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ORIGINAL RESEARCH

Helicopter-Based Search and Rescue Operations in the Dutch Caribbean: A Retrospective Analysis

Elena Argia Bianca Bensi, MD[1]; Roy Spijkerman, MD, PhD[1]; Philip A. Brown, MRAeS[2]; Shaun Knights, BSc (Hons)[2]; David R. Nellensteijn, MD, PhD[1,2]

[1]Department of Surgery, Curaçao Medical Center, Willemstad, Curaçao; [2]Dutch Caribbean Coast Guard, Ministry of Defense, Kingdom of the Netherlands

Introduction—Search and rescue (SAR) operations in the Dutch Caribbean offer basic and advanced prehospital care and transport for definitive care. Helicopter-based SAR in this geographic area has not been previously studied. Data from the Dutch Caribbean Coast Guard were analyzed with the aim of describing the current operational setting and optimizing SAR operations in the future.

Methods—Data were collected retrospectively from March 2018 through April 2021. Epidemiologic data, patient demographics, details of flight operations, medical interventions, and outcomes were collected and analyzed for this period.

Results—A total of 91 individuals were assisted through SAR, of whom 40 (44%) had a medical emergency. Most incidents occurred during high-tourism seasons. A yearly increase in helicopter tasking was observed. Boating was the most common activity (25%) requiring SAR. Injuries to the extremities were the most common injury (27%). The median time to reach the scene of SAR was 46 (interquartile range [IQR], 33–66) min. The most frequent reason for delay was the unavailability of a winch operator (15%). Of 16 fatalities, most (63%) were attributed to drowning. A total of 18 persons were transported to a hospital, with a median travel time of 63 (IQR, 47–79) min.

Conclusions—The number of SAR missions in the Dutch Caribbean is increasing. The response times might be reduced by the inclusion of an on-call winch operator. A hospital helipad would likely decrease the time to definitive care. Stand-by physicians might improve the quality of medical care. Collection of data should be optimized in the future.

Keywords: helicopter emergency medical services, trauma, prehospital emergency care

Introduction

The Dutch Caribbean is a group of islands in the Caribbean Sea, including Aruba, Curaçao, Sint Maarten, Bonaire, Saba, and Sint Eustatius (Figure 1). The population of the 6 islands is approximately 335,500. Tourism is the main source of income for the islands, with many activities in remote locations. For this reason, there is a need for an efficient search and rescue (SAR) system. Search and rescue operations are emergency medical services to aid individuals in distress, injured or ill individuals, or those lost in areas inaccessible by road.[1] The Dutch Caribbean Coast Guard (DCCG) is responsible for airborne SAR operations of the leeward Antilles (known as ABC islands): Aruba, Bonaire, and Curaçao. These 3 islands are mainly composed of beaches with beautiful coral reefs, inland waterways ideal for watersports, and dry hill landscapes with a variety of hiking trails. Situated <100 km from the coast of Venezuela, no nearby systems are in place to aid these small islands in SAR. Current operations initiated by DCCG focus on providing logistic and medical support for incidents in geographically challenging areas of the islands and surrounding sea. There have been previous studies of SAR operations outside the Caribbean, in coastal areas, and in the vicinity of large lakes.[1-5] To our knowledge, the DCCG is the first and only

Corresponding author: David R. Nellensteijn, MD, PhD, Department of Surgery, Curaçao Medical Center, Willemstad, Curaçao; e-mail: david.nellensteijn@cmc.cw.

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Figure 1. Geographic map of the Dutch Caribbean area. In this map, all 6 islands that are part of the Dutch Caribbean are labeled: Aruba, Bonaire, Curaçao, Sint Maarten, Saba, and Sint Eustatius. The first 3, also known as ABC islands, are part of the leeward Antilles, where helicopter-based search and rescue operations were performed in this study. Adapted from Dutch Caribbean Species Register. Available at: https://www.dutchcaribbeanspecies.org/. Accessed March 12, 2022.

helicopter rescue service in the Caribbean. The aim of this study was to better understand SAR operations in the Dutch Caribbean and make recommendations to improve the quality of emergency care.

Methods

This study was approved by the Curaçao medical center education administration and ethics committee. All patient data collected were anonymized in a way that they could not be traced back to an individual person. The methods are in conformity with the Declaration of Helsinki.[6]

The DCCG has 3 main facilities (Curaçao, Aruba, and Sint Maarten) providing mainly sea support, with air support only originating from Curaçao. Air-operated SAR is only performed in the leeward Antilles, where the flying radius is feasible. Operations are coordinated from the rescue coordination center situated in Curaçao. The DCCG has 2 helicopters based in Curaçao, 1 of which (an Augusta Westland AW139) is available at all times for SAR. This helicopter can perform off shore, land rescues, and night operations. It is winch capable. Depending on weather conditions, the flying radius is approximately 270 km, with an on-scene time of 30 min. Since 2012, the helicopter has been operated by a private company, with its main roles being surveillance (customs operations, border patrol, and counter-drug operations). Because of increased requirement to provide emergency medical care during SAR, additional staff training has been provided. The helicopter is currently used for both SAR and helicopter emergency medical services (HEMSs). The standard crew consists of a pilot, copilot, and radar operator stationed at the hangar from 0700 to 1900, 6 d a week. Outside of these hours, the crew is on call. There is no dedicated winch operator on call. Sending physicians on an operation is decided on a case-by-case basis. There is no helipad at the Curaçao medical center. All patients must be transported by ambulance from air station Hato. This hospital is equipped as a level 1 trauma center, including pediatric and neurosurgical facilities. The DCCG started using flight operations software (iSAR; Bellwade LTD., Newport, United Kingdom) in March 2018. This software records dates, flight times, location, delays, reason for activation, type of terrain, flight outcome, and operation narrative. For collection of medical information, separate printed sheets are used and filled out by the crew during SAR. These include patient demographic information, type of trauma or medical emergency, vital signs, interventions, and destination. In SAR operations in which no medical report is filed, this information is sometimes found in the digital iSAR narrative.

Cases were identified from the iSAR database for the period between March 1, 2018 and April 30, 2021. Data were extracted from the iSAR and hospital electronic and paper records.

The patients' age and sex were recorded. The dates on which SAR occurred were used to produce a monthly and yearly incident log. The activities requiring SAR were collected for all missions. The missions were divided into 2 groups: SAR (no medical emergency) and HEMS

(medical emergency). The type of emergencies was defined as trauma or medical emergency. The activities requiring either SAR or HEMS were separately analyzed. For the HEMS group, data on the type of emergency, injury, interventions performed, and destination were collected. The National Advisory Committee for Aeronautics (NACA) score was determined. The NACA score is widely used to evaluate the severity of trauma and medical emergencies.[7] For patients admitted to the hospital, data were collected on length of stay, surgical procedures, intensive care unit admission, and clinical outcomes. For those who died, the reasons for activation and activity requiring HEMS were analyzed separately.

Details of flight operations were collected for all missions. These included the time of operation, day of the week, location, type of terrain, and reasons for activation. Time of operation was classified as day (between 0700 and 1859) and night. Additional data were collected regarding delays. Data points for times were activation time (time alerted about SAR), launch time (from the base), scene arrival time (at the SAR scene), landing time (at the base), and hospital arrival time. Calculated times were response time (activation to launch), time to scene (activation to scene arrival), time to hospital (helicopter landing base to hospital arrival), and total flight time (launch to helicopter landing base).

Flight outcomes were search discontinued (mission was canceled during outbound flight), person(s) assisted (SAR assistance without rescue or transport of a patient), person(s) rescued (SAR with rescue or transport of a patient), and person(s) died (all patients who died any time during SAR until discharge from the hospital). In the case of "search discontinued," the reason was included: false alarm, no person(s) found, low fuel, or person(s) assisted by other means (this was the case when the search was both sea and air operated and the persons were assisted at sea entirely by the Coast Guard).

Data were entered into a preformatted Excel spreadsheet (Microsoft Corp. 2018, version 16.51, Redmond, WA) and exported into SPSS Statistics (IBM Corp. 2020, version 27.0, Armonk, NY) for statistical analysis. Normality was tested using the nonparametric Shapiro-Wilk test. Interpretations of Q-Q plots were used to determine the type of distribution. Normally distributed data were presented as mean±SD. Significance was tested using a t test to compare the means of 2 measurements taken from different patients. Nonnormally distributed data were presented as median with interquartile range (IQR; Q1−Q3). Significance was tested using a Mann-Whitney *U* test. Dichotomous data were shown as an absolute count with the percentage of the total. Differences were tested using the Pearson χ^2 test. Statistical analysis was performed on the yearly incidence data using R^2 and *P* values. Linear regression analysis was performed to determine how well the regression model fit the observed data indicated by R^2. A *P* value of <0.05 was considered to be significant. Measures of frequency were used for further descriptive statistics.

Results

One hundred three operations were identified from the iSAR database during the study period. Twelve cases were excluded because they were incorrectly labeled as SAR, leaving 91 for inclusion in the analysis. The total operations per year were 12 (13%) in 2018 (only 10 mo included), 27 (30%) in 2019, 42 (46%) in 2020, and 10 (11%) in the first 4 mo of 2021. The yearly median number of SAR operations was 20 (IQR, 12−31), including partial data from 2018 and 2021. Monthly peaks were observed for June, July, August, December, and January. Regression analysis yielded R^2=0.145 and *P*=0.181 (Figure 2). Men were involved in incidents requiring SAR or HEMS more often (77%) than women. Those aged 20−29 y were most frequently involved (n=14, 16%). The most frequent activity requiring SAR was boating. More than half (56%) of incidents were SAR cases, and 44% were HEMS cases.

The medical information for the HEMS group and the calculated NACA scores are presented in Table 1. In this group, 11 (28%) died at the scene, in which case no medical report was available. Medical reports were available for the other 29 (72%) injured individuals. Of all deceased persons (n=16), 11 died at the scene, 3 died during transport, and 2 died during hospitalization. Among the people who died, the most frequent reason for activation was "person(s) in the water" (n=10), and the activity requiring HEMS most frequently was "water activities" (n=7). Hospital records were available for 13 of 19 patients transported to the hospital. Eight patients were discharged home on the day of arrival, 2 were admitted to the intensive care unit and died, 2 underwent surgery and were discharged for home, and 1 stayed for 2 d before being discharged for home. Patients with injuries to the extremities rarely required admission to the hospital or immediate surgery.

The details of flight operations are presented in Table 2. Of all flights requiring a winch operator (n=40), 6 (15%) were delayed because of the unavailability of a winch operator. The calculated flight times, response times, and hospital arrival times are presented in Table 3. The median time to reach the scene varied from 36 (IQR, 27−47) min for flights to Curaçao to 65 (IQR, 30−82) min for flights to Bonaire, 70 (IQR, 66−75) min for flights to Aruba, and 75 (IQR, 44−112) min for flights to

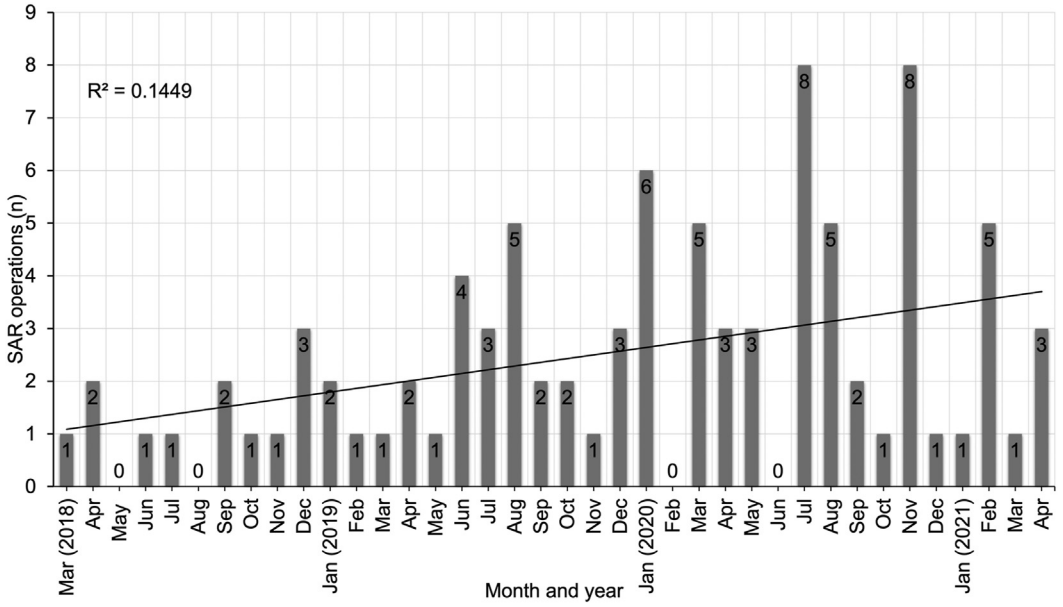

Figure 2. Column chart: number of search and rescue operations per month with linear regression (March 1, 2018 to April 30, 2021). SAR, search and rescue.

international waters. Outcomes were evenly divided among search discontinued (n=31, 34%), persons assisted (n=30, 33%), and persons rescued (n=30, 33%). When the search was discontinued, in most cases this was because no person was found (n=13, 42%). Other reasons included low fuel (n=6, 19%), false alarm (n=5, 16%), and persons being assisted by other means (n=2, 6%).

Discussion

The DCCG is the first and only helicopter rescue service in the Dutch Caribbean. The number of missions has increased over the study period, with most cases occurring during the high-tourism seasons. The on-call crew is required by the DCCG to have a response time of no longer than 60 min. Despite the geographically challenging area, the response times were well within the agreed-upon limits. Transport to definitive care was prolonged by the travel time from the landing base to the hospital. Water activities were the most frequent activity requiring assistance and were also the most frequent cause of mortality. Medical management provided by the SAR crew resulted in good outcomes.

The monthly peaks observed in SAR occurrence were similar to peaks in tourist arrivals from the Curaçao Tourist Board (Figure 3). This congruence suggests that watersports and hiking tourism are major sources of incidents requiring SAR. However, the sudden drop in tourist arrivals observed after March 2020, likely caused by the coronavirus disease 2019 pandemic, with an associated decrease in travel, was not observed in the SAR data.[8] Instead, we observed a general yearly increase in incidents, causing an increase in helicopter tasking.

The need to wait for a winch operator was the most common reason for delays. Time to definitive care has a direct impact on patient survival and outcome.[9-11] Having a winch operator stationed at the hangar might improve response times.[2] A helipad on or near the Curaçao medical center would markedly decrease the time between landing and arrival at the emergency department and might improve outcomes for severely injured patients.

Physicians from the Curaçao medical center are currently being trained to participate in SAR. The NACA scores presented illustrate that the severity of injuries varied between 2 extremes. The presence of physicians during rescue missions can lead to shorter on-scene times and is particularly important when there is a need for advanced analgesia or specific interventions.[12] In the case of severely injured patients, although being more costly, physician-staffed HEMSs lead to better outcomes.[13-15] Continued training of hospital physicians and tasking on a case-by-case basis will, therefore, likely improve SAR in the future.

Limitations

This study was retrospective and had a small sample size. Data registration was suboptimal and incomplete,

Table 1. Medical emergencies, activities, injuries, National Advisory Committee for Aeronautics scores, interventions, and transport to hospital (yes/no) in the helicopter emergency medical services group (n=40)

Medical information	*n*	*%*
Type of emergency		
Trauma	31	78
Medical emergency	9	22
Activity causing trauma		
Hiking	11	35
Swimming, snorkeling, or diving	9	29
Aviation	4	13
Boating	4	13
Motor vehicle	1	3
Unclear	2	7
Injuries/illnesses		
Trauma to extremities	12	30
Dead at scene	11	27
CPR in progress	5	13
Abdominal pain	4	10
Drowning	3	8
Chest pain	1	2
Other	4	10
NACA score[a]		
1	6	15
2	15	37
3	1	3
4	0	0
5	2	5
6	5	13
7	11	27
Interventions		
Oxygen	8	20
Analgesia	8	20
Mechanical ventilation	6	15
Intravenous fluids	5	13
CPR	5	13
Epinephrine	5	13
Splints	5	13
Supraglottic airway	4	10
Transport to hospital		
Yes	19	48
No	21	52

CPR, cardiopulmonary resuscitation; NACA, National Advisory Committee for Aeronautics.
[a]NACA score 1–7.

limiting the explanatory power. Conclusions can only be drawn using data from the last few years.

Conclusions

The number of SAR missions in the Dutch Caribbean has increased over the study period and will likely increase in the future and require continued attention. The inclusion of a dedicated winch operator in the on-call crew might reduce response times, which will improve outcomes for severely injured patients. Similarly, the placement of a

Table 2. Details of flight operations: day or night, weekend or weekday distribution, location, type of terrain, reason for activation, and delayed takeoff (n=91)

Flight information	*n*	*%*
Day or night[a]		
Day	74	81
Night	17	19
Weekend or weekday		
Weekday	70	77
Weekend	21	23
Location		
Curaçao	57	63
Bonaire	11	12
Aruba	11	12
International waters	11	12
Other	1	1
Type of terrain		
Maritime or coastal	37	41
Maritime	24	27
Land	11	12
Mountain	5	5
Inland waterway	4	4
Data missing	10	11
Reason for activation		
Person(s) in the water	28	31
Missing person(s)	25	27
Medical evacuation from land	15	17
Vessel in difficulties	13	14
Medical evacuation from vessel	9	10
Data missing	1	1
Delayed takeoff		
Awaiting winch operator's arrival	6	40
Unclear	4	27
Refueling required	2	13
Waiting for the cruise ship to be in range	2	13
Technical difficulties	1	7

[a]Daytime is defined as between 0700 and 1859.

Table 3. Calculated response time, flight time, and time to hospital for search and rescue operations (n=91)

Calculated times	*Median (min)*	*IQR (min)*
Response time[a]	26	20–39
Time to scene[b]	46	33–65
Total flight time[c]	98	64–145
Time to hospital[d]	63	47–79

IQR, interquartile range.
[a]Response time: activation time to launch time.
[b]Time to scene: activation time to scene arrival time.
[c]Total flight time: launch to helicopter landing base.
[d]Time to hospital: helicopter landing base to hospital arrival.

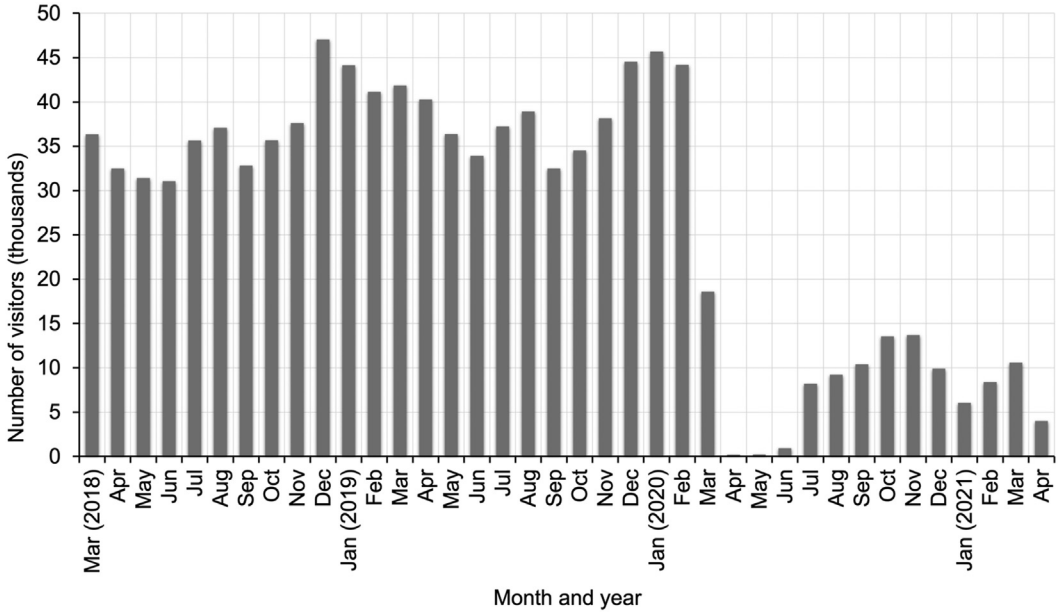

Figure 3. Column chart: total visitor arrivals per month in Curaçao (March 1, 2018 to April 30, 2021). Data from: Curaçao Tourist Board. Business intelligence: Annual reports. 2018-2021. Available at: https://www.curacaotouristboard.com/monthly-statistics/. Accessed July 15, 2021.

helipad at the Curaçao medical center would drastically reduce the time to definitive care during HEMS missions. Based on current knowledge regarding physician-staffed HEMSs, continued collaboration with hospital physicians on a case-by-case basis will ensure appropriate on-scene management of severely injured patients. Health data management should be improved for continued analysis and improvement of SAR.

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