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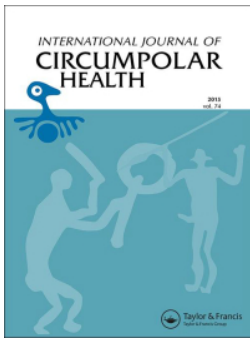
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# Surgical training strategies for physicians practicing in an isolated environment: an example from Antarctica. International survey of 13 countries with active winter stations

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## ABSTRACT

For 60 years, human presence in Antarctica has required particularly demanding medical skills. Nevertheless, the preparation of physicians working in this extreme environment remains unknown and deserves clarification. This study aimed to summarise data on the surgical training given to physicians by different countries. In April 2020, we conducted a questionnaire-based study of 14 countries wintering in Antarctica. Responses were descriptively analysed. Regarding the profiles of physicians recruited by the wintering countries, 30% to 55% were non-surgeon doctors compared with 45% to 70% for surgeons depending on the year. Of the 13 countries answering the questionnaire, nine organised practical surgical training and six used theoretical material. All countries reported practical training for dental surgery, while only five countries provided training in four other surgical specialities (orthopaedic, digestive, thoracic, and ear, throat, and nose). All 13 countries reported using a telemedicine system. These results revealed heterogeneous training strategies among the recruited physicians, reflecting the difficulties of practice on this extreme continent. Future work may assess the effectiveness of each strategy. A better understanding of surgical epidemiology and a detailed referencing of the equipment available at the bases would help better define the contours of surgical care in Antarctica.

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## Introduction

Every year, Antarctica hosts a mainly scientific population from 30 different countries. In summer, nearly 4,000 people work there at 76 research stations. About 1,100 people stay during the Austral winter. During this period, those at latitudes above 66.5 degrees south experience the polar night phenomenon, which lasts from 1 to 6 months [1]. Base staff turnover is punctuated by summer and winter seasons, and varies by country, occupation, and means of transportation. In most cases, wintering team stays for a maximum of one year and summer teams stays only a few months.

Due to its size, meteorology, and geographic isolation, this continent of extremes is one of the most inhospitable places on earth. Humans must adapt to negative temperatures dropping down to  $-98^{\circ}\text{C}$  [2] and katabatic winds reaching up to 205 km/h [3]. These environmental constraints also make landing of air rescue very complex and dangerous in winter. Despite its economic and technical capacities, the United States considers that the risk-benefit

balance and cost do not always favour evacuation, making it preferable to better prepare the medical personnel on site for an emergency [4,5]. For Ron Shemenski, a former Antarctic doctor, it would be more difficult to carry out an evacuation from a winter Antarctic station than to repatriate crew from the International Space Station [6].

Physicians recruited to work in Antarctica must be versatile in order to provide quality care with limited human and material resources. If surgery is indicated, a non-surgical doctor must be able to perform the life-saving technical procedure. These extreme conditions are emblematically illustrated by the case of Dr. Leonid Ivanovich Rogozov who was forced to operate on himself for appendicitis during an austral winter [7]. Previous studies [5,8–20] reported a significant proportion of surgical and orthopaedic pathologies in Antarctica, which represent between 28% and 45% of all consultations carried out on the Indian, Japanese, and Ukrainian bases. Dentistry alone represents 2.6% to 13% depending on the study [8,15,16]. It is therefore

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essential to provide physicians with surgical training that is adapted to the territory and their previous experience. The objective of this study is to summarise the surgical training strategies adopted at the international level.

## Materials and methods

### Definition of surgery

The study was based on the definition of “surgery” according to the MeSH terminology, namely as “operative procedures on organs, regions, or tissues in the treatment of disease, including the sectioning of tissues by laser” [21].

### Questionnaire design and distribution

A questionnaire was designed to collect details on the characteristics of the medical population in Antarctica, the possible existence of a training program, details of any theoretical and practical training given to physicians, and the use of telemedicine. The questionnaire was only written and sent in English. It generally took 30 to 45 minutes to complete the questionnaire, which was tested by two different examiners before its distribution in order to validate the absence of dysfunctions, design errors, or poor wording.

The survey had 13 sections with a total of 15 questions, including 12 quantitative (closed) responses and 3 qualitative (open) responses. Open-ended questions allowed for probing in order to gain more details and a better understanding. For the “surgical procedures performed” category, the list was taken from the surgical procedures carried out during the training of TAAF doctors [22].

In April 2020, an email containing a link to the online survey was sent to the medical coordinators of each national program in Antarctica. The email was sent from a single address [polarsurgerytraining@gmail.com](mailto:polarsurgerytraining@gmail.com). The medical coordinators were identified from the “Delegates” section of the Scientific Committee on Antarctic Research (SCAR) [23] and from the “Members” section of the SCAR/COMNAP Joint Expert Group on Human Biology and Medicine [24]. Then, an investigation was carried out using the email addresses registered at the medical office of the French Southern and Antarctic Lands.

The initial invitation included a cover letter providing information about the study objectives and a link to the online questionnaire. For the medical coordinators in the eligible countries who had not yet taken part in the study, a follow-up email was then sent every 3 days for

the first 3 weeks and then once a week. The data collection period was 12 weeks.

### Inclusion and exclusion criteria of the Antarctic programs

To be included in this survey, the Antarctic programs had to have a physician practicing at a winter station who was able to perform surgical procedures and/or dental surgery. These data were available in the latest catalogue of Antarctic stations published in 2017 by the Council of Managers of National Antarctic Programs (COMNAP) [25]. The medical care capacity of each station was classified according to three categories: none, basic, and surgery. The COMNAP catalogue does not define these categories. An email was sent to the medical coordinators of the Antarctic programs with a winter physician whose activity was described as basic, which corresponded to an absence of surgical activity.

### Data analysis

Extensive data quality checks were carried out to identify and fill in any gaps. Thus, the examiners read each response and then sent one or more additional emails when they considered that further explanations or details were necessary. Thus, any answers deemed imprecise were subsequently clarified. Data were entered into Microsoft Excel for descriptive analysis.

### Ethics committee approval

This survey falls within the framework of non-interventional studies and preserves the anonymisation of data collected in the literature. Survey participants were not exposed to any risk of physical harm, discomfort, or inconvenience. Therefore, it was not sent to an ethics committee for approval.

## Results

### Countries meeting the inclusion criteria

The COMNAP catalogue [25] identified the presence of 30 countries in Antarctica. The analysis excluded countries without an active base in winter ( $n=9$ ), without a winter doctor ( $n=2$ ), without any surgery or dental surgery declared in the COMNAP catalogue and confirmed by email ( $n=2$ ), and those that did not confirm their activity by email ( $n=3$ ). A total of 14 countries were deemed eligible (Figure 1).

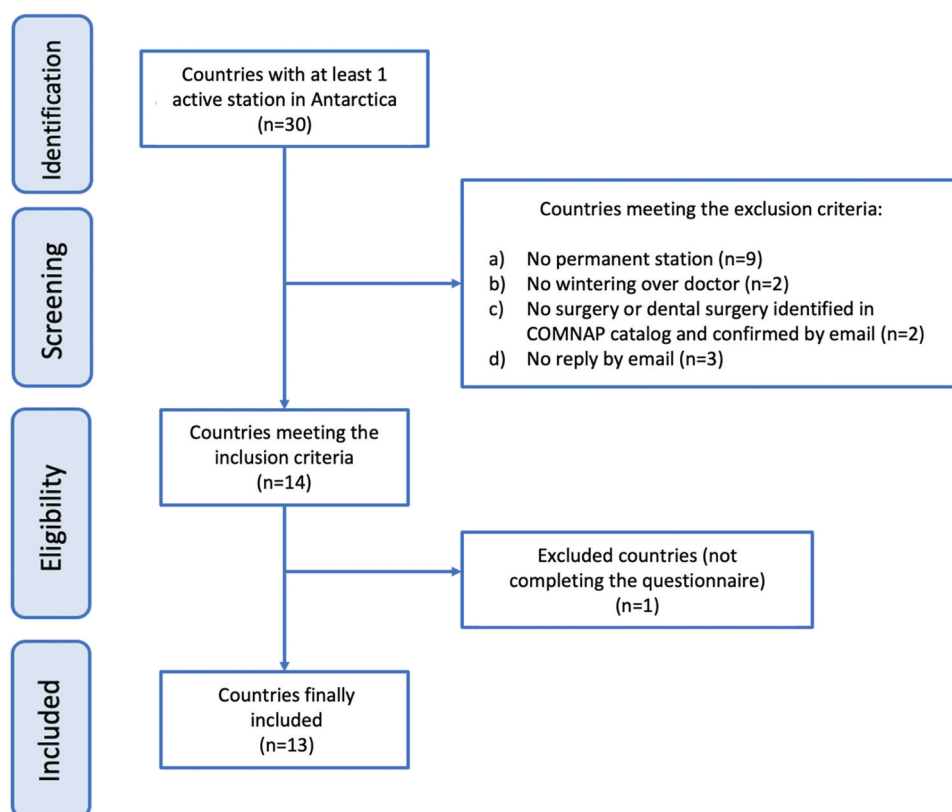


Figure 1. Flow chart.

The questionnaire was sent to the medical coordinator of each Antarctic program meeting the inclusion criteria ( $n = 14$ ); 13 questionnaires (92.8%) were returned. Only Argentina did not respond to the questionnaire within 4 months of recruitment despite various reminders and was therefore excluded. Six coordinators (46.1%) were recontacted by email to provide further information.

### Characteristics of the medical population

Among the participating countries, some only recruited surgeons ( $n = 3$ : China, Germany, Russia), while others only recruited non-surgeon doctors ( $n = 3$ : South Africa, France, USA). Japan and India systematically recruited a surgeon-non-surgeon pair. Some recruited doctors from all specialities ( $n = 5$ : Australia, Italy, UK, Norway, Ukraine), although none declared recruiting a dentist. The medical-surgical coverage of the Antarctic territory is summarised in Figure 2.

Among the non-surgical profiles, countries declared recruiting emergency physicians ( $n = 8$ : Italy, USA, Japan, UK, Australia, Norway, France, Ukraine) and general practitioners ( $n = 8$ : USA, Japan, India, UK, Australia, Norway, France, Ukraine), while eight countries

answered “other” without providing details about the medical speciality.

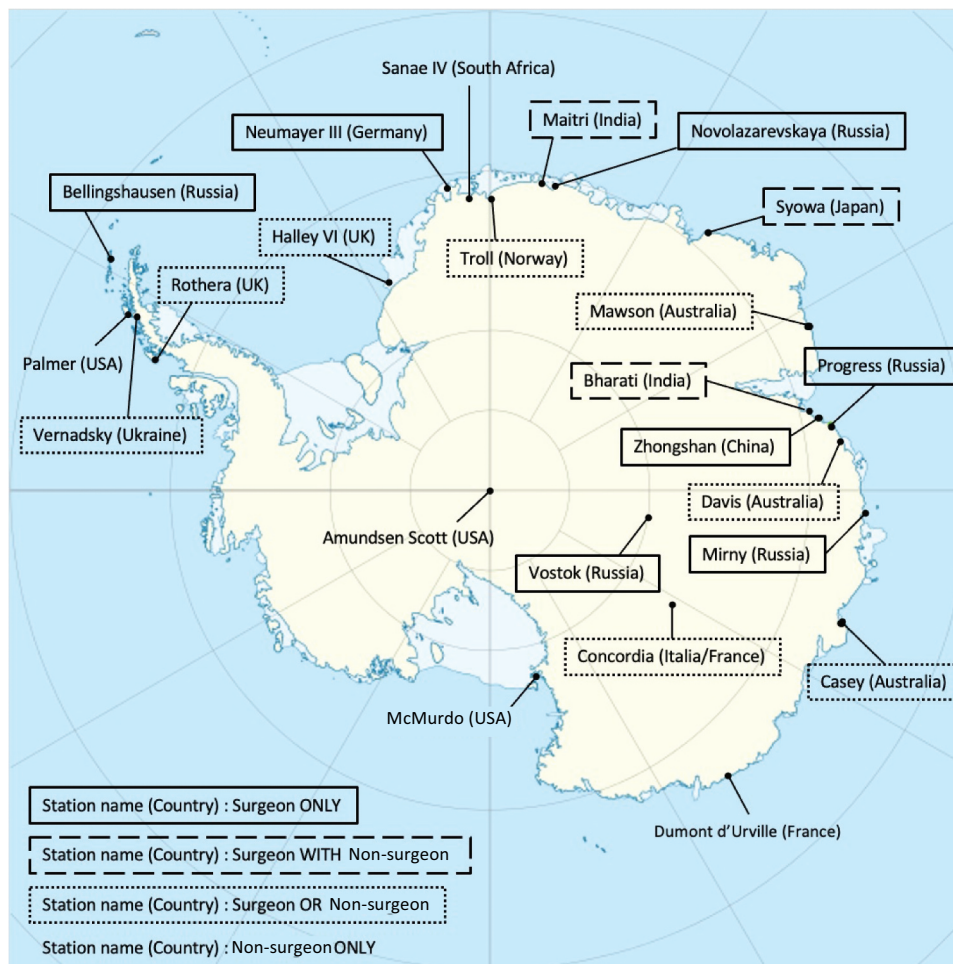
According to the COMNAP catalogue [25], 36 doctors are present at the permanent stations during the austral winter. The survey estimated that non-surgeons represented between 30% ( $n = 11/36$ ) and 55% ( $n = 20/36$ ) of physicians, while surgeons represented between 45% ( $n = 16/36$ ) and 70% ( $n = 25/36$ ) depending on the year (Table 1).

### Surgical training program

Among the 13 countries, nine confirmed that they provide surgical training before the mission (Australia, China, Germany, Italy, France, Japan, South Africa, UK, USA). For the remaining four countries, the doctors have to train themselves (Russia, Norway, India, Ukraine). Norway requires at least one day working in a dental practice and recommends training in orthopaedic surgery, anaesthesia, and emergency medicine. Ukraine relies solely on feedback from doctors from previous missions.

### Theoretical training

Regarding teaching, six countries declared that they relied on theoretical materials (Australia, China, France,



**Figure 2.** Mapping of surgeons and non-surgeons present on the permanent stations in Antarctica.

UK, Japan, USA), all of which were adapted to non-surgeons. All countries reported using textbooks, while four declared using videos (Australia, China, UK, USA). China and Australia used intranet platforms, namely a private computer network only accessible to users of an establishment or training course (Figure 3). Other media were also cited. The United Kingdom relied on a digital syllabus or digital course sheets. Australia organised courses with the Center for Antarctic Remote & Maritime Medicine (CARMM), which included notions of regional anaesthesia and digestive emergencies, as well as the Australian College of Remote & Rural Medicine (ACRRM). The United States reported relying on conferences. The three remaining countries (Italy, Germany, South Africa) offered only practical training.

### Practical training

For all surgical disciplines aside from dentistry, five countries (Italy, Germany, Australia, France, China) organised practical training sessions that took place in an

anatomy and/or simulation laboratory ( $n = 4$ , Germany, Australia, France, China) or in a conventional surgery department ( $n = 5$ , Italy, Germany, Australia, France, China). Some countries ( $n = 4$ ) provided no training in these disciplines (apart from dentistry), which was explained by different reasons. For example, the United States had the ability to repatriate expedition members in any season. Germany systematically recruited a surgeon, while Japan recruited a surgeon/non-surgeon pair. As for South Africa, it required non-surgical doctors to have practical experience in surgery.

By contrast, these nine countries all provided practical training in dental surgery.

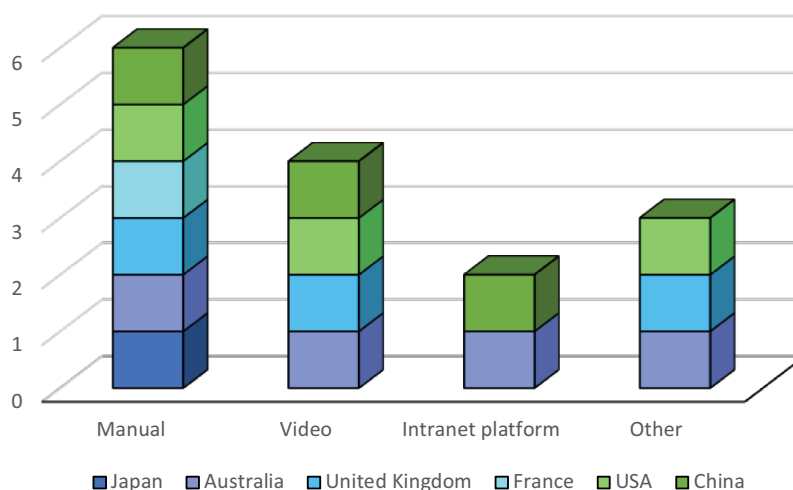
### Duration of training

The duration of surgical training varied between countries. The United Kingdom offered training ranging from 1 day to 2 weeks depending on the surgical experience of the recruited doctors. Australia provided training over 4 weeks, although it was adapted to the surgical experience of the recruited doctor. China and Italy offered



**Table 1.** Summary of medical and surgical staff per year and per country. The unknown numbers (NA) are expressed as an interval since their numbers vary each year. These data are taken from the COMNAP 2017 catalogue (25).

Country	Number of doctors per station during summer	Number of doctors per station during winter	Number of surgeons (winter)	Number of non-surgeons (winter)	Total number of medical staff per year
Australia	Casey: 2 David: 1 Mawson: 1	Casey: 1 Davis: 1 Mawson: 1	NA {0; 3}	NA {0; 3}	7
China	Zhongshan: 1	Zhongshan: 1	1	0	2
France	Dumont d'Urville: 1 Concordia: 1	Dumont d'Urville: 1 Concordia: 1	0	2	4
Germany	Neumayer: 3	Neumayer: 3	3	0	6
United Kingdom	Halley: 5 Rothera: 2	Halley: 1 Rothera: 1	NA {0; 3}	NA {0; 3}	9
India	Bharati: 2 Maitri: 2	Bharati: 2 Maitri: 2	2	2	8
Italy	Concordia: 1	Concordia: 1	NA {0; 1}	NA {0; 1}	2
Japan	Syowa: 4	Syowa: 2	1	1	6
Norway	Troll: 2	Troll: 1	NA {0; 1}	NA {0; 1}	3
Russia	Bellingshausen: 1 Mirny: 2 Novolazarevskaya: 2 Progress: 2 Vostok: 2	Bellingshausen: 1 Mirny: 2 Novolazarevskaya: 2 Progress: 2 Vostok: 2	9	0	18
South Africa	Sanae: 2	Sanae: 1	0	1	3
United States	Amundsen-Scott: 1 McMurdo: 8 Palmer: 1	Amundsen-Scott: 2 McMurdo: 2 Palmer: 1	0	5	15
Ukraine	Vernadsky: 1	Vernadsky: 1	NA {0; 1}	NA {0; 1}	2
Total {minimum; maximum}	50	36	{16; 25}	{11; 20}	86

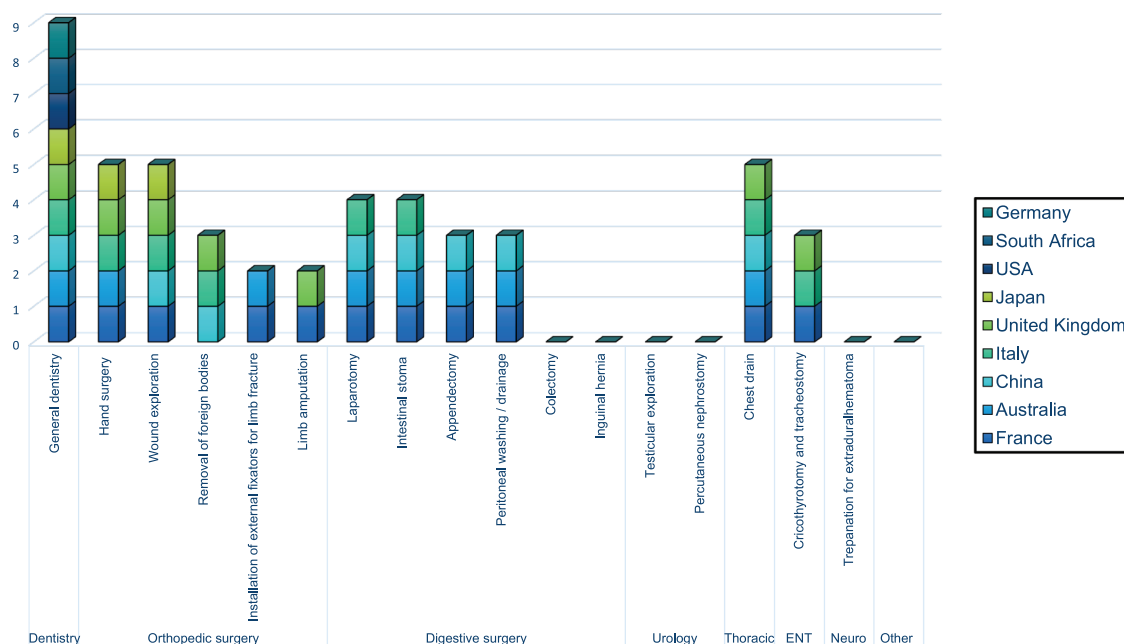
**Figure 3.** Number of countries using each type of theoretical training. The “other” category included digital syllabus (UK), conferences (USA), and courses with CARM (Australia).

a 2-week training session. As for France, a 3-month internship in a surgery department was supplemented by 3 days of practice in an anatomy laboratory with the teaching of specific techniques by specialist surgeons.

### Surgical procedures

The list of surgical procedures proposed in the questionnaire concerned seven surgical specialities: dentistry, orthopaedic surgery, digestive surgery, urology, thoracic surgery, ear, nose and throat (ENT), and neurosurgery. This list included 16 procedures in addition

to dental procedures. Questionnaire respondents mentioned only five surgical specialities. Dental surgery training was given by all nine countries. For the other procedures, hand surgery, wound exploration and washing, and insertion of chest drains were cited five times. Laparotomy and creation of an intestinal stoma were mentioned four times. Removal of foreign bodies, appendectomy, peritoneal lavage and drainage, cricothyrotomy, and tracheostomy were reported three times. The installation of external fixators, limb amputation, and colectomy were mentioned twice. Finally, the



**Figure 4.** Number of countries providing practical training for each gesture.

surgical management of a strangulated inguinal hernia, testicular exploration, percutaneous nephrostomy, and trepanation also known as craniotomy were not mentioned. No other type of intervention was reported by the participants (Figure 4).

### **Evaluation of skills acquired before departure**

For the nine countries providing surgical training, none evaluated the post-training skills of the doctors before their departure to Antarctica.

### **Medical equipment and telemedicine**

Cross-checking the data from the questionnaire with those from the COMNAP catalogue [25] made it possible to draw up a list of the surgical capacities and some of the equipment available at the stations. Of the 23 stations included in our study, 19 had general anaesthesia equipment, 7 were equipped for blood transfusions, and 22 had a telemedicine system available (Table 2).

Telemedicine for surgery could be used before the operation ( $n = 10$ , Italy, Japan, Germany, UK, Australia, South Africa, Russia, France, China, India), in real time ( $n = 6$ , Italy, Japan, Germany, Australia, Norway, China), or after surgery ( $n = 6$ , India, Japan, Germany, Australia,

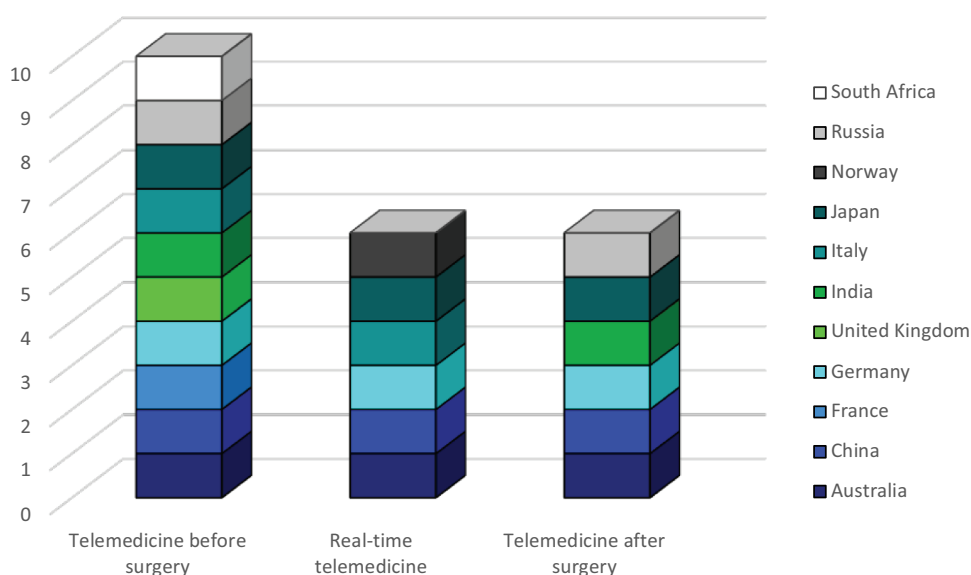
Russia, China). Ukraine also practiced telemedicine but did not mention when it was used (Figure 5).

### **Discussion**

A total of 14 Antarctic programs meeting our inclusion criteria were contacted to participate in this study. The response rate was 93%. It is not known why certain jurisdictions did not participate in our study. It cannot be interpreted as a country's reluctance to disclose sensitive information. Depending on the years of recruitment, non-surgical physicians constituted between 30% and 55% of all winter medical staff present in Antarctica and surgeons between 45% and 70%. Surgical training was offered by nine countries, with both theoretical ( $n = 6$ ) and practical ( $n = 9$ ) training over a heterogeneous duration. Five surgical specialties were included in the practical training.

This survey is the first publication to collect data on the surgical preparation of doctors practicing in Antarctica. Its questionnaire-based format allowed us to rapidly collect a large amount of data adapted to the descriptive nature of our study. The response rate was also very high, thus limiting the risk of selection bias. In addition, the completion of the questionnaire by email was well adapted to the geographic distribution of respondents, as it eliminated time zone issues for people living in different areas [26,27].





**Figure 5.** Number of countries using telemedicine before, during, or after surgery.

Despite two examiners proofreading the questionnaire, this study may have included an information bias related to the respondents' poor understanding of the questions, which could have led to incorrect answers. To limit this bias, additional emails were sent to participants when their response was unclear.

The recruitment strategy of physicians differed according to the Antarctic programs, which each had its own organisation. Some recruited surgeons and

non-surgeons alike (general practitioner, emergency doctor, or other) and preferred to train the recruited physicians in the skills that they lacked. Other countries only hired surgeons to minimise the risk of pre- and post-operative complications due to their experience. Nevertheless, these surgeons still have to treat medical pathologies of which they are not specialists. The countries that hired only non-surgeons are more in line with medical epidemiology, which reports

**Table 2.** Surgical management capabilities of the winter stations and the available equipment for general anaesthesia, blood transfusion, and telemedicine (25).

Country	Permanent station	Medical capabilities	Facilities		
			General anaesthesia	Blood bank for transfusion	Telemedicine
Australia	Casey	Surgery, dental, basic	Yes	Yes	Yes
	David	Surgery, dental, basic	Yes	Yes	Yes
	Mawson	Surgery, dental, basic	Yes	Yes	Yes
China	Zhongshan	Surgery	Yes	Unknown	Yes
France	Dumont d'Urville	Surgery, dental, basic	Yes	Yes	Yes
Germany	Neumayer	Surgery, dental, basic	Yes	Unknown	Yes
United Kingdom	Halley	Surgery	Yes	Yes	Yes
	Rothera	Dental, basic	Unknown	Unknown	Yes
India	Bharati	Surgery, basic	Yes	Unknown	Unknown
	Maitri	Surgery, basic	Yes	Unknown	Yes
Italy/France	Concordia	Surgery, dental, basic	Yes	Unknown	Yes
Japan	Syowa	Surgery, dental	Yes	Unknown	Yes
Norway	Troll	Surgery, dental	Yes	Yes	Yes
Russia	Bellingshausen	Surgery, dental, basic	Yes	Unknown	Yes
	Mirny	Surgery, dental, basic	Yes	Unknown	Yes
	Novolazarevskaya	Surgery, dental, basic	Yes	Unknown	Yes
	Progress	Surgery, dental, basic	Yes	Unknown	Yes
	Vostok	Surgery, dental, basic	Yes	Unknown	Yes
South Africa	Sanae	Surgery, dental	Yes	Unknown	Yes
United States	Amundsen-Scott	Dental, basic	Unknown	Unknown	Yes
	McMurdo	Dental, basic	Unknown	Unknown	Yes
	Palmer	Dental, basic	Unknown	Unknown	Yes
Ukraine	Vernadsky	Surgery, dental, basic	Yes	Yes	Yes

a majority of non-surgical referrals [16,20,28]. However, this exposes practitioners to the possibility of performing surgery without prior surgical experience, which would put patients at greater risk of intra- and post-operative complications. Finally, some countries like Japan and India systematically opt for a double recruitment with both a surgeon and a non-surgeon. Japan cited the following reasons for this choice [28] first, this allows one doctor to be treated by the other doctor, thus avoiding the situation of Leonid Rogozov's self-appendectomy [7]. Second, it means that medical support is simultaneously available for expedition members at the station and for scientists spending several days away from the base. Third, the recruitment of both a surgeon and a non-surgeon compensates for the geographical isolation of Syowa station given the impossibility of requesting medical assistance from a neighbouring station in winter. This is in contrast with other Antarctic programs that are situated closer to neighbouring stations. For example, the Maitri station requested the help of doctors from the neighbouring Russian station Novolazarevskaya in March 2008 in order to perform an appendectomy at the Indian station [20].

This non-exhaustive study did not seek to determine the speciality and initial training of the recruited surgeons. An additional study would be necessary to detail these data and analyse the training differences according to country and speciality.

Regardless of the recruitment strategy chosen, the number of non-surgeon doctors wintering in Antarctica was significant, since they represented at least one-third of physicians. Surgical training therefore seems justified before embarking on an expedition to this continent given the difficulties and cost of evacuations [4].

Countries without any surgical training program relied on the presence of at least one surgeon on their base or on the doctor undertaking their own training in various surgical disciplines. No data are currently available in the literature concerning the problems encountered by these countries without a surgical training program. Complementary studies would bring to light any significant differences between self-trained doctors and those receiving training from their Antarctic program in terms of treatment complications.

Two-thirds of the training countries stated that they provided theoretical training adapted to non-surgeons in addition to practical training. The training combined traditional and modern methods with manuals, thematic conferences as well as videos and course sheets summarised in digital format. According to a systematic

review, the combination of videos with traditional media (books, conferences, face-to-face courses) significantly improves knowledge gain in surgical training. Its use would also positively impact learning time, surgical skill acquisition, and trainee satisfaction when used in combination with simulator exercises [26]. Currently, only four countries use videos. The generalisation of its use could expand training to all future Antarctic doctors. The theoretical part of the training could also be based on pre-existing online platforms for surgical residents, such as WISE-MD (a series of online surgical modules) or WebSurg, a virtual surgical university, accessible from anywhere in the world via the Internet, available in 6 languages. However, they need to be adapted to the material and human constraints encountered in Antarctica. Exeter Medical School (UK) also offers a number of online modules for an international degree (MSc) in Extreme Medicine. However, it does not yet offer a module dedicated to emergency surgery in isolated environments.

For the training countries, the decision to provide practical training in dental surgery was unanimous in the absence of a dentist recruited during the austral winter. This included the American stations of McMurdo and Amundsen Scott South Pole, which only benefit from a dentist during the austral summer for a period of 6 to 9 months [29]. This choice may also be motivated by the cost/risk balance in favour of on-site care rather than medical evacuation [4]. Moreover, despite the frequency of appendicitis, fractures, amputations, wound explorations, and hand surgery reported in the literature [16,20,28], only half of the countries declared preparing their physicians for orthopaedic surgery and only one-third for digestive surgery. Other surgical procedures for rarer but life-threatening pathologies that have already been performed on the Antarctic continent could also be studied such as craniotomy [30]. Nevertheless, certain surgical procedures have not yet been described in the literature, which seems crucial. This is the case of cricothyrotomy and tracheostomy, which are indicated in the event of a life-threatening emergency due to upper airway obstruction or difficult intubation [31], or the creation of an intestinal stoma in the event of intestinal perforation or serious intestinal trauma [32].

The training time required before the mission represents an important limitation in the acquisition of practical skills, since it conditions the opportunities to see and practice as many surgical procedures as possible. The survey reported significant differences between the training countries, ranging from a single day to several months. However, establishing a consensus regarding the duration of practical training seems difficult given

the diversity of profiles recruited and their individual needs. In addition, this study revealed the total absence of any evaluations of surgical knowledge before the departure on mission. The reasons for this choice are not specified but may be explored in the future. A logbook of pedagogical objectives, completed with a final assessment of theoretical and practical knowledge before departure would ensure the traceability of this specific learning and provide an objective judgement of learners' skills, but also better guide their learning [33].

Conventional surgery departments were the main technical training platforms used. The majority of countries completed training in an anatomy and simulation laboratory. Since 2021, the French anatomy laboratory has been equipped with the "SimLife" system, which aims to make cadavers dynamic through vascularisation and pulsatile ventilation [34]. For the moment, simulations on a cadaver or dummy can only be used to reduce the steepness of learning curves; they cannot completely replace real-life situations. They must be used as part of a comprehensive training program [35,36].

The reasons justifying physicians' non-preparation for certain surgical procedures were not specified in the survey, although they were probably multiple and involved material, human, temporal, and budgetary criteria. Future research should evaluate the most relevant criteria in order to ensure informed choices that are adapted to on-site practices. Furthermore, as Hilary King suggested in 1986, the creation of an international systematic registry of epidemiology in Antarctica would help optimise training by considering the reality of the field [37].

Regardless of the type of surgical preparation, the perfect mastery of all surgical procedures remains difficult to acquire for any doctor. This requires both experience and self-confidence. Telemedicine is thus used in Antarctica to compensate for physicians' lack of expertise and knowledge on site. The improvement of telecommunications means that the practice of medicine is now less complicated. From now on, images can be sent via better connections. Some stations can even use high-definition televisions [28]. In the survey, 10 countries used telemedicine before treatment compared with only six during surgery (surgical mentoring). A pilot study investigating the potential use of surgical telementoring demonstrated that it would significantly increase the procedural confidence of non-surgeons and decrease physiological stress [38]. These initial results are encouraging. Further work on this subject would help clarify the effect of telemedicine on physicians'

efficiency when performing surgical procedures in Antarctica.

Despite the available human assistance and telemedicine support, surgical management capabilities depend on the equipment available at each station. The survey did not ask about the available medical equipment, although the COMNAP catalogue [25] indicates whether stations have a general anaesthesia machine and blood transfusion capacity. Overall, 82% of the stations included in the study had a general anaesthesia machine, which would allow major surgical procedures to be carried out depending on the availability of instruments and surgical sets, which is not described. One publication mentions all the equipment available on the Maitri station, namely a set of instruments for performing general, orthopaedic, digestive, thoracic, ENT, and neurosurgery procedures [39].

Only 30% of the stations were able to carry out a blood transfusion. Unfortunately, the expansion of blood transfusion capacities is not simple, since it depends directly on the number of expedition members at each station and their blood type, as observed by the United States. Frozen blood is not kept at every American station. Instead, they rely on the concept of a "walking blood bank" where individual donors can provide blood when needed depending on the blood types [40]. The list of medical equipment already reported in the COMNAP catalogue (i.e. laboratory testing, ultrasound, radiology, endoscopy, hyperbaric chamber, ophthalmology, defibrillator, electrocardiogram, electroencephalogram) could be supplemented with a new catalogue to precisely determine the material capacities (especially surgical equipment) of each station.

## Conclusion

Antarctica remains one of the most isolated territories in the world with the most extreme living conditions. Maintaining a human presence on this continent requires significant financial and human investment, including medical and surgical. This is the first study to examine the surgical training given to winter physicians. It reveals significant differences in terms of the profiles of recruited physicians, the surgical training strategy given before departure, the theoretical and practical training materials used, and the surgical procedures studied. These differences can be explained by the budget of each Antarctic program allocated to medical support, by the geographical location of the stations and the possibility of on-site assistance, depending on whether they are far from neighbouring stations, in

the centre of the continent, or near the coast. The growing experience of each country with a station in this specific environment along with the improved training of physicians with new educational tools and the support provided by telemedicine should progressively optimise the surgical care available in Antarctica.

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No potential conflict of interest was reported by the author(s).

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