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Greener Imaging: MRI on Wheels to Reduce Carbon Footprint

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Abstract

Mobile MRI units are a paradigm shift in healthcare delivery, addressing accessibility, diagnostic precision, and environmental sustainability.

This study examines an 18-year longitudinal initiative in Galicia, Spain, where mobile MRI units have eliminated more than 32 million kilometers of patient travel, have prevented 5,000 metric tons of CO_2 emissions, and have achieved exceptional patient (95%) and clinician (98%) satisfaction rates.

Integrating high-field imaging technology with optimized logistics, the program has demonstrated how mobile MRI services can break geographic barriers while advancing climate-conscious medical practices.

This study evaluates a long-term mobile MRI initiative in Galicia, Spain, and its impact on healthcare accessibility and environmental sustainability. Since 2006, mobile MRI units have reduced more than 32 million kilometers in patient travel, preventing approximately 5,000 metric tons of CO_2 emissions. Patient and clinician satisfaction rates exceed 95%. With optimized logistics and high-field imaging, mobile MRI demonstrates a scalable, climate-resilient solution for rural healthcare systems.

Keywords: Mobile MRI, Sustainability, Carbon Footprint, Rural Healthcare

List of Abbreviations

- **DEFRA:** Department for Environment, Food & Rural Affairs
- **DICOM:** Digital Imaging and Communications in Medicine
- **MR:** Magnetic Resonance
- **MRI:** Magnetic Resonance Imaging.
- **OECD:** Organization for Economic Co-operation and Development
- **PACS:** Picture Archiving and Communication System
- **VPN:** Virtual Private Network

Introduction

Sustainable development meeting the needs of the future without compromising future generation's ability to meet their own needs is an aim also in radiology [1].

Being conscious of radiology contribution to carbon footprint and greenhouse gas emissions is possible to rethink processes to reduce them [1-4].

Rural populations face systemic healthcare disparities due to geographic isolation, aging demographics, and limited infrastructure. Mobile MR units can fill the service void in small hospitals unable to purchase and fulfill fixed scanners.

MR is a modality that cannot be turned off [5]. To reduce its carbon footprint impact it is important to assure high utilization rates, but it is also important to deliver care closer to home. By reducing patient travelling, those travel kilometers saved can significantly improve carbon footprint of the modality.

The contribution of healthcare systems to carbon emissions is well-documented, with radiology playing a significant role. In response, innovative strategies are required to align medical imaging with sustainability goals. Galicia, Spain, implemented mobile MRI units to address healthcare disparities in rural regions while minimizing environmental impact. This study presents an analysis of the clinical, operational, and ecological outcomes of this 18-year initiative.

In Galicia, a region in Northwest Spain (Figure 1), 30% of residents live in villages with fewer than 1,000 inhabitants, and 25% are over 65 years old [6]. With such a much-dispersed and aged population, the public healthcare system has filled service void in secondary hospitals without in-house magnets with mobile MRI units since 2006.

Figure 1: Localization of Galicia, a region in the Northwest of Spain

Prior to 2006, patients requiring MRI scans had to travel up to 150 km round-trip to tertiary hospitals, delaying diagnoses for conditions like stroke, cancer, and degenerative diseases. These journeys not only strained vulnerable populations but also contributed significantly to transportation-related carbon emissions [4].

With rotating schedules based on the volume and need for the service in each hospital, scanning from 08:00 am to 8:00 pm, seven days a week, mobile MRI units have given equitable access to MRI, democratizing advanced imaging for underserved communities, being also environmentally responsible, as healthcare's carbon footprint has been reduced by minimizing patient travel [7].

This study evaluates the clinical, operational, and ecological outcomes of Galicia's mobile MRI program, offering insights for policymakers and healthcare leaders worldwide of how mobile MRI units can enhance access to essential imaging services, improving patient care, accessibility and equity to the MRI technique in underserved areas.

Materials and Methods

Program started in 2006 with one 1.5T mobile MRI unit, a second one was bought in 2008, a third one in 2019, and a fourth one is operating since 2023 (Figure 2).

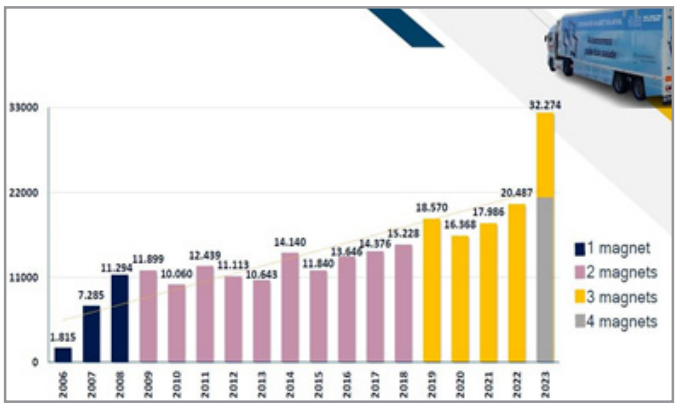

Figure 2: Number of MR scans performed in the MRI mobile units since 2006

Today, the mobile fleet has four 1.5T MRI scanners mounted on custom- designed trailers with hydraulic stabilization systems. Each unit features a 70 cm bore, enabling compatibility with bariatric and claustrophobic patients.

The mobile MRI program began with a 1.5T unit in 2006, expanding to four units by 2023. Each unit is installed in a trailer equipped with hydraulic stabilization and a 70 cm bore for accommodating various patient needs. Coverage includes 12 hospitals across Galicia, prioritized through a demand-based routing algorithm. Operational data, including scans per day, patient travel distances, and CO_2 reduction, were compiled from internal service records. Environmental impact was estimated using DEFRA's conversion factor (0.171 kg CO_2/km). Satisfaction surveys were administered to patients and referring clinicians.

Mobile MRI units cover various locations, including all the seven public second level hospitals without in-house MRI magnets, and five public third level hospitals across Galicia's four provinces (A Coruña, Lugo, Ourense, Pontevedra), in an area of 29.574 km2, contributing to serve a population of 2.7 million inhabitants (Figure. 3) [6].

Figure 3: Distribution of public healthcare hospitals in Galicia. Distances and time by car from public hospitals without MR to the nearest public hospital with an in-house MR

A dynamic routing system prioritizes hospitals based on demand, urgency, and geographic proximity, maximizing daily throughput and reducing idle time. Units operate 12-hour shifts (08:00–20:00), seven days a week, and perform any type of MR studies. Number of scans per unit, and setup times were calculated.

Travel distance saved by patients was calculated using distances from patient residences to the nearest public fixed MRI facility, and CO_2 savings were estimated using Department for Environment, Food & Rural Affairs´s (DEFRA) emission factor (0.171 kg CO_2/km) for avoided car travel [7].

Quality assurance was assessed with clinicians and patients satisfaction surveys, based on convenience, waiting times, staff courtesy and quality of reports.

Images have been always stored in the Picture Archiving and Communication System (PACS) of each hospital. Digital Imaging and Communications in Medicine (DICOM) files are accessed via an encrypted Virtual Private Network (VPN) from a central distant hub staffed by nine subspecialized radiologists, with patients admitted to the hospital cases prioritized for same-day reporting.

Results

During the last 18 years, patients in Galicia who received a MRI scan in a mobile unit saved an average of 74 km per scan, cumulatively avoiding 32,391,786 km, 40 round trips to the Moon or 810 laps around the Earth, which is also equivalent to removing 6,700 cars from roads annually (Figure 4) [7].

Between 2006 and 2024, mobile MRI units in Galicia performed over 1 million scans, saving an average of 74 km of patient travel per scan. This translates to 32,391,786 km avoided and 5,000 metric tons of CO_2 emissions prevented. Each unit performs an average of 26 scans daily with 98% uptime. Clinician satisfaction reached 98%, with no reported quality compromise. Patient satisfaction was 96%. Additional benefits include lower travel costs, reduced work absences, and fewer traffic-related risks.

Figure 4: Number of travel patients kilometers saved by patients with the MRI mobiles

As there is no travel required by the patient in order to benefit from MRI services, since 2006 5,000 tons of CO2 have been avoided (Figure 5) [4, 7].

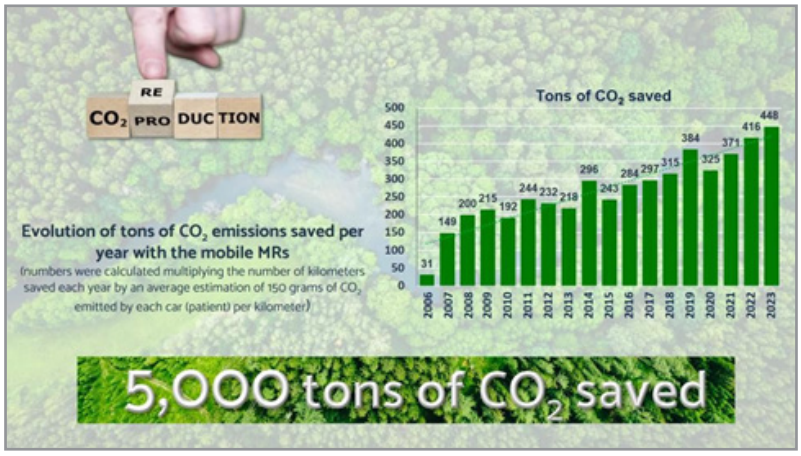

Figure 5: Evolution of tons of CO2 saved per year with the mobile MRI units

At the same time, other additional benefits were achieved, as patient travel costs and traffic accidents were eliminated, and there was significant reduction in the number of work hours lost.

The downtime due to equipment failure was very short, with an availability of the RM units exceeding 98%.

The actual number of MR scans per day is actually of 26 scans/day in each MRI unit, with a setup time of 21 minutes/scan, and with very low no-show rates (3.2%).

Most of the referring physicians (98%) reported no differences in image quality compared to fixed units and were satisfied or very satisfied with the MRI reports received.

Patient satisfaction rates with the service was also very high (96% of patients were satisfied or very satisfied).

Discussion

Healthcare contributes with a 4.4% of global CO_2 emissions, with imaging accounting for 1% of this footprint [3-5].

With mobile MRI units two critical levels can be adressed: Direct Emissions 3,4: As they lower energy use via shared infrastructure.

Indirect Emissions 3,4: As they avoid patient travelling (30% of healthcare's carbon output in Organization for Economic Co-operation and Development (OECD) nations.

This initiative aligns with the European Green Deal's goal of climate-neutral healthcare by 2050 [1, 2].

Besides Galicia's mobile MRI model shows other great advantages, including lowering waiting times to get an MR and improving resource optimization with centralized teleradiology pools expertise reducing the need for on-site specialists in small hospitals.

By reimagining healthcare delivery, Galicia's initiative illuminates a path toward equitable, low-carbon medicine and provides

a comprehensive blueprint for deploying mobile MRI units in rural populations, balancing clinical excellence with ecological accountability.

This mobile MRI program illustrates how radiological services can be delivered equitably and sustainably. The initiative supports both direct and indirect emissions reduction and aligns with the European Green Deal's 2050 targets. Beyond emissions, the program enhances diagnostic accessibility, particularly in underserved regions. The use of teleradiology further optimizes resource distribution and professional expertise.

The next big idea in health care might not be about inventing new ways to deliver what we already have, and any way, policymakers and healthcare leaders worldwide should always remember that we have a choice, to continue business as usual or drive a change to improve a sustainable, accessible and equitable imaging care in underserved areas.

Conclusion

The Galician mobile MRI model offers a replicable framework for sustainable imaging. By addressing accessibility and environmental impact, it sets a benchmark for healthcare systems seeking to balance innovation with ecological responsibility.

Funding

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Conflicts of Interest

None

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