 — No special trainings were conducted since our staff is already trained in the handling of pharmaceutical products and the operation of Covid-19 Vaccines was standard
- 4 — Existing internal procedures for the handling of pharmaceutical products in general were reinforced and employees were trained in the handling of pharmaceutical products
- 3 — Special trainings were conducted based on materials and specific information received from external sources regarding the handling of Covid-19 Vaccines
- 3 — We developed new activities (different from the usual ones) that required the development of new internal procedures to adapt our operations to special guidelines established by the manufacturers of Covid-19 Vaccines

6. Lessons learned and Recommendations

The experience in Uruguay showed that the logistics model named as "the Gateway Access Point" is feasible and efficient. Using an airport as a starting point for direct distribution to consumption centers eliminates unnecessary steps, reduces risks, costs and time, and provides greater flexibility to the entire supply chain.

"Using the airport as a center for storage, preparation and distribution of ultra-cold vaccines, including the handling of individual vials at extreme temperatures, is pretty unique."

Bruno Guella, Manager Director at MVD Free Airport

A key success factor in this case was that TCU - MVD Free Airport did not simply limit itself to the role of logistics operator, providing infrastructure and services, but became directly involved in the design and implementation of the distribution system. Its management team and the contribution of external experts in the field led to articulation between the public and private sectors, integration of information systems, and development of the supply planning system and the balanced scorecard to monitor its performance.

The Director of Sinae (National Emergency System), Sergio Rico, considered that the joint efforts "were excellent" and added: "We all learned about the possibilities that each one of us had". Rico explained that Sinae worked with representatives from the Ministry of National Defense and the transport company DAC to coordinate the distribution and managed to take the Pfizer vaccines "which were the most complex" to all areas of the country.

The *protective capacity* installed at the airport, as the only distribution center, made it possible to save at least one day in the supply chain, centralize stock management and provide greater flexibility to schedule changes in the vaccination plan throughout the months.

"The system designed made it possible to receive, fractionate, prepare and distribute the exact quantities to the entire country so that vaccination in the most distant cities began just 10 hours after the vaccines were received at the airport from Europe."

Bruno Guella, Manager Director at MVD Free Airport

The search for international support and cooperation to analyze and learn from the experiences of other countries helped to avoid mistakes and take advantage of good practices. Other actions complemented the initiative of the "Bringing Vaccines Closer" project launched by TCU - MVD Free Airport in October 2020: the Uruguayan team contacted scientific advisors and people who implemented the logistics of Israel's vaccination plan, and with the scientists who implemented Pfizer's Phase III trial in Argentina.

The integration of the information systems of the different players involved was essential for planning, executing and controlling the distribution of vaccines, although this was not noticed early enough to develop a more robust system. When the work team began to operate in early January 2021, it focused more on the design of the flow of materials, to the detriment of the design of the information flow. Developing the information system when the vaccination plan had already started generated difficulties for some people to schedule their appointments and the lack of a methodology to define quotas in each vaccination center, which would allow a more agile and error-free supply scheduling.

"The most difficult thing was to have the data to define the delivery of vaccines to each post. What took most time was to get the information from the vaccination schedule to flow and give us quality data. We should have worked on this issue earlier. We started to see the problems when vaccination started."

Marina Monteiro, Technical Director of Calmette Laboratory

The speed with which the vaccination plan was designed and implemented, and the results achieved were only possible thanks to the cooperative work between the public and private sectors, which integrated a team made up of people with decision-making skills.

"Public-private cooperation allowed us to anticipate needs, develop different scenarios and contingency plans and respond according to what the country needed."

Bruno Guella, Manager Director at MVD Free Airport

"The Uruguayan population and their adhesion to the vaccination program was the basis for us currently having 76% of the population vaccinated. This was a reflection of their trust in the government and the Ministry of Health and the decision based on facts and scientific evidence"

Lic. Jose Luis Satdjian, Vice-Minister of Health

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