

Can we build better? Challenges with geospatial and financial accessibility in the Caribbean. Illustrative case

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BACKGROUND Within the Caribbean, Curaçao provides a neurosurgical hub to other Dutch Caribbean islands. At times, the inefficiency of neurosurgical referrals leads to unsatisfactory patient outcomes in true emergency cases.

OBSERVATIONS This article reports an illustrative case of a patient in need of emergency neurosurgical care, who was referred to a tertiary health institution in Curaçao. This case highlights the challenges of timely neurosurgical referrals within the Dutch Caribbean.

LESSONS Highlighting this case may provide a foundation for further discussions that may improve neurosurgical care and access. Limiting long-distance surgical referrals in the acute care setting will aid in saving lives.

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KEYWORDS global surgery; global neurosurgery; health equity; medical transfers; Caribbean

The Caribbean is a region bounded by the Caribbean Sea, which is rich in diversity and culture. The differences within the Caribbean region extend across financial statuses, healthcare policies, spoken languages, and socio-political philosophies. Within the medical healthcare services, deficiencies are noted in the majority of Caribbean nations in terms of access to neurosurgical care. Curaçao is an island in the Caribbean and is part of the Dutch Kingdom. Other islands of the Dutch Kingdom include Sint Maarten and Aruba. Saba, Statia, and Bonaire are special municipalities of the Netherlands.¹ Of these islands, only Aruba and Curaçao offer neurosurgical services, inclusive of diagnostic imaging such as magnetic resonance imaging (MRI). Saba and Statia have no specialized neurological care on their respective islands. Hence, diagnostics may be sought from Sint Maarten, as an MRI suite is operational there.² Bonaire is the only island with an air ambulance (Learjet 35A) since 2013.³ Saba and Statia have shared a helicopter for emergency patient transport to Sint Maarten since 2011.⁴ Sint Maarten does not have an air ambulance stationed and uses

different air ambulance companies for emergency transportation, including those on Bonaire (Figs. 1 and 2).

Neurosurgical expertise is critical to traumatic brain and spine injuries and the need for urgent services, without which may lead to fatal consequences. Herein, we highlight a case that exemplifies the risks posed by delays in treatment, financial barriers, and geographic challenges in accessing timely neurosurgical services. Our goal was to identify obstacles that hinder the prompt delivery of surgical care and explore alternative approaches that deviate from past colonial frameworks and improve health disparities within this region of the Caribbean, ultimately igniting conversation and promoting action to improve health disparities and inequities within the Caribbean.

Illustrative Case

A 64-year-old male Haitian native with no previous medical history was seen at the emergency department of a referring hospital at 10:00 AM. He was found unresponsive at home. His neurological

ABBREVIATIONS CMC = Curaçao Medical Center; COVID-19 = coronavirus disease 2019; GCS = Glasgow Coma Scale; ICU = intensive care unit; LMIC = low- and middle-income country; MRI = magnetic resonance imaging; TBI = traumatic brain injury.

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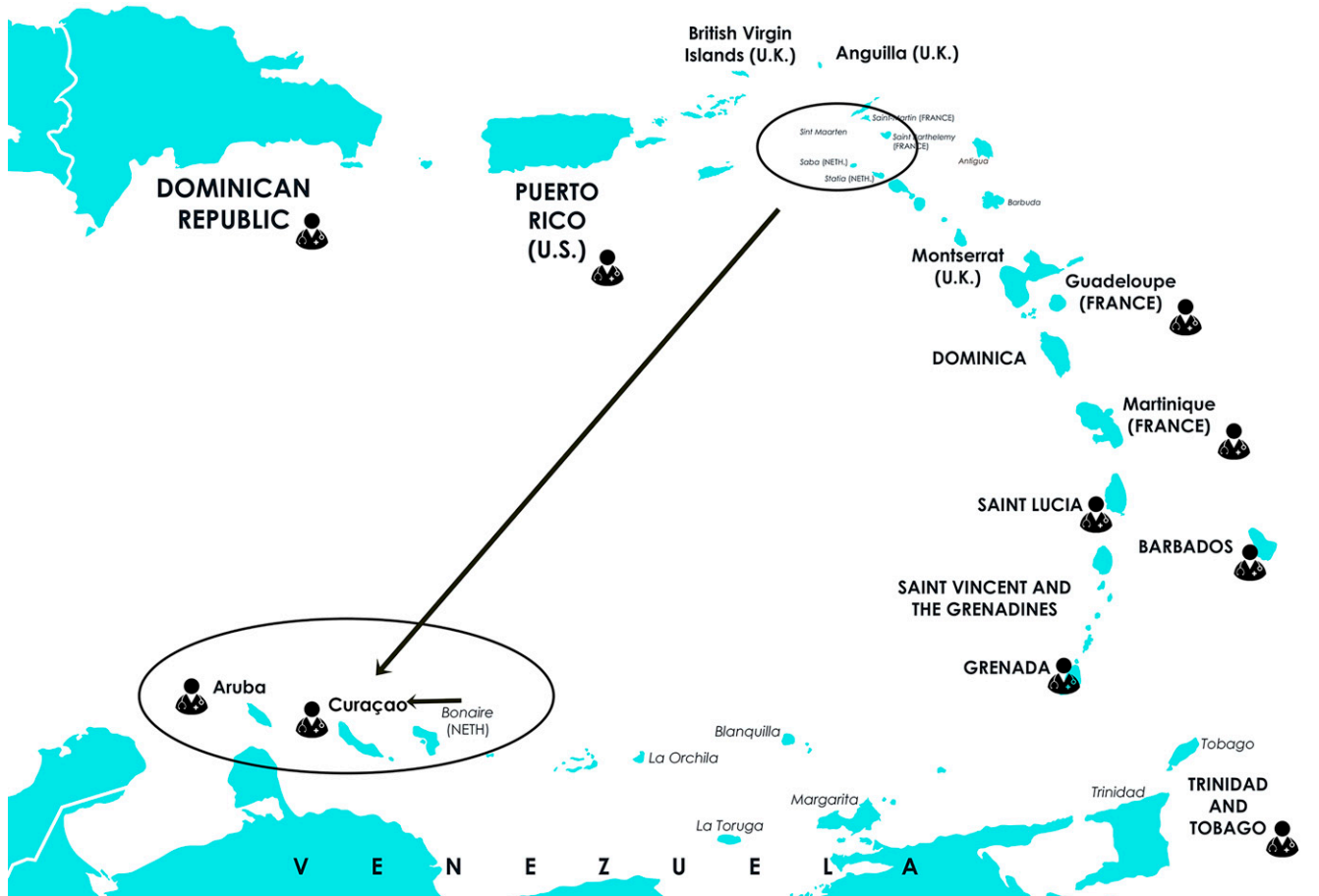


FIG. 1. Partial overview of the geography of the Caribbean and the island parts of the Dutch Caribbean. Arrows indicate medical referrals from Sint Maarten, Saba, Statia, and Bonaire to Curaçao. The *doctor icon* represents permanent neurosurgical care on the Caribbean islands.

examination showed a Glasgow Coma Scale (GCS) score of 7 (E1M5V1), with miotic and light-reactive pupils and reactive corneal reflexes. Computed tomography imaging was performed and demonstrated a left cerebellar hematoma and global intraventricular hemorrhage with secondary hydrocephalus. Basal cisterns were moderately compressed.

After imaging, at 10:53 AM, the neurosurgeon on call in Curaçao was contacted and briefed on the status of this case. Intensive care unit bed (ICU) space was confirmed at the Curaçao Medical Center (CMC), and the patient was accepted for transfer at 11:03 AM. The patient was intubated around 12:30 PM. At 12:50 PM, an update was given by the referring center, indicating that an air ambulance was approved to charter the patient transfer. The flight itinerary stated at 1:25 PM that departure from the referring hospital would occur at 4:00 PM, with a 5:18 PM arrival at CMC. Neurological checkup at 3:00 PM showed reactive pupils of the still hemodynamically stable patient (no known numbers), but no further evaluation was possible because of sedation. However, at 6:45 PM, the patient was still at the referring hospital, with present reactive pupils. At 7:12 PM, the patient departed via air ambulance and arrived at CMC at 11:10 PM with mydriatic, nonreactive pupils. No corneal or oculocephalic reflexes were present. The patient's GCS score was 3. A few moments later, the patient became hemodynamically unstable, and because of his poor prognosis, care was terminated.

Patient Informed Consent

The patient was in poor condition upon arrival and unable to consent to treatment. No family members were available.

Discussion

Dutch Caribbean

A neurosurgical department was re-established in Curaçao in 2017 after an absence of 1.5 years.⁵ Since then, it has been offering an increasing number of different neurosurgical interventions within the islands. Additionally, there has been progress on the academic level, with the aid of international academic collaborating centers, like the Erasmus Medical Centre and University Neurosurgical Center Holland in the Netherlands. This has led to an exponential decrease in medical referrals and consultations to other countries, creating a self-sustainable center for care. In emergency cases, it can provide timely (<2 hours) neurosurgical treatment according to the Lancet Commission on Global Surgery.⁶

During the coronavirus disease 2019 (COVID-19) pandemic, it became apparent that established medical care within the Caribbean Dutch Kingdom is very fragile and mostly dependent on care elsewhere. Most of the other islands were used to relying on neurosurgical care from Colombia, Panama, Dominican Republic, and the Netherlands. However, as country borders closed and air traffic

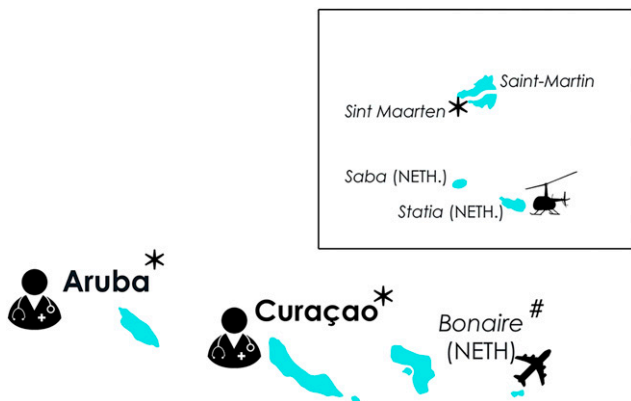


FIG. 2. Closer view of countries within the Dutch Caribbean. Aruba and Curaçao have a neurosurgical department (*doctor icon*). Sint Maarten and Bonaire have a neurological department. Aruba, Curaçao, and Sint Maarten have a computed tomography (CT) and magnetic resonance imaging (MRI) scanner (*). Bonaire has only a CT scanner (#). Bonaire is the only island with a Learjet (*plane icon*). Stata has a helicopter stationed for transport of patients from both Stata and Saba to Sint Maarten (*helicopter icon*). NETH = The Netherlands.

ceased to exist, a restructuring of medical care for the Dutch Caribbean arose.

The Dutch Caribbean Hospital Alliance was founded to strengthen the quality of medical care.⁷ It centralized specialized care and maintained a beneficial financial economic state in these countries. For neurosurgery in Curaçao, this was associated with an influx of referring patients from surrounding islands, mainly Sint Maarten, Saba, Stata, and Bonaire. The distance of these islands from Curaçao is 910 km (565 miles), 866 km (538 miles), 876 km (544 miles), and 79 km (40 miles), respectively.⁸ Medical referrals to the neurosurgical department in Curaçao have become the standard of care. Elective cases arrive by regular passenger plane transportation,⁹ which has improved care significantly for surrounding islands, and costs have been diminished. However, the logistics and finances around medical referrals, specifically in emergency cases, still need improvement and greater efficiency.

Neurosurgery and Trauma

Timing is essential in response to emergency neurotrauma cases and the prevention of secondary injury. It is a direct contributing factor to prognosis, morbidity, and mortality.^{10–16} Cases of traumatic brain injury (TBI) and spinal cord damage are significantly impacted by access to a neurosurgical facility and care. Many neurosurgical committees have highlighted the need and benefits of early intervention in cases of neurotrauma.^{12,13,17} With the global neurosurgery movement, TBI in low- and middle-income countries (LMICs) has become a major point for further exploration and amendment.^{6,18} Although most countries in the Caribbean have been affirmed as high income by the World Bank, there are still challenges that resemble those of other LMICs.^{19–21}

Observations

The reported case is an illustrative emergency neurosurgical case sent to Curaçao. Experience over the years of providing neurosurgical service has indicated a patient transfer time of at least 5 to 19 hours, depending on the referring island. The majority of

referrals take approximately 10–12 hours. These lengthy transfer times are directly correlated to neurological outcome, and as reported herein, some of these cases have a disastrous outcome. The described case occurred during the first year of the pandemic, and transfer times were thought to be related to this, especially with the new logistics surrounding referrals, quarantine rules, and mandated COVID-19 testing. This was an additional burden to the existing limitations of available ICU beds and operating theater access. During that time, Bonaire had two air ambulances situated with an additional crew (aided by a private Colombian air ambulance).²² And, although the pandemic is over and the rules are less stringent, the extended transfer times persist.

Outside the COVID-19 pandemic, transfers can be delayed due to in-hospital patient stabilization, patient insurance factors, airport pickup/transportation, air ambulance availability, air ambulance preparation time, crew preparation time, flight authorizations, long-distance travel, and weather conditions.^{23–25} Specific causes of delay include patients without a valid passport or when medical insurance requires permission from the local government and/or insurance company to travel. Attempts are made to expedite this process for emergency cases but can still take several hours. The preparation time of an emergency air ambulance and fully ready crew takes 2–4 hours, according to the literature.²⁶ Therefore, islands without a stationed air ambulance, which is the majority, face greater wait times. This is further impacted by transportation to and from the airport, air traffic control setbacks, or the unavailability of an air ambulance. The latter may be secondary to maintenance concerns or an aircraft that is already in use. As a result, the inter-island travel via air ambulance can lead to extensive delays even if properly organized.

Finances

Financing and maintaining an air ambulance require several millions of dollars and thus is a costly affair.²⁷ Bonaire has the Learjet to chiefly improve its inhabitants' healthcare.²⁸ For most of the inter-island air ambulance travel within the Dutch Caribbean, the Learjet should be used, as this is presumably "free of charge" between the islands (E.J. dos Santos Rubio, personal communication, 2022). However, other air ambulance services are also called upon (primarily Colombia and Dominican Republic), as logistics, communication, and availability appear to be challenging (E.J. dos Santos Rubio, personal communication, 2022). In some cases, emergency care requires patients to be sent outside the Dutch Caribbean, due to a lack of certain medical experience within the islands. The costs for emergency air travel vary and remain unclear but depend on several factors,²⁷ such as type of airplane, accompanying crew members, type of equipment, travel distance, and travel stops. It is estimated to cost approximately \$20,000 per case/flight in our region (E.J. dos Santos Rubio, direct communication). This is concurrent with the literature.^{29,30}

Given the low populations of the referring islands (Saba: approximately 2000; Stata: approximately 3100; Sint Maarten: approximately 43,000; Bonaire: approximately 23,000),²¹ we do not expect emergency neurosurgical medical referrals to be substantial, with an average of 10–12 patients per annum. This poses a challenge in computing a favorable cost-benefit analysis for investments with regard to full neurosurgical capacity building. However, there are still alternatives to saving lives that should be considered. Governing bodies will need to make financial investments to improve this type of care, while taking into account delays of medical referrals resulting

in unnecessary mortality and significant morbidities, with a resultant higher additional societal cost for severely disabled patients.³¹ We cannot forget that the Caribbean is a well-known tourist destination, receiving tourists from the United States and Europe. Pre-pandemic, the Dutch Caribbean, including Aruba, Curaçao, and Sint Maarten, received a total of approximately 5.82 million tourists (including ~3.74 million cruise ship visitors).³²⁻³⁶ Tourists frequently need neurosurgical emergency care because of falls, diving accidents, or road traffic accidents. They will also depend on these medical transfer methods, putting their lives at risk. Furthermore, inefficiency of this aspect of the medical infrastructure will hinder the development of medical tourism, a new and promising avenue for revenue.

Current Situation

Current practice at our institution is to accept patients requiring neuro-observation and cases that are not immediately life-threatening. Unfortunately, neurosurgical cases requiring emergent life-saving intervention have been declined because of the expected lengthy transfer times, knowing that without immediate surgical intervention the patient will succumb to its injuries. This is the harsh reality for Caribbean islands without sufficient neurosurgical access and only one neurosurgeon to provide care for multiple islands. The challenges surrounding lengthy medical transfers are not a new notion and are similar to the delayed surgical care noted in LMICs or rural areas.^{11,20,23,24,37,38}

Recently, a survey sent to neurosurgeons in the Caribbean reported a referral time of more than 8 hours³⁹ in most cases, and with the fragmented nature of the Caribbean given its colonial past, it is unclear how the organization of finances, policies, and quality control of these (emergency) aerial medical referrals takes place. This is worth exploring within the Caribbean to eventually create a new and efficient transferral system that decreases mortality and morbidity at an acceptable cost.

Lessons

A mandatory process that would focus specifically on air ambulance protocols, and quality control, with respect to patient outcomes for various specialties is needed. This way we can navigate methods to optimize the process, including rerouting travel trajectories. This may aid outcomes in (neurosurgical) emergency cases and demonstrate the importance of the efficacy of air ambulances.⁴⁰ Prior to COVID-19, the Dutch Caribbean also sent patients to other neurosurgically equipped islands.^{28,41} However, the specifics of these cases remain unclear. Either way, it is unlikely that inter-island transfers can be performed within the postulated time of less than 2 hours according to the Lancet Committee but this needs to be further investigated.⁶ Transfer delays of more than 4 hours have shown worse prognostic outcomes; hence, delays longer than this cannot be accepted.^{11,16}

Increasing access to local neurosurgical care needs to be the main goal. An alternative to improve patient outcomes needs to be considered such as task-shifting or task-sharing with the use of current technology and capacity building on more islands. Task-shifting or task-sharing is an approach frequently used in LMICs where there is a shortage of certain specialized physicians. Other medical or surgical specialties take over certain tasks to improve the provided healthcare.^{42,43} In our case, it would be feasible to teach local general surgeons additional skills for emergency cases, such as performing a burr hole evacuation, external ventricular shunt placement, and even a craniectomy. The cost of a high-speed drill with

accessories would be approximately \$45,000 dollars (quotations received by E.J. dos Santos Rubio), or a manual hand drill and Gigli saw (although very time consuming, but a lot cheaper) could be provided. Additional safety measures and competency evaluation with current virtual methods could be used in task-sharing such as neurosurgeon to surgeon assistance via telemedicine, which could only be provided with a strong internet connection between countries, or a video connection through the use of glasses in the operating room or an even an outpatient clinic, emergency room, or ICU (Fig. 3). Education through organizing periodical bootcamps to practice on life-like models and augmented or mixed-reality assistance on surgical procedures would prove beneficial (Fig. 4). Also, establishing a surgical simulation center throughout the islands might be an option to maintain skills if funding is available in the future. The patient can be provided with life-saving operations in the emergency setting before being transported to a tertiary hospital, if required.⁴⁴ However, physicians who are willing and comfortable to perform these additional skills in an emergency setting will need to be sought. Additionally, establishing a residency program or partnering up with a medical school in the region could preserve the valuable time of seasoned physicians and provide continuity; however, the size of these countries and current workforce are disadvantages, as surgical exposure and guidance of these residents would be mostly absent. Investing in physician assistants would be more feasible.

Building a permanent neurosurgical capacity on one of the referring islands needs to be considered. However, this is not a cheap or easy task and comes with several challenges: 1) costly equipment for an adequate level of function, 2) specialized nurses and



FIG. 3. **A:** Operating team using a camera on a headband/glasses during surgery. **B:** A healthcare worker wearing glasses with a camera and a remote healthcare worker monitoring and communicating through video streaming on a laptop. **C:** A laptop video stream to a remote surgeon. **D:** Remote healthcare worker looking at a video stream of a surgery while at home through a laptop and able to communicate with a team from a distance. ©Vuzix Corporation, reproduced with permission.

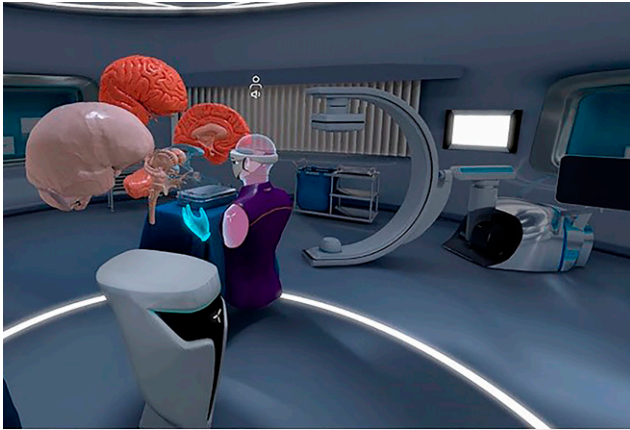


FIG. 4. UpSurgeOn Metaverse: a mixed-reality platform as a pre-patient training method. ©UpSurgeOn S.R.L., reproduced with permission.

doctors from additional specialties (ICU, operating room, neuro-unit, anesthesiologists, etc.), and 3) regular surgical exposure to maintain and develop generalist neurosurgical skills. Considering all of these challenges, in our case, the population of the referring hospitals is just too low to develop an additional full-functioning neurosurgical solo practice at this time.

Contracting more neurosurgeons at the tertiary hospital and then allocating one of them for a specific period of time to one or more referring islands and then rotating these neurosurgeons could also be considered.⁴⁵ The rotation of neurosurgeons has several advantages: 1) providing quality neurosurgical care for much of the catchment area, 2) continuity of care, 3) decreasing medical referral costs for elective and emergency patients in a catchment area, 4) maintaining surgical skills due to tertiary hospital activities, and 5) the ability to slowly develop capacity while maintaining quality control. Some disadvantages entail 1) frequent traveling, which would influence family life; 2) variation in the primary neurosurgeon during patient care, which would impact the doctor–patient relationship; and 3) a low number of (emergency) surgeries limits high operating numbers and thus possibly more complications.

Regardless, the prognosis of our patient would have been different if an external ventricular shunt had been placed at the referring hospital. We hope that we can improve healthcare delivery in the future to save as many lives as possible.

Recommendations for improving transfer times include the following: 1) create awareness of the issue of neurosurgical transfers and the formation of governing bodies that can affect change, 2) foster greater collaboration within the Caribbean community to facilitate aid from adjacent island nations with neurosurgery centers, 3) research current Caribbean air ambulance transportation and focus on improvements and faster mobilization and rerouting emergency neurosurgical cases to these islands with neurosurgery facilities in life-threatening situations, 4) equipping island nations that provide neurosurgery care with reliable air ambulance transportation systems, and 5) look into viable educational, digital, and virtual options and incorporate them into the current care system.

Within the Dutch Caribbean, Curaçao provides a neurosurgical hub to other Caribbean islands. At times, the efficiency of neurosurgical referrals is poor and leads to unsatisfactory patient outcomes

in true emergency cases. We believe that this provides a glimpse of the limitations faced within one aspect of the Caribbean region. Highlighting this case may provide a foundation for further advancements that may alter neurosurgical care and access. Patient outcome is important, and efficient access to primary neurosurgical care facilities can alter patient prognosis. Limiting long-distance surgical referrals in the acute care setting will aid in saving lives. This not only affects health status but is also a more cost-effective strategy for countries without permanent neurosurgeons.

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Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions

Conception and design: all authors. Acquisition of data: dos Santos Rubio. Analysis and interpretation of data: dos Santos Rubio, Calderon. Drafting of the article: dos Santos Rubio, Calderon, Boeykens. Critically revising the article: all authors. Reviewed submitted version of the manuscript: dos Santos Rubio, Calderon, Park. Approved the final version of the manuscript on behalf of all authors: dos Santos Rubio. Study supervision: Park.

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